Program Name : All Branches of Diploma in Engineering and Technology.
Program Code : CE/CR/CS/CH/PS/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/MU/EE/EP/EU/IS/IC/AE /FG/ME/PG/PT/DC/TX/TC/BC
Semester : First
Couse Title : Fundamentals of ICT
Couse Code : 22001

1. RATIONALE

In any typical business setup in order to carry out routine tasks related to create business documents, perform data analysis and its graphical representations and making electronic slide show presentations, the student need to learn various software as office automation tools like word processing applications, spreadsheets and presentation tools. They also need to use these tools for making their project reports and presentations. The objective of this course is to develop the basic competency in students for using these office automation tools to accomplish the job.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use computers for internet services, electronic documentation, data analysis and slide presentation.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Use computer system and its peripherals.
b. Prepare business document using word processing tool.
c. Interpret data and represent it graphically using spreadsheet.
d. Prepare professional presentations.
e. Use different types of web browsers.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2	--	2	4	--	--	--	--	--	--	--	25@S	10	25~	10	50	20

*(~[1]): For the courses having **ONLY practical** examination, the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 15 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 10 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment; # No theory exam.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

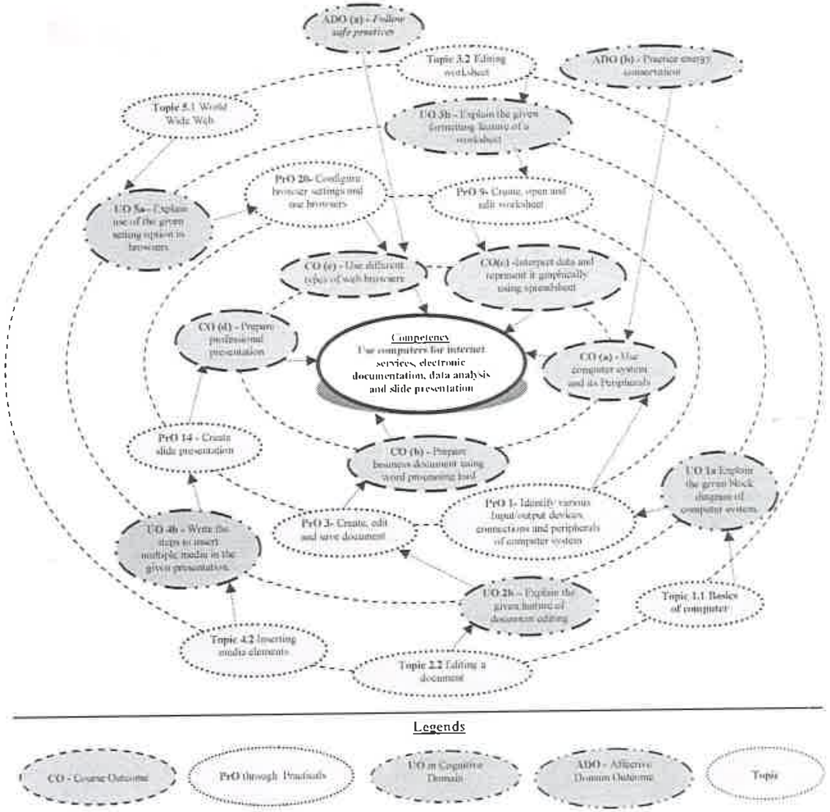


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	Computer system and Operating system:		
1	Identify various Input/output devices, connections and peripherals of computer system	I	1*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
2	Manage files and folders : Create, copy, rename, delete, move files and folder	I	1
	Word Processing		
3	Create, edit and save document : apply formatting features on the text - line, paragraph	II	2*
4	Use bullets, numbering, page formatting	II	2
5	Insert and edit images and shapes, sizing, cropping, colour, background, group/ungroup	II	2
6	Insert and apply various table formatting features on it.	II	2
7	Apply page layout features i. Themes, page background, paragraph, page setup ii. Create multicolumn page iii. Use different options to print the documents	II	2*
8	Use mail merge with options.	II	1
	Spreadsheets		
9	Create, open and edit worksheet i. Enter data and format it, adjust row height and column width ii. Insert and delete cells, rows and columns iii. Apply wrap text, orientation feature on cell.	III	2*
10	Insert formulas, "IF" conditions, functions and named ranges in worksheet.	III	2
11	Apply data Sort, Filter and Data Validation features.	III	2*
12	Create charts to apply various chart options.	III	2
13	Apply Page setup and print options for worksheet to print the worksheet	III	1
	Presentation Tool		
14	Create slide presentation i. Apply design themes to the given presentation ii. Add new slides and insert pictures/images, shapes	IV	2*
15	i. Add tables and charts in the slides. ii. Run slide presentation in different modes iii. Print slide presentation as handouts	IV	2
16	Apply animation effects to the text and slides.	IV	1
17	Add audio and video files in the given presentation	IV	1
	Internet Basics		
18	Configure Internet connection	V	1
19	Use internet for different web services.	V	2*
20	Configure browser settings and use browsers.	V	1*
	Total		**32**

'': compulsory practicals to be performed.*

Note

i. A suggestive list of practical UOs is given in the above table, more such PrOs can be added to attain the COs and competency.

ii. Hence, the 'Process' and 'Product' related skills associated with each PrOs of the laboratory/workshop/field work are to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Use of Appropriate tool to solve the problem (Process)	40
b.	Quality of output achieved (Product)	30
c.	Complete the practical in stipulated time	10
d.	Answer to sample questions	10
e.	Submit report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of PrOs, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1	Computer system with all necessary components like; motherboard, random access memory (RAM), read-only memory (ROM), Graphics cards, sound cards, internal hard disk drives, DVD drive, network interface card.	1
2	Double side printing laser printer.	1,6,12,13
3	Hubs, Switches, Modems.	1, 16,17
4	Any operating system.	2 to18
5	Any Office Software.	2 to 15
6	Any browser	16,17,18

Note: There are no specifications fixed for the above listed systems, devices and instruments. Depending on the availability in the institute they can be utilized for the purpose.

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics are to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to Computer System	1a. Explain the given block diagram of computer system. 1b. Classify the given type of software 1c. Explain characteristics of the specified type of network. 1d. Describe procedure to manage a file /folder in the given way. 1e. Describe application of the specified type of network connecting device	1.1 **Basics of Computer System:** Overview of Hardware and Software: block diagram of Computer System, Input/Output unit CPU, Control Unit, Arithmetic logic Unit (ALU), Memory Unit 1.2 **Internal components:** processor, motherboards, random access memory (RAM), read-only memory (ROM), video cards, sound cards and internal hard disk drives) 1.3 **External Devices:** Types of input/output devices, types of monitors, keyboards, mouse, printers: Dot matrix, Inkjet and LaserJet, plotter and scanner, external storage devices CD/DVD, Hard disk and pen drive 1.4 **Application Software:** word processing, spreadsheet, database management systems, control software, measuring software, photo-editing software, video-editing software, graphics manipulation software System Software compilers, linkers, device drivers, operating systems and utilities 1.5 **Network environments**: network interface cards, hubs, switches, routers and modems, concept of LAN, MAN, WAN, WLAN, Wi-Fi and Bluetooth 1.6 **Working with Operating Systems**: Create and manage file and folders, Copy a file, renaming and deleting of files and folders, Searching files and folders, application installation, creating shortcut of application on the desktop.
Unit– II Word Processing	2a. Write steps to create the given text document. 2b. Explain the specified feature for document editing. 2c. Explain the given page setup features of a document. 2d. Write the specified table formatting feature.	2.1. **Word Processing:** Overview of Word processor Basics of Font type, size, .colour, Effects like Bold, italic, underline, Subscript and superscript, Case changing options, Previewing a document, Saving a document, Closing a document and exiting application. 2.2. **Editing a Document:** Navigate through a document, Scroll through text, Insert and delete text, Select text, Undo and redo commands, Use drag and drop to move text, Copy, cut and paste, Use the clipboard, Clear formatting, Format and align text, Formatting Paragraphs, Line and paragraph spacing, using FIND and REPLACE, Setting line

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		spacing, add bullet and numbers in lists, add borders and shading, document views, Page settings and margins, Spelling and Grammatical checks 2.3. **Changing the Layout of a Document:** Adjust page margins, Change page orientation, Create headers and footers, Set and change indentations, Insert and clear tabs. 2.4. **Inserting Elements to Word Documents**: Insert and delete a page break, Insert page numbers, Insert the date and time, Insert special characters (symbols), Insert a picture from a file, Resize and reposition a picture 2.5. **Working with Tables:** Insert a table, Convert a table to text, Navigate and select text in a table, Resize table cells, Align text in a table, Format a table, Insert and delete columns and rows, Borders and shading, Repeat table headings on subsequent pages, Merge and split cells. 2.6. **Working with Columned Layouts and Section Breaks:** a Columns, Section breaks, Creating columns, Newsletter style columns, Changing part of a document layout or formatting, Remove section break, Add columns to remainder of a document, Column widths, Adjust column spacing, Insert manual column breaks.
Unit– III Spreadsheets	3a. Write steps to create the given spreadsheet. 3b. Explain the specified formatting feature of a worksheet. 3c. Write steps to insert formula and functions in the given worksheet. 3d. Write steps to create charts for the specified data set. 3e. Explain steps to perform advance operation on the given data set.	3.1. **Working with Spreadsheets:** Overview of workbook and worksheet, Create Worksheet Entering sample data, Save, Copy Worksheet, Delete Worksheet, Close and open Workbook. 3.2. **Editing Worksheet:** Insert and select data, adjust row height and column width, delete, move data, insert rows and columns, Copy and Paste, Find and Replace, Spell Check, Zoom In-Out, Special Symbols, Insert Comments, Add Text Box, Undo Changes, - Freeze Panes, hiding/unhiding rows and columns. 3.3. **Formatting Cells and sheet:** Setting Cell Type, Setting Fonts, Text options, Rotate Cells, Setting Colors, Text Alignments, Merge and Wrap, apply Borders and Shades, Sheet Options, Adjust Margins, Page

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Orientation, Header and Footer, Insert Page Breaks, Set Background. 3.4. **Working with Formula:** Creating Formulas, Copying Formulas, Common spreadsheet Functions such as sum, average, min, max, date, In, And, or, mathematical functions such as sqrt, power, applying conditions using IF. 3.5. **Working with Charts:** Introduction to charts, overview of different types of charts, Bar, Pie, Line charts, creating and editing charts. Using chart options: chart title, axis title, legend, data labels, Axes, grid lines, moving chart in a separate sheet. 3.6. **Advanced Operations:** Conditional Formatting, Data Filtering, Data Sorting, Using Ranges, Data Validation, Adding Graphics, Printing Worksheets, print area, margins, header, footer and other page setup options.
Unit– IV Presentation Tool	4a. Write the steps to create the specified slide presentation. 4b. Write the steps to insert multiple media in the given presentation. 4c. Write steps to apply table features in the given presentation 4d. Write steps to manage charts in the given presentation	4.1 **Creating a Presentation:** Outline of an effective presentation, Identify the elements of the User Interface, Starting a New Presentation Files, Creating a Basic Presentation, Working with textboxes, Apply Character Formats, Format Paragraphs, View a Presentation, Saving work, creating new Slides, Changing a slide Layout, Applying a theme, Changing Colours, fonts and effects, apply custom Colour and font theme, changing the background, Arrange Slide sequence, 4.2 **Inserting Media elements:** Adding and Modifying Graphical Objects to a Presentation - Insert Images into a Presentation, insert audio clips, video/animation, Add Shapes, Add Visual Styles to Text in a Presentation, Edit Graphical Objects on a Slide, Format Graphical Objects on a Slide, Group Graphical Objects on a Slide, Apply an Animation Effect to a Graphical Object, Add Transitions, Add Speaker Notes, Print a Presentation. 4.3 **Working with Tables:** Insert a Table in a Slide, Format Tables, and Import Tables from Other Office Applications.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		4.4 **Working with Charts:** Insert Charts in a Slide, Modify a Chart, Import Charts from Other Office Applications.
Unit– V Basics of Internet	5a. Explain use of the given setting option in browsers. 5b. Explain features of the specified web service. 5c. Describe the given characteristic of cloud. 5d. Explain the specified option used for effective searching in search engine.	5.1 **World Wide Web:** Introduction, Internet, Intranet, Cloud, Web Sites, web pages, URL, web servers, basic settings of web browsers-history, extension, default page, default search engine, creating and retrieving bookmarks, use search engines effectively for searching the content. 5.2 **Web Services:** e-Mail, Chat, Video Conferencing, e-learning, e-shopping, e-Reservation, e-Groups, Social Networking.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN
- Not Applicable -

10. SUGGESTED STUDENT ACTIVITIES
Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Prepare journal of practicals.
b. Prepare a sample document with all word processing features (Course teacher shall allot appropriate document type to each students)
c. Undertake micro projects

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)
These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Guide student(s) in undertaking various activities in the lab/workshop.
g. Demonstrate students thoroughly before they start doing the practice.
h. Show video/animation films for handling/functioning of instruments.
i. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Word documents**: Prepare Time Table, Application, Notes, Reports .(Subject teacher shall assign a document to be prepared by the each students)
b. **Slide Presentations:** Prepare slides with all Presentation features such as: classroom presentation, presentation about department, presentation of report. (Subject teacher shall assign a presentation to be prepared by the each student).
c. **Spreadsheets:** Prepare Pay bills, tax statement, student's assessment record using spreadsheet. (Teacher shall assign a spreadsheet to be prepared by each student).

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Computer Fundamentals	Goel, Anita	Pearson Education, New Delhi, 2014, ISBN: 978-8131733097
2	Computer Basics Absolute Beginner's Guide, Windows 10	Miller, Michael	QUE Publishing; 8th edition August 2015, ISBN: 978-0789754516
3	Linux: Easy Linux for Beginners	Alvaro, Felix	CreatevSpace Independent Publishing Platform- 2016, ISBN: 978-1533683731
4	Microsoft Office 2010: On Demand	Johnson, Steve	Pearson Education, New Delhi India, 2010; ISBN: 9788131770641
5	Microsoft Office 2010 for Windows: Visual Quick Start	Schwartz, Steve	Pearson Education, New Delhi India, 2012, ISBN:9788131766613
6	OpenOffice.org for Dummies	Leete, Gurdy, Finkelstein Ellen, Mary Leete	Wiley Publishing, New Delhi, 2003 ISBN: 978-0764542220
7	Computer Fundamentals	Dr. Rajendra Kawale	Devraj Publications, Dist Solapur, Maharashtra

14. SOFTWARE/LEARNING WEBSITES

a. https://www.microsoft.com/en-in/learning/office-training.aspx
b. http://www.tutorialsforopenoffice.org/
c. https://s3-ap-southeast-1.amazonaws.com/r4ltue295xy0d/Special_Edition_Using_StarOffice_6_0.pdf

Course Name : **Mechanical, Electrical, Chemical, Civil & Textile Program Group**
Course Code : **AE/CE/CR/CS/CH/EE/EP/EU/ME/PG/PT/PS/FG/DC/TC/TX**
Semester : **First**
Subject Title : **Engineering Graphics**
Subject Code : **22002**

1. RATIONALE

Engineering graphics is the language of engineers. The concepts of graphical language are used in expressing the ideas, conveying the instructions, which are used in carrying out the jobs on the sites, shop floor. It covers the knowledge and application of drawing instruments and also familiarizes the learner about Bureau of Indian standards related to engineering drawing. The curriculum aims at developing the ability to draw and read various engineering curves, projections and dimensioning styles. The course mainly focuses on use of drawing instruments, developing imagination and translating ideas into sketches. The course also helps to develop the idea of visualizing the actual object or part on the basis of drawings and blue prints. This preliminary course aims at building a foundation for the further courses related to engineering drawing and other allied courses in coming semesters.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Prepare engineering drawing manually using prevailing drawing instruments.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Draw geometrical figures and engineering curves.
b. Draw the views of given object using principles of orthographic projection.
c. Draw isometric views of given component or from orthographic projections.
d. Use drawing codes, conventions and symbols as per IS SP-46 in engineering drawing.
e. Draw free hand sketches of given engineering elements.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2	--	4	6	--	--	--	--	--	--	--	50@	20	50~	20	100	40

(**) marks should be awarded on the basis of internal end semester theory exam of 50 marks based on the specification table given in S. No. 9.
*(~²): For the courses having **ONLY practical** examination, the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e.30 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e.20 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment, #: No theory paper.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

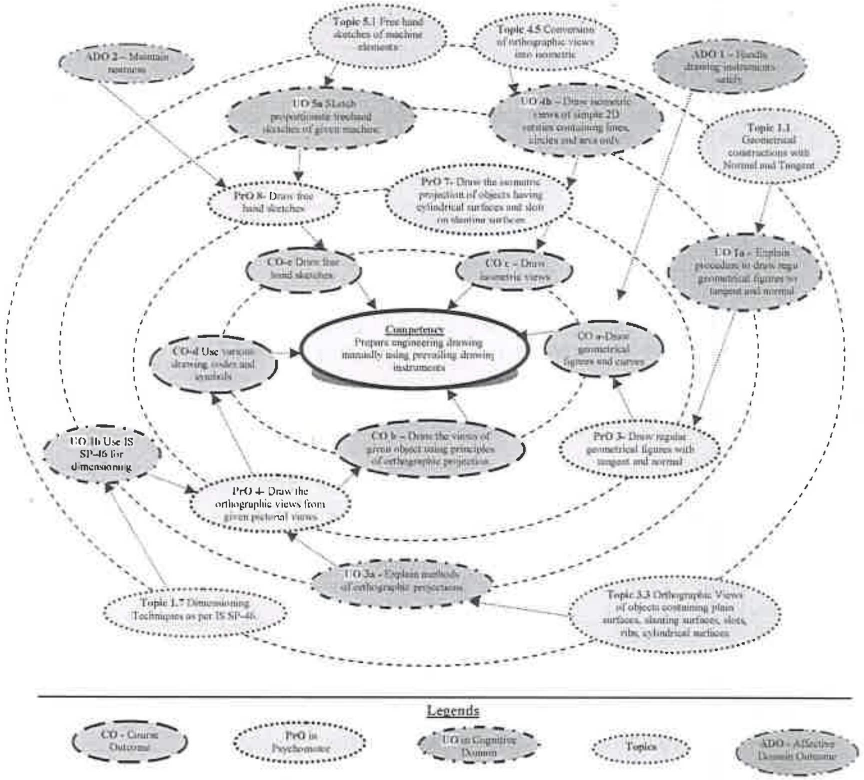


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency. Following practicals (except 1, 2, 3, 4, 31 and 32) are to be attempted on A2 drawing sheets.

S. No.	Practical Outcomes (PrOs) (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. Required
Sketch Book			

S. No.	Practical Outcomes (PrOs) (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. Required
1	Draw horizontal, vertical, 30 degree, 45 degree, 60 and 75 degrees lines, different types of lines, dimensioning styles using Set squares/ drafter.	I	02
2	Write alphabets and numerical (Vertical only)	I	02
3	Draw regular geometric constructions	I	02
4	Redraw the given figure	I	02
Sheet No. 1(Three problems)			
5	Draw one figure showing dimensioning techniques. (Problem 1)	I	02
6	Draw one problem on redraw the figure. (Problem 2)	I	02
7	Draw one problem on loci of points - slider crank mechanism. (Problem 3)	I	02
Sheet No. 2 (Two problems)			
8	Draw Engineering Curves. (Problem 1)	II	02
9	Draw Engineering Curves. (Problem 1 continued)	II	02
10	Draw Engineering Curves. (Problem 2)	II	02
11	Draw Engineering Curves. (Problem 2 continued)	II	02
Sheet No. 3(Two problems)			
12	Draw a problem on orthographic projections using first angle method of projection having plain and slanting surfaces. (Problem 1)	III	02
13	Draw problem on orthographic projections using first angle method of projection having plain and slanting surfaces. (Problem 1 continued)	III	02
14	Draw another problem on orthographic projections using first angle method of projection having plain and slanting surfaces. (Problem 2)	III	02
15	Draw another problem on orthographic projections using first angle method of projection having plain and slanting surfaces. (Problem 2 continued)	III	02
Sheet No. 4 (Two problems)			
16	Draw two problems on orthographic projections using first angle method of projection having cylindrical surfaces, ribs. (Problem 1)	III	02
17	Draw two problems on orthographic projections using first angle method of projection having cylindrical surfaces, ribs. (Problem 1 continued)	III	02
18	Draw two problems on orthographic projections using first angle method of projection having cylindrical surfaces, ribs. (Problem 2)	III	02
19	Draw two problems on orthographic projections using first angle method of projection having cylindrical surfaces, ribs. (Problem 2 continued)	III	02
Sheet No. 5 (Two problems)			
20	Draw two problems on Isometric view of simple objects having plain and slanting surface by using natural scale. (Problem 1)	IV	02
21	Draw two problems on Isometric view of simple objects having plain and slanting surface by using natural scale. (Problem 1 continued)	IV	02

S. No.	Practical Outcomes (PrOs) (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. Required
22	Draw two problems on Isometric view of simple objects having plain and slanting surface by using natural scale. (Problem 2)	IV	02
23	Draw two problems on Isometric view of simple objects having plain and slanting surface by using natural scale. (Problem 2 continued)		
Sheet No. 6(Two problems)			
24	Draw a problem on Isometric Projection of objects having cylindrical surface by using isometric scale. (Problem 1)	IV	02
25	Draw a problem on Isometric Projection of objects having cylindrical surface by using isometric scale. (Problem 1 continued)	IV	02
26	Draw a problem on Isometric Projection of objects having slot on slanting surface by using isometric scale. (Problem 2)	IV	02
27	Draw a problem on Isometric Projection of objects having slot on slanting surface by using isometric scale. (Problem 2 continued)	IV	02
Sheet No. 7 (Six problems)			
28	Draw free hand sketches/conventional representation of machine elements in sketch book such as thread profiles, nuts, bolts, studs, set screws, washers, Locking arrangements. (Problem 1,2)	V	02
29	Draw free hand sketches/conventional representation of machine elements in sketch book such as thread profiles, nuts, bolts, studs, set screws, washers, Locking arrangements. (Problem 3,4)	V	02
30	Draw free hand sketches/conventional representation of machine elements in sketch book such as thread profiles, nuts, bolts, studs, set screws, washers, Locking arrangements. (Problem 5,6)	V	02
Sketch Book (Two problems)			
31	Problem Based Learning: Given the 3D model of an object ,student will try to imagine the three views and draw them in the sketch book.(Problem 1)	III, II, V	02
32	Problem Based Learning: Given the 3D model of an object ,student will try to imagine the three views and draw them in the sketch book.(Problem 2)	III, II, V	02
	Total		64

All practicals are to be performed.

Note

i. A suggestive list of PrOs is given in the above table, more such PrOs can be added to attain the COs and competency.

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Neatness, Cleanliness on drawing sheet	10
2	Uniformity in drawing and line work	10

S. No.	Performance Indicators	Weightage in %
3	Creating given drawing	40
4	Dimensioning the given drawing and writing text	20
5	Answer to sample questions	10
6	Submission of drawing in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow cleanliness and neatness.
b. Follow ethics and standards.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1	Drawing Table with Drawing Board of Full Imperial/ A1 size.	All
2	Models of objects for orthographic / isometric projections	4,5,6,7
3	Models/ Charts of objects mentioned in unit no. 5	-
4	Set of various industrial drawings being used by industries.	All
5	Set of drawings sheets mentioned in section 6.0 could be developed by experienced teachers and made used available on the MSBTE portal to be used as reference/standards.	All
6	Drawing equipment's and instruments for class room teaching-large size: a. T-square or drafter (Drafting Machine) b. Set squares (45^0 and 30^0- 60^0) c. Protractor d. Drawing instrument box (containing set of compasses and dividers)	All
7	Interactive board with LCD overhead projector	All

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics is to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basic elements of Drawing	1a. Prepare drawing using drawing instruments. 1b. Use IS SP-46 for dimensioning. 1c. Use different types of lines. 1d. Draw regular geometrical figures. 1e. Draw figures having tangency constructions.	1.1 Drawing Instruments and supporting material: method to use them with applications. 1.2 Standard sizes of drawing sheets (ISO-A series) 1.3 I.S. codes for planning and layout. 1.4 Letters and numbers (single stroke vertical) 1.5 Convention of lines and their applications. 1.6 Scale - reduced, enlarged and full size 1.7 Dimensioning techniques as per SP-46 (Latest edition) – types and applications of chain, parallel and coordinate dimensioning 1.8 Geometrical constructions.
Unit– II Engineering curves and Loci of Points	2a. Explain different engineering curves with areas of application. 2b. Draw different conic sections based on given situation. 2c. Draw involute and cycloidal curves based on given data. 2d. Draw helix and spiral curves from given data 2e. Plot Loci of points from given data.	2.1 Concept of focus, directrix, vertex and eccentricity. Conic sections. 2.2 Methods to draw an ellipse by Arcs of circle method and Concentric circles method. 2.3 Methods to draw a parabola by Directrix-Focus method and Rectangle method 2.4 Methods to draw a hyperbola by Directrix-Focus method. 2.5 Methods to draw involutes: circle and pentagon, 2.6 Methods to draw Cycloidal curve: cycloid, epicycloid and hypocycloid 2.7 Methods to draw Helix and Archimedean spiral. 2.8 Loci of points on Single slider crank mechanism with given specifications.
Unit– III Orthographic projections	3a. Explain methods of Orthographic Projections. 3b. Draw orthographic views of given simple 2D entities containing lines, circles and arcs only. 3c. Draw the orthographic views from given pictorial views.	3.1 Projections-orthographic, perspective, isometric and oblique: concept and applications.(No question to be asked in examination) 3.2 Orthographic projection, First angle and Third angle method, their symbols. 3.3 Conversion of pictorial view into Orthographic Views – object containing plain surfaces, slanting surfaces, slots, ribs, cylindrical surfaces. (use First Angle Projection Method Only)
Unit– IV Isometric projections	4a. Prepare isometric scale. 4b. Draw isometric views of given simple 2D entities containing lines,	4.1 Isometric projection. 4.2 Isometric scale and Natural Scale. 4.3 Isometric view and isometric projection. 4.4 Illustrative problems related to simple

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	circles and arcs only. 4c. Interpret the given orthographic views. 4d. Draw Isometric views from given orthographic views.	objects having plain, slanting, cylindrical surfaces and slots on slanting surfaces. 4.5 Conversion of orthographic views into isometric View/projection.
Unit– V Free Hand Sketches of engineerin g elements	5a. Sketch proportionate freehand sketches of given machine elements. 5b. Select proper fasteners and locking arrangement for given situation.	5.1 Free hand sketches of machine elements: Thread profiles, nuts, bolts, studs, set screws, washers, Locking arrangements. (For branches other than mechanical Engineering, the teacher should select branch specific elements for free hand sketching)

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER (INTERNAL) DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Principles of Drawing	04	-	02	04	06
II	Engineering curves and Loci of Points.	06	-	02	04	06
III	Orthographic projections	06	-	02	08	10
IV	Isometric projections	08	02	07	07	16
V	Free Hand Sketches of m/c elements	08	02	02	08	12
	Total	**32**	**4**	**15**	**31**	**50**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.
This specification table also provides a general guideline for teachers to frame internal end semester practical theory exam paper which students have to undertake on the drawing sheet.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Student should maintain a separate A3 size sketch book which will be the part of term work and submit it along with drawing sheets. Following assignment should be drawn in the sketch book
   i. Single stoke vertical Letters and Numbers.

   ii. Type of lines.
   iii. Redraw the figures (any one).
   iv. Engineering Curves. One problem for each type of curve.
   v. Orthographic projections. Minimum 5 problems.
   vi. Isometric Projections/Views. Minimum 5 problems.
   vii. Free hand sketches. All types of machine elements mentioned in Unit no-5.
   viii. Note- Problems on sheet and in the sketch book should be different.

b. Students should collect Maps, Production drawings, Building Drawings, Layouts from nearby workshops/industries/builders/contractors and try to list
   i. Types of lines used
   ii. Lettering styles used
   iii. Dimension styles used
   iv. IS code referred

c. List the shapes and curves you are observing around you in real life with name of place and item. (For Ex. ellipse, parabola, hyperbola, cycloid, epicycloids, hypocycloid, involute, spiral helix).
d. Take one circular shape. Assume one point on circumference and mark it. Roll that shape on flat and circular surface. Observe the path of the point and try to correlate with the theory taught in the class
e. Take circular and pentagonal shape and wrap a thread over the periphery, now unwrap this thread and observe the locus of the end of the thread and try to correlate with the theory taught in the class
f. Each student should explain at least one problem for construction and method of drawing in sheet to all batch colleagues. Teacher will assign the problem of particular sheet to be explained to each student batch.
g. Each student will assess at least one sheet of other students (May be a group of 5-6 students identified by teacher can be taken) and will note down the mistakes committed by them. Student will also guide the students for correcting the mistakes, if any.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in section No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Guide student(s) in fixing the sheet and mini drafter on drawing board.
g. Show video/animation films to explain orthographic and Isometric projection.
h. Demonstrate first and third angle method using model.
i. Use charts and industrial drawing/drawing sheets developed by experienced faculty to teach standard symbols and current industrial/teaching practices

12. SUGGESTED MICRO PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs, and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Helical springs:** Each batch will collect 5 open coil and closed coil helical springs of various sizes. Each student will measure the significant parameters of one spring and draw corresponding helix curve in his sketch book.
b. **Flat coil or spiral springs:** Each batch will collect 10 spiral springs of various sizes. Each student will measure the significant parameters of one spring and draw corresponding helix curve in his sketch book.
c. **Isometric views**: Each student of the batch will try to collect at least one production drawings/ construction drawings/plumbing drawings from local workshops/builders /electrical and mechanical contractors and try to generate isometric views from the orthographic views given in the drawings.
d. **Isometric views**: Each student of a batch will select a household/industrial real item and will draw its isometric view in the sketch book.
e. **Isometric and orthographic views**: Each batch will collect a single point cutting tool from workshop and draw its Isometric and orthographic views with a ten times enlarged scale. In carpentry shop each batch will try to make wooden model from these views.
f. **Isometric views**: The teacher will assign one set of orthographic projections and ask the student to develop 3D thermocol models of the same.
g. **Involute curves:** Each batch will try to develop cardboard/thermocol working models which can generate involute curve of any regular geometrical shape.
h. **Cycloidal curves:** Each batch will collect 3 different sizes bicycle tyres and compare the locus of tube air valve by rolling them on flat road.
i. **Conic curves:** Each batch will go to institute's play ground and one student standing on the boundary throws a ball to the wicket keeper who is 30 meters away from the thrower and the ball has reached a maximum height of 20 meters from the ground, draw the path of the ball and identify the type of conic curve it has traced in air.
j. **Involute and Cycloidal curves:** Each batch will collect one Involute and one cycloidal tooth profile spur gear and find out the Involute function.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Drawing Practice for Schools and Colleges IS: SP-46	Bureau of Indian Standards.	BIS. Government of India, Third Reprint, October 1998; ISBN: 81-7061-091-2

S. No.	Title of Book	Author	Publication
2.	Engineering Drawing	Bhatt, N.D.	Charotar Publishing House, Anand, Gujarat 2010; ISBN: 978-93-80358-17-8
3.	Machine Drawing	Bhatt, N.D.; Panchal, V. M	Charotar Publishing House, Anand, Gujarat 2010; ISBN: 978-93-80358-11-6
4.	Engineering Drawing	Jolhe, D.A.	Tata McGraw Hill Edu. New Delhi, 2010, ISBN: 978-0-07-064837-1
5.	Engineering Drawing	Dhawan, R. K.	S. Chand and Company New Delhi, ISBN:81-219-1431-0
6.	Engineering Drawing	Shaha, P. J.	S. Chand and Company, New Delhi, 2008, ISBN: 81-219-2964-4

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=TJ4jGyD-WCw
b. https://www.youtube.com/watch?v=dmt6_n7Sgcg
c. https://www.youtube.com/watch?v=_MQScnLXL0M
d. https://www.youtube.com/watch?v=3WXPanCq9LI
e. https://www.youtube.com/watch?v=fvjk7PlxAuo
f. http://www.me.umn.edu/courses/me2011/handouts/engg%20graphics.pdf
g. https://www.machinedesignonline.com

Program Name : **Mechanical, Civil Chemical & Plastic Program Group.**
Program Code : CE/CR/CS/CH/PS/CM/EE/EP/AE/FG/ME/PG/PT
Semester : First
Courset Title : Workshop Practice
Course Code : 22004

1. RATIONALE

Workshop Practice is a basic practical engineering course. The knowledge of basic workshops such as wood working, fitting, welding, plumbing and sheet metal shop is essential for technician to perform his/her duties in industries. Students are able to perform various operations using hand tool equipment and machineries in various shops. Working in workshop develops the attitude of group working and safety awareness. This course provides miniature industrial environment in the educational institute.

2. COMPETENCY

The course should be taught and implemented with the aim to develop the course outcomes (COs) so that student demonstrates the following competency needed by the industry:

- **Prepare simple jobs on the shop floor of the engineering workshop.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Select tools and machinery according to job.
b. Use hand tools in different shops for performing different operation.
c. Operate equipment and machinery in different shops.
d. Prepare job according to drawing.
e. Maintain workshop related tools, equipment and machinery.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
--	--	4	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40

*(~^{2}): For the courses having **ONLY practical** examination, the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 30 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 20 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*
***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

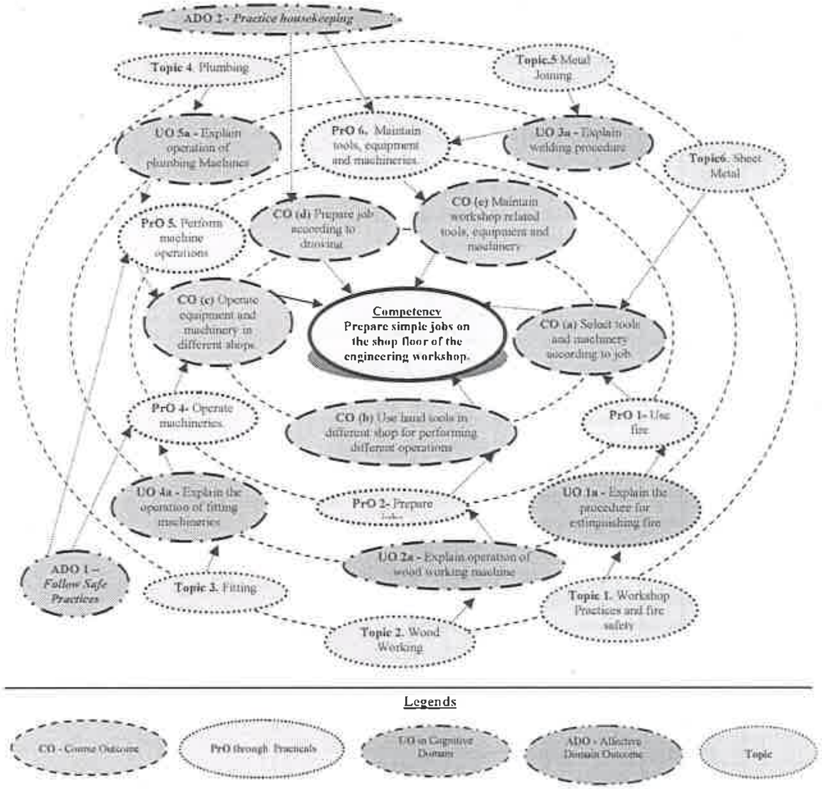


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
1	Perform mock drill session in group of minimum 10 students for extinguishing fire – Part I	I	2*
2	Perform mock drill session in group of minimum 10 students for extinguishing fire – Part II	I	2

S. No.	Practical Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
3	Prepare job with following operations: – Part I a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing g. tapping operation as per drawing	II	2*
4	Prepare job with following operations: – Part II a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing g. tapping operation as per drawing	II	2
5	Prepare job with following operations: – Part III a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing g. tapping operation as per drawing	II	2
6	Prepare job with following operations: – Part IV a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing g. tapping operation as per drawing	II	2
7	Prepare job with following operations: – Part V a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing g. tapping operation as per drawing	II	2
8	Prepare job with following operations: – Part VI a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing	II	2

S. No.	Practical Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
	g. tapping operation as per drawing		
9	Prepare job with following operations: – Part VII a. Marking operation as per drawing b. punching operation as per drawing c. filing operation as per drawing d. chamfering operation as per drawing e. sawing operation as per drawing f. drilling operation as per drawing g. tapping operation as per drawing	II	2
10	Prepare T joint pipe fitting job as per given drawing (individually)	III	2*
11	Prepare elbow joint pipe fitting job as per given drawing	III	2*
12	Prepare bill of material for given pipeline layout – Part I	III	2*
13	Prepare bill of material for given pipeline layout – Part II	III	2
14	Prepare lap joint using gas welding as per given drawing – Part I	IV	2*
15	Prepare lap joint using gas welding as per given drawing – Part II	IV	2
16	Prepare butt joint using gas welding as per given drawing – Part I	IV	2
17	Prepare butt joint using gas welding as per given drawing – Part II	IV	2*
18	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part I a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2 *
19	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part II a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2
20	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part III a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2*
21	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part IV a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2
22	Prepare utility job(like stool, benches, tables or similar jobs)	IV,	2

S. No.	Practical Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
	involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part V a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	V	
23	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part VI a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2*
24	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part VII a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2
25	Prepare utility job(like stool, benches, tables or similar jobs) involving arc welding and artificial wood as per given drawing (in group of 4 to 5 students) – Part VIII a. Fabrication operation involve measuring, marking, cutting, edge preparation, welding b. Carpentry operation involve measuring, marking cutting and assembly with fabrication part.	IV, V	2
26	Prepare sheet metal utility job using following operations – Part I: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering f. Riveting	VI	2*
27	Prepare sheet metal utility job using following operations – Part II: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering f. Riveting	VI	2
28	Prepare sheet metal utility job using following operations – Part III: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering	VI	2

S. No.	Practical Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
	f. Riveting		
29	Prepare sheet metal utility job using following operations – Part IV: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering f. Riveting	VI	2
30	Prepare sheet metal utility job using following operations – Part V: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering f. Riveting	VI	2
31	Prepare sheet metal utility job using following operations – Part VI: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering f. Riveting	VI	2
32	Prepare sheet metal utility job using following operations – Part VI: a. Cutting and Bending b. Edging c. End Curling d. Lancing e. Soldering f. Riveting	VI	2
	Total		**64**

Note

*i. A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Setting of experimental set up	20
2	Operate equipment skillfully	30
3	Follow Safety measures	10
4	Work in team	10
5	Record Observations	10
6	Interpret Results to conclude	10

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

S. No.	Performance Indicators	Weightage in %
7	Answer to sample questions	5
8	Submit report in time	5
	Total	100

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1	Fire buckets of standard size.	I, II, III, IV,V, VI
2	Fire extinguisher A,B and C types	I, II, III, IV,V, VI
3	Wood Turning Lathe Machine, Height of Centre: 200mm, Distance between Centers: 1200mm, Spindle Bore: 20mm with Taper, Range of Speeds: 425 to 2800 with suitable Motor Drive. with all accessories	II
4	Circular Saw Machine, Diameter of saw blade 200 mm, Maximum Depth of Cut 50 mm, Table Size -350 x 450 mm, Table Tilting - 45^0	II
5	Wood working tools- marking and measuring tools, saws, claw hammer, mallet, chisels, plans, squares,	II
6	Carpentry Vice 200 mm	II
7	Work Benches- size:1800 x 900 x 750 mm	III
8	Bench Drilling machine (upto 13 mm drill cap.) with ½ H.P. Motor 1000 mm. Height.	III
9	Power Saw machine 350 mm mechanical with 1 HP Motor & all Accessories.	III
10	Bench Grinder 200 mm Grinding Disc diameter 200 mm. with 25 mm. bore 32 mm. with ½ HP/1HP Motor.	III
11	Vernier height Guage 450 mm	III

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
12	Surface Plate 600 x 900 mm Grade I	III
13	Angle Plate 450 x 450 mm	III
14	Welding machine 20 KVA 400A welding current 300A at 50, 100, 200, 250, 300 with std. Accessories and Welding Cable 400 amp. ISI with holder	IV
15	Oxygen and acetylene gas welding and cutting kit with cylinders and regulators.	IV
16	Pipe Bending Machine	IV
17	Pipe Vice – 100 mm	IV
18	Pipe Cutter- 50 mm	IV
19	Bench Vice 100 mm	I.,III,IV, V,VI
20	Portable Hammer Drill Machine 0-13 mm A.C. 230 V, 2.5Amp, Pistol type, having different types of bits	II, III, IV,V, VI
21	Sheet Bending Machine	VI
22	Sheet Cutting Machine	VI
23	Brazing Equipment	VI
24	Fitting tools - hammers, chisels, files, hacksaw, surface plate, punch, v block, angle plate, try square, marking block, steel rule, twist drills, reamers, tap set, die set.	III
25	Plumbing tools- pipe vice, pipe bending equipment, pipe wrenches, dies	IV
26	Gas welding hand tools- welding torch, welding tip, pressure regulator, oxygen and acetylene cylinders, spark lighter	V
27	Arc welding hand tools- electrode holder, cable connector, cable lugs, chipping hammer, earthing clamp, wire brush.	V
28	Sheet metal hand tools- snip, shears sheet gauge, straight edge, L square, scriber, divider, trammel, punches, pliers, stakes, groovers, limit set	VI

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics are to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I General Workshop Practice	1a. Describe the procedure for extinguishing the given type of fire 1b. Describe the procedure to use the given firefighting equipment 1c. Locate the specified equipment in workshop 1d. Describe the ways to maintain good housekeeping in the given situation.	1.1 Safety Practices, Causes of accidents, General safety rules, Safety signs and symbols. 1.2 First Aid 1.3 Fire, Causes of Fire, Basic ways of extinguishing the fire Classification of fire, Class A, B,C, D, Firefighting equipment, fire extinguishers, and their types. 1.4 Workshop Layout 1.5 Issue and return system of tools, equipment and consumables
Unit– II	2a. Explain operation of the given	2.1 Fitting hand tools bench vice,

Fitting	fitting shop machines 2b. Describe the procedure to use the given fitting tools 2c. Describe the operation the given machinery. 2d. Describe the procedure to perform fitting operations 2e. Describe the procedure to maintain tools, equipment and machinery.	hammers, chisels, files, hacksaw, surface plate, punch, v block, angle plate, try square, marking block, steel rule, twist drills, reamers, tap set, die set and their Specifications 2.2 Operation of fitting shops machineries - Drilling machine, Power saw, grinder their specifications and maintenance. 2.3 Basic process chipping, filling, scraping, grinding, marking, sawing, drilling, tapping, dieing, reaming.
Unit– III Plumbing	3a. Explain operation of fitting shop machines 3b. Describe the procedure to use the given plumbing tools 3c. Describe the procedure to operate the given type of plumbing machinery. 3d. Describe the procedure to maintain the given type of plumbing tools, equipment and machinery.	3.1 Plumbing hand tools pipe vice, pipe bending equipment, pipe wrenches, dies and their Specifications 3.2 Pipe fittings- bends, elbows, tees, cross, coupler, socket, reducer, cap, plug, nipple and their Specifications 3.3 Operation of Machineries in plumbing shops- pipe bending machine their specifications and maintenance. 3.4 Basic process cutting, threading.
Unit– IV Metal Joining	4a. Describe the procedure to identify the given metal joining tools. 4b. Explain the given type of welding procedure 4c. Describe the procedure to use the given metal joining tools. 4d. Describe the procedure to perform the given type of joining metals	4.1 Gas welding hand tools- welding torch, welding tip, pressure regulator, oxygen and acetylene cylinders, spark lighter and their Specifications 4.2 Arc welding hand tools- electrode holder, cable connector, cable lugs, chipping hammer, earthing clamp, wire brush and their Specifications 4.3 Operation of machineries in welding shops- arc welding transformer their specifications and maintenance. 4.4 Welding Electrode, filler rod, fluxes, and solders. 4.5 Basic process welding, brazing and soldering.
Unit– V Furniture Making	5a. Select wood working tools as per job/ requirement with justification 5b. Explain operation of wood working machines 5c. Describe the procedure to use the given furniture making tools 5d. Describe the procedure to	5.1 Types of artificial woods such as plywood, block board, hardboard, laminated boards, Veneer, fiber Boards and their applications. 5.2 Wood working hand tools carpentry vice, marking and measuring tools, saws, claw hammer, mallet, chisels, plans, squares, and their specifications 5.3 Operation of wood working

	operate the given wood working machinery. 5e. Describe the procedure to maintain given wood working tools, equipment and machinery.	machineries - Wood turning lathe, circular saw, their specifications and maintenance. 5.4 Basic process- marking, sawing, planning, chiseling, turning, grooving, boring.
Unit–VI Sheet Metal	6a. Identify sheet metal tools. 6b. Explain operation of sheet metal machineries. 6c. Use sheet metal tools 6d. Describe the procedure to operate the sheet metal machinery. 6e. Describe the procedure to perform the given bending operations 6f. Describe the procedure to maintain the given sheet metal tools, equipment and machinery.	6.1 Sheet metal hand tools snip, shears sheet gauge, straight edge, L square, scriber, divider, trammel, punches, pliers, stakes, groovers, limit set and their Specifications 6.2 Operation of machineries in sheet metal shops- sheet cutting and bending machine their specifications and maintenance. 6.3 Basic process- marking, bending, folding, edging, seaming, staking, riveting.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

- Not applicable.-

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Prepare work diary based on practical performed in workshop. Work diary consist of job drawing, operations to be perform, required raw materials, tools, equipments, date of performance with teacher signature.
b. Prepare journals consist of free hand sketches of tools and equipments in each shop, detail specification and precautions to be observed while using tools and equipment.
c. Prepare/Download a specifications of followings:
   a) Various tools and equipment in various shops.
   b) Precision equipment in workshop
   c) Various machineries in workshop
d. Undertake a market survey of local dealers for procurement of workshop tools, equipment machineries and raw material.
e. Visit any fabrication/wood working/sheet metal workshop and prepare a report.

11. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.

c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Arrange visit to nearby industries and workshops for understanding various manufacturing process.
g. Show video/animation films to explain functioning of various processes like shaping, lapping, honing, turning, milling, knurling etc.
h. Prepare maintenance charts various workshop machineries.

12. SUGGESTED TITLES OF MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a utility job using various wood working shop operations as per given drawing.
b. Prepare a utility job using various plumbing operations as per given drawing.
c. Prepare a utility job using various sheet metal operations as per given drawing.

Note:

i. Utility job will be assigned by the teacher.
ii. Utility Job will be completed in a group of 4 to 5 students and students have to maintain work diary consist of job drawing, operations details, required raw materials, tools, equipments, date wise performance record.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Workshop Practice	Bawa, H.S.	McGraw Hill Education, Noida; ISBN: 978-0070671195
2.	A Textbook of Manufacturing Process (Workshop Tech.)	Gupta, J.K.; Khurmi, R.S.	S.Chand and Co. New Delhi ISBN:81-219-3092-8
4.	Introduction to Basic Manufacturing Process & Workshop Technology	Singh, Rajender	New Age International, New Delhi; 2014, ISBN: 978-81-224-3070-7

14. SOFTWARE/LEARNING WEBSITES

a. http://www.asnu.com.au
b. http://www.abmtools.com/downloads/Woodworking%20Carpentry%20Tools.pdf
c. http://www.weldingtechnology.org
d. http://www.newagepublishers.com/samplechapter/001469.pdf
e. http://www.youtube.com/watch?v=TeBX6cKKHWY
f. http://www.youtube.com/watch?v=QHF0sNHnttw&feature=related
g. http://www.youtube.com/watch?v=Kv1zo9CAxt4&feature=relmfu
h. http://www.piehtoolco.com
i. http://sourcing.indiamart.com/engineering/articles/materials-used-hand-tools/
j. https://www.youtube.com/watch?v=9_cnkaAbtCM

Program Name : All Branches of Diploma in Engineering and Technology.

Program Code : CE/CR/CS/CH/PS/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC

Semester : First

Course Title : English

Course Code : 22101

1. RATIONALE

English language skills have become inevitable in the era of globalization. The skills of language contribute substantially to the career of engineering profession, where almost all the service manuals, installation and commissioning manuals of the various equipment are in English and technologist has to interpret them correctly. Competency in English is need of the hour, not only for Indian industry, but also worldwide, where diploma engineers have the employable opportunity. Therefore, the basic English skills- listening, speaking, reading and writing have become almost mandatory for employability. This course is therefore designed to help the students to communicate in English effectively.

2. COMPETENCY

The aim of this course is to help the students to attain the following industry identified competency through various teaching learning experiences:

- **Communicate in English in spoken and written form effectively.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Formulate grammatically correct sentences.
b. Summarise comprehension passages.
c. Compose dialogues and paragraphs for different situations.
d. Use relevant words as per context.
e. Deliver prepared speeches to express ideas, thoughts and emotions.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	--	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: *L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P - Practical; C – Credit, ESE - End Semester Examination; PA - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

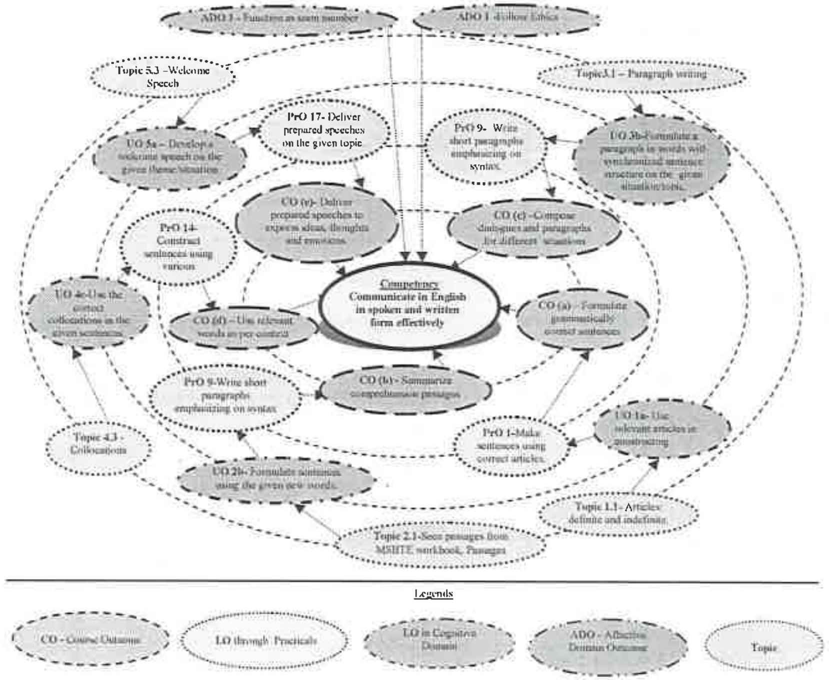


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	Use 'language laboratory' for different practical tasks		
1	Make sentences using correct articles.	I	2
2	Construct sentences using correct prepositions.	I	2*
3	Formulate sentences using correct conjunctions/connectors.	I	2
4	Rewrite sentences using relevant forms of verbs.	I	2*
5	Change the voice from active to passive and vice –versa.	I	2*
6	Change the narration direct to indirect and vice –versa.	I	2*
7	Repeat words on Language Lab software after listening to them.	I	2*
8	Deliver oral presentations using correct grammar.	I	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
9	Write short paragraphs emphasizing on syntax.	II	2*
10	Compose dialogues on various situations.	III	2
11	Enact a role play.	III	2*
12	Construct sentences using idioms.	IV	2*
13	Narrate anecdotes of various situations.	IV	2
14	Construct sentences using various collocations.	IV	2
15	Answer questions based on the given passage.	IV	2
16	Use correct pronunciations and voice modulation while reading articles from different sources.	IV	2*
17	Deliver prepared speeches on the given topic.	V	2*
18	Repeat dialogues on Language Lab software after listening to them.	V	2*
	Total		36

Note

*i. A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Setting up of language laboratory	10
b.	Using the language laboratory skillfully	30
c.	Follow Safety measures	10
d.	Work in teams	20
e.	Respond to given questions	10
f.	Self-learning	20
	Total	100

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Maintain Cleanliness.
c. Demonstrate working as a leader/a team member.
d. Follow ethics.

Acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The following topics/subtopics is to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1	Language Lab with relevant software and Computer system with all necessary components like: Motherboard, Random Access Memory (RAM), Read-Only Memory (ROM), Graphic cards, Sound Cards, Internal Hard Disk Drives, DVD drive, Network Interface Card	All
2	LCD Projector with document reader	All
3	Smart Board with networking	All

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop LOs in cognitive domain for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain) — Writing Skills	Unit Outcomes (UOs) (in cognitive domain) — Speaking Skills	Topics and Sub-topics
Unit – I Applied Grammar	1a. Use relevant articles in constructing sentences. 1b. Apply prepositions to construct meaningful sentences. 1c. Identify conjunctions to connect phrases and clauses in the specified sentences. 1d. Use correct form of tenses in given situation. 1e. Change the active and passive voice from the specified passage/list. 1f. Change the narration for the given situation.	1g. Formulate grammatically correct sentences for the specified situation. 1h. Use relevant Prepositions for the situation mentioned. 1i. Apply relevant conjunctions to use idiomatic language for the given situation. 1j. Apply the relevant voice in formal communication for the given passage. 1k. Use relevant narrations for the given situation.	1.1. Articles: Definite and Indefinite 1.2. Prepositions: Usage 1.3. Conjunctions: Coordinating and Subordinating 1.4. Types of sentences: Assertive, Imperative, Exclamatory, Interrogative 1.5. Tenses - Present Tense (Simple, Continuous, Perfect) - Past Tense (Simple, Continuous, Perfect) - Future Tense (Simple) 1.6. Active and Passive Voice 1.7. Direct and Indirect Speech
Unit– II Comprehension	2a. Answer the given questions of the specified passage. 2b. Formulate sentences using the given new words	2e. Pronounce the words correctly in the given passage. 2f. Give oral instructions with correct pronunciation and	2.1 Seen Passages From Msbte Work Book 2.2 Importance Of Comprehension 2.3 Unseen Passages 2.4 Interpretation Of

Unit	Unit Outcomes (UOs) (in cognitive domain)		Topics and Sub-topics
	Writing Skills	Speaking Skills	
	2c. Use correct syntax to construct meaningful sentences for the given situation. 2d. Answer the questions on the given unseen passage.	intonation for the given situation. 2g. Answer the questions orally on the given unseen passage with correct pronunciation.	Passages In Written And Spoken Form
Unit– III Paragraph and Dialogue Writing	3a. Differentiate the given types of paragraphs with justification. 3b. Formulate a paragraph in words with synchronized sentence structure on the given situation / topic. 3c. Explain the theme on given paragraph precisely.	3d. Summarise the given paragraph with correct pronunciation and intonation. 3e. Take part in debates with correct pronunciation, intonation and using verbal and non-verbal gestures on the given themes.	3.1 Types of Paragraph i. Technical ii. Descriptive iii. Narrative iv. Compare and Contrast 3.2 Dialogue Writing i. Greetings ii. Development of Dialogue iii. Closing Sentence
Unit– IV Vocabulary Building	4a. Remove the spelling errors in the given sentences/paragraph. 4b. Use relevant words to correctly express for the given themes/situation. 4c. Use the collocations correctly. 4d. Construct sentences using given idioms.	4e. Speak in specified formal situations with correct pronunciation. 4f. Speak in specified informal situations with correct pronunciation. 4g. Speak sentences using relevant collocations	4.1. Rules of Spelling 4.2. Words Often Confused 4.3. Collocations 4.4. Idioms
Unit-V Speeches	5a. Develop a welcome speech on the given theme/situation. 5b. Develop a farewell speech for the given theme/situation. 5c. Formulate a speech for introducing a guest in the given situation. 5d. Develop a vote of thanks for the given	5e. Introduce oneself with correct pronunciation, intonation and using verbal and non-verbal gestures. 5f. Give extempore talks with correct pronunciation, intonation and using verbal and non-verbal gestures for the given theme/ situation.	5.1. Importance of Public Speaking 5.2. Characteristics of Good Speech 5.3. Welcome Speech 5.4. Farewell Speech 5.5. Introducing a Guest 5.6. Vote of Thanks

Unit	Unit Outcomes (UOs) (in cognitive domain)		Topics and Sub-topics
	Writing Skills	Speaking Skills	
	situation.		

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Blooms's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Applied Grammar	12	02	04	08	14
II	Comprehension	20	05	06	13	24
III	Paragraph and Dialogue Writing	06	02	04	06	12
IV	Vocabulary Building	06	02	04	06	12
V	Speeches	04	02	02	04	08
	Total	**48**	**13**	**20**	**37**	**70**

***Legends**: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Collect good articles from newspapers and find and write the meanings of words.
b. Listen to TV news.
c. Read articles from magazines/newspapers.
d. Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
a. Arrange various communication activities using functional grammar.
b. Show video/animation films to develop listening skills and enhance vocabulary.
c. Use real life situations for explanation.

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

d. Prepare and give oral presentations.
e. Guide micro-projects in groups as well as individually.

12. SUGGESTED TITLES OF MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of practicals PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement*** hours during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. Develop language games, activities, crossword puzzles enhancing word power to be used in English language.
b. Prepare advertisement for five technical projects using contextual vocabulary.
c. After studying standard English newspapers, prepare a booklet identifying various grammatical aspects of sentences.
d. Prepare a booklet of the interviewing any successful person in your locality in context with his life journey, inspiration, social contribution, role model and keys to success.
e. Prepare a booklet of the contribution of eminent Indian scientists and develop well organized paragraphs.
f. Summarise the contents of a famous book/books.[fiction/non fiction]
g. Prepare a collage using different idioms with their origins and their contextual usage.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	English Workbook	MSBTE	MSBTE, Mumbai, 2017
2	Effective English with CD	Kumar, E. Suresh; Sreehari, P.; Savithri, J.	Pearson Education, Noida, New Delhi, 2009 ISBN: 978-81-317-3100-0
3	English Grammar at Glance	Gnanamurali, M.	S. Chand and Co. New Delhi, 2011 ISBN:9788121929042
4	Essential English Grammar	Murphy, Raymond	Cambridge University Press, New Delhi, Third edition, 2011, ISBN: 9780-0-521-67580-9
5	Living English Structure	Allen, W.S.	Pearson Education, New Delhi, Fifth edition, 2009, ISBN:108131728498,99

14. SOFTWARE/LEARNING WEBSITES

a. https://www.britishcouncil.in/english/learn-online
b. http://learnenglish.britishcouncil.org/en/content

c. http://www.talkenglish.com/
d. languagelabsystem.com
e. www.wordsworthelt.com

Course Name : **All Branches of Diploma in Engineering and Technology.**
Course Code : **CE/CR/CS/CH/PS/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC**
Semester : **First**
Subject Title : **Basic Science (Physics & Chemistry)**
Subject Code : **22102**

1. RATIONALE

Diploma engineers (also called technologists) have to deal with various materials and machines. This course is designed with some fundamental information to help the technologists apply the basic concepts and principles of physics and chemistry to solve broad-based engineering problems. The study of basic principles of sciences and the concepts related to various materials such as metals, alloys, inorganic salts, polymers, lubricants, paints, varnishes, adhesives, heat, electricity, magnetism, optics, semiconductors and others will help in understanding the technology courses where emphasis is on the applications of these in different technology applications.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Solve broad-based engineering problems applying principles of physics and chemistry.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Estimate errors in the measurement of physical quantities.
b. Apply the principles of electricity and magnetism to solve engineering problems.
c. Use the basic principles of heat and optics in related engineering applications.
d. Apply the catalysis process in industries.
e. Use corrosion preventive measures in industry.
f. Use relevant engineering materials in industry.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2	--	2	4	2	70*#	28	15*	00	100	40	25@	10	25	10	50	20
2	--	2	4				15*	00			25@	10	25	10	50	20

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment (5 marks each for Physics and Chemistry) to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.
***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

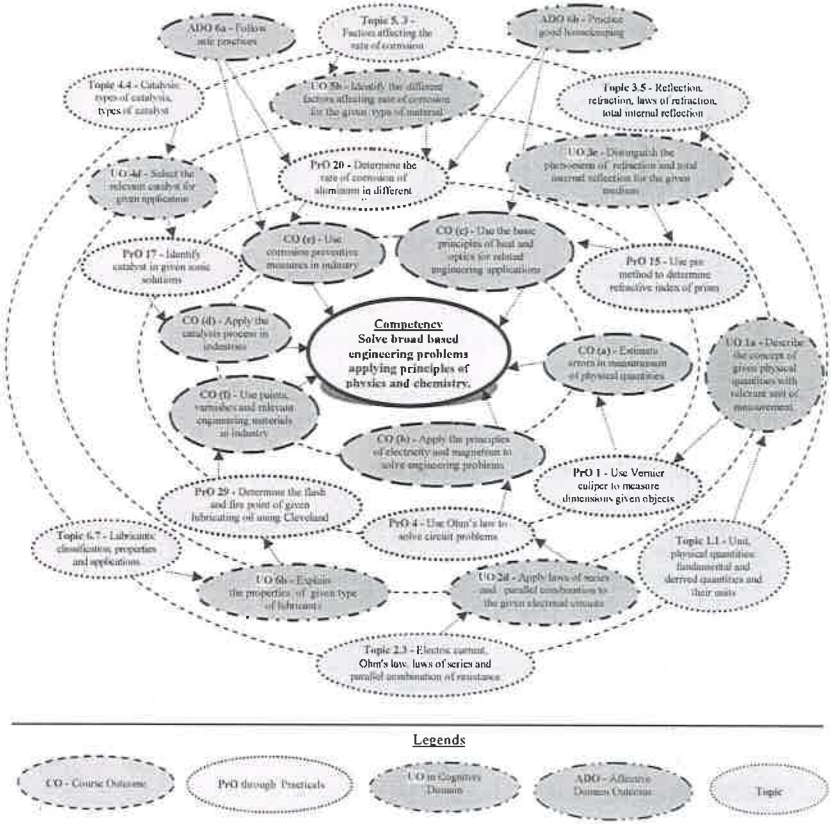


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Physics		

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use Vernier caliper to : (i) Measure dimensions of given objects. (ii) Measure the dimensions of objects of known dimensions. (iii) Estimate the errors in measurement.	I	02*
2	Use Screw gauge to: (i) Measure dimensions of given objects. (ii) Measure the dimensions of objects of known dimensions. (iii) Estimate the errors in measurement.	I	02*
3	Use Spherometer to measure radius of curvature of any curved surface.	I	02
4	Use Ohm's law to solve circuit problems.	II	02*
5	Determine the specific resistance of given wire.	II	02*
6	Use the principle of series resistance in solving electrical engineering problems.	II	02
7	Use the principle of parallel resistance in solving electrical engineering problems.	II	02
8	Use magnetic compass to draw the magnetic lines of forces of magnet of different shapes.	II	02*
9	Use magnetic compass to determine the neutral points when (i) North pole of bar magnets points towards the north pole of earth. (ii) South pole of bar magnets points towards the north pole of earth.	II	02
10	Use p-n junction diode to draw forward bias and reverse bias I-V characteristics.	II	02*
11	Determine forbidden energy band gap in semiconductors.	II	02
12	Determine the pressure-volume relation using Boyle's law.	III	02
13	Use Joule's calorimeter to determine Joule's mechanical/electrical equivalent of heat.	III	02*
14	Use Searle's thermal conductivity apparatus to find co-efficient of thermal conductivity of a given material.	III	02*
15	Use pin method to determine refractive index of prism.	III	02*
16	Determine the refractive index of glass slab using TIR phenomenon.	III	02
	Chemistry		
17	Identify cation in given ionic solutions.	IV	02*
18	Identify anion in given ionic solutions.	IV	02
19	Determine the percentage of iron in the given sample using redox titration.	IV, V	02*
20	Prepare the corrosive medium for Aluminium at different temperature.	V	02
21	Determine the rate of corrosion on different temperatures for Aluminium.	V	02*
22	Determine the electrode potential of Copper metal.	V	02
23	Determine the electrode potential of Iron metal.	V	02*
24	Determine the voltage generated from chemical reaction using Daniel Cell.	V	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
25	Determine the pH value of given solution using pH meter and universal indicator.	V	02*
26	Determine electrochemical equivalent of Cu metal using Faraday's first law.	V	02
27	Determine equivalent weight of metal using Faraday's second law.	V	02
28	Determine the effect of temperature on viscosity for given lubricating oil using Redwood viscometer-I.	VI	02*
29	Determine the steam emulsification number of given lubricating oil.	VI	02
30	Determine the flash and fire point of given lubricating oil using Cleveland open cup apparatus.	VI	02*
31	Determine the flash point of given lubricating oil using Abel's closed cup apparatus.	VI	02*
32	Determine thinner content in oil paint.	VI	02*
	Total		64

Note

i. *A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 (each in Physics and Chemistry) or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs

according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of PrOs, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1	Vernier Calipers: Range: 0-150mm, Resolution: 0.1mm	1
2	Micrometer screw gauge: Range: 0-25mm, Resolution:0.01mm, Accuracy: ±0.02mm or better	2
3	Spherometer: range:-10 to +10 mm, LC = 0.01mm	3
4	Digital multimeter: 3½ digit display, 9999 counts, digital multimeter measures: V_{ac}, V_{dc} (1000V max), A_{dc}, A_{ac} (10 amp max), Hz, Resistance (0-100 MΩ), Capacitance and Temperature	4, 5, 6, 7, 21, 22, 23
5	Resistance Box: 4 decade ranges from 1 ohm to 1KΩ ,accuracy 0.1 % - 1 %	4,5,6,7
6	Battery eliminator: 0- 12V, 2A	6,7, 25, 26
7	Boyle's apparatus: U tube manometer, digital barometer	12
8	Joule's calorimeter: well insulated 'mechanical/Electrical equivalent of heat apparatus' in wooden box, digital/analog thermometer	13
9	Searle's thermal conductivity apparatus : Cylindrical copper, aluminum, brass, glass and iron rod, steam chamber, digital / analogue thermometer, arrangement for fitting tubes and thermometer	14
10	Forbidden energy band gap set up: Oven : temperature range up to 100°C, thermometer, micro ammeter, Ge diode	11
11	pH meter reading up to pH14: ambient temp. -40 to 70° C.; pH/mV resolution: 13 bit	24
12	Electronic balance, with the scale range of 0.001g to 500gm pan size 100 mm; response time 3-5 sec.; power requirement 90-250 V, 10 watt	13,17, 19, 25, 26, 31
13	Electric oven inner size 18''x18''x18''; temperature range 100 to 250° C. with the capacity of 40 lt.	31
14	Ammeter 0-2 amp	25,26
15	Redwood viscometer-I	27
16	Cleveland open cup apparatus	29
17	Abel's close cup apparatus	30

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics are to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Physics	

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Units and Measurements	1a. Describe the given measurement device and its application. 1b. Describe with justification the device required to measure the radius of curvature of the given object. 1c. State with justification the error in the given measurement quantity. 1d. Describe the procedure to determine the dimensions of the given physical quantities.	1.1 Unit, physical quantities: fundamental and derived quantities and their units 1.2 Systems of unit: CGS, MKS, FPS and SI 1.3 Dimensions, dimensional formula 1.4 Errors, types of errors: instrumental, systematic and random error, estimation of errors: absolute, relative and percentage error, significant figures
Unit– II Electricity, Magnetism and Semiconductors	2a. Calculate electric field, potential and potential difference of the given static charge. 2b. Describe the concept of given magnetic intensity and flux with relevant units. 2c. Explain the heating effect of the given electric current. 2d. Apply laws of series and parallel combination in the given electric circuits.	2.1 Concept of charge, Coulomb's inverse square law, Electric field, Electric field intensity, potential and potential difference 2.2 Magnetic field and magnetic field intensity and its units, magnetic lines of force, magnetic flux 2.3 Electric current, Ohm's law, specific resistance, laws of series and parallel combination of resistance, heating effect of electric current
	2e. Distinguish the given conductors, semiconductors and insulators on the basis of energy bands. 2f. Explain the I-V characteristics and applications of the given p-n junction diodes.	2.4 Conductors, Insulators and Semiconductors, Energy bands, intrinsic and extrinsic semiconductors 2.5 p-n junction diode, I-V characteristics of p-n junction, applications of p-n junction diode
Unit– III Heat and Optics	3a. Convert the given temperature in different temperature scales. 3b. Describe the properties of the given good and bad conductors of heat. 3c. Relate the characteristics of the three gas laws. 3d. Determine the relation between specific heats for the given materials.	3.1 Heat, temperature, temperature scales 3.2 Modes of transfer of heat, good and bad conductors of heat, law of thermal conductivity 3.3 Boyle's law, Charle's law, Gay Lussac's law, perfect gas equation 3.4 Specific heat of gas at constant pressure and volume (C_p and C_V), ratio of specific heats
	3e. Distinguish the phenomena of total internal reflection for	3.5 Reflection , refraction, laws of refraction, total internal reflection

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the given mediums. 3f. Describe light propagation in the given type of optical fiber.	3.6 Optical fiber: Principle, construction and path of light through optical fiber, applications of optical fibers.
	Chemistry	
Unit-IV Chemical bonding and Catalysis	4a. Explain the properties of given material based on the bond formation. 4b. Describe the molecular structure of given solid, liquid and gases. 4c. Describe the crystal structure of the given solids. 4d. Select the relevant catalyst for given application.	4.1 Electronic theory of valency, chemical bonds: types and characteristics, electrovalent bond, covalent bond, coordinate bond, hydrogen bond, metallic bond, metallic properties, intermolecular force of attraction. 4.2 Molecular arrangement in solid, liquid and gases. 4.3 Structure of solids: crystalline and amorphous solid, properties of metallic solids-, unit cell- of simple cubic, body centre cubic, face centre cubic, hexagonal close pack crystals. 4.4 Catalysis: Types of catalysis, Catalyst, Types of Catalyst, Positive Catalyst, Negative Catalyst, Auto-catalyst, Catalytic Promoter and Catalytic inhibitor, Industrial Application of Catalyst
Unit –V Metal Corrosion, its prevention and Electrochemistry	5a. Describe the phenomenon of the given type of corrosion and its prevention. 5b. Identify the different factors affecting rate of corrosion for the given type of material. 5c. Select the protective measures to prevent the corrosion in the given corrosive medium.	5.1 Corrosion: Types of corrosion- Dry corrosion, Wet corrosion. Oxidation corrosion (Atmospheric corrosion due to oxygen gas), mechanism, Types of oxide film, Wet corrosion mechanism (Hydrogen evolution in acidic medium) 5.2 Concentration cell corrosion -oxygen absorption mechanism in neutral or alkaline medium, Pitting corrosion, Waterline corrosion, Crevice corrosion. 5.3 Factors affecting the rate of corrosion control: Modification of environment, Use of protective coatings- coating of less active metal like Tin (Tinning), coating of more active metal like Zinc (Galvanizing), Anodic and cathodic protection, Choice of material-using pure metal and using metal alloys
	5d. Differentiate the salient features of the given electrolytic cell and electrochemical cell. 5e. Distinguish the given	5.4 Electrolyte- strong and weak, Non-Electrolyte, Electrolytic cell, Electrochemical cell. Cathode, Anode, Electrode potential- oxidation and reduction, Construction and working of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	primary and secondary electrolytic cells. 5f. Describe the process of electrolysis for the given electrolyte. 5g. Describe the process of electroplating of the given material.	Daniel cell Ionisation and dissociation 5.5 Faradays first and second law 5.6 Primary cell and secondary cell Electrolysis- Mechanism, Electroplating and electro-refining of copper.
Unit-VI Paints, Varnishes, Insulators, Polymer, Adhesives and Lubricants	6a. Identify the ingredients of the given paints. 6b. Differentiate salient properties of the given paint and varnish. 6c. Describe the properties of insulating materials for the given application.	6.1 Paints: Purpose of applying paint, Characteristics of paints, Ingredients of paints, Function and Examples of each ingredients 6.2 Varnish: Types, Difference between paints and varnishes 6.3 Insulators: Characteristics, Classification, Properties and Application of Glass wool, Thermo Cole
	6d. Differentiate the given types of structural polymers. 6e. Describe the polymerization process of the given polymer. 6f. Explain the properties and uses of the given polymer, elastomer and adhesive. 6g. Describe the application of relevant adhesives required for the given material. 6h. Explain the properties of given type of lubricants.	6.4 Polymer and Monomer. Classification: on the basis of Molecular structure, on the basis of monomers (homo polymer andcopolymer). on the basis of Thermal behavior(Thermoplastics and Thermosetting) 6.5 Types Polymerization Reaction, Addition Polymerization, Condensation Polymerization. Synthesis, properties and application of Polyethylene. Polyvinyl chloride, Teflon. Polystyrene, Phenol formaldehyde, Epoxy Resin 6.6 Adhesives: Characteristics, Classification and their uses 6.7 Lubricants: Classification, properties and applications

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	Physics					
I	Units and Measurements	06	02	03	-	05
II	Electricity, Magnetism and Semiconductors	14	03	05	08	16

Program Name : **All Branches of Diploma in Engineering and Technology.**

Program Code : CE/CR/CS/CH/PS/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/MU/EE/EP/EU/IS/IC/AE /FG/ME/PG/PT/DC/TX/TC

Semester : **First**

Course Title : **Mathematics**

Course Code : **22103**

1. RATIONALE

Mathematics is the core course to develop the competencies of most of the technological courses. This basic course of Mathematics is being introduced as a foundation which will help in developing the competency and the requisite course outcomes in most of the engineering diploma programmes to cater to the needs of the industry and thereby enhance the employability. This course is an attempt to initiate the multi-dimensional logical thinking and reasoning capabilities. It will help to apply the principles of basic mathematics to solve related technology problems. Hence, the course provides the insight to analyze engineering problems scientifically using logarithms, determinants, matrices, trigonometry, coordinate geometry, mensuration and statistics.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Solve broad-based technology problems using the principles of basic mathematics.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Apply the concepts of algebra to solve engineering related problems.
b. Utilize basic concepts of trigonometry to solve elementary engineering problems.
c. Solve basic engineering problems under given conditions of straight lines.
d. Solve the problems based on measurement of regular closed figures and regular solids.
e. Use basic concepts of statistics to solve engineering related problems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	2	--	6	3	70	28	30*	00	100	40	--	--	--	--	--	--

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,*
ESE *- End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP (with sample COs, Unit Outcomes i.e.UOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

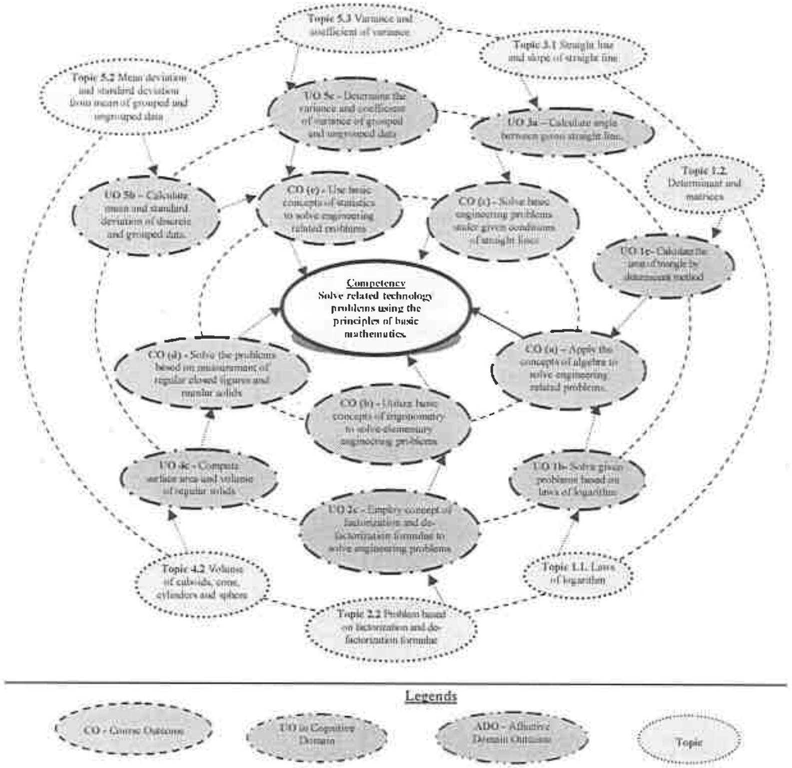


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The tutorials in this section are UOs (i.e. sub-components of the COs) to be developed and assessed in the student to lead to the attainment of the competency.

S. No.	Tutorials	Unit No.	Appro. Hrs. Required
1	Solve simple problems of Logarithms based on definition and laws.	I	2
2	Solve problems on determinant to find area of triangle, and solution of simultaneous equation by Cramer's Rules.	I	2
3	Solve elementary problems on Algebra of matrices.	I	2

S. No.	Tutorials	Unit No.	Appro. Hrs. Required
4	Solve solution of Simultaneous Equation using inversion method.	I	2
5	Resolve into partial fraction using linear non repeated, repeated, and irreducible factors.	I	2
6	Solve problems on Compound, Allied, multiple and sub multiple angles.	II	2
7	Practice problems on factorization and de factorization.	II	2
8	Solve problems on inverse circular trigonometric ratios.	II	2
9	Practice problems on equation of straight lines using different forms.	III	2
10	Solve problems on perpendicular distance, distance between two parallel lines, and angle between two lines.	III	2
11	Solve problems on Area, such as rectangle, triangle, and circle.	IV	2
12	Solve problems on surface and volume, sphere, cylinder and cone.	IV	2
13	Solve practice problems on the surface area, volumes and its applications.	IV	2
14	Solve problems on finding range, coefficient of range and mean deviation.	V	2
15	Solve problems on standard deviation.	V	2
16	Solve problems on coefficient of variation and comparison of two sets.	V	2
	Total		**32**

Note: *The above tutorial sessions are for guideline only. The remaining tutorial hours are for revision and practice.*

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

- Not applicable -

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Algebra	1a. Solve the given simple problem based on laws of logarithm. 1b. Calculate the area of the given triangle by determinant method. 1c. Solve given system of linear equations using matrix inversion method and by Cramer's rule. 1d. Obtain the proper and improper partial fraction for the given simple rational function.	1.1 Logarithm: Concept and laws of logarithm 1.2 Determinant and matrices a. Value of determinant of order 3x3 b. Solutions of simultaneous equations in three unknowns by Cramer's rule. c. Matrices, algebra of matrices, transpose adjoint and inverse of matrices. Solution of simultaneous equations by matrix inversion method. d. Types of partial fraction based on nature of factors and related

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		problems.
Unit– II Trigonometry	2a. Apply the concept of Compound angle, allied angle, and multiple angles to solve the given simple engineering problem(s). 2b. Apply the concept of Sub- multiple angle to solve the given simple engineering related problem(s). 2c. Employ concept of factorization and de-factorization formulae to solve the given simple engineering problem(s). 2d. Investigate given simple problems utilizing inverse trigonometric ratios.	2.1 Trigonometric ratios of Compound, allied, multiple and sub-multiple angles (without proofs) 2.2 Factorization and de-factorization formulae(without proofs) 2.3 Inverse trigonometric ratios and related problem. 2.4 Principle values and relation between trigonometric and inverse trigonometric ratio.
Unit– III Coordinate Geometry	3a. Calculate angle between given two straight lines. 3b. Formulate equation of straight lines related to given engineering problems. 3c. Identify perpendicular distance from the given point to the line. 3d. Calculate perpendicular distance between the given two parallel lines.	3.1 Straight line and slope of straight line a. Angle between two lines. b. Condition of parallel and perpendicular lines. 3.2 Various forms of straight lines. a. Slope point form, two point form. b. Two points intercept form. c. General form. d. Perpendicular distance from a point on the line. e. Perpendicular distance between two parallel lines.
Unit-IV Mensuration	4a. Calculate the area of given triangle and circle. 4b. Determine the area of the given square, parallelogram, rhombus and trapezium. 4c. Compute surface area of given cuboids, sphere, cone and cylinder. 4d. Determine volume of given cuboids, sphere, cone and cylinder.	4.1 Area of regular closed figures, Area of triangle, square, parallelogram, rhombus, trapezium and circle. 4.2 Volume of cuboids, cone, cylinders and sphere.
Unit –V Statistics	5a. Obtain the range and coefficient of range of the given grouped and ungrouped data. 5b. Calculate mean and standard deviation of discrete and grouped data related to the given simple engineering problem. 5c. Determine the variance and coefficient of variance of given grouped and ungrouped data.	5.1 Range, coefficient of range of discrete and grouped data. 5.2 Mean deviation and standard deviation from mean of grouped and ungrouped data, weighted means 5.3 Variance and coefficient of variance. 5.4 Comparison of two sets of observation.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	5d. Justify the consistency of given simple sets of data.	

Note: To attain the COs and competency, above listed Unit Outcomes (UOs) need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Algebra	20	02	08	10	20
II	Trigonometry	18	02	08	10	20
III	Coordinate Geometry	08	02	02	04	08
IV	Mensuration	08	02	02	04	08
V	Statistics	10	02	05	07	14
	Total	**64**	**10**	**25**	**35**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course.

a. Identify engineering problems based on real world problems and solve with the use of free tutorials available on the internet.
b. Use graphical softwares: EXCEL, DPLOT and GRAPH for related topics.
c. Use MathCAD as Mathematical Tools and solve the problems of Calculus.
d. Identify problems based on applications of matrix and use MATLAB to solve these problems.
e. Prepare models to explain different concepts.
f. Prepare a seminar on any relevant topic.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the

development of the UOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Apply the mathematical concepts learnt in this course to branch specific problems.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty.

a. Prepare charts using determinants to find area of regular shapes.
b. Prepare models using matrices to solve simple problems based on cryptography.
c. Prepare models using matrices to solve simple mixture problems.
d. Prepare charts displaying regular solids.
e. Prepare charts displaying regular closed figures.
f. Prepare charts for grouped and ungrouped data.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Higher Engineering Mathematics	Grewal, B.S.	Khanna publications, New Delhi, 2015 ISBN: 8174091955
2	Advanced Engineering Mathematics	Krezig, Ervin	Wiley Publications, New Delhi, 2014 ISBN :978-0-470-45836-5
3	Engineering Mathematics (third edition).	Croft, Anthony	Pearson Education, New Delhi, 2014 ISBN 978-81-317-2605-1
4	Getting Started with MATLAB-7	Pratap, Rudra	Oxford University Press, New Delhi, 2014, ISBN: 0199731241
5	Advanced Engineering Mathematics	Das, H.K.	S. Chand & Co.; New Delhi; 2008, ISBN-9788121903455

14. SOFTWARE/LEARNING WEBSITES

a. www.scilab.org/ - SCI Lab
b. www.mathworks.com/products/matlab/ - MATLAB
c. www.dplot.com/ - DPlot
d. www.allmathcad.com/ - MathCAD
e. www.wolfram.com/mathematica/ - Mathematica
f. https://www.khanacademy.org/math?gclid=CNqHuabCys4CFdOJaAoddHoPig

g. www.easycalculation.com
h. www.math-magic.com

Maharashtra State Board of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechnical Engineering

Program Code : ME — **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters — **Duration : 16 Weeks**

Semester : Second — **Scheme - I**

S. N.	Course Title		Course Abbre viation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme													Grand Total
									Theory							Practical						
					L	T	P		Exam Duration in Hrs.	ESE Max Marks	ESE Min Marks	PA Max Marks	PA Min Marks	Total Max Marks	Total Min Marks	ESE Max Marks	ESE Min Marks	PA Max Marks	PA Min Marks	Total Max Marks	Total Min Marks	
1	Applied Science	Physics	ASM	22202	2	-	4	8	90 Min	70*#	28	15*	00	100	40	25@	10	25	10	50	20	200
		Chemistry			2	-						15*	00			25@	10	25	10	50	20	
2	Applied Mechanics		AME	22203	3	1	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Applied Mathematics		AMP	22206	4	2	-	6	3	70	28	30*	00	100	40	--	--	--	--	--	--	100
4	Engineering Drawing		EDR	22207	3	-	4	7	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
5	Business Communication Using Computers		BCC	22009	-	-	2	2	--	--	--	--	--	--	--	35@^	14	15~	06	50	20	50
6	Mechanical Engineering Workshop		MEW	22010	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
				Total	14	3	16	33	--	280	--	120	--	400	--	185	--	165	--	350	--	750

Student Contact Hours Per Week: **33 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks **: 750**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment (5 marks each for Physics and Chemistry) to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **It is mandatory for the candidate to appear for practical (ESE) of both the part of Applied Science (Physics & Chemistry). Candidate remaining absent in exam of any one part, will be considered as absent for the head ESE (PR) of Applied Science.**
- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Mechanical and Civil Engineering Program Group**

Program Code : **AE/CE/FG/ME/PT/PG**

Semester : **Second**

Course Title : **Applied Science (Physics & Chemistry)**

Course Code : **22202**

1. RATIONALE

Diploma engineers have to deal with various materials and machines. The study of concepts and principles of science like elasticity, viscosity, surface tension, motion, thermo couples, photo-sensors, LASERs, X-Rays, metals, alloys, cement, lime, refractory materials water treatment and analysis, fuel and combustion will help the student to select and use relevant materials and methods which will be economical and eco-friendly.

2. COMPETENCY

This aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Solve broad-based engineering problems using principles of advanced physics and chemistry.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Select relevant material in industry by analyzing its physical properties.
b. Apply laws of motion in various applications.
c. Use LASERs, X-Rays and photo electric sensors..
d. Select the relevant metallurgical process related to industrial applications.
e. Use relevant water treatment process to solve industrial problems.
f. Use relevant fuel in relevant applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2	-	4	8	90 Min	70*#	28	15*	00	100	40	25@	10	25	10	50	20
2	-						15*	00			25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment (5 marks each for Physics and Chemistry) to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.
***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*
***Note:** Practical of Chemistry and Physics will be conducted in alternate weeks for each batch.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

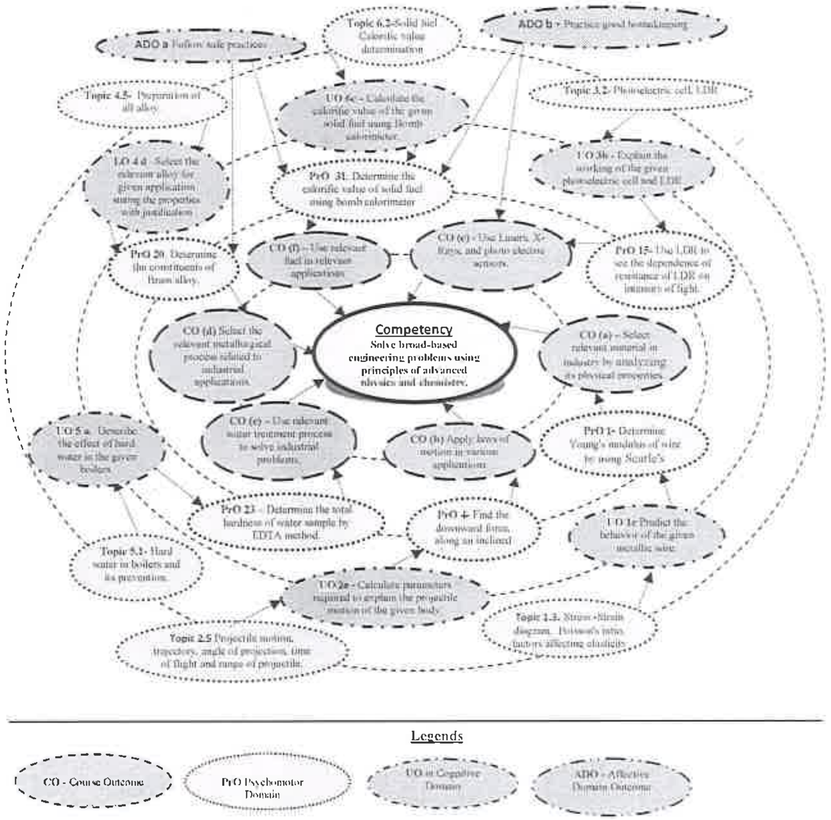


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Physics		
1	Use Searle's method to determine the Young's modulus of given	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	wire		
2	Apply Archimedes' principle to determine the buoyancy force on a solid immersed in liquid.	I	02
3	Determine the coefficient of viscosity of given liquid by Stoke's method.	I	02
4	Find the downward force, along an inclined plane, acting on a roller due to gravity and its relationship with the angle of inclination.	I	02
5	Predict the range of the projectile from the initial launch speed and angle.	II	02*
6	i) Find the dependence of the stopping potential on the frequency of light source in photo electric effect experiment. ii) Find the dependence of the stopping potential on the intensity of light source in photo electric effect experiment.	III	02
7	Determine the I-V characteristics of photoelectric cell and LDR.	III	02*
8	Determine the divergence of laser beam.	III	02
	Chemistry		
9	Standardization of $KMnO_4$ solution using standard oxalic acid and Determine the percentage of iron present in given Hematite ore by $KMnO_4$ solution.	IV	02*
10	Determine the percentage of copper in given copper ore .	IV	02
11	Determine total hardness, temporary hardness and permanent hardness of water sample by EDTA method.	V	02*
12	Determine the alkalinity of given water sample.	V	02
13	Determine the turbidity of given water sample by Nephelometric method.	V	02
14	Determine the moisture and ash content in given coal sample using proximate analysis.	VI	02*
15	Determine the calorific value of given solid fuel using Bomb calorimeter.	VI	02*
16	Determine the percentage of Sulphur in given coal sample by ultimate analysis.(Gravimetric analysis)	VI	02
		Total	**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20

S. No.	Performance Indicators	Weightage in %
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	Exp. No.
1	Searle's apparatus(with slotted mass of 0.5 kg each)	1
2	Liquid container	2
3	Solid body (different size and materials)	3,4
4	Stoke's apparatus (glass tube, viscous liquid, spherical balls of varying sizes)	3
5	Stop watch	4,5
6	Photo transducer	4
7	Timer	4
8	Projectile motion detector	5
9	Photo electric effect apparatus	6
10	Experimental setup for characteristics of photoelectric cell	7
11	Experimental setup for characteristics of LDR	7
12	Laser Source (He Ne, diode laser)	8
13	Electronic balance, with the scale range of 0.001g to 500g. pan size 100 mm; response time 3-5 sec.; power requirement 90-250 V, 10 watt.	All
18	Electric oven inner size 18''x18''x18''; temperature range 100 to 250^0 C with the capacity of 40 lt.	14,16
19	Bomb calorimeter	15

S. No.	Equipment Name with Broad Specifications	Exp. No.
20	Muffle furnace, Temperature up to 900^{0}C,digital temperature controller with an accuracy of +/- 3^{0}C	14,16
21	Nephelometer ; Auto-ranging from 20-200 NTU,+/- 2% of reading plus 0.1 NTU, power 220 Volts +/- 10% AC 50 Hz	13

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop LOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Physics	
Unit – I Properties of matter and Non-Destructive Testing	1a. Explain concept of elasticity and plasticity for the given material. 1b. Establish relation between given types of modulii of elasticity. 1c. Predict the behavior of the given metallic wire.	1.1 Deforming Force and Restoring Force, Elasticity, Plasticity, Rigidity 1.2 Stress and Strain and their types, Elastic limit and Hooke's law, types of moduli of elasticity 1.3 Stress -Strain diagram, Poisson's ratio, factors affecting elasticity
	1d. Explain pressure-depth relation for the given law. 1e. Explain Newton's law of viscosity for the given liquid. 1f. Explain Stokes' law for the free fall of the body through the given viscous medium.	1.4 Fluid friction, pressure, pressure- depth relation, Pascal's law, Archimedes' principle 1.5 Viscosity, velocity gradient, Newton's law of viscosity. 1.6 Free fall of spherical body through viscous medium and Stokes' law, derivation of coefficient of viscosity 'η' by Stokes' method, effect of temperature and adulteration on viscosity of liquids.
	1g. Describe the salient features of the given NDT method.	1.7 Non-destructive testing (NDT),Various NDT methods used, Criteria for the selection of NDT method, merits and demerits of NDT
Unit– II Types of Motion	2a. Explain the equations of motion for the given body moving in the given type of path. 2b. Calculate the angular velocity of the given body. 2c. Explain the relevant Newton's laws of motion for the given moving object. 2d. Calculate the work/power/ energy for the given situation. 2e. Calculate the given	2.1 Displacement, velocity, acceleration and retardation, equations of motion, equations of motion under gravity. 2.2 Angular displacement, angular velocity, angular acceleration, three equations of angular motion 2.3 Momentum, impulse, impulsive force, Newton's laws of motion and their Applications 2.4 Work, power and energy: potential energy, kinetic energy, work -energy principle.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	parameters for the given projectile in motion.	2.5 Projectile motion, trajectory, angle of projection, time of flight and range of projectile with formulae.
Unit– III Photoelectricity, X-Rays and LASERs	3a. Explain the concept of the given parameters of the given material. 3b. Explain the working of the given photoelectric device.	3.1 Planck's hypothesis, properties of photons, Photo electric effect: threshold frequency, threshold wavelength, stopping potential, Work function, characteristics of photoelectric effect, Einstein's photoelectric equation. 3.2 Photoelectric cell and LDR: principle, working and applications.
	3c. Explain the production of X-Rays of the given material with properties and applications.	3.3 Production of X-rays by modern Coolidge tube, properties and applications.
	3d. Differentiate between LASER and given colour of light 3e. Explain the given terms with examples.	3.4 Laser: properties, absorption, spontaneous and stimulated emission, applications of Laser 3.5 Population inversion, active medium, optical pumping, three energy level system, He-Ne Laser.
	Chemistry	
Unit-IV Metals, alloys, Cement, and Refractory materials	4a. Describe construction and working of the given type of furnace. 4b. Describe the extraction process of the given ore with chemical reaction. 4c. Explain purposes and preparation methods of making the given alloy. 4d. Select the relevant alloy for the given application stating the properties with justification. 4e. Describe the constituents, hardening and setting process of the given type of cement. 4f. Select the relevant refractory for given application stating the properties with justification.	4.1 Metallurgy: Mineral, ore, gangue, flux, slag. 4.2 Types of furnace: Muffle furnace, Blast furnace. 4.3 Extraction processes of Haematite, copper pyrite ores: Crushing, concentration, reduction, refining. 4.4 Properties of iron and copper: Hardness, tensile strength, toughness, malleability, ductility, refractoriness, fatigue resistance, specific gravity, specific heat, brazing, castability, stiffness. 4.5 Preparation of alloys (Fusion and compression method). 4.6 Ferrous alloys: Low carbon, medium carbon, high carbon steels. 4.7 Non-ferrous alloy: Brass, Bronze, Duralumin, Tinman Solder, Woods metal. 4.8 Cement: Types; Biocement and Portland cement; constituents, setting and hardening, applications 4.9 Lime: classification, constituents, setting and hardening, applications.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		4.10 Refractory material: Types, properties.
Unit –V Water treatment	5a. Describe the given terminologies related to hard water and their effects 5b. Describe the given process for softening of the given water sample. 5c. Describe with sketches the purification of the given type of water. 5d. Describe the given type of of waste water treatment.	5.1 Hardness; Classification 5.2 Hard water in boilers and prevention: Boiler corrosion, caustic embrittlement, priming and foaming, scales and sludges. 5.3 Water softening: lime soda process (hot lime soda and cold lime soda process), zeolite process, ion exchange process (cation exchange and anion exchange). 5.4 Potable water treatment: Sedimentation, coagulation, filtration and sterilization. 5.5 Waste water treatment: sewage treatment, BOD and COD of sewage water; Reverse Osmosis, recycling of waste water.
Unit-VI Fuels and Combustion	6a. Describe salient properties of the given type of fuel. 6b. Explain the given type of analysis of the given type of coal. 6c. Calculate the calorific value of the given solid fuel using Bomb calorimeter. 6d. Describe composition, properties of given gaseous fuel with their applications. 6e. Calculate the mass and volume of air required for complete combustion of the given fuel.	6.1 Fuel: Calorific value and ignition temperature, classification. 6.2 Solid fuels: Coal, Classification and composition , proximate analysis, Ultimate analysis, Bomb calorimeter. Carbonization of coke by Otto Hofmann's oven. 6.3 Liquid fuels: Fractional distillation of crude petroleum, boiling range, composition, properties. Knocking, cracking, octane number and cetane number. 6.4 Gaseous fuels: Biogas, LPG, and CNG. Combustion equation of gaseous fuels, mass and volume of air required for complete combustion.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	Physics					
I	Properties of matter and NDT	14	03	05	06	14
II	Types of motion	09	02	02	06	10
III	Photoelectricity, X-Ray and LASER,	09	03	04	04	11
	Chemistry					

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
IV	Metals, alloys, cement, refractory materials	12	02	04	06	12
V	Water treatment	10	02	03	06	11
VI	Fuels and combustion.	10	03	04	05	12
	Total	**64**	**15**	**22**	**33**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Seminar on any relevant topic.
b. Library survey regarding engineering material used in different industries.
c. Prepare power point presentation or animation for showing applications of lasers

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Elasticity:** Prepare working model to demonstrate the stress – strain behavior of different wires of different thickness and material.
b. **Viscosity:** Collect 3 to 5 liquids and prepare a working model to differentiate liquids on the basis of viscosity and demonstrate their applications.
c. **Motion:** Prepare model of ball rolling down on inclined plane to demonstrate the conservation of energy and motion of an object in inclined plane.
d. **Photo Sensors**: Prepare simple photo sensor using LDR.
e. **Properties of Laser**: Use Key chain laser to differentiate laser with ordinary light.
f. **Water analysis**: Collect water samples from different water sources and find the characteristics like acidity, conductivity, dissolved solids, suspended particles.
g. **Water treatment:** Collect 3 to 5 water samples to find the dosage of bleaching powder required for its sterilization.
h. **Water analysis:** Prepare model to find the soap foaming capacity of bore water on addition of soda ash.
i. **Fuels:** Prepare chart showing different types of liquid fuels showing their calorific values and uses.
j. **Cement:** Collect different samples of cement and find their initial and final setting time.
k. **Refractory materials**: Prepare chart showing properties of refractory materials.
l. **Metal properties:** Prepare chart showing different industrial application of metal and relate it with required property or properties using internet.
m. **Alloy steel:** Find the effect of alloying elements like Mn, Cr, Ni, W, V, Co on properties of steel. Prepare chart of showing percentage composition, properties and industrial applications of different types of steel based on above alloying elements using internet.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Physics Textbook Part I and Part - Class XI	Narlikar, J. V.; Joshi, A. W.; Mathur, Anuradha; *et al*	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Physics Textbook Part I and part II - Class XII	Narlikar, J.V.; Joshi, A. W.; Ghatak A.K. *et al*	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314
3	Engineering Physics	Bhattacharya, D. K.; Tandon Poonam	Oxford Publishing, New Delhi, ISBN:0199452814
4	Principles of Engineering Physics -I	Md. Nazoor Khan and Simanchala Panigrahi	Cambridge university press; New Delhi, 2016 ISBN : 9781316635643
5	Engineering Physics	Palanisamy, P. K.	SCITECH Publications, Chennai, ISBN: 9788183711012
6	Principles of Physics	Walker, J.; Halliday, D; Resnick, R	Wiley Publications, New Delhi, 10th edition ISBN: 9788126552566
7	Textbook of Engineering Physics	Avadhanulu, M. N.; Kshirsagar, P. G.	S. Chand and Co., New Delhi, 2015 ISBN: 9788121908177
8	Engineering Chemistry	Agarwal, Shikha	Cambridge university press ; New Delhi, 2015 ISBN : 9781107476417

S. No.	Title of Book	Author	Publication
9	Engineering Chemistry	Dara, S. S.; Umare S.S.	S.Chand and Co. Publication, New Delhi, 201, ISBN: 8121997658
10	Engineering Chemistry	Jain & Jain	Dhanpat Rai and sons; New Delhi, 2015, ISBN : 9352160002
11	Engineering Chemistry	Vairam, S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 9788126543342
10	Chemistry for engineers	Agnihotri, Rajesh	Wiley India Pvt.Ltd. New Delhi, 2014, ISBN: 9788126550784

14. SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/course.php?disciplineId=115
b. http://nptel.ac.in/course.php?disciplineId=104
c. http://hperphysics.phy-astr.gsu.edu/hbase/hph.html
d. www.physicsclassroom.com
e. www.fearofphysics.com
f. www.sciencejoywagon.com/physicszone
g. www.science.howstuffworks.com
h. https://phet.colorado.edu
i. www.chemistryteaching.com
j. www.visionlearning.com
k. www.chem1.com
l. www.onlinelibrary.wiley.com
m. www.rsc.org
n. www.chemcollective.org
o. www.wqa.org
p. www.em-ea.org

Program Name : **Mechanical, Civil Chemical and Fabrication Technology and Erection Engineering Program Group**

Program Code : **AE/CE/CH/FG/ME/PT/PG**

Semester : **Second**

Course Title : **Applied Mechanics**

Course Code : **22203**

1. RATIONALE

In day-to-day working we come across different types of structures created for different purposes and functions. While designing the structures, analysis of forces and stresses` is an important and prerequisite step. Correct analysis is possible only when one knows the types and effects of forces acting on the structures. This course provides the scope to understand fundamental concepts of laws of mechanics and their applications to different engineering problems. This course is designed to provide basic understanding about the different types of forces, moments and their effects on structural elements, which will analysing different structural systems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use principles of applied mechanics to solve broad-based engineering related problems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Identify the force systems for given conditions by applying the basics of mechanics.
b. Select the relevant simple lifting machine(s) for given purposes.
c. Determine unknown force(s) of different engineering systems.
d. Check the stability of various force systems.
e. Apply the principles of friction in various conditions for useful purposes.
f. Find the centroid and centre of gravity of various components in engineering systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	1	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

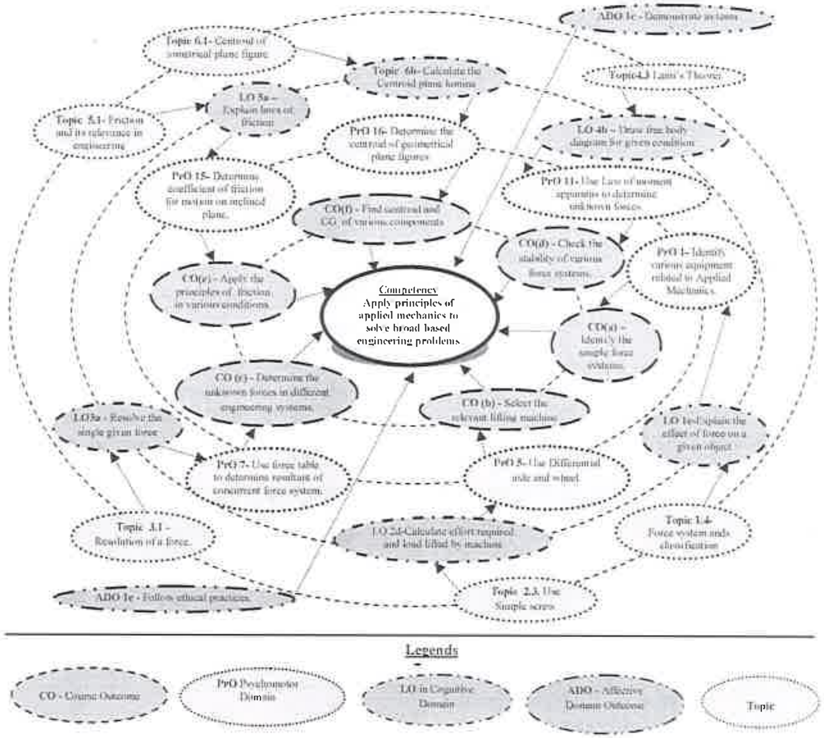


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Identify various equipment related to Applied Mechanics.	I to VI	02
2	Use Differential axle and wheel.	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
3	Use Simple screw jack.	II	02
4	Use worm and worm wheel.	II	02
5	Use single or double purchase crab.	II	02
6	Use Weston's differential or wormed geared pulley block.	II	02
7	Use force table to determine resultant of concurrent force system applying Law of Polygon of forces. (Part-I)	III	02*
8	Use force table to determine resultant of concurrent force system applying Law of Polygon of forces. (Part-II)	III	02*
9	Graphically determine resultant of concurrent force system.	III	02
10	Graphically determine resultant of parallel force system.	III	02
11	Use Law of moment apparatus to determine unknown forces.	IV	02*
12	Apply Lami's theorem to determine unknown force.	IV	02
13	Determine support reactions for simply supported beam.	IV	02
14	Determine coefficient of friction for motion on horizontal plane.	V	02*
15	Determine coefficient of friction for motion on inclined plane.	V	02
16	Determine centroid of geometrical plane figures.	VI	02
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year.
- 'Organising Level' in 2nd year.
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	Exp. No.
1	Differential axle and wheel (wall mounted unit with the wheel of 40 cm diameter and axles are insteps of 20 cm and 10 cm reducing diameter.	2
2	Simple screw Jack (Table mounted metallic body , screw with a pitch of 5 mm carrying a double flanged turn table of 20 cm diameter.	3
3	Worm and worm wheel (wall mounted unit with threaded spindle, load drum, effort wheel; with necessary slotted weights, hanger and thread)	4
4	Single Purchase Crab winch (Table mounted heavy cast iron body. The effort wheel is of C.I. material of 25 cm diameter mounted on a shaft of about 40mm dia. On the same shaft a geared wheel of 15 cm dia.	5
5	Double Purchase Crab winch (Having assembly same as above but with double set of gearing arrangement.)	5
6	Weston's Differential pulley block (consisting of two pulleys; one bigger and other smaller.	6
7	Weston's Differential worm geared pulley block (Consists of a metallic (preferably steel) cogged wheel of about 20 cm along with a protruded load drum of 10 cm dia to suspend the weights of 10 kg, 20 kg-2 weights and a 50 kg weights)	6
8	Universal Force Table (Consists of a circular 40 cm dia. Aluminum disc, graduated into 360 degrees.) with all accessories..	7, 10
9	Law of moments apparatus consisting of a stainless steel graduated beam 12.5 mm square in section, 1m long, pivoted at centre.	9
10	Beam Reaction apparatus (The apparatus is with two circular dial type 10 kg.	11
11	Friction apparatus for motion along horizontal and inclined plane (base to which a sector with graduated arc and vertical scale is provided. The plane may be clamped at any angle up to 45 degrees. pan. Two weight boxes (each of 5 gm,10 gm, 2-20 gm, 2-50 gm, 2-100 gm weight),	12
12	Models of geometrical figures.	13

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Mechanics and force system	1a. Explain concepts of the given terms. 1b. Use the relevant units of various quantities in the given situations. 1c. Explain effects of a force on the given object. 1d. Identify the force system for the given situation.	1.1. Significance and relevance: Mechanics, applied mechanics, statics, dynamics. 1.2. Space, time, mass, particle, body, rigid body. 1.3. Scalar and vector quantity, Units of measurement (SI units)- Fundamental units and derived units. 1.4. Force – unit, representation as a vector and by Bow's notation, characteristics and effects of a force, Principle of transmissibility of force, Force system and its classification.
Unit – II Simple lifting machine	2a. Describe the components of the given lifting machine. 2b. Differentiate the working principle of the given two types of simple lifting machines. 2c. Determine velocity ratio, efficiency and law of the given simple lifting machine. 2d. Calculate effort required and load lifted by the given simple lifting machine. 2e. Interpret the graphs after drawing them with the given data. 2f. Select the relevant simple lifting machine required for the given purpose with justification.	2.1 Simple lifting machine, load, effort, mechanical advantage, applications and advantages. Velocity ratio, efficiency of machines, law of machine. 2.2 Ideal machine, friction in machine, maximum Mechanical advantage and efficiency, reversible and non-reversible machines, condition for reversibility 2.3 Velocity ratios of Simple axle and wheel, Differential axle and wheel, Worm and worm wheel, Single purchase and double purchase crab winch, Simple screw jack, Weston's differential pulley block, geared pulley block. 2.4 Graphs of Load verses Effort, Load verses ideal Effort, Load verses Effort lost in friction, Load verses MA, Load verses Efficiency.
Unit- III Resolution and compositio n	3a. Resolve the given single force. 3b. Calculate the resultant of the given force system analytically. 3c. Determine graphically the resultant of the given force system. 3d. Find the resultant of the given force system using law of triangle and law of parallelogram.	3.1 Resolution of a force - Orthogonal and Non Orthogonal components of a force, moment of a force, Varignon's Theorem. 3.2 Composition of forces – Resultant, analytical method of determination of resultant for concurrent, non concurrent and parallel co-planar force systems – Law of triangle, parallelogram and polygon of forces. 3.3 Graphic statics, graphical representation of force, Space diagram, force diagram, polar diagram and funicular polygon, Graphical method of determination of resultant for concurrent and parallel co-planar force systems.
Unit– IV Equilibriu m	4a. Draw the free body diagram for the given condition. 4b. Determine unknown force in the given situation using Lami's theorem. 4c. Identify the types of beams required for the given situation. 4d. Determine reactions in the given type of beam analytically and graphically.	4.1 Equilibrium and Equilibrant, Free body and Free body diagram, Analytical and graphical conditions of equilibrium, 4.2 Equilibrium of force systems analytically 4.3 Lami's Theorem. 4.4 Types of beam, supports (simple, hinged, roller and fixed) and loads acting on beam (vertical and inclined point load, UD load, couple), span of beam. 4.5 Beam reaction for cantilever, simply supported beam with or without overhang – subjected to combination of Point load and UD load or Vertical Point load and couple. 4.6 Beam reaction graphically for simply supported beam subjected to vertical loads only.
Unit– V Friction	5a. Determine force of friction and coefficient of friction for the given condition. 5b. Describe the conditions for friction for the give situation. 5c. Determine friction force in the given situation. 5d. Identify the various forces acting on a ladder for the given conditions using free body diagram.	5.1 Friction and its relevance in engineering, types and laws of friction, limiting equilibrium, limiting friction, co-efficient of friction, angle of friction, angle of repose, relation between co-efficient of friction and angle of friction. 5.2 Equilibrium of bodies on level surface subjected to force parallel and inclined to plane. 5.3 Equilibrium of bodies on inclined plane subjected to force parallel to the plane only. 5.4 FBD of ladder in friction
Unit– VI Centroid and centre of gravity	6a. Determine the centroid of geometrical plane figures and centre of gravity of the given simple solid. 6b. Calculate centroid of the given composite plane lamina 6c. Determine centre of gravity of the given solids. 6d. Determine centre of gravity of the given composite solid.	6.1 Centroid of geometrical plane figures (square, rectangle, triangle, circle, semi-circle, quarter circle) 6.2 Centroid of composite figures composed of not more than three geometrical figures 6.3 Centre of Gravity of simple solids (Cube, cuboid, cone, cylinder, sphere, hemisphere) 6.4 Centre of Gravity of composite solids composed of not more than two simple solids.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Mechanics and Force System	04	02	02	02	06
II	Simple Lifting Machines.	08	02	04	06	12
III	Resolution and Composition	10	02	04	08	14
IV	Equilibrium	10	02	02	10	14
V	Friction	08	02	04	06	12
VI	Centroid and Centre of Gravity	08	02	02	08	12
	Total	**48**	**12**	**18**	**40**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Collect five different photographs indicating concurrent, parallel, general force system in equilibrium.
b. Prepare a table of type of machine and relevant industrial application.
c. Collect five different situations where law of moment plays an important role.
d. Prepare models representing various types of supports (hinged, roller and fixed)
e. Illustrate situations wherein friction is essential and not essential.
f. Prepare models in the form of geometrical figures and solids and locate centroid and centre of gravity of them.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
a. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Types of Forces**: Prepare chart showing real-life examples indicating various types of forces
b. **Lifting Machine**: Collect photographs of specific simple lifting machine and relate these machines with the machines being studied and prepare models of simple lifting machines using tools in "MECHANO" and "MECHANIX"
c. **Types of support:** Prepare chart showing actual and corresponding schematic diagram of various type of support
d. **Beams:** Prepare models of beam subjected to point loads, uniformly distributed loads, simply supported, overhang and cantilever type beam.
e. **Friction:** Prepare chart regarding type of friction in various field conditions and collect data regarding coefficient of friction by referring books, Determine coefficient of friction for three different types of surfaces
f. **Centre of Gravity:** Prepare a chart of situations wherein concept of Centre of Gravity is vital.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Applied Mechanics	Khurmi, R.S.	S.Chand & Co. New Delhi 2014 ISBN: 9788121916431
2	Engineering Mechanics	Ramamrutham, S.	S Chand & Co. New Delhi 2008 ISBN:9788187433514
3	Foundations and Applications of Applied Mechanics	Ram, H. D.; Chauhan, A. K.	Cambridge University Press, Thomson Press India Ltd., New Delhi, 2015, ISBN: 9781107499836
4	Engineering Mechanics- Statics, Vol. I	Meriam, J. L.; Kraige, L.G.	Wiley Publication, New Delhi, ISBN: 978-81-265-4396

14. SOFTWARE/LEARNING WEBSITES

a. http://www.asnu.com.au
b. www.youtube.com for videos regarding machines and applications, friction
c. www.nptel.ac.in
d. www.discoveryforengineers.com

Program Name : **Mechanical and Chemical Engineering Program Group**

Program Code : **AE, CH, FG, ME, PT**

Semester : **Second**

Course Title : **Applied Mathematics**

Course Code : **22206**

1. RATIONALE

Subject of applied mathematics is being introduced in diploma courses to provide mathematical background to the students. This course follows in developing theory and competency needed for a wide range of engineering applications. In particular the technique of calculus, differentiation, integration, differential equations and probability distribution for modeling and analysis in a wide range of applications. This course further develops the skills and understanding of mathematical concepts which underpin the investigative tools used in Mechanical engineering.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Solve mechanical engineering related problems using the principles of applied mathematics.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Calculate the equation of tangent, maxima, minima, radius of curvature by differentiation.
b. Solve the given problem(s) of integration using suitable methods.
c. Apply the concept of integration to find area and volume.
d. Solve the differential equation of first order and first degree using suitable methods.
e. Utilize basic concepts of probability distribution to solve elementary engineering problems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	2	--	6	3	70	28	30*	00	100	40	--	--	--	--	--	--

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP(with sample COs, Unit Outcomes i.e. UOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

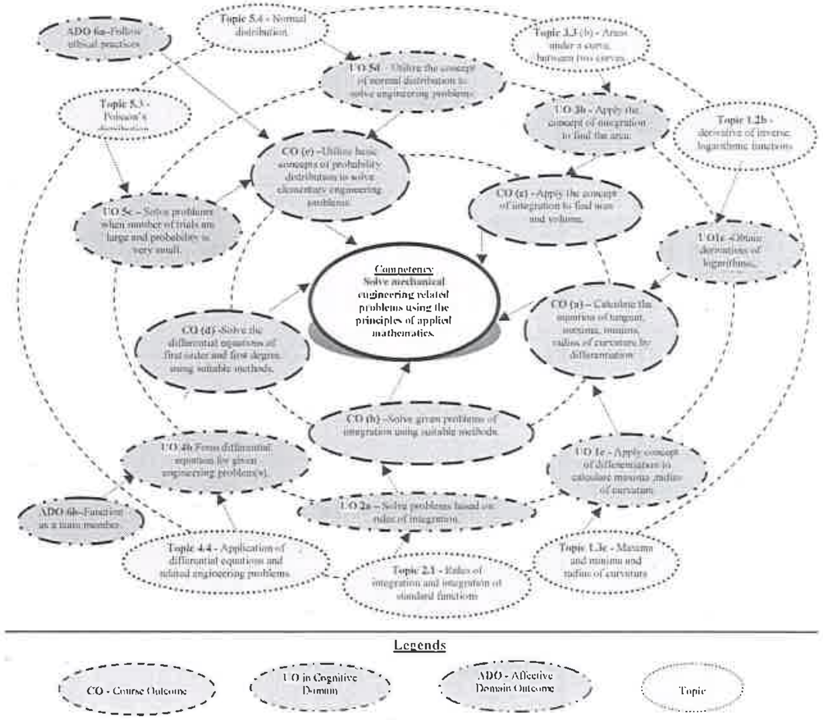


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The tutorials in this section are sub-components of the COs to be developed and assessed in the student to lead to the attainment of the competency.

S. No.	Tutorials	Unit No.	Approx. Hrs. Required
1	Solve problems based on finding value of the function at different points.	I	2
2	Solve problems to find derivatives of implicit function and parametric function	I	2
3	Solve problems to find derivative of logarithmic and exponential functions.	I	2

S. No.	Tutorials	Unit No.	Approx. Hrs. Required
4	Solve problems based on finding equation of tangent and normal.	I	2
5	Solveproblems based on finding maxima, minima of function and radius of curvature at a given point.	I	2
6	Solve the problems based on standard formulae of integration.	II	2
7	Solve problems based on methods of integration, substitution, partial fractions.	II	2
8	Solve problems based on integration by parts.	II	2
9	Solve practice problems based on properties of definite integration.	III	2
10	Solve practice problems based on finding area under curve, area between two curves and volume of revolutions.	III	2
11	Solve the problems based on formation, order and degree of differential equations.	IV	2
12	Develop a model using variable separable method to related engineering problem.	IV	2
13	Develop a model using the concept of linear differential equation to related engineering problem.	IV	2
14	Solve problems based on Binomial Distribution related to engineering problems.	V	2
15	Solve problems based on Poisson Distribution related to engineering problems.	V	2
16	Solve problems based on Normal Distribution related to engineering.	V	2
	Total		32

Note: The above tutorial sessions are for guideline only. The remaining tutorial hours are for revision and practice.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

- Not applicable –

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Differential Calculus	1a. Solve the given simple problems based on functions. 1b. Solve the given simple problems based on rules of differentiation. 1c. Obtain the derivatives of logarithmic, exponential functions. 1d. Apply the concept of differentiation to find given equation of tangent and normal 1e. Apply the concept of differentiation to calculate maxima and minima and radius of curvature of given problem.	1.1 Functions and Limits : a) Concept of function and simple examples b) Concept of limits without examples. 1.2 Derivatives : a) Rules of derivatives such as sum, product, quotient of functions. b) Derivative of composite functions (chain Rule), implicit and parametric functions. c) Derivatives of inverse, logarithmic and exponential functions. 1.3 Applications of derivative : a) Second order derivative without examples. b) Equation of tangent and normal c) Maxima and minima d) Radius of curvature
Unit– II Integral Calculus	2a. Solve the given simple problem(s) based on rules of integration. 2b. Obtain the given integral(s) using substitution method. 2c. Integrate given simple functions using the integration by parts. 2d. Evaluate the given simple integral by partial fractions.	2.1 Simple Integration: Rules of integration and integration of standard functions. 2.2 Methods of Integration: a) Integration by substitution. b) Integration by parts c) Integration by partial fractions.
Unit– III Applications of Definite Integration	3a. Solve given simple problems based on properties of definite integration. 3b. Apply the concept of definite integration to find the area under the given curve(s). 3c. Utilize the concept of definite integration to find area between given two curves. 3d. Invoke the concept of definite integration to find the volume of revolution of given surface.	3.1 Definite Integration: a) Simple examples b) Properties of definite integral (without proof) and simple examples. 3.2 Applications of integration : a) Area under the curve. b) Area between two curves. c) Volume of revolution.
Unit-IV First Order First Degree Differential Equations	4a. Find the order and degree of given differential equations. 4b. Form simple differential equations for simple given engineering problem(s). 4c. Solve given differential equations using the method of variable separable. 4d. Solve the given simple problem(s) based on linear differential equations.	4.1 Concept of differential equation 4.2 Order, degree and formation of differential equation. 4.3 Solution of differential equation a. Variable separable form. b. Linear differential equation. 4.4 Application of differential equations and related engineering problems.

Unit –V Probability Distributio n	5a. Make use of probability distribution to identify discrete and continuous probability distribution 5b. Solve given problems based on repeated trials using Binomial distribution. 5c. Solve given problems when number of trials are large and probability is very small. 5d. Utilize the concept of normal distribution to solve related engineering problems.	5.1 Probability distribution a. Discrete Probability distribution b. Continuous Probability distribution. 5.2 Binomial distribution. 5.3 Poisson's distribution. 5.4 Normal distribution.

Note: *To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Differential calculus	20	04	08	12	24
II	Integral calculus	14	02	06	08	16
III	Applications of Definite Integration.	10	02	02	04	08
IV	First Order First Degree Differential Equations	08	02	02	04	08
V	Probability distribution.	12	02	05	07	14
	Total	**64**	**12**	**23**	**35**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Identify engineering problems based on real world problems and solve with the use of free tutorials available on the internet.
b. Use graphical software's: EXCEL, DPLOT, and GRAPH for related topics.
c. Use Mathcad as Mathematical Tools and solve the problems of Calculus.
d. Identify problems based on applications of differential equations and solve these problems.
e. Prepare models to explain different concepts of applied mathematics.
f. Prepare a seminar on any relevant topic based on applications of integration.
g. Prepare a seminar on any relevant topic based on applications of probability distribution to related engineering problems.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the UOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare models using the concept of tangent and normal to bending of roads in case of sliding of a vehicle.
b. Prepare models using the concept of radius of curvature to bending of railway track.
c. Prepare charts displaying the area of irregular shapes using the concept of integration.
d. Prepare charts displaying volume of irregular shapes using concept of integration.
e. Prepare models using the concept of differential equations for mixing problem.
f. Prepare models using the concept of differential equations for radio carbon decay.
g. Prepare models using the concept of differential equations for population growth.
h. Prepare models using the concept of differential equations for thermal cooling.
i. Prepare a chart of binomial distribution by collection of suitable manufacturing industry base data.
j. Prepare a chart of normal distribution by collection of suitable manufacturing industry base data
k. Prepare a chart of Poisson distribution by collection of suitable manufacturing industry base data

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Higher Engineering Mathematics	Grewal, B.S.	Khanna publications, New Delhi , 2013 ISBN: 8174091955
2	A Text Book of Engineering Mathematics	Dutta, D.	New Age Publications, New Delhi, 2006, ISBN-978-81-224-1689-3
3	Advanced Engineering Mathematics	Krezig, Ervin	Wiley Publications, New Delhi, 2016 ISBN:978-81-265-5423-2,
4	Advanced Engineering Mathematics	Das, H.K.	S. Chand Publications, New Delhi, 2008, ISBN:9788121903455 .
5	Engineering Mathematics, Volume 1 (4th edition)	Sastry, S.S.	PHI Learning, New Delhi, 2009 ISBN-978-81-203-3616-2,
6	Comprehensive Basic Mathematics, Volume 2	Veena, G.R.	New Age Publications, New Delhi, 2005 ISBN: 978-81-224-1684-8
7	Getting Started with MATLAB-7	Pratap, Rudra	Oxford University Press, New Delhi, 2009, ISBN: 10: 0199731241
8	Engineering Mathematics (3rd edition).	Croft, Anthony	Pearson Education, New Delhi,2010 ISBN: 978-81-317-2605-1

14. SOFTWARE/LEARNING WEBSITES

a. www.scilab.org/ - SCI Lab
b. www.mathworks.com/products/matlab/ - MATLAB
c. Spreadsheet applications
d. www.dplot.com/ - DPlot
e. www.allmathcad.com/ - MathCAD
f. www.wolfram.com/mathematica/ - Mathematica
g. http://fossee.in/
h. https://www.khanacademy.org/math?gclid=CNqHuabCys4CFdOJaAoddHoPig
i. www.easycalculation.com
j. www.math-magic.com

Program Name : **Mechanical Engineering Program Group**
Program Code : **AE/ME/PT/PG**
Semester : **Second**
Course Title : **Engineering Drawing**
Course Code : **22207**

1. RATIONALE

Engineering drawing is the language of engineers. The concepts of drawing language are used in visualizing the situation, materializing the ideas, conveying the instructions which are used in carrying out engineering jobs. The course aims at developing the ability to draw and read projections of lines/planes/solids and develops imagination and translating skills in drawing orthographic sectional, missing views and auxiliary views of common engineering components. Knowledge of conventional representation of various joints helps to read and draw various production drawings. This course also aims at building foundation for further courses related to engineering drawing and other allied courses in coming semesters.

2. COMPETENCY

This aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Prepare engineering drawings using prevailing drawing standards and instruments.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Draw projections of 2D and 3D standard regular entities.
b. Draw sectional views of objects.
c. Draw orthographic sectional and missing views.
d. Draw auxiliary views of objects.
e. Use various drawing codes, conventions and symbols as per IS SP-46.
f. Draw free hand sketches of given engineering elements.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	4	7	3	70	28	30*	00	100	40	25#	10	25	10	50	20

***(*)**: Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.*
***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

4. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

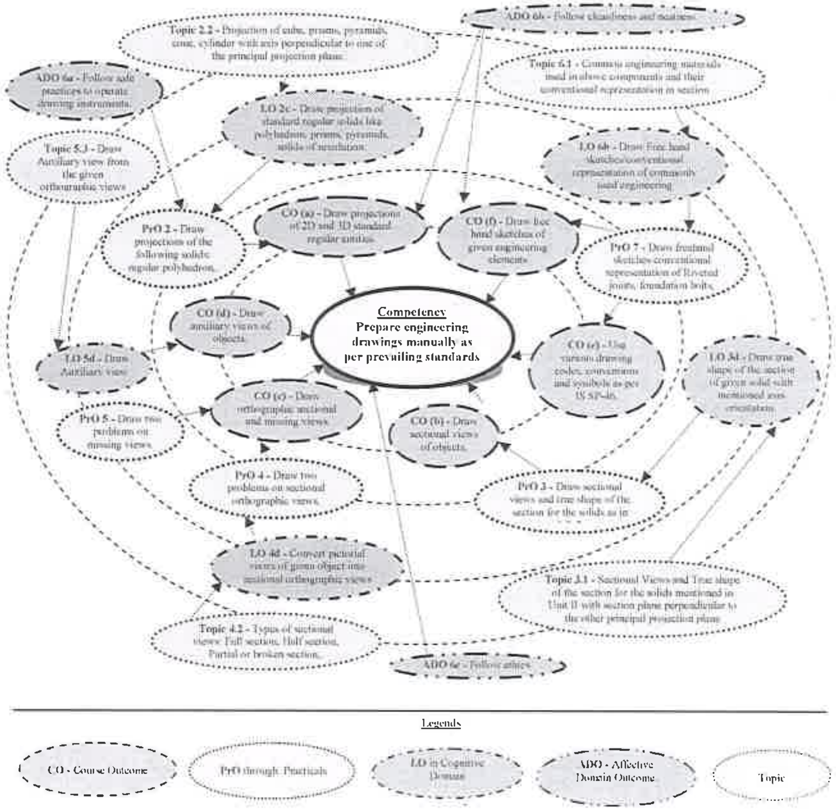


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Draw two problems on projection of straight lines Part I	I	02*
2.	Draw two problems on projection of planes Part II	I	02
3.	Draw projections of Regular polyhedron. Part I	II	02*
4.	Draw projections of Regular polyhedron. Part II	II	02
5.	Draw projections of Regular prisms. Part III	II	02
6.	Draw projections of Regular pyramids Part. IV	II	02
7.	Draw projections of Regular solids of revolution. Part V	II	02
8.	Draw sectional views and true shape of the section for the solids mentioned in S. No.3-6. Part I	III	02*
9.	Draw sectional views and true shape of the section for the solids mentioned in S. No.3-6. Part II	III	02
10.	Draw sectional views and true shape of the section for the solids mentioned in S. No.3-6. Part III	III	02
11.	Draw sectional views and true shape of the section for the solids mentioned in S. No.3-6. Part IV	III	02
12.	Draw sectional views and true shape of the section for the solids mentioned in S. No.3-6. Part V	III	02
13.	Draw two problems on sectional orthographic views. Part I	IV	02*
14.	Draw two problems on sectional orthographic views. Part II	IV	02
15.	Draw two problems on sectional orthographic views. Part III	IV	02
16.	Draw two problems on sectional orthographic views. Part IV	IV	02
17.	Draw two problems on missing views. Part I	V	02*
18.	Draw two problems on missing views. Part II	V	02
19.	Draw two problems on missing views. Part III	V	02
20.	Draw two problems on missing views. Part IV	V	02
21.	Draw two problems on missing views. Part V	V	02
22.	Draw two problems on missing views. Part VI	V	02
23.	Draw auxiliary view from the given orthographic views - one problem. Part I	V	02
24.	Draw auxiliary view from the given orthographic views - one problem. Part II	V	02
25.	Draw auxiliary view from the given orthographic views - one problem. Part III	V	02
26.	Draw principal view from the given auxiliary view and other principal view - one problem. Part IV	V	02
27.	Draw principal view from the given auxiliary view and other principal view - one problem. Part V	V	02
28.	Draw principal view from the given auxiliary view and other principal view - one problem. Part VI	V	02
29.	Draw free hand sketches/conventional representation of:	VI	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	i. Rivet heads(1 sheet, at least 10 sketches/conventional representations). ii. Riveted joints: Lap Joint – Single and Double Riveted.		
30.	Draw free hand sketches/conventional representation of: i. Butt Joint – Single Strap, Double Strap. ii. Foundation bolts: Eye and Lewis.	VI	02
31.	Draw free hand sketches/conventional representation of: i. Couplings: Muff, Protected Flange and Flexible Flange. ii. Pulleys: Rope and V-Belt.	VI	02
32.	Draw free hand sketches/conventional representation of: i. Welding joints. ii. Common engineering materials used in practice and their conventional representation in section.	VI	02
	Total		**64**

'*': *compulsory practicals to be performed.*

Note

i. *A suggestive list of practical PrOs is given in the above table, more such practical PrOs can be added to attain the COs and competency.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Neatness. Cleanliness on drawing sheet	10
2	Uniformity in drawing and line work	10
3	Creating given drawing	40
4	Dimensioning the given drawing and writing text	20
5	Answer to sample questions	10
6	Submission of drawing in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices to operate drawing instruments.
b. Follow cleanliness and neatness.
c. Follow ethics and standards.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	Exp. No.
1	Drawing Table with Drawing Board of A1 or full imperial size	All
2	Drawing sheet of A2 or half imperial size	All
3	Models of various types of solids	2
4	Models of cut section of various solids	3
5	Models of cut sections of objects	4
6	Models of Mechanical Components	5
7	Models of objects with inclined surfaces	6
8	Specimen library of various rivet heads, foundation bolts, welding joints, valves and pipe fittings	7
9	Set of various industrial drawings being used by industries	All
10	Set of drawings sheets mentioned in section 6.0 could be developed by experienced teachers and made available on the MSBTE portal to be used as reference/standards	All
11	Drawing equipment's and instruments for class room teaching-large size: a. T-square or drafter (Drafting Machine) b. Set squares (45^0 and 30^0- 60^0) c. Protractor d. Drawing instrument box (containing set of compasses and dividers)	All
12	Interactive board with LCD overhead projector	All

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop LOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Projection of straight lines and planes	1a. Classify various positions of lines with respect to projection planes. 1b. Draw projection of lines in different positions based on given situation. 1c. Classify various types of planes according to orientations. 1d. Draw projection of planes with different orientations based on given situation.	1.1 Projection of straight lines with following positions: a) Parallel to both the planes. b) Perpendicular to one plane. c) Inclined to one plane and parallel to the other. d) Inclined to both the planes. 1.2 Traces of a Line. 1.3 Projection of Planes with following orientations: i. Plane parallel to one principal plane and perpendicular to the other. ii. Plane inclined to one principal plane and perpendicular to the other.
Unit– II Projection	2a. Classify various types of solids.	2.1 Types of Solids 2.2 Projection of the following solids:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
of solids	2b. Explain orientation of axis with respect to projection planes. 2c. Draw projection of given standard regular solids like polyhedron, prisms, pyramids, solids of revolution.	a) Regular Polyhedron – Tetrahedron, Hexahedron (cube) b) Regular prisms and Pyramids – Triangular, Square, Pentagonal, Hexagonal c) Regular solids of Revolution – Cylinder, Cone, Sphere. **With Axis**: i. Perpendicular to one of the principal projection plane. ii. Inclined to one of the principal plane and parallel to the other. iii. Parallel to both principal planes
Unit– III Sections of solids	3a. Describe cutting planes and their orientation with respect to given solid and projection planes. 3b. Explain significance of sectional view and true shape. 3c. Draw sectional view of given solid. 3d. Draw true shape of the section of given solid with mentioned axis orientation.	3.1 Sectional Views and True shape of the section for the solids mentioned in Unit II with section plane in following positions: i parallel to one of the principal projection plane ii inclined to one and perpendicular to the other principal projection plane *Note: Position of solid is restricted to the following:* i. Axis parallel to both principal projection planes ii. Axis perpendicular to one and parallel to the other principal projection plane
Unit– IV Sectional orthographic views	4a. Classify various types of sectional views. 4b. Explain sectioning and hatching conventions. 4c. Convert pictorial views of given object into sectional orthographic views. 4d. Interpret the given drawing.	4.1 Cutting plane line 4.2 Types of sectional views: Full section, Half section, Partial or broken section, Revolved section, Removed section, offset section, Aligned section. 4.3 Sectioning conventions 4.4 Hatching or section lines 4.5 Conversion of pictorial views into sectional orthographic views
Unit– V Missing and Auxiliary views	5a. Interpret the given views. 5b. Draw the missing view from given situation. 5c. Interpret given Auxiliary view 5d. Draw Auxiliary view based on given situation.	5.1 Draw Missing lines and views from the given orthographic views 5.2 Auxiliary planes and views 5.3 Draw Auxiliary view from the given orthographic views 5.4 Complete the partial view from the given auxiliary and other principal view
Unit VI	6a. Identify various	6.1 Draw Free hand sketches/conventional

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Free Hand sketches/conventional representation	engineering components and their materials in the given sectional view. 6b. Draw Free hand sketches/conventional representation of given engineering components.	representation of: i Rivet heads ii Riveted joints: Lap Joint – Single and Double Riveted, Butt Joint – Single strap, Double Strap iii Foundation bolts: Eye and Lewis iv Couplings: Muff, Protected Flange and Flexible Flange v Pulleys: Rope and V-Belt vi Welding joints 6.2 Common engineering materials used in above components and their conventional representation in section.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Projection of straight Lines and Planes	10	-	02	08	10
II	Projection of solids	06	-	02	10	12
III	Section of solids	08	-	02	10	12
IV	Sectional orthographic views	08	-	02	10	12
V	Missing and Auxiliary views	12	02	04	12	18
VI	Free hand/conventional representation	04	04	02	-	06
	Total	**48**	**06**	**14**	**50**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Student should maintain a separate A3 size sketch book which will be the part of term work and submit it along with drawing sheets. Following assignment should be drawn in the sketch book
   i. Minimum 5 problems each on Unit No I to VI.
   ii. Free hand sketches. All types of machine elements mentioned in Unit no-VI.
   iii. Note- Problems on sheet and in the sketch book should be different.
b. Students should collect Production drawings, Layouts from nearby workshops/industries and try visualize the part from the given views.

c. Each student should explain at least one problem for construction and method of drawing in sheet to all batch colleagues. Teacher will assign the problem of particular sheet/assignment to be explained to each student batch.
d. Each student will assess at least one sheet of other students (May be a group of 5-6 students identified by teacher can be taken) and will note down the mistakes committed by them. Student will also guide the students for correcting the mistakes, if any.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Show video/animation films to explain sectional orthographic and missing views and other topics.
g. Use charts and industrial drawing/drawing sheets developed by experienced faculty to teach standard symbols and current industrial/teaching practices.
h. Assign different types of micro projects.
i. Use wooden models to explain the problems.
j. Show the actual parts / models of machine elements mentioned in Unit VI.
k. Use Computer Aided Instructional software for teaching various concepts.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Wood/Thermocol Related Jobs:** Students should use the wooden/thermocol models and verify the correctness of views drawn in the problems solved in the sketch book.
b. **Production drawings:** Each student of the batch should collect at least one production drawings from local workshops or industry and list various types of sections used in the drawings.

c. **Production drawings:** Each student should be given 10 problems in which two views of the objects are given with missing lines. Student should identify the missing lines and complete the views.
d. **Thermocol Models:** The teacher will assign one set of orthographic views/auxiliary views and ask the student to develop 3D thermocol models of the same.
e. Students should collect samples / catalogues of the standard mechanical components available in the market.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Drawing	Bhatt, N.D.	Charotar Publishing House Pvt. Anand, Gujarat Ltd.; ISBN No. 978-93-80358-55-0
3.	Machine Drawing	Bhatt, N.D.; Panchal, V. M	Charotar Publishing House Pvt. Ltd. Anand, Gujarat, ISBN No. 978-93-80358-69-7
4.	Engineering Drawing	Narayana, K.L. ; Kannaiah, P.	Scitech Publications India Pvt. Ltd. ISBN No. 978-81-8371-422-8
5.	Machine Drawing	Singh, Ajeet	Tata McGraw Hill Education, New Delhi ISBN No.: 0 -07-065992-3
6.	Engineering Drawing	Agrawal, Basant; Agrawal, C. M.	Tata McGraw Hill Education, New Delhi ISBN No. 10: 0 – 07 -066863 - 9

14. SOFTWARE/LEARNING WEBSITES

a. http://www.youtube.com/watch?v=o1YPja2wCYQ
b. http://www.youtube.com/watch?v=9AGD4tihjCg&feature=plcp
c. http://www.youtube.com/watch?v=n65NU32inOU
d. http://www.youtube.com/watch?v=tyRVsSsNiUQ
e. http://www.youtube.com/watch?v=_M5eYB6056M
f. http://www.youtube.com/watch?v=UyROI-bAMu4
g. http://www.youtube.com/watch?v=eix8xbqb93s
h. http://www.youtube.com/watch?v=kWOl6ttDTBc
i. http://www.youtube.com/watch?v=gJbrO2jtoa8&feature=related
j. http://www.youtube.com/watch?v=PXgkBadGHEE
k. Engineering Graphics & Drawing v 1.0 from Cognifront

Program Name: All Branches of Diploma in Engineering and Technology.

Program Code: CE/CR/CS/CH/PS/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/MU/EE/ EP/EU/IS/IC/AE /FG/ME/PG/PT/DC/TX/TC

Semester : Second

Course Title : Business Communication Using Computers

Course Code : 22009

1. RATIONALE

Communication is the key factor for smooth and efficient functioning of any industry or business activity. Effective business communication is the lifeblood of any organization and is required to maintain quality and progress. The efficacy of business communication skills are essential for engineering professionals for instructing, guiding and motivating subordinates to achieve desired goals at work place. It is very crucial for an entrepreneur to run organization successfully by communicating effectively and skillfully with employees, customers and investors. Thus this course has been designed to enhance the skills to '*Communicate effectively and skillfully at workplace.*'

2. COMPETENCY

The aim of this course is to help the students to attain the following industry identified competency through various teaching learning experiences

- **Communicate effectively and skillfully at workplace.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above-mentioned competency:

a. Communicate effectively by avoiding barriers in various formal and informal situations.
b. Communicate skillfully using non-verbal methods of communication.
c. Give presentations by using audio- visual aids.
d. Write reports using correct guidelines.
e. Compose e-mail and formal business letters.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
--	--	2	2	--	--	--	--	--	--	--	35@^	14	15~	06	50	20

(~[1]): For only practical courses, the PA (15 marks) has two components under practical marks i.e. the assessment of practical has a weightage of 60% (i.e.09 marks) and micro-project assessment has a weightage of 40% (i.e.06 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

Legends: *L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P - Practical; C – Credit, ESE - End Semester Examination; PA - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

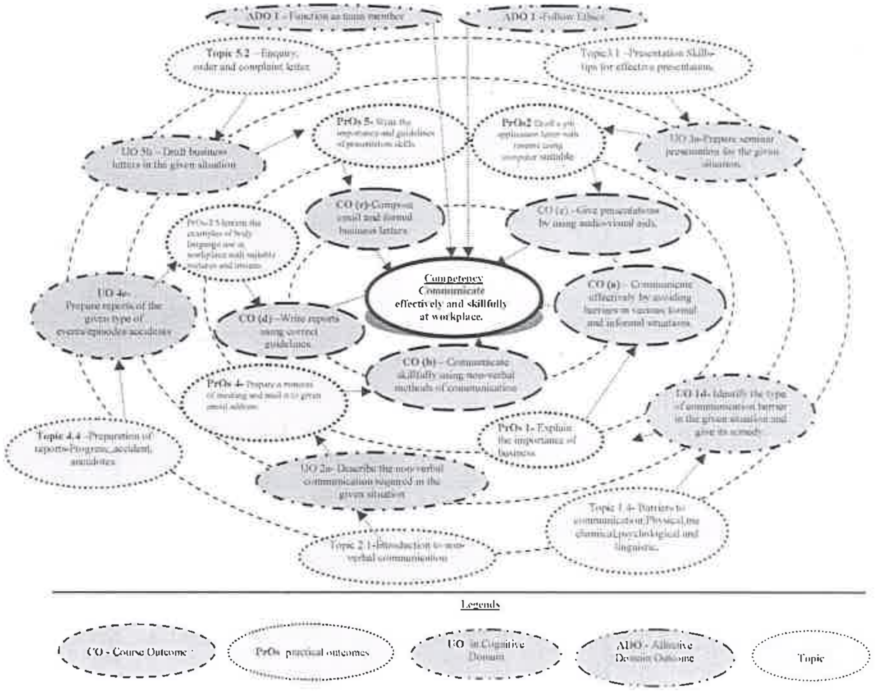


Figure 1 - Course Map

6. SUGGESTED PRACTICALS ACTIVITIES / EXERCISES (Integrate the theory in the laboratory when conducting practical)

The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Explain the importance of business communication for an organization using case study	I	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
2	Draft a job application letter with resume using computer.	V	2*
3	Mention the examples of body language use at workplace with suitable pictures and images.	II	2*
4	Prepare a minutes of meeting and mail it to given email address	VI	2
5	Write the importance and guidelines of presentation skills.	III	2*
6	Draft a detailed Progress Report.	IV	2*
7	Organize a debate on types of communication.	I & III	2
8	Summarize an industry report using techniques of summarizing.	IV	2
9	Draft a complaint letter on given topic.	V	2
10	Design PowerPoint presentation on any technical topic.	III	2*
11	Explain the eight principles of effective communication.	I	2*
12	Explain various non-verbal codes with examples.	II	2
13	Explain the importance of personal appearance stating tips of grooming for a professional.	II	2*
14	Draft a memo on given topic.	V	2
15	Present any Two barriers to communication using case study.	I	2*
16	Present a technical paper using IEEE format.	III	2*
			32

Note

i. A suggestive list of practical LOs is given in the above table, more such practical LOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical LOs/tutorials need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry. The size of batch for the practical should not exceed more than 21 students strictly for the maximum attainment of COs and PrOs.*

ii. Hence, the 'Process' and 'Product' related skills associated with each LO of the laboratory/workshop/field work are to be assessed according to a suggested sample given below:

7. MAJOR EQUIPMENTS / INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1	LCD Projector	All
2	Smart Board with networking	All
3	Language lab with internet	All
4	Printer	Wherever Applicable

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain) Writing Skills	Speaking Skills	Topics and Sub-topics
Unit – I Introduction to Business Communication	1a. Describe the importance of the business communication in the given situation. 1b. Identify the missing element in the given communication process. 1c. Identify the type of communication in the given situation. 1d. Identify the type of communication barrier in the given situation and its remedy.	1e. Use different types of verbal and non–verbal communication for the given situation.	1.1 Introduction to Communication- Elements, Importance, Functions. 1.2 Types (meaning and importance) –Verbal (Oral-Written), Formal, Informal, Vertical, Horizontal and Diagonal communication. 1.3 Principles of effective communication. 1.4 Barriers to communication - Physical, mechanical, psychological and linguistic. 1.5 Business communication: Meaning, characteristics and importance.
Unit– II Non-Verbal Communication	2a. Describe the non-verbal communication required in the given situation. 2b. Describe personal appearance required in the given communication situation. 2c. Describe the given facial expressions.	2d. Use relevant facial expressions in the given situation. 2e. Answer questions after listening to presentations.	2.1 Introduction to Non-Verbal communication (Meaning and importance) 2.2 Body Language: Aspects of body language: gestures, eye contact, posture, facial expressions, personal appearance (dressing and grooming) vocalics. 2.3 Body language - positive and negative body language.
Unit– III Presentation skills	3a. Prepare seminar presentation for the given situation. 3b. Prepare debate points 'for' and 'against' the given topic. 3c. Prepare the points for computer presentation	3d. Make seminar presentation 3e. Participate in debate speaking 'for' or 'against' the given topic. 3f. Make effective	3.1 Presentation skills- tips for effective presentation. 3.2 Guidelines for developing power point presentation. 3.3 Presenting Technical papers.

Unit	Unit Outcomes (UOs) (in cognitive domain) Writing Skills	Speaking Skills	Topics and Sub-topics
	for the given topic.	computer presentations	
Unit– IV Office Drafting	4a. Draft the given notice using the relevant format. 4b. Draft the given memorandum using the relevant format. 4c. Prepare agenda for the given type of meetings. 4d. Prepare minutes of the given type of meetings. 4e. Prepare reports of the given type of events/episodes/ accidents	4f. Read the agenda of the given meeting. 4g. Read the report of the given event. 4h. Initiate telephone calls for given situation. 4i. Answer official phone calls for given situation.	4.1. Office drafting: Formats and Guidelines. 4.2. Formulating notices and memoranda. 4.3. Preparation of agenda and writing minutes of meetings. 4.4. Preparation of reports- progress reports, Accident reports, case study. 4.5. Summarizing techniques.
Unit-V Business Correspon dence	5a. Respond to given job advertisements by writing your CV/ Resume. 5b. Draft business letters in the given situations. 5c. Draft complaint letters for the given situations. 5d. Compose E- mails with relevant for the given situation.		5.1 Business correspondence. 5.2 Enquiry, order and complaint letters. 5.3 E-mails- netiquettes. 5.4 Difference –Curriculum Vitae, Bio-data and Resume. 5.5 Job application and resume writing

Note: To attain the COs and competency, above listed Learning Outcomes (UOs) need to be undertaken to achieve the 'Application Level' of Blooms's 'Cognitive Domain Taxonomy' Theory related topic should be covered during practical hours using multimedia.

9. SUGGESTED SPECIFICATION TABLE FOR INTERNAL END SEMISTER EXAMINATION

Unit No.	Unit Title	Distribution of practical Marks R Level	U Level	A Level	Total Marks
I	Introduction to Business Communication	02	02	01	05
II	Non-verbal Communication	02	01	02	05
III	Presentation Skills	02	01	02	05
IV	Office Drafting	02	04	04	10
V	Business Correspondence	02	04	04	10
	Total	**10**	**12**	**13**	**35**

Legends: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)
Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of PrOs and UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED GUIDELINES FOR ASSESSMENT TOOL TO CONDUCT INTERNAL END SEMETER EXAM (ESE).

Weightage (20 Marks) A	Weightage (15 Marks) B	Total
Assessment based on PrOs, practicals conducted during semester Based on computer and written skill. (Minimum four questions each five marks) Sample questions: Eg. I Draft an email to The manager regarding the shortage of raw material at production department. Note-submit the printout of mail. (Computer based) Eg. II Write job application with resume. (written)	**Oral examination based on UOs Topics mentioned in syllabus. (Minimum five questions each two marks to be asked) Eg. I Explain the importance of communication in professional life. II. State any four guidelines of presentation skills.**	**(35 Marks) A+B Duration: 2 hours**

SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

a. Collect good articles from newspapers and magazines and read them with correct intonation.
b. Listen to Business news on TV and radio.
c. Watch videos of effective presentations on television and open learning sources for presentation skills and body language.
d. Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b. *'L' in item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
a. Arrange various communication activities using functional grammar.
b. Show video/animation films to develop listening skills and enhance vocabulary.
c. Use real life situations for explanation.
d. Prepare and give oral presentations.
e. Guide micro-projects in groups as well as individually.

12. SUGGESTED TITLES OF MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of CrAs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement* hours during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. Study the personal appearance and grooming of employees visiting sales store, shopping mall in the vicinity.
b. Comparative study of Bio-data, Resume and Curriculum vitae.
c. A detailed study of guidelines required for presentation skills.
d. Summarize technical content using English newspaper, magazines or online resources.
e. Prepare a booklet on aspects of body language in pictorial form.
f. A detailed study of the importance, of technical paper of technical paper presentation.
g. Case study on the importance of Business communication in an organization.
h. Report on various formal/business activities.
i. Study of oral presentation of famous business leader.
j. Detailed study of business etiquettes observed in organization.
k. Summarize the business article with the help of English newspapers/magazines and other sources.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Effective Communication Skills	M Ashraf Rizvi	Tata McGraw-Hill

S. No.	Title of Book	Author	Publication
2	Communication Skills	Sanjay Kumar and Pushp Lata	Oxford University Press
3	Personality Development and Soft Skills	Barun K. Mitra	Oxford University Press

14. SOFTWARE/LEARNING WEBSITES

a. https://www.britishcouncil.in/english/learn-online
b. http://learnenglish.britishcouncil.org/en/content
c. http://www.talkenglish.com/
d. languagelabsystem.com
e. www.wordsworthelt.com
f. www.notesdesk.com
g. http://www.tutorialspoint.com
h. www.studylecturenotes.com
i. totalcommunicator.com
j. www.speaking-tips.com

Program Name : **Mechanical Engineering Program Group**

Program Code : **AE / ME**

Semester : **Second**

Course Title : **Mechanical Engineering Workshop**

Course Code : **22010**

1. RATIONALE

Diploma Automobile engineer is expected to develop advanced workshop skills, furniture making, fitting, smithy operations, fabrication work, lathe and shaper operations. These operations are useful in manufacturing, fabrication and construction industries. Working in workshop develops the skills related to cost effectiveness, team working, and safe practices. The technologists have to apply advanced workshop skills industrial jobs using hand tools, equipment and machineries and accordingly, this course has been designed.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Perform repairing work of utility jobs in the mechanical engineering workshop.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Select tools and machinery according to job.
b. Use hand tools in different shops for performing different operations.
c. Operate equipment and machines in various shops.
d. Prepare composite / utility jobs according to drawing.
e. Maintain workshop related tools, instruments and machines.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
--	--	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40

*(~): For the **practical only courses,** the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 30 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 20 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

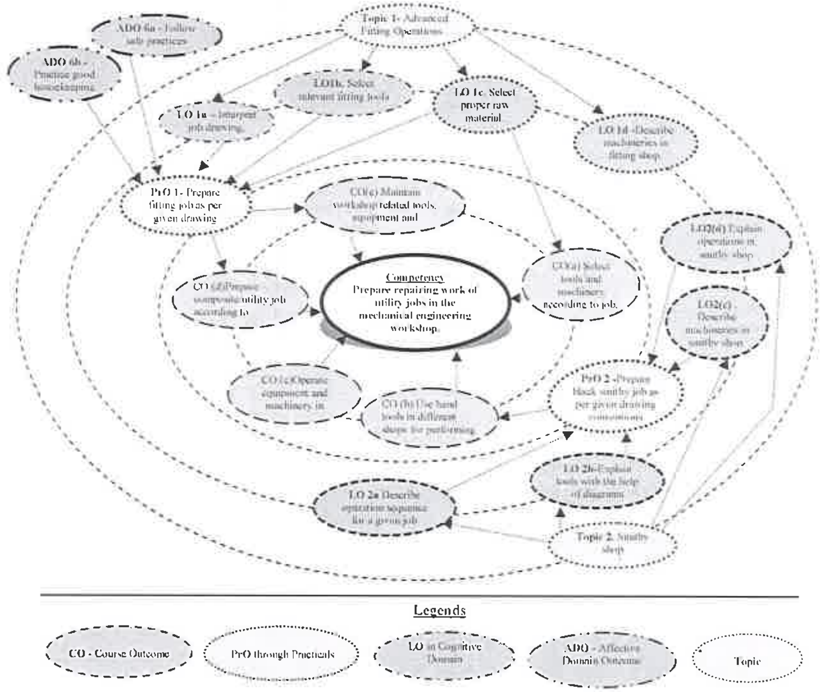


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcome (PrOs)	Unit No.	Approx. Hrs. required
1	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation, Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts.*** Part I	I	2*
2	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation,***	I	2*

S. No.	Practical Outcome (PrOs)	Unit No.	Approx. Hrs. required
	Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts. Part II		
3	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation, Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts***. Part III	I	2
4	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation, Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts.*** Part IV	I	2
5	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation, Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts***. Part V	I	2
6	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation, Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts***. Part VI	I	2
7	Prepare fitting job (male and female assembly type) as per given drawing or job with following operations: ***Marking operation, Punching operation, Drilling operation, Cutting operation, Filing operation, Fitting operation (male and female assembly), Checking correctness of fit of mating parts***. Part VII	I	2
8	Prepare black smithy job (like Hook, peg, flat chisel, bolt head or any hardware item)as per given drawing or job with following operations: ***Cutting operation, Heating operation, Upsetting operation, Punching operation, Swaging operation, Fullering operation, Bending operation***. Part I	II	2*
9	Prepare black smithy job (like Hook, peg, flat chisel, bolt head or any hardware item)as per given drawing or job with following operations: ***Cutting operation, Heating operation, Upsetting operation, Punching operation, Swaging operation, Fullering operation, Bending operation***. Part II	II	2
10	Prepare black smithy job (like Hook, peg, flat chisel, bolt head or any hardware item)as per given drawing or job with following operations: ***Cutting operation, Heating operation, Upsetting operation, Punching operation, Swaging operation, Fullering operation, Bending operation***. Part III	II	2
11	Prepare black smithy job (like Hook, peg, flat chisel, bolt head or any hardware item)as per given drawing or job with following operations: ***Cutting operation, Heating operation, Upsetting operation, Punching operation, Swaging operation, Fullering***	II	2

S. No.	Practical Outcome (PrOs)	Unit No.	Approx. Hrs. required
	operation, Bending operation. Part IV		
12	Prepare black smithy job (like Hook, peg, flat chisel, bolt head or any hardware item)as per given drawing or job with following operations: ***Cutting operation, Heating operation, Upsetting operation, Punching operation, Swaging operation, Fullering operation, Bending operation***. Part V	II	2
13	Prepare bill of material along with estimated cost according given drawing of jobs, such as -repairing of classroom furniture/ book shelves/ metallic doors/motor saree guard/ battery stand with locking device considering the following applicable operations: a. Marking operation as per drawing b. Cutting operation as per drawing c. Cleaning operation as per drawing d. Edge preparation operation as per drawing e. Filing operation as per drawing f. Bending operation as per drawing g. Welding operation as per drawing	III	2*
14	Prepare steel frame / structure of utility job (like stool, benches, tables, drawing desk, window grill, ventilator, door frame or similar job) involving arc welding joint as per given drawing or job. Part I	III	2
15	Prepare steel frame / structure of utility job (like stool, benches, tables, drawing desk, window grill, ventilator, door frame or similar job) involving arc welding joint as per given drawing or job. Part II	III	2
16	Prepare steel frame / structure of utility job (like stool, benches, tables, drawing desk, window grill, ventilator, door frame or similar job) involving arc welding joint as per given drawing or job. Part III	III	2
17	Perform fabrication operations to prepare job (wire mesh tray/ drawing sheet holder/tree guard/shoe stand as per given drawing. Part I	III	2*
18	Perform fabrication operations to prepare job (wire mesh tray/ drawing sheet holder/tree guard/shoe stand as per given drawing. Part II	III	2
19	Perform fabrication operations to prepare job (wire mesh tray/ drawing sheet holder/tree guard/shoe stand as per given drawing. Part III	III	2
20	Perform ***Cutting operation*** operations to prepare small notice board for your workshop/institute using soft board, velvet cloth with bidding as per given drawing.	IV	2*
21	Perform ***Planing operation*** operations to prepare small notice board for your workshop/institute using soft board, velvet cloth	IV	2

S. No.	Practical Outcome (PrOs)	Unit No.	Approx. Hrs. required
	with bidding as per given drawing.		
22	Continue experiment No. 20 and perform ***Wood turning*** operations to prepare small notice board for your workshop/institute using soft board, velvet cloth with bidding as per given drawing.	IV	2*
23	Continue experiment No. 20 and perform ***Joining*** operations to prepare small notice board for your workshop/institute using soft board, velvet cloth with bidding as per given drawing.	IV	2
24	Continue experiment no. 20 and 22 and complete the small notice board for your workshop/institute using soft board, velvet cloth with bidding as per given drawing by performing ***Finishing*** operations.	IV	2
25	Continue experiment no. 20 and 22 and complete the small notice board for your workshop/institute using soft board, velvet cloth with bidding as per given drawing by performing ***Varnishing*** operations.	IV	2
26	Prepare simple turning job with facing operation as per drawing	V	2*
27	Perform centering operation as per drawing to prepare simple turning job.	V	2
28	Prepare simple turning job with ***Plane*** turning operation as per drawing.	V	2
29	Prepare simple turning job with ***Step*** turning operation as per drawing.	V	2
	Total		**58**

Note

i. A suggestive list of practical PrOs is given in the above table, more such practical PrOs can be added to attain the COs and competency.

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1.	Prepare experimental set up	20
2.	Prepare Job using different operations	30
3.	Follow Safety measures	10
4.	Check the quality of finished job	20
5.	Answers to job related questions	5
6.	Submit journal report on time	5
7.	follow Housekeeping	5
8.	Attendance and punctuality	5
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Function as a team member.
e. Function as a team leader.
f. Follow ethics.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
1.	**Marking table with scribers** : Black Granite surface flat, non magnetic non glaring, planning accuracy as per IS- size 1000mm x 630mm x 150mm of workshop grade with slab carbide scriber 150mm.	1
2.	**Surface plate:** C.I. Surface plate, planed, hand swapped and seasoned, Brown and sharp type ribbing complete with handles for lifting and wooden protector cover. Conforming to IS- 2285 - 1963. 1) 450 mm x 450 mm. or 2) 450 mm x 600 mm	1
3.	**Measuring Instruments, Marking Instruments, Fitting Hand Tools:** Vice block, height gauges, vernier calipers, outside and inside calipers, micrometers, bevel protractor, files of different sizes and grades, Hacksaw frames, chisels, steel rules, try squares, drills, surface gauge, Number punch, dot punch, Divider , Angle plate, screw drivers, spanners etc.	1
4.	**Tap and Die Set:** Both tap and die set complete in box with accessories 0 - 10 BA , 1/4 " to 1 " BSF,1/2"to 3/4" NF ,1/4" to 3/4 " NC,6mmto 16mm metric, one set each .	1
5.	**Bench Drilling Machine**: 13mmcapacity motorized Drilling Machine, with 0. 5 HP / AC / 230 / 1 / 1420r. p. m., with motor starter switch, 13mmcapacity drilling chuck, V belt with 100 mm machine vice.	1
6.	**Bench Grinder:** Double ended bench grinder wheel size 150mmx 16mm x 12mm with standard accessories with single phase 0. 25 HP motor high speed.	1
7.	**Vice:** Bench Vice 150 mm	1
8.	**Electrically operated Hand Drilling Machine (pistol Type)**: 8mm capacity steel drilling . Power Input300- 400 W.	1
9.	**Power Hack Saw Machine:** Mechanical type hacksaw machine equipped	1

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
	with coolant pump , vice, length gauge, machine drive belt guard , with capacity to cut / round materials up to175mmand square materials 150mm x 150mm, Blade size 350mm x 25mm and 1 HP /AC440 / 3 / 50 / 1440 RPM Electric motor and starter.	
10.	**Pedestal Grinder**: 200mm Spindle speed 2600 to 3000 rpm, diameter of wheel 200 mm width 25mm	1
11.	**Hand Grinder**: Two speed flexible shaft, 370watts, full load speed, 6410 rpm and 665 rpm.	1
12.	**Work Bench:** 1800x1200x750mm	1
13.	**Hearth with blower**: Centrifugal motorized blower 3 HP / 440/3 / 50 with Forges, pipe Fittings valves, Hearth Size Made of M. S. Sheets 750 mm x 750 mm with water jacket, Height of 2.5 m (with chimney)	2
14.	**Anvil:** Single Horn 150 kg malleable cast iron with stand.	2
15.	LegVice:15cm size.	2
16.	**Swage Black:** Wrought Iron or Malleable cast Iron 1)450 x 450 x100 mm. Or 2)500 x500 x 150 mm	2
17.	**Tools and Gauges**: Hammers of different size , Tong, Chisels flatteners pullers, Dies, Punch , Drift etc.	2
18.	**Power Hammer:**1Tonne capacity, motorised, equipped with foot lever operated, clutch to control strokes, spring loaded hand lever for adjustment of strokes, ram and C. I. anvil and the vertical pull rod , 3HP / 440 V A.C. / 3 / 50 Hz. / 960 rpm electric motor and starter. Having ram weight about 70 kgs. maximum lift 190mm, strokes / minute 160 to 200, hammers upto diameter 56 mm to 80 mm.	2
19.	**Bench Grinder:** Double ended bench grinder with 1HP 3Phase50 cycles 440 V and one side rough and other side smooth 250mm x 25mm x16mmgrinding wheel complete with wheel guard , tool rest and rotary switch.	2
20.	**Work Bench With vice**:1800x1200x750mm	2
21.	**Arc welding transformer three phase with standard accessories** – Welding Transformer to provide current from 50 amps to 600 amps for Single operator and 25 amps to 300 amps for two operators at 80 v open current , alternate voltage of 100 V open circuit provision, rotary switch for quick selection of current with following technical specifications conforming to IS 1851 -1975 Standard Accessories : 1. Copper cable single core conforming to IS - 9857 / 1981 for 600 amps. 2. Electrode holder up to 600 amps. 3. Hand Screw. 4. Earth clamp, tommy bar type. 5. Pair of welders Goggles. 6. Welders apron. 7. Welders glass	3,4,5
22.	**Single Phase Air-cooled arc Welding Transformer with Accessories:** Single phase air cooled arc welding, transformer, step less variable current regulator for welding current range 40 to300amps. Conforming to IS- 1851 – 1975.	3,4,5
23.	**Light Duty Spot Welding Machine**: Portable type spot Welder rating 2.5 KVA. for welding up to 2mm + 2mm M. S. Sheet, Max throat depth 20 cms .	3,4,5

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
24.	**Band Saw**: Heavy duty vertical bend saw machine, size of cast iron table 600 mm x 600 mm, 2HP / AC , 440 V, 50 Hz,3 phase AC motor with starter , Dia of wheel 450mm , width of wheel 38mm , depth of cut 300mm with standard accessories including dust collector .	6
25.	**Band saw and Circular Saw Sharpner:** 150 mm to 1054 mm dia circular saw 06 mm to 150 mm width bend saw blades, alternate saw, sharpening machine, equipped with roller swelling of arm spindle having pivoting motion for level of blade teeth. Feeds 40 and 80 teeth per minute, provided with 1 HP / AC 440 v, 3 Phase50Hz. Electric motor with starter, cast Iron pedestal grinding wheel. Motor pulley and V Belt .	6
26.	**Chain and Chisel Mortising Machine:** Floor model provided with endless chain cutter or chisel, headstock counter balanced, table having compound slide for lateral movement by screw adjustment and longitudinal traverse by hand wheel, provided with quick screw clamp, having capacity maximum size of chain 9mm to19mm, max. size of chisel 9mm, depth of bore150 mm, longitudinal table movement 225 mm, lateral movement150 mm, complete with 3ph A. C. 440 v 50 hz electric motor and switch .	6
27.	**Vertical Sander:** Vertical sander sands and polishes flat surfacescapacity180 mm Input (full load):-500watts No load speed 2200 rpm Full load speed :- 1200 rpm	6
28.	**Heavy Duty Circular Saw:**1400 watts/5800rpm. Compact and well balanced. Powerful motor for maximum performance.100 % ball and roller bearings construction. Reversible i n n e r clamp flange.	6
29.	**Heavy Duty Variable Speed Reciprocating Saw Kit:** 640 watts/0-2,400rpm,Variable speed, ball and roller bearings construction. Low vibration. Rubber boot. Flush cutting blade position. Externally replaceable brushes. Capacity-184 mm	6
30.	**Single Speed Impact Drill:** Powerful motor for maximum performance. Compact and well balanced. Helical gear system. Bearing block for precision gear and spindle alignment. Capacity -10mm	6
31.	**Angle Grinder:** Powerful long life motor, spindle lock. Durable and reliable design. Maximum airflow with aero-dynamic fan system. Compact gear case External brush access panel. Capacity-100mm	4
32.	Riveting Gun, Hammers, Spanners and torque wrench, Punch, Allen keys	
33.	**Centre Lathe (General type):** Max. Swing over bed: 450 mm. Max swinging gap770 mm Admit between centers: 555 mm Spindle bore:52 mm. Power of motor:3hp, 3phase, 50Hz. With accessories.	7
34.	**Hydraulic Power - Hacksaw Machine:** Length of stroke (Max.) 200mm for cutting round and square material (Max.) 300mm speed1440 rpm. Power of motor 1.5 k W (AC 3 p h a s e 4 4 0 v o l t). Accessories Vice for holding bars, saw blade, coolant pump with fittings limit switch, bar rest assembly set of wrenches and belts.	7
35.	**Shaping Machine:** Max. Length ofstroke630mm.Length and width of ram bearing 914x 279 mm Max. distance table to ram 490 mm. Min. distance tabletoram100mm. Max. Horizontal travel of table610 mm. Max. Vertical travel of table 390 mm. No of speedsofram4 Max.Traveloftoolslide 152mm. Swiveling of tool slide on either side oftheverticał60Deg. Power of maindrivemotor3HP, 440V,3 phase, 950 rpm. Accessories Auto Lubrication,	7

S. No.	Equipment Name with Broad Specifications	Exp. S.No.
	operating handle, Vice, key way cutting attachment.	
36.	**Measuring Instruments and Tools:** Vernier Caliper- 0 to 300mm, Dial Caliper- 0-300 mm, Vernier Depth Gauge-0 to 300 mm, Digital Height Gauge- 0 to 4 50mm, Digital Micrometer- 0 to 25 mm, Combination Set	7

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics is to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Advanced Fitting Operations	1a. Interpret the given job drawing. 1b. Select relevant fitting tools for the specified data. 1c. Select proper raw material for the given condition. 1d. Describe the specified machinery in fitting shop. 1e. Explain the maintenance procedure of the given tool/ equipment in fitting shop.	1.1 Fitting tools-holding tools like bench vice, V-block with clamp, C-clamp. Marking and measuring tools like surface plate, angle plate , universal scribing block, try square , combination set, scriber, odd leg caliper, divider, punches, calipers, Vernier caliper, Vernier depth gauge, Vernier height gauge, outside micrometer, inside micrometer , hammers, screw driver, spanners and their Specifications 1.2 Cutting tools-Hacksaw, Chisels, combination plier, nose plier, twist drill, taps and tap wrenches, dies and die holder, bench drilling machine, portable electric drill, reamers 1.3 Finishing tools-Files, Hand file, flat file square file, Triangular file, half round file, round file 1.4 Fitting shop machineries-drilling machine, power saw, grinder, their specification, care and maintenance 1.5 Basic processes - chipping, filing, scrapping, grinding, marking, sawing, drilling, tapping, dieing, reaming 1.6 Marking and measuring angles, safety practices.
Unit-II Smithy shop work	2a. Describe operation sequence for a given job. 2b. Explain the function of the given tools with the help of diagrams. 2c. Describe the given machinery in smithy shop. 2d. Describe the specified operations in the smithy shop.	2.1 Tools and equipment- hearth, anvil, swage block, leg vice, hammers, tongs- flat bit tongs, square bit tongs, round bit tongs, pick up tongs. 2.2 Forging operations-upsetting, drawing down and fullering, flattening, waging, bending, twisting, piercing, punching and drifting, welding, finishing, riveting, cutting(hot and cold chisels 2.3 Safe practices

	2e. Explain the maintenance procedure for tools, equipment and machinery.	
Unit– III Domestic fabrication work	3a. Select the relevant arc welding tool for welding the given job. 3b. Describe the function of the given machinery in fabrication shop. 3c. Describe the fabrication proceedure in given situation. 3d. Explain maintenance procedure for the given equipment in the fabrication shop.	3.1 Arc welding equipment: Power sources for arc welding - transformers, motor generators and rectifiers 3.2 Arc welding hand tools- welding cables, electrodes, electrode holder, ground clamp, wire brush, chipping hammer, working table and cabin, face shield, apron, hand gloves. 3.3 Technique of welding- preparation of work, striking an arc, weaving, effect of current and speed, welded joints, welding positions 3.4 Operation of machinery in welding shop-arc welding transformer their specification and maintenance 3.5 Safe practices
Unit– IV Advanced carpentry work	4a. Describe with sketches the function of the given advanced furniture making and carpentry tool(s). 4b. Select the relevant furniture making tools for the given job. 4c. Describe the operation of the given wood working machine. 4d. Explain maintenance procedure for the given equipment in carpentry shop.	4.1 Types of artificial wood such as plywood, block board, hand board, laminated boards, veneer, fibre boards and their applications. 4.2 Furniture making hand tools- Marking and measuring tools-steel rule, steel tape, marking gauge, try square, compass and divider, scriber or marking knife, bevel 4.3 Holding tools-carpenters vice, c- clamp, bar cramp. 4.4 Planning tools-jack plane, smoothening plane, rebate plane, plough plane. 4.5 Cutting tools- saws, crosscut and hand saw, rip saw, tenon saw, compass saw, chisels, firmer chisel, dovetail chisel, mortise chisel. 4.6 Drilling and boring tools-carpenters brace hand drill, auger bit, hand drill, gimlet, 4.7 Miscellaneous tools-mallet, pincer, claw hammer, screw driver, wood rasp file, bradawl. 4.8 Safe practices.
Unit– V Workshop machines	5a. Describe with sketches the function of the given work and tool holding device. 5b. Explain with sketches the working principle of the given lathe operation. 5c. Calculate speed, feed, depth of cut of lathe machine for the given	5.1 Working principle and types of lathe 5.2 Parts of lathe, bed, headstock, tailstock, carriage or saddle, compound rest, tool post, lead screw, centres 5.3 Work holding devices- three jaw chuck, four jaw chuck, face plate,lathe dogs and driving plate 5.4 Measuring instruments- outside and inside caliper, vernier caliper, micrometer 5.5 Cutting parameters-cutting speed, feed,

	job 5d. Explain working principle of the given workshop machine	depth of cut, tools materials, tools geometry. 5.6 Lathe operations- turning Shaper machine- Working principle and operation, classification, main parts and their functions

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

- Not applicable -

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes:

a. Prepare work diary based on practical performed inworkshop. Work diary consist of job drawing, operations to be perform, required raw materials, tools, equipment's, date of performance with teacher signature.
b. Prepare journals consist of free hand sketches of tools and equipment's in each shop, detail specification and precautions to be observed while using tools and equipment.
c. Prepare/Download a specifications of followings:
   a) Various tools and equipment in various shops.
   b) Precision equipment in workshop
   c) Various machineries in workshop
d. Undertake a market survey of local dealers for procurement of workshop tools, equipment machineries and raw material.
e. Visit any fabrication/wood working/sheet metal workshop and prepare a report.

11. SUGGESTEDSPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Arrange visit to nearby industries and workshops for understanding various manufacturing process.
g. Show video/animation films to explain functioning of various processes of turning operations and shaping operations.
h. Prepare maintenance charts for various workshop machineries.
i. In respect of item 10 above, teachers need to ensure to create opportunities and provisions for such co curricular activities.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs, ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. **Black Smithy Jobs:** Each batch will collect minimum 5 different utility jobs of black smithy from the local workshop / market. Each student will measure the significant parameters and draw the sketch. Each student will also note the material of the utility jobs and their field applications.
b. **Fabrication Utility Jobs:** Each batch will collect information related to fabrication utility jobs including name of job, sketch, material used, fabrication process and their field applications of minimum 5 different jobs of fabrication used in civil construction from the local market.
c. **Fabrication Utility Jobs:** Each batch will select at least one fabrication utility job used in civil construction and prepare steel frame / structure of utility job like window grill, ventilator, door frame or similar job involving arc welding including drawing, field application of selected job.
d. **Wood Related Jobs:** Each batch will collect minimum 4 different samples of artificial woods such as plywood, block board, hand board, laminated boards, veneer, fiber board's etc and write their applications.
e. **Wood Related Jobs**: Each batch will collect and record the information related to furniture making tools and furnitures used in educational institutes from the local carpentry / furniture workshops with their major specifications and sketch.
f. **Miscellaneous Jobs**: Each batch will prepare jobs (like tree guard/shoe stand etc.) by using appropriate material and method of fabrication.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Workshop Practice	Bawa, H.S.	McGraw Hill Education, Noida; ISBN-13: 978-0070671195
2.	A Textbook of Manufacturing Process (Workshop Tech.)	Gupta, J.K.; Khurmi,R.S.	S. Chand and Co. New Delhi ISBN:81-219-3092-8
4.	Introduction to Basic Manufacturing Process and Workshop Technology	Singh, Rajender	New Age International, New Delhi; 2014, ISBN: 978-81-224-3070-7
6.	Workshop Technology Vol-I and II	Raghuvanshi B.S.	Dhanpat Rai New Delhi; 2014, ISBN 4567144376

14. SOFTWARE/LEARNING WEBSITES

a. http://www.asnu.com.au
b. http://www.abmtools.com/downloads/Woodworking%20Carpentry%20Tools.pdf
c. http://www.weldingtechnology.org
d. http://www.newagepublishers.com/samplechapter/001469.pdf
e. http://www.youtube.com/watch?v=TeBX6cKKHWY
f. http://www.youtube.com/watch?v=QHF0sNHnttwandfeature=related
g. http://www.youtube.com/watch?v=Kv1zo9CAxt4andfeature=relmfu
h. http://www.piehtoolco.com
i. http://sourcing.indiamart.com/engineering/articles/materials-used-hand-tools/
j. https://www.youtube.com/watch?v=9_cnkaAbtCM

Maharashtra State Board of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechnical Engineering

Program Code : ME | **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters | **Duration : 16 Weeks**

Semester : Third | **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme													Grand Total
								Theory							Practical						
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total		
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Strength of Materials	SOM	22306	3	2	2	7	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
2	Basic Electrical and Electronics Engineering	BEE	22310	4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Thermal Engineering	TEN	22337	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
4	Mechanical Working Drawing	MWM	22341	4	-	4	7	4	70	28	30*	00	100	40	50@	20	50	20	100	40	200
5	Engineering Metrology	EME	22342	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
6	Mechanical Engineering Materials	MEM	22343	3	-	2	5	3	70*#^	28	30*	00	100	40	25#	10	25	10	50	20	150
			Total	**19**	**2**	**14**	**35**	--	**420**	--	**180**	--	**600**	--	**175**	--	**175**	--	**350**	--	**950**

Student Contact Hours Per Week: **35 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **950**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI ★

Program Name : **Mechanical Engineering Program Group**

Program Code : **AE/ME/PG/PT/FG**

Semester : **Third**

Course Title : **Strength of Materials**

Course Code : **22306**

1. RATIONALE

Strength of Material is a core technology subject which aims at enabling the student to understand and analyze various types of loads, stresses and strains along with main causes of change in physical properties and failure of machine parts. All Mechanical Engineering components are subjected to different loadings and behave in a specific way. The subject is pre-requisite for understanding principles of machine design and strengths of various materials used in industries. Understanding mechanical properties of materials will help in selecting the suitable materials for various engineering applications.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Estimate stresses in structural members and mechanical properties of materials.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Compute Moment of Inertia of symmetric and asymmetric structural sections.
b. Estimate simple stresses in machine components.
c. Perform test to evaluate mechanical properties according to India Standards.
d. Compute shear force and bending moment and corresponding shear and bending stresses in beams subjected to point and uniformly distributed load.
e. Estimate stresses in shafts under twisting moments.
f. Estimate stresses in short member subjected to eccentric loading.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	2	2	7	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

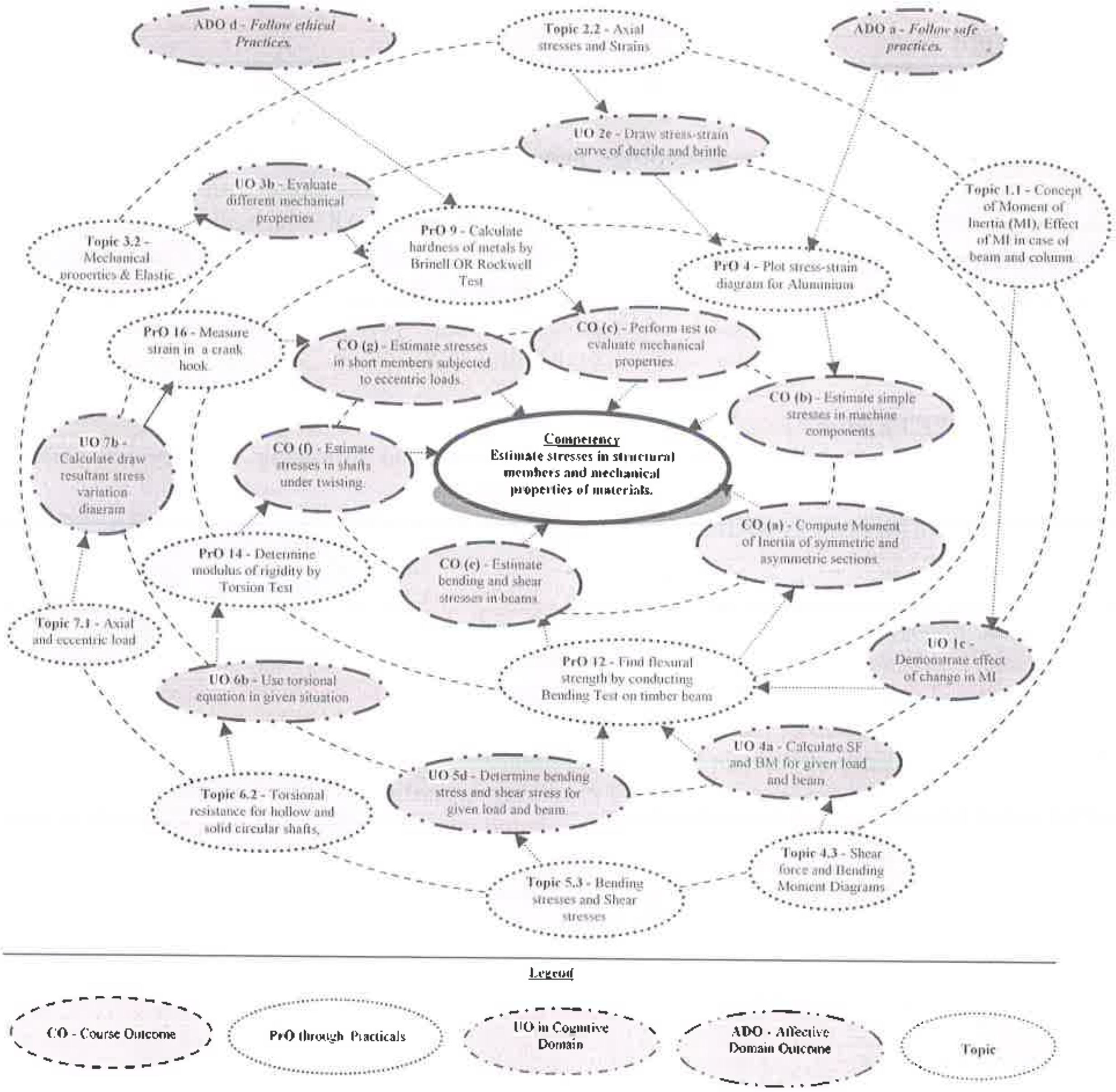


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part I) as per IS432 (I)	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
2	Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part II) as per IS432 (I)	II	02
3	Plot stress-strain diagram for Aluminium by conducting Tension test (Part I) as per IS 1608	II	02
4	Plot stress-strain diagram for Aluminium by conducting Tension test (Part II) as per IS 1608	II	02
5	Calculate compressive strength of Ductile such as Mild Steel (MS), Aluminium (Al), Brass (Br), Copper (Cu), using Compression testing machine as per IS 14858	II	02*
6	Calculate compressive strength of Brittle materials such as Cast Iron (CI), High Carbon steel using Compression testing machine as per IS 14858	II	02
7	Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Single Shear test as per IS 5242	II	02*
8	Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Double Shear test as per IS 5242	II	02
9	Evaluate toughness of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Izod Impact test as per IS 1757	III	02*
10	Determine energy absorption capacity of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Charpy Impact test as per IS 1598	III	02*
11	Draw Shear force and Bending moment diagrams of given loading using open source SF/BM simulation software.	IV	02*
12	Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side horizontally oriented as per IS 1708, IS 2408	IV	02
13	Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side vertically oriented as per IS 1708, IS 2408	IV	02
14	Determine modulus of rigidity by conducting Torsion Test on MS (Part I) as per IS 1717	V	02*
15	Determine modulus of rigidity by conducting Torsion Test on MS (Part II) as per IS 1717	V	02
16	Determination of Direct stress, Bending stress and Resultant stresses for a given practical approach	VI	02
	Total		**32**

Note

1. *A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*
2. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below.*

S. No.	Performance Indicators	Weightage in %
a.	Awareness about significance of particular test	15
b.	Understanding working principle of machine	15
c.	Preparation of experimental set up	20
d.	Setting and operation	20
e.	Observations and recording	10
f.	Interpretation of result and conclusion	10
g.	Answer to sample questions	5
h.	Submission of report in time	5
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1^{st} year
- 'Organizing Level' in 2^{nd} year
- 'Characterizing Level' in 3^{rd} year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	**Universal Testing Machine:** Capacity - 100 tonnes. Type: Mechanical type digital, electrically Operated. Accessories: (1) Tensile test attachment for flat and round specimen up to32 mm. (2) Compression test attachment (3) Shear test attachment with sizes of bushes 5.6,8,10,12,16,20,24 mm, (4) Transverse test attachment with bending Punch,(5)Service tools,(6) Operation and maintenance manuals - 2 nos. (7)Hardness attachment	1 to 8 and 12,13
2	**Digital Extensometer:** Least count - 0.001 mm. Max. Extension = 5 mm. Single dial gauge for 30,40 mm. 60 mm, 80 mm, 100 mm, 125 mm gauge length.	1 to 2
3	**Impact Testing Machine:** CHARPY Test Apparatus: Pendulum drop angle 140°; Pendulum effective Wt 20-25 kg; Striking velocity of pendulum 5-6 m/sec; Pendulum impact energy 300 j; Min scale graduation 2 J; Distance of axis of pendulum rotation	9, 10

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
	from center of specimen to specimen hit by pendulum 815 mm. IZOD Impact Test Apparatus: Pendulum drop angle: 90°-120; Pendulum effective Wt: 20-25 kg; Striking velocity of pendulum: 3-4 m/sec; Pendulum impact energy: 168 j; Min scale graduation: 2 J; Distance of axis of pendulum rotation from center of specimen to specimen hit by pendulum : 815 mm	
4	**Torsion Testing Machine:** Fixed with auto torque selector to regulate torque ranges Contains geared motor to apply torque to specimen through gearbox Attached with autographic recorder for relation between torque and angle of twist Accuracy + 1 % of the true torque Suitable For: Torsion and Twist test on diverse metal rods and flats Torque Measurement by pendulum dynamometer system	14, 15
7	**Compression Testing Machine:** Digital display manual control compression testing; machine; Max. Capacity (KN): 2000 ; Measuring range: 4%-100% of FS; Relative error of reading: ≤ ±1%; Max. distance between two platen (mm): 330; Compression platen size (mm): 220×220; Max. piston stroke (mm): 0-20; Max. piston speed (mm/min): Approx. 30; Column clearance (mm): 300×200; Oil pump motor power (KW): 1.5; Whole dimensions (mm): 855*380*1435	12, 13
8	Strain Gages set: CEA-13-125UR-350 Strain Gages; CEA-00-125UR-350 Strain Gages; CEA-00-125UT-350 Strain Gages. With strain gauge data logger and connecting cables.	16
9	Freeware/open source software for drawing SF and BM diagrams.	11

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit –I Moment of Inertia	1a. Calculate MI of the given standard shape. 1b. Calculate MI of the given simple composite shape. 1c. Explain with sketches effect of change in MI in case of the given beam and column. 1d. Calculate Polar MI and radius of gyration for the given body.	1.1 Concept of Moment of Inertia (MI), Effect of MI in case of beam and column. 1.2 MI about axes passing through centroid, Parallel and Perpendicular axes theorem, Polar MI, radius of gyration. 1.3 MI of standard basic shapes. 1.4 MI of Composite plane figures.
Unit– II Simple Stress and Strains	2a. Calculate axial deformation and axial stress for the given stress condition. 2b. Use Hooke's law for the	2.1 Equilibrium, Rigid body, Deformable body. 2.2 Axial Stress- meaning, Resistance, Types of stresses; Axial (linear) Strain – concept.

	given stress condition. 2c. Calculate Modulus of Elasticity and Rigidity for the given situation. 2d. Determine nature and magnitude of thermal stress in the given situation. 2e. Draw stress-strain curve of the given ductile and brittle material(s) in tension. 2f. Calculate shear stresses for the given single/double shear condition.	types. 2.3 Hooke's Law, Young's Modulus, Axial deformation in a body and bodies in series. 2.4 Behavior of ductile and brittle materials subjected to axial tension, stress-strain or Load-deformation curve, Limit of proportionality, yielding, permanent set, yield stress, ultimate stress. 2.5 Shear stress and shear strain, Modulus of rigidity, punching shear, shear connectors, single and double shear. 2.6 Temperature stress and strain in case of bodies having uniform cross-section, deformation fully prevented, field examples.
Unit – III Mechanical Properties and Elastic Constants of Metals	3a. Identify type of deformation for the given type of load with justification. 3b. Evaluate different mechanical properties of the given material. 3c. Identify types of load acting in the given situation with justification. 3d. Identify type of material from the given data with justification. 3e. Calculate strain and axial deformation in each direction under the given bi- and tri-axial stresses. 3f. Estimate Resilience, Modulus of resilience, Proof Resilience for the given case.	3.1 Types of loads (actions) and related deformations, Flexure, torsion, shear. 3.2 Mechanical properties: Elasticity, Plasticity, Ductility, Brittleness, Malleability, Fatigue, Creep, Toughness, Hardness. 3.3 Strength, Factor of Safety, Stiffness and flexibility. 3.4 Linear and lateral strain, Poisson's ratio, changes in lateral dimension. 3.5 Uni- Bi –Tri-axial stress systems, strain in each direction, Bulk modulus, volumetric strain. 3.6 Relation between three moduli. 3.7 Stress due to Gradual, Sudden and Impact load, corresponding deformation. Strain Energy, Resilience, Proof Resilience and Modulus of resilience.
Unit-IV Shear Force - Bending Moment and Shear Stresses- Bending Stresses	4a. Calculate SF and BM for the given load and beam. 4b. Draw SFD and BMD for the given loaded beam. 4c. Locate point of maximum BM and point of contra-flexure in the given case. 4d. Draw deflected shape of beam from the given BMD. 4e. Use flexural formula for the given bending situation. 4f. Draw NA and extreme	4.1 Types of Beams (Simply supported with or without overhang, Cantilever) , Types of loads (Point load, Uniformly Distributed load), Bending of beam, deflected shape. 4.2 Meaning of SF and BM, Relation between them, Sign convention. 4.3 SFD and BMD, Location of point of maximum BM, Deflected shape from BMD, Location of Point of Contra-flexure. 4.4 Theory of simple bending, Assumptions in

	fibers in bending for the given beam. 4g. Determine Section modulus and Moment of resistance for the given beam. 4h. Determine bending stress and shear stress for the given load and beam. 4i. Draw bending stress and shear stress variation diagram for the given beam.	theory of bending, Flexural formula, Neutral axis. 4.5 Moment of resistance, Section modulus. 4.6 Bending stress variation diagram across depth for cantilever and simply supported beam for symmetrical and unsymmetrical sections. 4.7 Transverse shear stress, average and maximum shear stress, Shear stress variation diagram.
Unit-V Torsion	5a. Use torsional equation in the given situation 5b. Calculate torque and power transmitted by a shaft in the given situation. 5c. Determine shear stress and angle of twist in a shaft for the given power to be transmitted/torque. 5d. Determine diameter of shaft for the given shear stress/ angle of twist.	5.1 Torsion: Concept, field applications (Shaft, flange couplings, shear bolts), torsional rigidity, torsional equation and assumptions. 5.2 Torsional resistance for hollow and solid circular shafts, Power transmitted by shaft, replacement of section.
Unit-VI Direct and Bending Stresses	6a. Identify machine components subjected to eccentricity with justification. 6b. Calculate resultant stress and draw resultant stress variation diagram for the given situation. 6c. Mark core (kernel) of the given standard section. 6d. Determine size of component for the given stress condition.	6.1 Axial and eccentric load, effects of eccentricity, Field cases (Hook, clamp, Bench Vice, Frame etc). 6.2 Axial stress and bending stress, resultant stress intensities, resultant stress variation (Eccentricity about one axis only). 6.3 Limiting eccentricity, Core of section. 6.4 No tension condition.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Moment of Inertia	04	02	00	04	06
II	Simple stresses and Strains	08	02	02	06	10
III	Mechanical properties and Elastic Constants	08	02	02	04	08
IV	Shear force- Bending Moment and Shear stresses- Bending stresses	16	02	06	20	28*
V	Torsion	06	00	02	06	08
VI	Direct and Bending stresses	06	02	02	06	10
Total		48	10	14	46	70

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*
* These 28 marks should be equally divided between 'Shear force- Bending Moment' and 'Shear stresses- Bending stresses', hence questions of 14 marks should be asked from each of these topics.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

a. Undertake micro-projects.
b. Prepare journals based on practical performed in laboratory.
c. Poster presentation on any one topic.
d. Market survey specific to properties of various type of materials used in Mechanical Engineering

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.

g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.
i. Show video/animation film to demonstrate the testing of different materials.
j. Arrange a visit to nearby material testing lab.
k. Use flash/animations to explain the failure of different machine components under various load situations.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Collect information and present in tabular form, values of different engineering properties of five standard mechanical engineering materials.
b. Present a seminar on different testing methods used in industry.
c. Prepare models of single and double shear conditions.
d. Prepare a model of a shaft to demonstrate relation between length and angle of twist.
e. Prepare an excel sheet to calculate SF and BM in a simply supported beam and cantilever beam.
f. Collect information comprising of different machine components subjected to direct and bending stresses.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Strength of Materials	Punmia B.C.	Laxmi Publications (p) Ltd. New Delhi, 10/e, 2015,ISBN: 9788131809259
2	Strength of Materials	Ramamurtham S.	Dhanpat Rai Publishing , New Delhi; 2014, ISBN: 9789384378264
3	Strength of Materials	Timoshenko Gere	CBS,2 edition, 2006, New Delhi, ISBN: 9788123908946
4	Strength of Materials	Khurmi R.S.	S. Chand Publishing, New Delhi, 2006 , ISBN: 9788121928229
5	Strength of Materials	Rattan S.S.	McGraw Hill Education;, New Delhi, 2016, ISBN: 9789385965517

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
b. en.wikipedia.org/wiki/Shear_and_moment_diagram
c. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
d. www.engineerstudent.co.uk/stress_and_strain.html
e. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf

Program Name : **Mechanical Engineering & Automobile Engineering Program**

Program Code : **AE / ME**

Semester : **Third**

Course Title : **Basic Electrical & Electronics Engineering**

Course Code : **22310**

1. RATIONALE

Diploma engineers (also called technologists) passouts have to deal with electrical and electronics engineering principles and applications in industrial processes of different fields. It is therefore necessary for them to apply the principles of electrical and electronics engineering. This course will make them conversant with electrical / electronic engineering aspects of manufacturing, production, fabrication, automobile and mechanical engineering based processes in industries.

2. COMPETENCY

This course is to be taught and implemented with the aim to develop in the student, the course outcomes (COs) leading to the attainment of following industry identified competency expected from this course:

- **Use electrical and electronic equipment safely in mechanical engineering applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a. Use principles of electric and magnetic circuits to solve engineering problems.
b. Determine voltage and current in A.C. circuits.
c. Connect transformers and electric motors for specific requirements.
d. Identify electronic components in electric circuits.
e. Use relevant electronic components safely.
f. Use relevant electric/electronic protective devices safely.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

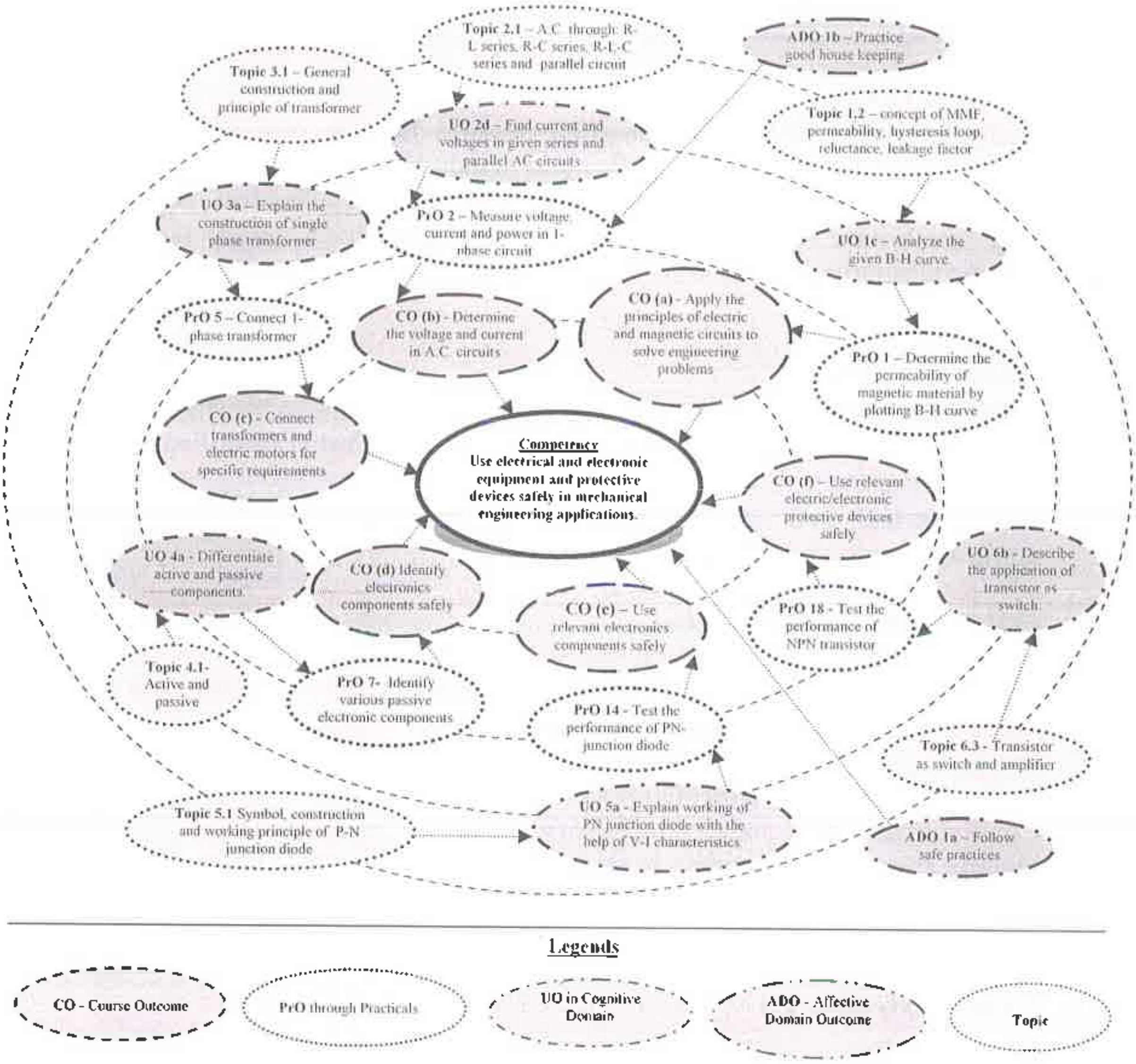


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine the permeability of magnetic material by plotting its B-H curve.	I	02*
2	Measure voltage, current and power in 1-phase circuit with resistive load.	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Measure voltage, current and power in R-L series circuit.	II	02*
4	Determine the transformation ratio (K) of 1-phase transformer.	III	02
5	Connect single phase transformer and measure input and output quantities.	III	02
6	Make Star and Delta connection in induction motor starters and measure the line and phase values.	III	02
7	Identify various passive electronic components in the given circuit	IV	02
8	Connect resistors in series and parallel combination on bread board and measure its value using digital multimeter.	IV	02
9	Connect capacitors in series and parallel combination on bread board and measure its value using multimeter.	IV	02*
10	Identify various active electronic components in the given circuit.	IV	02
11	Use multimeter to measure the value of given resistor.	IV	02
12	Use LCR-Q tester to measure the value of given capacitor and inductor.	IV	02
13	Determine the value of given resistor using digital multimeter to confirm with colour code.	IV	02*
14	Test the PN-junction diodes using digital multimeter.	V	02*
15	Test the performance of PN-junction diode.	V	02
16	Test the performance of Zener diode.	V	02
17	Test the performance of LED.	V	02
18	Identify three terminals of a transistor using digital multimeter.	VI	02
19	Test the performance of NPN transistor.	VI	02*
20	Determine the current gain of CE transistor configuration.	VI	02
21	Test the performance of transistor switch circuit.	VI	02
22	Test the performance of transistor amplifier circuit.	VI	02
	Total		**44**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Pro. S.No.
1	Single Phase Transformer: 1kVA, single-phase, 230/115 V, air cooled, enclosed type.	1,5
2	Single phase auto transformer (Dimmerstat) - Single-Phase, Air cooled, enclosed model, Input: 0 ~ 230, 10A, Output: 0 ~ 270Volts	2,3,4
3	Lamp Bank - 230 V 0-20 A	17
4	Single phase Induction motor – ½ HP,230 V,50 Hz, AC supply	5
5	Different types of starters	6
6	Digital multimeter , 3and ½ digit, seprate range for resistancs and capacitance,component tester, AC and DC measurement.	7,8,11,13, 14,15,16
7	Dual trace CRO/DSO, 50MHz.	4,5,19, 20
8	Function generator,:0-2MHz. for generation of Sin ,square, pulse and triangular wave shapes	17,21,22
9	LCR-Q Meter/Tester	12

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Electrical Engineering	
Unit – I Electric	1a. Explain the given technical terms related to electric and	1.1 EMF, Current, Potential Difference, Power and Energy.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
and Magnetic Circuits	magnetic circuits. 1b. Intrepret the given B-H curve. 1c. Intrepret hysteresis loop of the given material. 1d. Apply Fleming's right hand rule and Lenz's law for determination of direction of induced emf in the given situation.	1.2 M.M.F, magnetic force, permeability, hysteresis loop, reluctance, leakage factor and B-H curve. 1.3 Analogy between electric and magnetic circuits. 1.4 Electromagnetic induction, Faraday's laws of electromagnetic induction, Lenz's law, Dynamically induced emf. 1.5 Statically induced emf.-(a) Self induced emf (b) Mutually induced emf; Equations of self and mutual inductance.
Unit– II A.C. Circuits	2a. Explain attributes of the given AC quantities. 2b. Find currents and voltages in the given series and parallel AC circuits. 2c. Derive the current and voltage relationship in the given star and delta connected circuits 2d. Determine the current and voltage in the given star and delta connection. 2e. Solve simple numerical problems related to the given AC circuits.	2.1 Cycle, Frequency, Periodic time, Amplitude, Angular velocity, RMS value, Average value, Form Factor , Peak Factor, impedance, phase angle, and power factor. 2.2 Mathematical and phasor representation of alternating emf and current; Voltage and Current relationship in Star and Delta connections. 2.3 A.C. in resistors, inductors and capacitors; A.C. in R-L series, R-C series, R-L-C series and parallel circuits; Power in A. C. Circuits, power triangle.
Unit– III Transformer and single phase induction motors	3a Explain with sketches the construction and working principle of the given type of single phase transformer. 3b Explain with sketches the working principle of the given Autotransformer. 3c Describe with sketches the the construction of the given single phase motor. 3d Explain with sketches the working principle of the given single phase induction motors.	3.1 General construction and principle of different type of transformers, Emf equation and transformation ratio of transformers. 3.2 Auto transformers. 3.3 Construction and Working principle of single phase A.C. motor. 3.4 Types of single phase motors, applications of single phase motors.
	Electronics Engineering	
Unit – IV Electronic Components	4a. Differentiate between the given active and passive electronic components. 4b. Calculate value of the given	4.1 Active and passive components; Resistor, capacitor, inductor symbols, colour codes, specifications.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
and Signals	resistor and capacitor using colour code. 4c. Explain the given signal parameters with sketches. 4d. Identify the given type of ICs based on the IC number.	4.2 Voltage and Current Sources. 4.3 Signals: waveform (sinusoidal, triangular and square), time and frequency domain representation, amplitude, frequency, phase, wavelength. 4.4 Integrated Circuits – analog and digital.
Unit– V Diodes and Applications	5a. Explain with sketches the working of the given type of diode usiing V-I characteristics. 5b. Locate the zener voltage on the given V-I characteristic with justification. 5c. Explain with sketches the working of the given type of rectifier using circuit diagrams. 5d. Justify selection of power supply and LEDs for the given circuit.	5.1 P-N junction diode: symbol, construction , working and applications. 5.2 Zener diode: working, symbol, voltage regulator. 5.3 Rectifiers: Half wave, Full wave and Bridge Rectifier, Performance parameters: PIV, ripple factor, efficiency. 5.4 Filters: circuit diagram and working of 'L', 'C' and 'π'' filter 5.5 Light Emitting Diodes: symbol, construction, working principle and applications.
Unit– VI Bipolar Junction Transistor	6a. Explain with sketches the the application of the given type of transistor as a switch. 6b. Determine the current gain of the given type of transistor configurations using transfer characteristic curve. 6c. Compare the performance of the given transistor configurations. 6d. Select the type of transistors and their configurations for the given application.	6.1 BJT: symbol, construction and working principle. 6.2 Transistor as switch and amplifier. 6.3 Input and Output characteristics: CE, CB and CC configurations. 6.4 Operating regions: Cut-off, saturation and Active. 6.5 Transistor parameters: CB gain α, CE gain β, input resistance, output resistance, relation between (α) and (β).

Note: *To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	Electrical Engineering					
I	Electric and Magnetic Circuits	08	02	02	04	08
II	A.C. Circuits	10	02	04	06	12
III	Transformer and single phase	14	04	06	06	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	induction motors					
	Electronics Engineering					
IV	Electronic components and Signals	10	02	04	06	12
V	Diodes and applications	10	02	04	06	12
VI	Bipolar Junction Transistor	12	02	04	04	10
	Total	**64**	**14**	**24**	**32**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Make star delta connections of transformer.
b. Connect the various meters to measure the current and voltage of induction motor.
c. Visit site and interpret the name plate ratings and identify the parts of a transformer.
d. Present seminar on any of the above or relevant topic.
e. Conduct market survey and interpret the name plate ratings and identify the parts of an induction motor.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use Animations to explain the construction and working of electrical machines.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Electric and magnetic circuit**: Each batch will prepare a coil without core. Students will note the deflection of galvanometer connected across the coil for: movement of the North Pole of permanent magnet towards and away from the coil (slow and fast movement), movement of the South Pole of permanent magnet towards and away from the coil (slow and fast movement). Students will demonstrate and prepare a report based on their observations. (**Duration: 8 hours**)

b. **Transformer**: Each batch will visit nearby pole mounted sub-station and prepare a report based on the following points:
   i. Rating: kVA rating, primary and secondary voltage, connections
   ii. Different parts and their functions
   iii. Earthing arrangement

c. **Single phase induction motor:** Each batch will select a three phase squirrel cage type induction motor for a particular application (assume suitable rating). They will visit local electrical market (if the market is not nearby you may use the Internet) and prepare a report based on the following points:
   i. Manufactures
   ii. Technical specifications
   iii. Features offered by different manufacturers
   iv. Price range

d. **Transistor as a switch:** Each batch (3-4 students) will search and study datasheet of transistor and relevant component and will build / test transistor switch circuit on breadboard/General purpose PCB for various input signal.

e. **Prepare display boards consisting of electronic components**: Each batch (3-4 students) will prepare display boards/ models/ charts/ Posters to visualize the appearance of electronic active and passive components.

f. **Diode:** Build a circuit on general purpose PCB to clamp a waveform at 3.0V using diode and passive components.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Basic Electrical Engineering	Mittle and Mittal	McGraw Education, New Delhi, 2015, ISBN : 978-0-07-0088572-5
2	Fundamentals of Electrical Engineering	Saxena, S. B. Lal	Cambridge University Press, latest edition ISBN : 9781107464353
3	Electrical Technology Vol – I	Theraja, B. L.	S. Chand publications, New Delhi, 2015, ISBN: 9788121924405

S. No.	Title of Book	Author	Publication
4	Electrical Technology Vol – II	Theraja, B. L.	S. Chand publications, New Delhi, 2015, ISBN: 9788121924375
5	Basic Electrical and Electronics Engineering	Jegathesan, V.	Wiley India, New Delhi, 2015 ISBN : 97881236529513
6	A text book of Applied Electronics	Sedha, R.S.	S.Chand ,New Delhi, 2008 ISBN-13: 978-8121927833
7	Electronics Principles	Malvino, Albert Paul, David	McGraw Hill Eduction, New Delhi, 2015, ISBN-13: 978-0070634244
8	Principles of Electronics	Mehta, V.K. Mehta, Rohit	S. Chand and Company, New Delhi, 2014, ISBN-13-9788121924504
9	Fundamental of Electronic Devices and Circuits	Bell Devid	Oxford University Press, New Delhi 2015 ISBN : 9780195425239

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. en.wikipedia.org/wiki/Transformer
b. www.animations.physics.unsw.edu.au//jw/AC.html
c. www.alpharubicon.com/altenergy/understandingAC.htm
d. www.electronics-tutorials
e. learn.sparkfun.com/tutorials/transistors
f. www.pitt.edu/~qiw4/Academic/ME2082/Transistor%20Basics.pdf
g. www.technologystudent.com/elec1/transis1.htm
h. www.learningaboutelectronics.com/
i. www.electrical4u.com

Program Name : **Diploma in Production Engineering / Diploma in Production Technology / Diploma in Mechanical Engineering**

Program Code : **PG / PT / ME**

Semester : **Third**

Course Title : **Thermal Engineering**

Course Code : **22337**

1. RATIONALE

Thermal engineering forms one of the core engineering subjects for mechanical engineering students. Diploma mechanical engineers (also called technologists) have to work with various power producing and power absorbing devices like boilers, turbines, compressor, I.C. engines, and refrigerators. The course will enable students to establish foundation required to design, operate and maintain these devices. Thermal power plants are still contributing major share in electricity production in India. Thiscourse emphasizes on steam boilers and allied components that are used in many industrial sectors. Students will be able to calculate various parameters required to determine the performance of these devices.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use principles of thermal engineering to maintain thermal related equipment.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Apply laws of thermodynamics to devices based on thermodynamics.
b. Use first law of thermodynamics for ideal gas in closed systems.
c. Use relevantsteam boilers.
d. Use relevant steam nozzles and turbines.
e. Use relevant steam condensers.
f. Use suitable modes of heat transfer.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

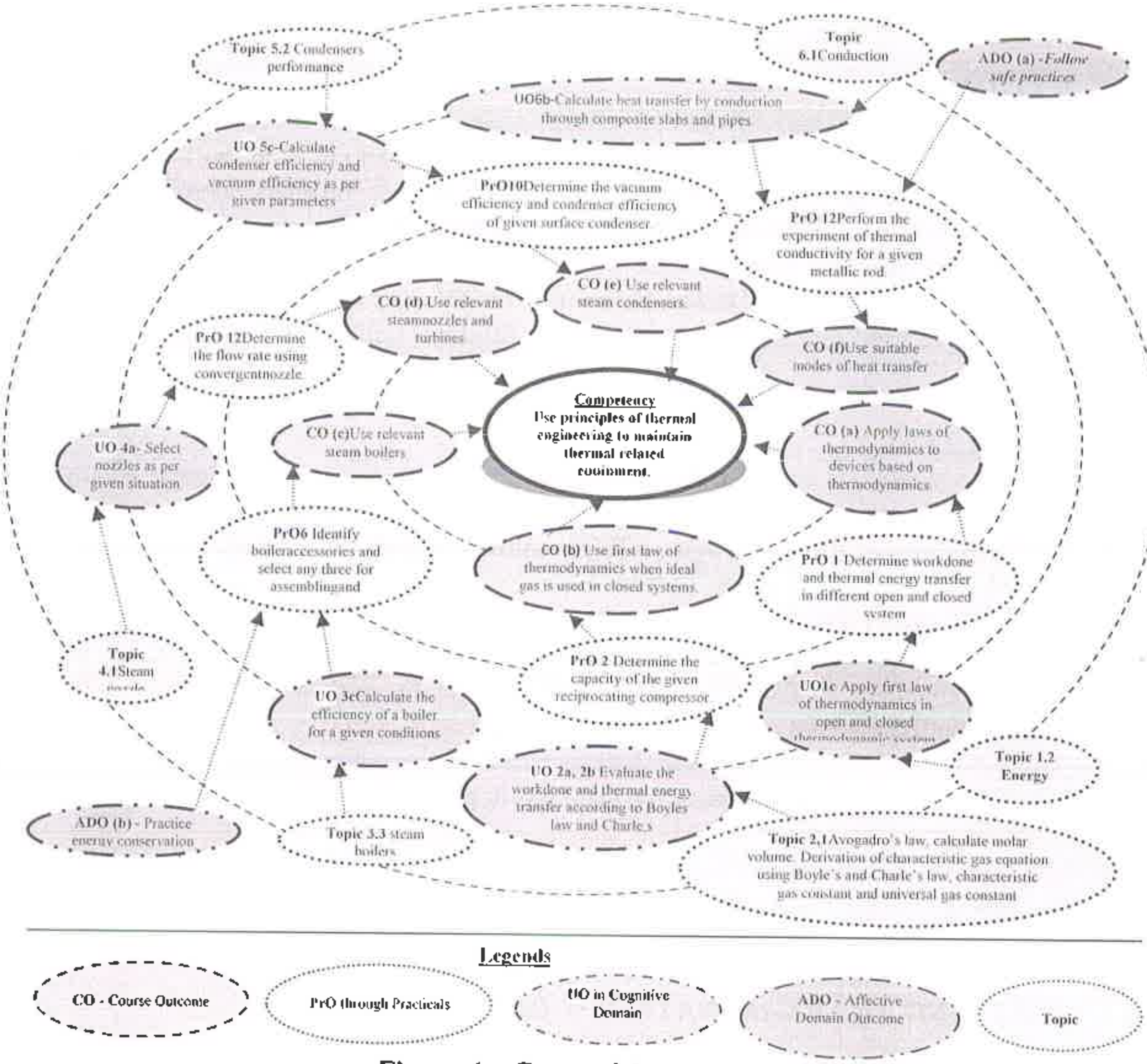


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determination of actual volume per second at the suction of reciprocating air compressor.	II	02*
2	Trace the path of Flue Gases and Water Steam circuit of the boiler.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Assembly and dismantling ofboiler mountings.	III	02
4	Assembly and dismantling ofboiler accessories.	III	02
5	Perform simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers and electrical generators.	III	02
6	Determination of dryness fraction of a given sample of steam by using separating calorimeter.	III	02*
7	Plot steam properties on Mollier chart for a given sample of wet steam.	III	02*
8	Assembly and dismantling of impulse and reaction turbines (working Model).	IV	02
9	Assembly and dismantling of cooling tower (working Model).	IV	02
10	Dismantle given model of surface condenser, draw sketches of various parts and assemble it.	V	02
11	Perform simulation software to determinethe vacuum efficiencyandcondenserefficiencyof a surface condenser using advanced simulation software.	V	02
12	Calculate the thermal conductivity of Metallic Rod.	VI	02*
13	Identify different equipment in power engineering lab having heat exchangers and classify heat exchangers. Write construction and working any 03 of above heat exchangers.	VI	02*
14	Calculate mass flow rate of one fluid using energy balance equation in heat exchanger.	VI	02*
15	Calculate convective heat transfer coefficient for the given fluid.	VI	02
16	Determine the value of Stefan-Bolzman constant for radiation.	VI	02*
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Two stage reciprocating air compressor with intercooler test rig. Maximum Pressure – 10 bar, digital watt meter.	2,3
2	Models of water tube and fire tube boilers (cut section models).	4
3	Various mountings and accessories of boilers for assembly and dismantling purpose.	5,6
4	Relevant simulation software.	4,
5	Cut section models of impulse turbine and reaction turbine.	9
6	Experimental setup with convergent and divergent nozzle.	12,13
7	Model of surface steam condenser with assembly and dismantling purpose.	14,15
8	Experimental setup of shell and tube steam condenser. (Minimum shell diameter 45cm).	14,15
9	Experimental set up for determination of thermal conductivity.	16,17, 18
10	Models of different heat exchangers.	19
11	Experimental set up to verify Stefan Boltzman law.	21
12	Experimental set up to determine convective heat transfer coefficient.	20

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of Thermodynamics	1a. Determine the properties of the given substance using thermodynamic tables. 1b. Explain the phenomena when thermodynamic principles is applied to the given condition of gas. 1c. Explain the phenomena when first law of thermodynamics in the given thermodynamic system. 1d. Determine the rate of workdone and thermal energy transfer during thermodynamic process in the given type of open system.	1.1 Basic Concepts - Concept of pure substance, types of systems , properties of systems, Extensive and Intensive properties, flow and non-flow processes, specific volume, temperature, density, pressure.Processes and cycles. 1.2 Energy - Work, Heat Transfer and Energy Thermodynamic definition of work and heat, difference between heat and work. energy –Potential Energy, kinetic Energy, internal Energy, Flow Work, concepts of enthalpy andphysical concept of entropy. 1.3 Laws of Thermodynamics- Zeroth law, first law of thermodynamics, second law of thermodynamics, Kelvin Planks, Clausius statements and their equivalence. Reversible and irreversible processes, factors making process irreversible, reversible carnot cycle for heat engine and refrigerator. 1.4 Application of Laws of Thermodynamics Steady flow energy equation and its application to boilers, engine, nozzle, turbine, compressor and condenser. Application of second law of thermodynamics to heat engine, heat pump and refrigerator.
Unit– II Ideal Gases and Ideal Gas Processes	2a. Evaluate the workdone and thermal energy transfer according to Boyles law for the given situation. 2b. Evaluate the workdone and thermal energy transfer according to Charle's law for the given situation. 2c. Calculate the mass of a gas and its final condition parameters after undergoing Polytropic process for the given situation.. 2d. Determinecharacteristic gas constant of commonly used gases for the given data. 2e. Calculatedifferent energy	**2.1** Avogadro's law, calculate molar volume. Derivation of characteristic gas equation using Boyle's and Charle's law, characteristic gas constant and universal gas constant. **2.2** Ideal gas processes –Isobaric, Isochoric, Isothermal, Isentropic, Polytropic, Throttling and their representation on P-V and T-S diagrams. Determination of work, heat, internal energy, enthalpy change and entropy change.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	changes during ideal gas processes for the given situation.	
Unit– III Steam and steam boiler	3a. Determine dryness fraction for the given steam sample. 3b. Represent different vapor processes on suitable co-ordinates in the given situation. 3c. Calculate the efficiency of given type of boiler for the given conditions. 3d. Calculate the rates of thermal energy transfer in the given type of boiler and superheater for the given conditions.	3.1 Steam fundamentals - Applications of steam, generation of steam at constant pressure with representation on various charts such as PV, T-S, H-S. Properties of steam and use of steam table, dryness fraction, degree of superheat, sensible and latent heat, boiler efficiency, Mollier chart. 3.2 Vapour processes - Constant pressure, constant volume, constant enthalpy, constant entropy process (numerical using steam table to determine dryness fraction and enthalpy), Rankine cycle. 3.3 Steam Boilers - Classification, Construction and working of - Cochran, Babcock and Wilcox, La-mont and Loeffler boiler, packaged boilers. Boiler draught. Indian Boiler Regulation (IBR) (to be covered in practical periods). 3.4 Boiler mountings and accessories. 3.5 Boiler instrumentation. 3.6 Methods of energy conservation in boilers.
Unit-IVSteam turbines	4a. Select the nozzles for the given situation. 4b. Determine thermal efficiency for the specified type of steam turbine for given conditions. 4c. Interpret thegiven types of steam cycles to estimate efficiencies in a steam power plant 4d. Compare the performance for the given steam turbine stages.	4.1 Steam nozzle - Continuity equation, types of nozzles, concept of Mach number, critical pressure and choked flow condition, application of steam nozzles. 4.2 Steam turbine - Classification of turbines, Construction and working of impulse and reaction turbine. 4.3 Compounding of turbines and its types. Regenerative feed heating, bleeding of steam, governing and its types, losses in steam turbines.
Unit –V Steam Condensers	5a. Identify the elements and processes of the given type of steam condensers. 5b. Identify the elements and processes of the given cooling towers.	5.1 Steam condensers - Dalton's law of partial pressure, function and classification of condensers, construction and working of surface condensers and jet condensers. 5.2 Condenser performance - Sources of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	5c. Calculate condenser efficiency and vacuum efficiency for the given parameters. 5d. Evaluate the thermal performance for the given data of the team condenser 5e. Interpret the thermal design of the given type of cooling tower. 5f. Select condensers for the given situation with justification 5g. Select cooling tower for the given situation with justification	air leakage and its effect, concept of condenser efficiency, vacuum efficiency (Simple numerical). 5.3 Cooling Towers-Construction and working of forced, natural and induced draught cooling tower.
Unit-VI Heat transfer and heat exchangers.	6a. Calculate heat transfer by conduction through composite slabs and pipes for the given data. 6b. Use Stefan Boltzman law of radiation in the given situation. 6c. solve thermal engineering problems with the given data using principles of energy mechanisms. 6d. Explain construction and working of a given type of heat exchangers with sketches. 6e. Select heat exchangers for the given situation with justification.	6.1 Modes of heat transfer - Conduction, convection and radiation. 6.2 Conduction - Fourier's law, thermal conductivity, conduction through cylinder, thermal resistance, composite walls,list of conducting and insulating materials. 6.3 Convection - Newton's law of cooling, natural and forced convection. 6.4 Radiation- Thermal Radiation, absorptivity, transmissivity, reflectivity, emissivity, black and gray bodies, Stefan-Boltzman law. 6.5 Heat Exchangers - Classification, construction and working of shell and tube, shell and coil, pipe in pipe type and plate type heat exchanger, automotive heat exchanger and its applications.

***Note:**To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of thermodynamics	08	02	02	04	08
II	Ideal gases and ideal gas processes	08	04	04	06	14
III	Steam and steam boilers	10	02	04	08	14
IV	Steam turbines	08	04	04	08	16
V	Steam condensers	08	02	04	04	10
VI	Heat transfer and heat exchangers	06	02	02	04	08
	Total	**48**	**16**	**20**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
<u>Note</u>*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journal of practical.
b. Prepare and present a seminar on boiler instrumentation using appropriate sources of information.
c. Prepare charts on compounding, regenerative feed heating processes.
d. Prepare charts of PV & TS charts of different ideal gas processes.
e. Prepare charts of PH, HS, TS diagrams for different steam processes.
f. Draw manually enthalpy-entropy (Mollier) chart and represent different vapor processes on the same using different color combinations.
g. Prepare a report on visit to Sugar Factory / Steam Power Plant / Dairy industry with specification of boiler and list of mountings and accessories along with their functions.
h. List insulating and conducting materials used in various applications.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare charts on fundamentals concepts of thermodynamics. E.g. First/Second law applications, heat and work transfer.
b. Investigate energy transfer in thermodynamic system.
c. Investigate combustion process and calorific values.
d. Prepare at least one model explaining ideal gas processes.
e. Prepare at least one model of boiler mountings and accessories.
f. Collect and analyze technical specifications of steam turbines, boilers from manufacturers' websites and other sources.
g. Prepare a report on steam traps used in steam piping.
h. Carry out comparative study of conventional cooling towers, cooling towers used in power plants and upcoming cooling towers. .
i. Make power point presentation including videos on heat exchangers commonly used.
j. Make models of Shell and Tube, Plate, tube in tube heat exchangers in workshop.
k. Organize a group discussion session on relative merits and demerits of different types of turbines, condensers, boilers.
l. Make a model of steam condenser and show how vacuum is created after steam condensation.
m. Undertake a 03 days training at Thermal Power Plant.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Thermal Engineering	Rathore, Mahesh M.	Tata McGraw-Hill Education, New Delhi 2010, ISBN: 9780070681132
2	Basic Thermodynamics	Nag, P. K.	McGraw-Hill Education, New Delhi
3	Thermal Engineering	Rajput, R. K.	Firewall Media, New Delhi 2005, ISBN: 978-8170088349
4	A Textbook of Thermal Engineering	Gupta, J. K.; Khurmi R. S.	S. Chand Limited, New Delhi 1997, ISBN: 9788121925730
5	A course in Thermal Engineering	Domkundwar, S; Kothandaraman, C. P;Domkundwar, A. V.	DhanpatRai and company, New Delhi, 2004, ISBN:9788177000214

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://www.sfu.ca/~mbahrami/ENSC%20388/Notes/Intro%20and%20Basic%20Concepts.pdf
b. http://web.mit.edu/16.unified/www/FALL/thermodynamics/notes/node12.html
c. https://www.youtube.com/watch?v=9GMBpZZtjXM
d. https://www.youtube.com/watch?v=3dyxjBwqF-8
e. https://www.youtube.com/watch?v=02p5AKP6W0Q
f. http://www.learnengineering.org/2013/02/working-of-steam-turbine.html
g. https://www.youtube.com/watch?v=MulWTBx3szc
h. http://nptel.ac.in/courses/103106101/Module%20-%208/Lecture%20-%202.pdf
i. https://www.youtube.com/watch?v=Jv5p7o-7Pms
j. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Heat%20and%20Mass%20Transfer/Course_home_1.html
k. http://www.rinfra.com/energy_generation.html

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Mechanical Working Drawing**

Course Code : **22341**

1. RATIONALE

A Mechanical Engineering Diploma holder, irrespective of his field of operation in an industry, is expected to possess a thorough understanding of drawing, which includes clear spatial visualization of objects and the proficiency in reading and interpreting a wide variety of production drawings. The course aims at developing the ability to visualize and draw curves of intersection and develop lateral surfaces of various solids. Knowledge of conventional representation, limits, fits and tolerances, geometrical tolerances, surface roughness representation are also included in the course which helps in reading and drawing various production drawings. In industry, the components are manufacture on the basis of their detailed drawings. Theses drawings comprise of all the information required to produce the component. The course aims to develop ability to visualize and draw assembly and detail drawings. This course envisages reinforcing and enhancing the knowledge and skill acquired in the earlier two courses viz. Engineering Graphics & Engineering Drawing.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Interpret and prepare mechanical working drawing /production drawing of a given component.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Draw development of lateral surface of various solids.
b. Draw intersection curves of different solids.
c. Use various drawing codes, conventions and symbols as per IS SP-46.
d. Draw production drawings used to produce products.
e. Draw assembly and detailed drawings of products.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	4	7	4	70	28	30*	00	100	40	50@	20	50	20	100	40

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

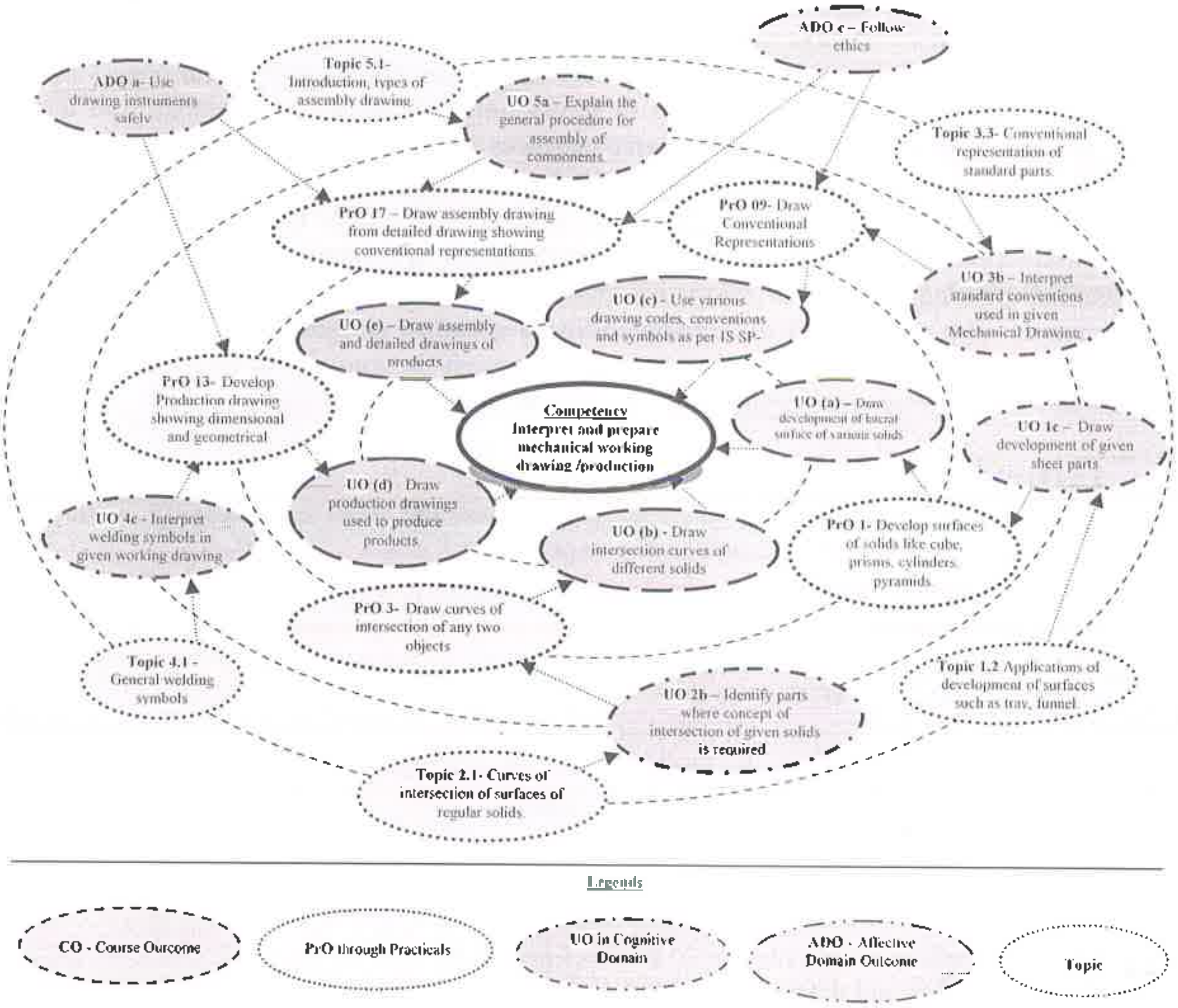


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency. Following practicals are to be attempted on A2 drawing sheets.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
Sheet No.:1			
1	Develop surfaces of solids like cube, prisms, cylinders, pyramids. (Part I)		
2	Develop surfaces of solids like pyramids, cones. (Part II)	I	02
Sheet No.:2			
3	Draw curves of intersection of any two objects like Prism with prism(Tri-angular and square), Cylinder with cylinder, Square Prism with Cylinder, Cylinder with Cone. (Part I)	II	02
4	Draw curves of intersection of any two objects like Prism with prism(Tri-angular and square), Cylinder with cylinder, Square Prism with Cylinder, Cylinder with Cone. (Part II)	II	02
5	Draw curves of intersection of any two objects like Prism with prism(Tri-angular and square), Cylinder with cylinder, Square Prism with Cylinder, Cylinder with Cone. (Part III)	II	02
6	Draw curves of intersection of any two objects like Prism with prism(Tri-angular and square), Cylinder with cylinder, Square Prism with Cylinder, Cylinder with Cone. (Part IV)	II	02
Sheet No.:3			
7	Draw various Conventional Representations as per SP – 46 (1988) (Part I)	III	02
8	Draw various Conventional Representations as per SP – 46 (1988) (Part II)	III	02
9	Draw various Conventional Representations as per SP – 46 (1988) (Part III)	III	02
Sheet No.:4			
10	Draw Dimensional and Geometrical Tolerances, welding symbols, surface roughness and Machining Symbols on given figures and tables. (Part I)	IV	02
11	Draw Dimensional and Geometrical Tolerances, welding symbols, surface roughness and Machining Symbols on given figures and tables. (Part II)	IV	02
12	Draw Dimensional and Geometrical Tolerances, welding symbols, surface roughness and Machining Symbols on given figures and tables. (Part III)	IV	02
Sheet No.:5			
13	Develop Production drawing of at least two machine components showing dimensional and geometrical tolerance, surface finish etc. (Part I)	IV	02
14	Develop Production drawing of at least two machine components showing dimensional and geometrical tolerance, surface finish etc. (Part II)	IV	02
15	Develop Production drawing of at least two machine components showing dimensional and geometrical tolerance, surface finish etc. (Part III)	IV	02
16	Develop Production drawing of at least two machine components showing dimensional and geometrical tolerance, surface finish etc.	IV	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	(Part IV)		
Sheet No.:6			
17	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part I)	V	02
18	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part II)	V	02
19	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part III)	V	02
20	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part IV)	V	02
21	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part V)	V	02
22	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part VI)	V	02
23	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part VII)	V	02
24	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part VIII)	V	02
Sheet No.:7			
25	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part I)	VI	02
26	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part II)	VI	02
27	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part III)	VI	02
28	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part IV)	VI	02
29	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part V)	VI	02
30	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part VI)	VI	02
31	Draw detailed drawings from given assembly drawing showing	VI	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part VII)		
32	Draw detailed drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part VIII)	VI	02
	Total		**64**

Note:

i. *A suggestive list of* ***PrOs*** *is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, all practicals are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1.	Interpretation of given problem	20
2.	Draw sheet using different drafting instrument	35
3.	Follow line work for neat and accurate drafting	10
4.	Dimensioning the given drawing and writing text	10
5.	Answers to sheet related questions	10
6.	Submit the assigned sheet on time	5
7.	Follow cleanliness and housekeeping in Drawing Hall	5
8.	Attendance and punctuality	5
TOTAL		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Use drawing instruments safely.
b. Practice cleanliness and neatness.
c. Follow ethics and standards.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	PrO. Unit.No.
1.	Drawing Table with Drawing Board of Full Imperial/ A1 size	All
2.	Paper Models of objects for development of Lateral surfaces of solid	01, 02
3.	Models of solids showing intersection curves	03 to 06
4.	Models of machine components for conventional representation	07 to 09
5.	Actual assemblies mentioned in unit V	13 to 32
6.	Set of various production drawings being used by industries	All
7.	Specimen library of various machine components	All
8.	Set of drawings sheets mentioned in section 6.0 could be developed by experienced teachers and made available on the MSBTE portal to be used as reference/standards	All
9.	Drawing equipment's and instruments for class room teaching-large size: a. T-square or drafter (Drafting Machine) b. Set squares (45^0 and 30^0- 60^0) c. Protractor Drawing instrument box (containing set of compasses and dividers)	All
10.	Interactive board with LCD overhead projector	All

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics is to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Development of Surfaces	1a. Draw development of lateral surfaces of the given solid. 1b. Identify parts where concept of development of the given surfaces is required. 1c. Draw development of given sheet metal/non metal parts.	1.1 Developments of Lateral surfaces of cube, prisms, cylinder, pyramids, cone. 1.2 Applications of development of surfaces such as tray, funnel.
Unit-II Intersection of Solids	2a. Identify parts where concept of intersection of the given solids is required. 2b. Draw curves of intersection of the given solid combinations.	Curves of intersection of surfaces of the regular solids in the following cases: 2.1 Prism with prism(Tri-angular and square), Cylinder with cylinder, Square Prism with Cylinder when (i) the axes are at 90° and bisecting (ii) The axes are at 90° and Offset 2.2 Cylinder with Cone: when axis of cylinder is parallel to both the reference planes and cone resting on base on HP with axis intersecting and offset from axis of cylinder.
Unit– III Conventional Rrepresentation	3a. Use IS SP-46 (1988) codes. 3b. Interpret standard conventions used in the	3.1 Conventional breaks in pipe, rod and shaft. 3.2 Conventional representation of

	given Mechanical working Drawing. 3c. Use standard conventions in practice.	common features like slotted head, radial rib, knurling, serrated shaft, splined shaft, ratchet and pinion, repeated parts, square on shafts, holes on circular pitch, internal and external thread. 3.3 Conventional representation of standard parts like ball and roller bearing, gears, springs. 3.4 Pipe joints and valves. 3.5 Counter sunk and Counter bored holes. 3.6 Tapers (As per standard conventions using IS SP – 46 (1988)
Unit– IV Production Drawings	4a. Calculate tolerances on the given machine components. 4b. Identify fit required between mating parts of machine components based on the given tolerance values. 4c. Interpret welding symbols in the given working drawing. 4d. Interpret surface roughness characteristics from the values the given on component drawing. 4e. Draw above conventional representations for the given situation.	4.1 Limits, Fits and Tolerances: a) Definitions, introductions to ISO system of Tolerance. b) Dimensional tolerances:-Terminology, selection and representation of dimensional tolerance- number and grade method. Definitions concerning Tolerancing and Limits system, unilateral and bilateral tolerance, Hole and shaft base systems, Types of fits- Clearance, transition and Interference, Selection of fit for engineering applications. Calculation of limit sizes and identification of type of fit from the given sizes like Ø50 H7/s6, Ø30 H7/d9 etc. 4.2 Geometrical Tolerances: Types of geometrical tolerances, terminology for deviation, representation of geometrical tolerance on drawing. 4.3 General welding symbols, length and size of weld, surface contour and finish of weld, all round and site weld, symbolic representation in Engineering practices and its interpretation. 4.4 Machining symbol and surface texture: Indication of machining symbol showing direction of lay, sampling length, roughness grades, machining allowances, manufacturing methods. Representation of surface roughness on drawing.

Unit– V Details to Assembly	5a. Explain the general procedure for assembly of components. 5b. State details of components and the sequence of components of the given assembly. 5c. Draw assembly drawing from the given detailed drawing.	5.1 Introduction, types of assembly drawing, accepted norms to be observed for assembly drawings. sequence for preparing assembly drawing. Bill of Material. 5.2 Couplings: Oldham & Universal couplings. 5.3 Bearing: Roller, Foot Step & Pedestal Bearing. 5.4 Lathe: Single(pillar type) and Square tool Post. 5.5 Bench vice & Pipe Vice. 5.6 Screw Jack. 5.7 Valve: Steam stop, Non return valve. 5.8 Piston and connecting rod of IC engine. 5.9 Lathe machine: tail stock 5.10 Drill Jig 5.11 Any other assembly consisting of 6 - 10 parts.
Unit– VI Assembly to Details	6a. Identify various components in the given assembly and the sequence of dismantling it. 6b. Describe the procedure for dismantling the assembly into components. 6c. Draw detailed drawing from the given assembly drawing.	6.1 Basic principles of process of dismantling the assembly into components. 6.2 Details of all assemblies mentioned in unit V.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Development of surfaces.	08	-	-	08	08
II	Intersection of solids	12	-	-	14	14
III	Conventional representation.	04	06	-	-	06
IV	Production drawing	08	02	08	-	10
V	Details to Assembly	16	-	04	12	16
VI	Assembly to Details	16	-	04	12	16
Total		**64**	**08**	**16**	**46**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual*

distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Student should maintain a separate A3 size sketch book which will be the part of term work and submit it along with drawing sheets. Following assignment should be drawn in the sketch book
   i. Minimum 5 problems each on Unit No I and II.
   ii. Minimum 2 problems each on Unit No III to VI.
   Note- Problems on sheet and in the sketch book should be different.
b. Students should collect Production drawings from nearby workshops/industries and try to visualize the part from the given views.
c. Prepare paper models of development of lateral surfaces of solids
d. Visit any sheet metal workshop and prepare a report related to type of components, dimensions, material, area of application, raw material required, name of operations performed.
e. Prepare clay/ paper models of solids showing curves of intersection

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in section No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students during practice.
i. Arrange visit to nearby industries and workshops for understanding various production drawings.
j. Show video, animation films, solid modeling software to explain intersection of solid, Assembly and details
k. Prepare wall charts for Dimensional and Geometrical Tolerances.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. Visit nearby fabrication workshop and prepare report on various types of welding symbols used for fabrication work.
b. Visit nearby process industries like sugar factory, chemical industries etc and prepare report representing conventional representation of various piping joints.
c. Visit Institute's Power engineering Lab and prepare detailed drawings of Various IC Engine components using proper measuring instruments.
d. Visit Institute's workshop and prepare assembly drawing and working drawing of machine vice/ lathe tailstock/ tool post etc.
e. Any other micro-projects suggested by subject faculty on similar line.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Machine Drawing	Bhatt N.D., Panchal V.M.	Charotar Publishing house Pvt. Ltd., Anand, Gujarat, 2013, ISBN 9789380358635
2	Engineering Drawing practice for schools and colleges IS : SP- 46	Bureau of Indian standard	BIS Delhi, Third reprint, October 1998 ISBN 8170610912
3	Production Drawing	Narayanan L.K., Kannaich P., VenkatReddy K.	New Age International Publication, New Delhi, 2009 ISBN: 9788122435016
4	Engineering Drawing	Bhatt N.D.	Charotar Publishing house Pvt. Ltd. Anand, Gujarat, ISBN:9789380358178
5	A text book of Machine Drawing	Gill P.S.	S.K.Kataria and Sons, New Delhi,2007, ISBN: 9789350144169
6	Machine Drawing	Sidheshwar	McGraw Hill, New Delhi, 2009 ISBN : 9780074603376

14. SOFTWARE/LEARNING WEBSITES

a. sketch up 7 software for solid modelling
b. http://www.weldingtechnology.org
c. http://www.newagepublishers.com
d. Engineering graphics and Drawing v 1.0 from cognifront
e. http://www.youtube.com/watch?v=o1YPja2wCYQ
f. http://www.youtube.com/watch?v=9AGD4tihjCg&feature=plcp
g. http://www.youtube.com/watch?v=n65[illegible]
h. http://www.youtube.com/watch?v=tyBVsSsNiUQ

i. http://www.youtube.com/watch?v=_M5eYB6056M
j. http://www.youtube.com/watch?v=UyROI-bAMu4
k. http://www.youtube.com/watch?v=eix8xbqb93s
l. http://www.youtube.com/watch?v=kWOl6ttDTBc
m. http://www.youtube.com/watch?v=gJbrO2jtoa8&feature=related
n. http://www.youtube.com/watch?v=PXgkBadGHEE
o. Engineering Graphics & Drawing v 1.0 from Cognifront
p. http http://npkauto.com/assignments

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Engineering Metrology**

Course Code : **22342**

1. RATIONALE

Measurement activities are given prime importance in industry. The diploma technicians often come across measuring different parameters of machined components and the appropriate fitment of interchangeable components in the assemblies. The student has to identify the variables to be measured, decide the accuracy required, select the instrument, investigate reasons for defects and give suggestions, decide whether to accept or reject the jobs, suggest methods of salvaging the defective material manufactured. The different methods and instruments which can be used for linear and angular measurements, geometrical parameters (like surface finish, Squareness, Parallelism, Roundness etc) and the use of gauges and system of limits, fits, tolerances etc. are often required to be dealt in detail by a diploma engineer on the shop floor. Therefore, this course attempts to impart the necessary knowledge and develop the required abilities so that he can perform his job efficiently and effectively in modern industry.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use relevant instruments to measure various parameters of machine components.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Select the relevant instrument for measurement.
b. Use different types of comparators.
c. Select gauges, fits and tolerances for machine components.
d. Use relevant instruments to measure different parameters of screw thread and gear.
e. Use linear and angular measuring instruments.
f. Select relevant surface testing methods.

4 TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

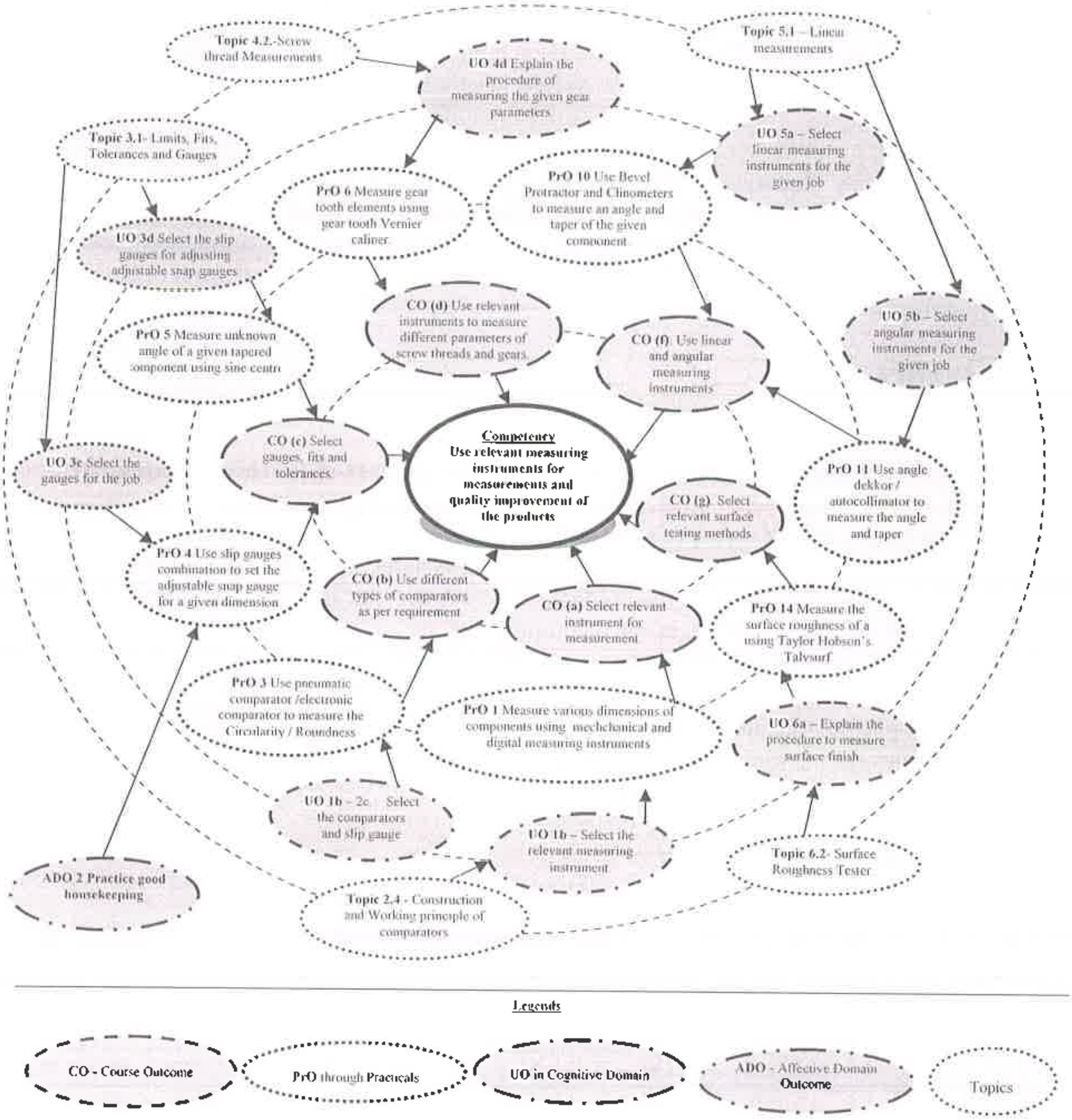


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Measure various dimensions of a given components using radius gauge, Vernier caliper, Vernier height gauge, micrometer (use both mechanical and digital).	I	02
2	Measure bores of a give sample using internal micrometers and dial bore indicators.	II	02*
3	Use pneumatic comparator /electronic comparator to Measure the Circularity / Roundness of the given specimen and compare it with the given standard	II	02
4	Use slip gauges combination to set the adjustable snap gauge Go end and No-Go end for a given dimension.	III	02*
5	Measure gear tooth elements using gear tooth Vernier caliper.	IV	02
6	Measure the effective diameter of the screw thread using profile projector / Tool maker Microscope.	IV	02*
7	Use floating carriage micrometer to measure minor, major and effective diameter of screw thread.	IV	02*
8	Measure unknown angle of a given tapered component using sine centre in combination with slip gauges.	V	02
9	Use Bevel Protractor and Clinometers to measure an angle and taper of the given component.	V	02*
10	Use angle dekkor / autocollimator to measure the angle and taper of given component.	V	02*
11	Measure flatness of the given component by interpreting fringes using monochromatic light source and optical flat.	VI	02
12	Measure flatness of a given surface plate using spirit level.	VI	02*
13	Measure the surface roughness of a given sample using Taylor Hobson's Talysurf / surface roughness tester.	VI	02*
14	Use dial indicator to check the Lathe machine parameters like parallelism, squareness, trueness, alignment.	VI	02
15	Measure run out of cylindrical component using dial indicator.	VI	02
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1.	Prepare experimental set up	10

S. No.	Performance Indicators	Weightage in %
2.	Handling of measuring instruments precisely during performing practical.	30
3.	Follow Safety measures	10
4.	Accuracy in Measurement	20
5.	Answers to questions related with performed practices.	10
6.	Submit journal report on time	10
7.	Follow Housekeeping	5
8.	Attendance and punctuality	5
	TOTAL	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. Follow ethical practices

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	PrO S.No.
1	Vernier Calliper-0-200mm (Mannual)	1
2	Digital Vernier Caliper- 0-200mm	1
3	Radius gauge (0.01mm to 14mm)	1
4	Screw pitch gauge – mm and TPI	1
5	Filler gauge (0.01 to 1.9mm)	1
6	Micrometer-0-25mm, 25-50mm.	1
7	Dial Micrometer (0- 25mm),(25-50mm)	1
8	Surface Plate-Granite. (200 x200x 50)	1
9	Vernier Height and Depth Gauge (mechanical and digital) 0-300mm	1
10	Micrometer Depth Gauge. (0-150mm)	1
11	Sine Bar, Sine Centre (0-200mm)	7
12	Slip Gauge set- Grade 1, 87 Pieces	2,7
13	Angle gauges box. Grade I	7

S. No.	Equipment Name with Broad Specifications	PrO S.No.
14	Universal bevel protractor:Graduation: 5min.(0°- 90°- 0°) Blade 150, 300 mm.	8
15	Angle dekkor and Autocollimator (0 to 30')	9
16	Profile projector with gear profile/Thread profile Templates: Opaque fine grained ground glasss screen with 90°, 60°, 30° cross line Location; fitted with graduated ring (0-360°) L.C. 1min; Optics Std10X, 20X, Measuring Range Std 100mm x 100mm; Opt X axis upto 400mm, Y axis upto 200mm; Focusing Travel 100mm; Magnification Accuracy Contour ±0.05% Surface ±0.05%; Illumination Countor 24V/150W halogen lamp with illumination control; Resolution 0.005/0.001/0.0005 mm.	5
17	Screw pitch gauge. (0-25mm)	4
18	Floating Carriage Micrometer: Least count: 0.001 mm; Standard micrometer or electronic type; Non rotary 8mm micrometer spindle; Indicator with 0.001mm std dial; Admit between center 200 mm; Max Diameter capacity 100mm; Standard Accuracy + or – 0.005mm;	6
19	Monochromatic light source unit – 1 unit Light Source: 35W Sodium Wavelength: 0.575 micron; Power 220V/50HZ (110V available on request)	10
20	Optical flat set Range (0.2μm) Diameter/thickness 45/12mm and 60/15mm.	10
21	Gauges-plug (3piece) Grade A/X	2,3,6
22	Snap gauge- adjustable/ double ended (3piece) Grade A/X	3
23	Steel Ring gauges: Grade A/X, 1.5-2.00, 2.0-4.0, 4.0-12.0, 12.0-20.0 mm	2,3
24	Dial Indicator(0-25mm) with magnetic stand	12
25	Clinometer: Base length: 200 mm / 1000 mm • Measuring range: ± 17.5 mm/m (± 1°) • Sensitivity per Digit: ± 0.001 mm/m • Accuracy: < ± 0.2% (full scale) • Linearity: < ± 0.2% (full scale) • Operating temperature: – 10° to + 40°C	8
26	Gear tooth vernier caliper (0-25mm)	4
27	Spirit Level: Base length : 200 mm + 1 mm; Base width : 20 mm + 0 – 1; Height : 25 + 1 mm; Bubble opening : 50 mm x 8 mm (length x width); Sensitivity : 2 Min. 30 Sec per 2 mm arc division of the vial; Least count of graduation : 2 mm; Effective length of bubble : 20 + 1 mm	12
28	Tool maker's microscope: Dimensions 152 x 152mm; Stage glass size 96 x 96mm; Feeding range 50 x 50 mm; Maximum height 115mm x 107mm; Workpiece 5Kg; Light source :24V, 2W (special bulb); Continuously adjustable light intensity; Green filter.	5
29	Parkinson's Tester/ Gear Rolling Tester with master gears: Accuracy 0.25mm, Gear diameter of 40-80mm, Base size 320 x 100mm, Prject magnification 5x, Involute profile testing.	4
30	Roundness measuring machine (0-1000mm)	13
31	Pneumatic comparator – Air gauge unit with compressor; Generated pressure range: (-0.95~60)bar; media: Air; Adjust resolution:0.1mbar(10Pa); Buna-N for seals; Output interface connection:M20×1.5Female.	2
32	Electronic Comparator: Work Base : high chrome high carbon, hardened, ground & lapped; A precision electronic probe is provided with the unit with a measuring range of + / - 2.0 m.m; Counter : A single line display counter unit resolution 0.0001 m.m, 0.001 m.m.	2
33	Surface roughness Taylor Hobson's Tester (max. sample length 0.8mm)	11

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to Metrology	1a.Explain the testing parameters used for the given instrument. 1b.Select the relevant measuring instrument for the given job with justification. 1c.Select the various measuring standards as per situation with justification. 1d.Calculate the least count of all basic measuring instruments.	**Metrology Basics** 1.1 Definition of metrology, objectives of metrology. 1.2 Categories of metrology, Scientific metrology, Industrial metrology, Legal metrology. 1.3 Need of inspection, Precision, Accuracy ,Sensitivity, Readability, Calibration, Traceability, Reproducibility. 1.4 Sources of errors, Factors affecting accuracy. 1.5 Selection of instrument, Precautions while using an instruments for getting higher precision and accuracy. 1.6 Concept of least count of measuring Instrument.
Unit– II Standards and Comparators	2a. Select the various measuring standards for given situation with justification. 2b. Explain the construction and working principle of the given comparator. 2c. Select the comparators and slip gauge for the given job.	2.1 Definition and introduction to line Standard, end standard, Wavelength standard and their comparison. 2.2 Slip gauge and its accessories. 2.3 Definition and Requirement of good comparator, Classification, use of comparators. 2.4 Construction and Working principle of comparators- Dial indicator, Sigma Comparator, Pneumatic comparator- high pressure differential type. 2.5 Relative advantages and disadvantages.
Unit– III Limits, Fits, Tolerances and Gauges	3a. Apply limits, fits and tolerances on the given job. 3b. Select grades, fits and tolerances from tolerance chart for the given sample. 3c. Select the gauges for the given job with justification. 3d. Select the slip gauges for adjusting adjustable snap gauges with	3.1 Concept of Limits and Fits, deviation and Tolerances. 3.2 Basic Terminology, Selective Assembly, Interchangeability. 3.3 Indian standard (IS 919-1993) Fits, types of fits,Hole and Shaft Basis System, guide for selection of fit. 3.4 ISO system of limit and fit,(Numerical on finding the limit and tolerances of hole andshaft assembly). 3.5 Gauges: Limit gauges. Taylors principle of gauge design Plug, Ring Gauges, snap gauge, adjustable snap gauge.

	justification.	
Unit– IV Screw thread Measurements and Gear Measurement	4a. Calculate screw thread Parameters using the given method. 4b. Identify different elements of the given screw thread. 4c. Explain different types of errors in thread and pitch of the given screw thread. 4d. Explain the procedure of measuring the given gear parameters.	4.1 Screw thread terminology, Errors in threads and Pitch 4.2 Measurement of different elements such as major diameter, minor diameter, effective diameter, pitch diameter , Best size of wire Two wire method, Thread gauge micrometer. 4.3 working principle of floating carriage micrometer. 4.4 Introduction to Tool Maker's Microscope, applications and working principle. **Gear Measurement** 4.5 Analytical and functional inspection of Gear, Measurement of tooth thickness by constant chord method and base tangent Method by Gear Rolling tester / Parkinson's Gear Tester. 4.6 Measurement of tooth thickness by Gear tooth Vernier and Profile projector Errors in gears such as backlash, run out.
Unit– V Linear and Angular Measurement	5a. Select linear measuring instruments for the given job with justification. 5b. Select angular measuring instruments for the given job with justification. 5c. Explain the concept of angular measurement with the help of given sample. 5d. Explain the procedure of measuring angles using different instruments for the given job.	5.1 Concept of linear measurement and its instruments: surface plate, V-block, calipers, combination set, depth gauge, vernier instruments, micrometer instruments, slip gauges. 5.2 Concept of angular measurement. 5.3 Instruments for angular Measurements. 5.4 Use and working of universal bevel protractor, sine bar, spirit level. 5.5 Principle of Working of Clinometers, Angle Gauges (With Numerical on Setting of Angle Gauges), Angle dekkor as an angular comparator.
Unit–VI Other Measurements	6a. Explain the procedure to measure surface finish of the given components. 6b. Select machine tool test and alignment test for the given job with justification.	61 Primary and secondary texture, terminology of surface texture as per IS 3073-1967, CLA, Ra, RMS, Rz values and their interpretation, Symbol for designating surface finish on drawing. 62 Various techniques of qualitative analysis, working principle of stylus probe type instruments, Surface

	6c. Measure the surface finish of the given components. 6d. Explain the procedure for measuring complex dimensions of the given job using CMM.	Roughness Tester, Interferometry. 63 Parallelism, Straightness, Squareness, roundness, run out, alignment tests of Lathe and Drilling, machine tools as per IS standard. 64 Flatness testing using Monochromatic light source with optical flat, Introduction to CMM.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Metrology	06	02	04	04	10
II	Standards and Comparators	10	02	04	04	10
III	Limits, Fits ,Tolerances and Gauges	08	02	04	06	12
IV	Screw thread Measurements and Gear Measurement	08	02	04	06	12
V	Linear and Angular Measurement	08	04	04	04	12
VI	Other Measurements	08	04	04	06	14
	Total	**48**	16	24	30	70

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews

a. Prepare journal based on practical performed in Metrology laboratory .Journal consist of drawing, observations , required measuring tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
   i. Measuring Tools and equipment in Metrology laboratory.
   ii. Machineries in Metrology laboratory
c. Undertake a market survey of local dealers for Measuring equipments and prepare a report.
d. Visit to any Tool room and prepare a report consisting
   i. Different advanced Measuring Instruments
   ii. Different Measuring standards and Calibration process
   iii. Care and maintenance of measuring instruments observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
b. 'L' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About 15-20% of the topics/sub-topics which is relatively simpler or descriptive in nature is to be given to the students for self-directed learning and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for co-curricular activities.
e. Guide student(s) in undertaking micro-projects.
f. Arrange visit to nearby industries for understanding various Measuring processes.
g. Show video/animation films to explain functioning of various measuring Instruments.
h. Give Micro projects.
i. Use different instructional strategies in classroom teaching.
j. In respect of item no.10 above the teachers need to ensure to create opportunities and pursue for such co-curricular activities.

12. SUGGESTED TITLES OF MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Comparative study of various linear measuring Instruments Like Steel Rule, Inside – outside Calliper, Inside-outside Vernier caliper, Inside-outside Micrometer, Digital Vernier caliper, Digital Micrometer (any one) with proper justifications.
b. Comparative Study of surface finish of Various Samples manufactured by various manufacturing processes (min.5) using surface roughness instruments with proper justification
c. Collect information of Coordinate Measuring Machine and prepare a report.
d. Comparative study of different parameters of Spur gear (Min. 5) having same module using appropriate instruments.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Metrology	R K Jain	Khanna Publication, New Delhi, 2014, ISBN-10: 817409153X
2.	Metrology and Measurement	A K Bewoor and V A Kulkarni	McGraw Hill Education (India) Pvt. Ltd. , New Delhi, 2017, ISBN13-9780070140004
3.	Engineering Metrology and Measurement	S B Raghvendra and Krishnamurthy	Oxford Publication, New Delhi, 2013, ISBN-13: 978-0198085492
4.	Measurement and Metrology	R K Rajput	S.K. Kataria and Sons, New Delhi, 2013, ISBN-13: 978-9350142301
5	Engineering Metrology for Engineers	J. F. W. Galyer and C.R. Shotbolt	Prentice Hall Publication, New Delhi, 2007, ISBN-10: 8179928486

14. SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112106138
b. https://cosmolearning.org/video-lectures/pyrometry-cont
c. Tangram Software for CMM
d. Dong-Do software for Electronic comparator
e. https://www.youtube.com/watch?v=VpmZjIsV4C4
f. www.youtube.com/watch?v=qNlIZYAk9pI
g. https://www.youtube.com/watch?v=xcvNl1HHY9o
h. https://www.youtube.com/watch?v=DxdFiIDrFBc
i. https://www.youtube.com/watch?v=-_ZeUgVjajc
j. https://www.youtube.com/watch?v=iTjBPHtADA4
k. https://www.youtube.com/watch?v=I4h644S_64w
l. https://www.youtube.com/watch?v=XQT6RSNN9sA
m. https://www.youtube.com/watch?v=FgNAIKTTNtE
n. https://www.youtube.com/watch?v=sLZeR7RMGFA
o. https://www.youtube.com/watch?v=QGBRwXwxnuU
p. https://www.youtube.com/watch?v=jTbRMMgbnNU
q. https://www.youtube.com/watch?v=KeZ5CfPOIBc
r. https://www.youtube.com/watch?v=3hOVfbGSQ0c
s. https://www.youtube.com/watch?v=80sNyYPTXPA
t. https://www.youtube.com/watch?v=EWqThb9Z1jk
u. https://www.youtube.com/watch?v=j-u3IEgcTiQ
v. https://www.youtube.com/watch?v=CLEP5LQ-y0I

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Mechanical Engineering Materials**

Course Code : **22343**

1. RATIONALE

With the advances made in the field of material science millions of materials are now available to cater various need of mankind. These needs and service conditions dictate the properties to be developed in the materials therefore the subject mechanical engineering materials has attracted lot of attention. Materials like ferrous and non ferrous metals, polymer, ceramics and composites are widely used in verity of engineering applications. This course deals with these materials along with advance materials, their metallurgical considerations, heat treatment processes, structure property relationship and applications. This course will enable diploma engineering students to identify variety of material and their selection for various applications.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use relevant mechanical engineering materials in different applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify properties of materials.
b. Select relevant ferrous materials for mechanical components.
c. Select relevant cast iron for the engineering application.
d. Use non-ferrous metals for mechanical components.
e. Suggest relevant advanced materials for mechanical components.
f. Select relevant heat treatment process.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70*#^	28	30*	00	100	40	25@	10	25	10	50	20

(#):Online Exam; (*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.*

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

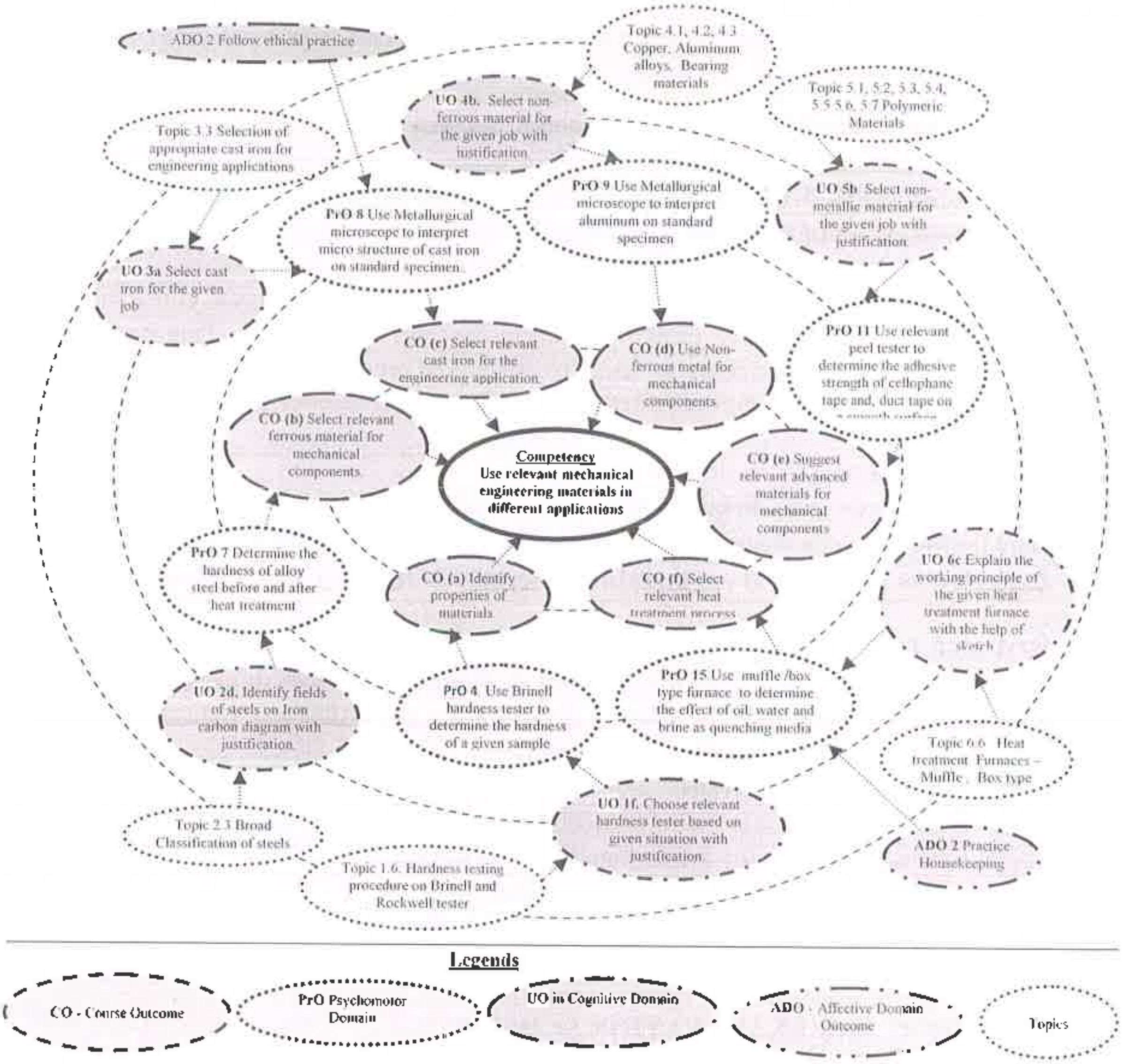


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Prepare specimen of a given material for microscopic examination.	I	2*
2	Use metallurgical microscope to interpret micro structure of steels and alloy steels on standard specimen.	I	2
3	Use Brinell hardness tester to determine the hardness of a given	I	2*

S. No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	sample.		
4	Use Rockwell Hardness tester to determine the hardness of given sample.	I	2*
5	Use relevant hardness tester to determine the hardness of mild steel before and after heat treatment.	II	2
6	Use relevant hardness tester to determine the hardness of alloy steel before and after heat treatment.	II	2*
7	Use Metallurgical microscope to interpret micro structure of cast iron on standard specimen.	III	2*
8	Use Metallurgical microscope to interpret aluminum on standard specimen.	IV	2
9	Use relevant hardness tester to determine the hardness of copper.	IV	2*
10	Use relevant peel tester to determine the adhesive strength of cellophane tape and, duct tape on a smooth surface.	V	2*
11	Perform flame test to identify different types of plastics.	V	2
12	Use High-temperature oven or electrical current to Identify behavior of the shape-memory alloy as a function with regards to temperature.	V	2*
13	Use relevant peel tester to determine the adhesive strength of scotch tape, electrical tape and masking tape on a smooth surface.	V	2
14	Use muffle /box type furnace to compare • the effect of ***oil*** as quenching media on the hardness of mild steel • the effect of ***water*** as quenching media on the hardness of mild steel • the effect of ***Brine*** as quenching media on the hardness of mild steel	VI	4*
	Total		**30**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1.	Preparation of experimental set up	10
2.	Prepare sample using different operations	30
3.	Check the microstructure and hardness of the sample	30
4.	Follow Safety measures	10
5.	Observations and Recording	5
6.	Interpretation of result and Conclusion	5
7.	Answer to sample questions	5
8.	Submission of report in time	5

S. No.	Performance Indicators	Weightage in %
	Total	100

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Metallurgical Reflected light Microscope 6V, 30W halogen Light,200x magnification,191x126x100 mm specimen stage .Size With 100 mm travel	1,2,3,4,
2	Slitting Machine- Slitting width- standard 300 mm or extensible. Slitting blade, Slitting each width at least 15 mm	2,3,4,
3	Polishing Machine Grinding/polishing disc diameter: 200mm. Rotation speed: 0-600 rpm	2,3,4
4	Digital Rockwell hardness tester- Easy-to-use Electronics Console Hi/Lo Tolerance Settings, Adjustable Time @ Load Average Test Group Results 2-9; Test Result Memory Capacity 5000 results, RS232 Output,-Average Range.	5,6,7
5	Digital Brinell Hardness Machine- Hardness range HBW<125	5,6,7
6	Laboratory box furnaces 1200°c	11,12,14
7	Peel Tester	10,13

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of Engineering Materials	1a. Interpret crystal structure of the given material. 1b. Interpret the structure of specified materials at the given level. 1c. Identify microstructure of the given material with justification. 1d. Explain with sketches the procedure to prepare given sample. 1e. Explain with sketches procedure of hardness testing for the given tester. 1f. Choose relevant hardness tester based on the given situation with justification.	1.1 Classification of engineering materials, 1.2 Crystal structure, Unit cell and space lattice 1.3 Microstructure, types of microscopes 1.4 Sample preparation, etching process, types of etchant. 1.5 Properties of metals Physical Properties, Mechanical Properties. 1.6 Hardness testing procedure on Brinell and Rockwell tester
Unit – II Steel and its Alloys	2a. Interpret the given equilibrium diagram. 2b. Use the Iron –carbon equilibrium diagram for the given application. 2c. Identify the given phase diagrams and reactions with justification. 2d. Identify the given fields of steels on Iron carbon diagram with justification. 2e. Select relevant steel for the given application with justification.	2.1 Concept of phase, pure metal, alloy and solid solutions. 2.2 Iron Carbon Equilibrium diagram various phases i. Critical temperatures and significance ii. Reactions on Iron carbon equilibrium diagram 2.3 Broad Classification of steels, i. Plain carbon steels: Definition, Types and Properties, Compositions and applications of low, medium and high carbon steels. ii. Alloy Steels: Definition and Effects of alloying elements on properties of alloy steels. iii. Tool steels: Cold work tool steels, Hot work tool steels, High speed steels(HSS) iv. Stainless Steels: Types and Applications v. Spring Steels: Composition and Applications vi. Specifications of steels and their equivalents 2.4 Steels for following: Shafts, axles, Nuts, bolts, Levers, crank shafts, camshafts, Shear blades, agricultural equipments, house hold utensils, machine tool beds, car bodies, Antifriction bearings and gears.
Unit- III	3a. Select the relevant cast	3.1 Types of cast irons as white, gray,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Cast Iron	iron for the given job with justification. 3b. Interpret the given material designations. 3c. Identify the properties of the given composition of cast iron with justification.	nodular, malleable 3.2 Specifications of cast Iron. 3.3 Selection of appropriate cast iron for engineering applications. 3.4 Designation and coding (as per BIS, ASME, EN, DIN, JIS) of cast iron, plain and alloy steel.
Unit– IV Non-ferrous Metals and alloys	4a. Describe the properties and applications of the given copper alloy. 4b. Describe the properties and applications of the given aluminium alloy. 4c. Describe the properties and applications of the given bearing material 4d. Select relevant non-ferrous material for the specified application with justification.	4.1 Copper and its alloys - brasses, bronzes Chemical compositions, properties and Applications. 4.2 Aluminium alloys –Y-alloy, Hindalium, duralium with their composition and Applications. 4.3 Bearing materials like white metals (Sn based), aluminium bronzes. Porous, Self lubricating bearings.
Unit– V Non-metallic and Advanced Materials	5a. Distinguish between metallic and nonmetallic materials on the basis of given composition, properties and applications. 5b. Select relevant non-metallic material for the given job with justification. 5c. Select relevant composite material for the given job with justification. 5d. Suggest relevant alternative materials for the given job with justification.	5.1 Polymeric Materials i. Polymers- types, characteristics, ii. Properties and uses of Thermoplastics, Thermosetting Plastics and Rubbers. 5.2 Thermoplastic and Thermosetting Plastic materials 5.3 Characteristics and uses of ABS, Acrylics. Nylons and Vinyls,Epoxides, Melamines and Bakelites 5.4 Rubbers: Neoprene, Butadiene, Buna and Silicons – Properties and applications. 5.5 Ceramics –types of ceramics, properties and applications of glasses and refractories 5.6 Composite Materials - properties and applications of Laminated and Fibre reinforced materials 5.7 Advanced Engineering Materials - Properties and applications of Nano materials and smart materials.
Unit– VI Heat Treatment processes	6a. Describe with sketches the specified heat treatment processes. 6b. Select the relevant heat treatment process for the	6.1 Annealing: Purposes of annealing, Annealing temperature range, Types and applications 6.2 Normalizing: Purposes of Normalizing, Temperature range, Broad applications of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given material with justification. 6c. Explain with sketches the working principle of the given heat treatment furnace. 6d. Suggest the relevant heat treatment process for the given situation with justification.	Normalizing 6.3 Hardening: Purposes of hardening, Hardening temperature range ,application 6.4 Tempering: Purpose of tempering, Types of tempering and its applications 6.5 Case hardening methods like Carburizing, Nitriding, and Cyaniding. 6.6 Heat treatment Furnaces – Muffle , Box type

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Engineering Materials	06	02	04	04	10
II	Steel and its alloys	10	04	04	06	14
III	Cast Iron	08	02	04	04	10
IV	Non ferrous Metal and Alloys	08	02	04	02	10
V	Non Metallic and advanced Material	08	04	04	04	12
VI	Heat Treatment processes	08	04	06	04	14
	Total	**48**	**18**	**26**	**26**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews

a. Prepare journal based on practical performed in Material Testing laboratory .Journal consist of drawing, observations , required materials, tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
   i. Tools and equipment in material testing laboratory.
   ii. Machineries in material testing laboratory
a. Undertake a market survey of local dealers for tools, equipments; machineries and raw material prepare a report.
b. Visit any Industrial heat treatment shop and prepare a report consisting

i. Types of heat treatment process
ii. Types of furnaces
iii. Types of quenching mediums used
iv. Types of Testing equipments
v. Safety precautions observed.

c. Guide student(s) in undertaking micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Arrange visit to nearby industries for understanding various Heat treatment processes.
g. Show video/animation films to explain functioning of various hardness testing and heat treatment processes.
h. Draw Iron Carbon charts.
i. Use different instructional strategies in classroom teaching.

12. SUGGESTED TITLES OF MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Comparative study**: Comparative study of various materials used in previous and current generation components of mechanical engineering equipments like IC Engine, Compressor, turbine, pumps, refrigerator, water cooler, Lathe Machine, Milling Machine, Drilling Machine grinding machine (any one) with proper justifications.
b. **Experimentation:** Determine the hardness of different metallic components (min.5) and compare hardness and plot a bar chart indicating hardest and soft material in the given group

c. **Experimentation:** Determine the microstructure of different metallic components (min.5) using metallurgical Microscope and compare their microstructure in the given group
d. **Collection:** Collect sample of various types of plastics, ceramics, composites used in day to day applications and prepare chart containing properties, applications of the samples.
e. Collect information related to Types, Properties and applications of smart materials from websites. Present the information in the form of Chart.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Material	Sharma, C. P.	PHI Learning, New Delhi 2015 ISBN 978-81-203-2448-0
2.	Engineering Materials	Agrawal, B. K.	McGraw Hill Education, New Delhi ISBN 978-00-745-1505-1
3.	Material Science and metallurgy	Kotgire, V. D.	Everest publishing House, New Delhi 2015; ISBN 81 86314 008
4.	Material Science and metallurgy	Khanna, O. P.	Dhanpat Rai and sons, New Delhi 2015; ISBN- 978-81-899-2831-5
5	Material Science for Polytechnic	Rajput, R. K.	S K Katariya and sons; New Delhi 2015; ISBN- 81-85749-10-8

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://vimeo.com/32224002
b. http://www.substech.com/dokuwiki/doku.php?id=iron-carbon_phase_diagram
c. http://www-g.eng.cam.ac.uk/mmg/teaching/typd/
d. http://www.ironcarbondiagram.com/
e. http://www.youtube.com/watch?v=fHt0bOfj3T0andfeature=related
f. http://www.youtube.com/watch?v=cN5YH0iEvTo
g. http://www.youtube.com/watch?v=m9l1tVXyFp8
h. http://www.studyvilla.com/electrochem.aspx
i. http://www.sakshat.ac.in/

Maharashtra State Board of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechnical Engineering

Program Code : ME — **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters — **Duration : 16 Weeks**

Semester : Fourth — **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme													Grand Total
								Theory							Practical						
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total		
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Theory of Machines	TOM	22438	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
2	Mechanical Engineering Measurements	MEM	22443	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Fluid Mechanics and Machinery	FMM	22445	4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Manufacturing Processes	MPR	22446	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
5	Environmental Studies	EST	22447	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
7	Computer Aided Drafting	CAD	22042	-	-	4	4	--	--	--	--	--	--	--	25#	10	25~	10	50	20	50
8	Fundamentals of Mechatronics	FOM	22048	2	-	2	4	--	--	--	--	--	--	--	25#	10	25~	10	50	20	50
			Total	**18**	-	**14**	**32**	--	**350**	--	**150**	--	**500**	--	**150**	--	**150**	--	**300**	--	**800**

Student Contact Hours Per Week: **32 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **800**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**
- **In-Plant Training during Summer vacation for minimum Six Weeks at the end of Fourth Semester (Second Year).**

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fourth**

Course Title : **Computer Aided Drafting**

Course Code : **22042**

1. RATIONAL

The market driven economy demands frequent changes in product design to suit the customer needs. With the introduction of computers the task of incorporating frequent changes as per requirement is becoming simpler. Moreover, the technology driven competitive environment in today's market is compelling design/consulting engineering firms and manufacturing companies to seek CAD conversion of their existing paper based engineering documents. The focus of this course is to provide the student with hands-on experience in drafting and editing of an industrial production drawing using one of the commercial Computer Aided Drafting software with particular emphasis on the application of CAD software.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Prepare digital drawings using computer aided drafting software.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use file management techniques in a CAD software.
b. Draw complex 2D geometric figures using a CAD software.
c. Modify complex 2D geometric figures using a CAD software
d. Use software to dimension and write text on existing 2D geometric entities.
e. Use software to plot existing drawing with desired plot parameters.
f. Create Isometric drawings using a CAD software
g. Use layers and blocks to create digital drawings using relevant softwares.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
-	-	4	4	--	--	--	--	--	--	--	25#	10	25 ~	10	50	20

(**) *marks should be awarded on the basis of internal end semester theory exam of 50 marks based on the specification table given in S. No. 9.* (~)*For the* ***practical only courses***, *the PA* *has two components under practical marks i.e. the assessment of practicals (see in section 6) has a weightage of 60% (i.e. 15 marks) and micro-project assessment (see in section 12) has a weightage of 40% (i.e. 10 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE..*

Legends: ***L***-*Lecture;* ***T*** – *Tutorial/Teacher Guided Theory Practice;* ***P*** - *Practical;* ***C*** – *Credit,* ***ESE*** - *End Semester Examination;* ***PA*** - *Progressive Assessment.* @ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

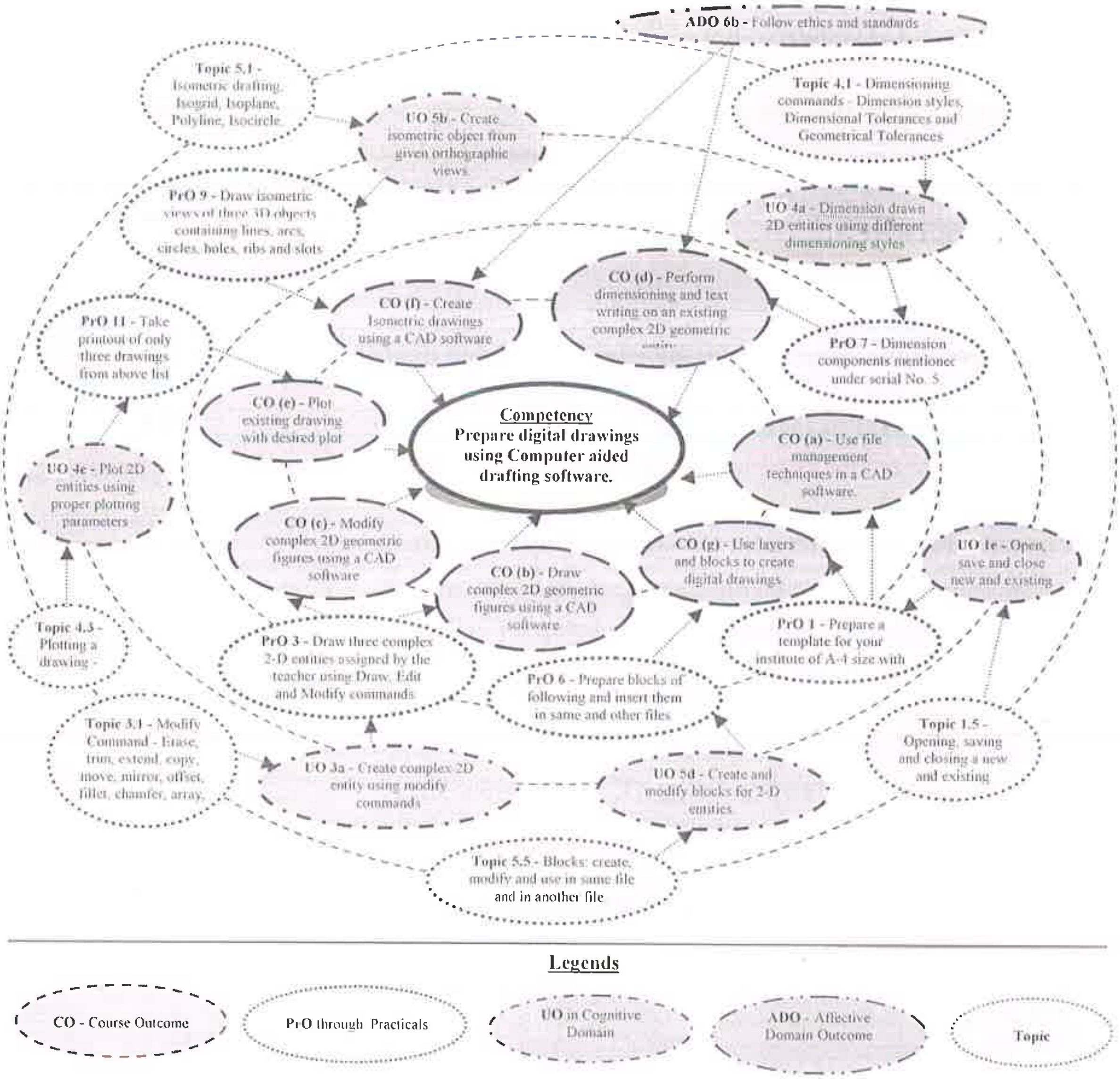


Figure 1 - Course Map

6. SUGGESTED PRACTICALS / EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare a template for your institute of A-2/A3 size with title block and institute logo.	All	02*
	1		
2.	Use the software to draw one simple 2-D entities using Draw commands individually. Part I	II	02*
3.	Use the software to draw another simple 2-D entities using Draw commands individually. Part II	II	02
4.	Use the software to draw another simple 2-D entities using Draw commands individually. Part III	II	02
	2		
5.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part I	II, III	02*
6.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part II	II, III	02*
7.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part III	II, III	02
8.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part IV	II, III	02
	3		
9.	Use the software to draw to estimate Area, Perimeter, and Centroid for the given 2D entities like Circle, Pentagon, Trapezium, hexagon and 2D entity with arcs and spline curves using 'Enquiry' and 'List' commands. Part I	II	02
10.	Use the software to draw to estimate Area, Perimeter, and Centroid for the given 2D entities like Circle, Pentagon, Trapezium, hexagon and 2D entity with arcs and spline curves using 'Enquiry' and 'List' commands. Part II	II	02
	4		
11.	Use the software to draw Epicycloid and Hypocycloid curves using pitch circle as directing circle of a cycloidal gear and an appropriate size smaller circle as generating circle. Part I	II	02
12.	Use the software to draw Epicycloid and Hypocycloid curves using pitch circle as directing circle of a cycloidal gear and an appropriate size smaller circle as generating circle. Part II	II	02
	5		
13.	Use the CADD software to create any two problems of orthographic projections using first angle method of Projection Part I.	II, III	02*
14.	Use the CADD software to create any two problems of orthographic projections using first angle method of Projection Part II	II, III	02*
15.	Plot the above Orthographic Projection Drawing on A2/A3 size Paper with title block and institute logo.	II, III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
6			
16.	Use the CADD software to create any two problems of orthographic projections using Third angle method of Projection Part I.	II, III	02*
17.	Use the CADD software to create any two problems of orthographic projections using Third angle method of Projection Part II	II, III	02*
18.	Plot the above Sectional Orthographic Projection Drawing on A2/A3 size Paper with title block and institute logo	II, III	02*
7			
19.	Use the CADD software to create any two problems of Sectional orthographic projections using Both (First and Third) angle method of Projection Part I	II, III	02*
20.	Use the CADD software to create any two problems of Sectional orthographic projections using Both (First and Third) angle method of Projection Part II	II, III	02*
21.	Plot the above Sectional Orthographic Projection Drawing on A2/A3 size Paper with title block and institute logo	II, III	02*
8			
22.	Use the software to draw isometric views of given two objects containing lines, arcs, circles, holes, ribs and slots. Part I	II, III	02*
23.	Use the software to draw isometric views of two objects containing lines, arcs, circles, holes, ribs and slots. Part II	II, III	02*
24.	Plot the above Isometric Projection Drawing on A2/A3 size Paper with title block and institute logo	II, III	02*
9			
25.	Use the CADD software to draw an assembly drawing from the given detailed drawing showing conventional representations, Bill of Material. (Part I)	IV	02*
26.	Use the CADD software to draw an assembly drawing from the given detailed drawing showing conventional representations, Bill of Material . (Part II)	IV	02*
27.	Plot the above assembly drawing on A2/A3 size Paper with title block and institute logo	IV	02*
10			
28.	Use the CADD software to draw an assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part I)	IV	02
29.	Use the CADD software to draw an assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part II)	IV	02
30.	Plot the above assembly drawing on A2/A3 size Paper with title block and institute logo	IV	02
11			

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
31.	Use the CADD software to draw working drawings from given assembly drawing (Sr.No 21,22) showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part I)	IV	02*
32.	Use the CADD software to draw working drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part II)	IV	02*
33.	Plot the above working drawing on A2/A3 size Paper with title block and institute logo	IV	02*
	12		
34.	Use the CADD software to draw working drawings from given assembly drawing (Sr.No 23,24) showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part I)	IV	02
35.	Use the CADD software to draw working drawings from given assembly drawing showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part II)	IV	02
36.	Plot the above working drawing on A2/A3 size Paper with title block and institute logo	IV	02
	Total		**64**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Developing/ using Institute Template	20
2	Selecting relevant set up parameters	05
3	Creating given drawing using relevant Commands.	40
4	Dimensioning the given drawing and writing text using blocks and layers effectively.	15
5	Answer to sample questions	10
6	Submission of digital drawing file/plot in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices to operate CAD workstations.
b. Practice energy conservation.

c. Follow ethics and standards.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment/Instruments/Other resources name with Broad Specifications	PrO. No.
1	Networked Licensed latest version of Computer Aided Drafting software freeware	All
2	CAD workstation with latest configurations for each student.	All
3	Plotter/Printer with latest versions.	All
4	LCD projector and Screen/ Interactive board	All

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics is to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of CAD Drawing Setup	1a. Explain use of computer in drafting and designing. 1b. Use the AutoCAD workspace and interface. 1c. Work with the User Coordinate System and World Coordinate System. 1d. Apply different object selection methods in a given situation 1e. Open, save and close new and given drawings/ templates	1.1 Fundamentals of Computer Aided Drafting (CAD) and its applications, Various Softwares for Computer Aided Drafting. 1.2 Co-ordinate System- Cartesian and Polar Absolute, Relative mode, UCS,WCS. 1.3 CAD initial setting commands- Snap, grid, Ortho, Osnap, Limits, Units, Ltscale, Object tracking. 1.4 Object Selection methods- picking, window, crossing, fence, last and previous. 1.5 Opening, saving and closing a new and existing drawing/template
Unit– II Draw,	2a. Use viewing commands. 2b. Apply formatting commands	2.1 Zoom Commands – all, previous, out, in, extent, Realtime, dynamic,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Enquiry, Zoom and Formatting Commands	2c. Draw simple 2D entities using given draw commands 2d. Determine coordinates, distance, area, length, centroid of the given 2D entity	window, pan. 2.2 Formatting commands - Layers, block, linetype, lineweight, color. 2.3 Draw Command - Line, arc, circle, rectangle, polygon, ellipse, spline, block, hatch 2.4 Enquiry commands – distance, area.
Unit– III Edit and Modify Commands	3a. Create given complex 2D entity using modify commands 3b. Use grip command to manipulate given 2D entity	3.1 Modify Command - Erase, trim, extend, copy, move, mirror, offset, fillet, chamfer, array, rotate, scale, lengthen, stretch, measure, break, divide, explode, align. 3.2 Grips editing- Move, Copy, Stretch.
Unit– IV Dimensioning, Text and Plot Commands	4a. Dimension given 2D entities using different dimensioning styles 4b. Apply Geometric and dimension tolerance symbols on the given entity. 4c. Write text on given 2D entity. 1f. Create user defined dimension and text styles for a given situation 4d. Plot given 2D entities using proper plotting parameters.	4.1 Dimensioning commands - Dimension styles, Dimensional Tolerances and Geometrical Tolerances, Modify dimension style. 4.2 Text commands - dtext, mtext command. 4.3 Plotting a drawing - paper space, model space, creating table, plot commands.
Unit– V Isometric Drawings, Layers, and Blocks	5a. Draw isometric entities. 5b. Create isometric object from given orthographic views. 5c. Use Layers for 2D drawings. 5d. Create and modify blocks for given 2D entities. 5e. Use blocks in same and in another given file.	5.1 Isometric drafting, Isogrid, Isoplane, Polyline, Isocircle. 5.2 Dimensioning Isometric drawings. 5.3 Text writing on Isometric drawing. 5.4 Layer, Layer properties and applications. 5.5 Blocks: create, modify and use in same file and in another file.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER (INTERNAL) DESIGN

Unit No.	Unit Title	Practice Hours	Distribution of Practical Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of CAD Drawing	06	-	02	02	04

Unit No.	Unit Title	Practice Hours	Distribution of Practical Marks			
			R Level	U Level	A Level	Total Marks
	Setup					
II	Draw, Enquiry, Zoom and Formatting Commands	12	01	-	02	03
III	Edit and Modify Commands	24	02	-	08	10
IV	Dimensioning, Text and Plot Commands	12	01	-	02	03
V	Isometric Drawings, Layers, and Blocks	10	01	00	04	05
Total		**64**	**05**	**02**	**18**	**25**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Maintain a separate folder on Computer workstation allotted, in which all above mentioned practicals should be saved and will be submitted/ mailed as a part of term work.
b. Collect at least one 2D drawing like Production drawings, Layouts from nearby workshops/industries/builders/contractors and develop them using computer aided drafting approach.
c. Explain at least one problem for drafting to all batch colleagues. Teacher will assign the problem to be explained by student.
d. Assess at least one 2D drawing of other students (A group of 5-6 students may be identified by teacher) and note down the mistakes committed by the group. Selected students will also guide other students for correcting mistakes, if any.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

f. Bring real objects in the classroom for demonstration purpose.
g. Demonstrate use of various commands of CAD using LCD projector/ interactive board. during hands on sessions.
h. Show videos and animations to explain use of layers, blocks and other relevant commands.
i. Demonstrate use of hardware like plotter.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However. in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects. the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based. laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **2D Transmission**: Each batch will identify fasteners, couplings, joints used in plastic machines and using CAD software prepare drawings. The figures should be labeled and dimensioned using software.
b. **2D Machinery components**: Each batch will identify machinery components used in plastic machines and using CAD software prepare drawings. The figures should be labeled and dimensioned using software.
c. **3D Transmission**: Each batch will identify fasteners, couplings, joints used in plastic machines and using CAD software prepare isometric drawings. The figures should be labeled and dimensioned using software.
d. **3D Machinery components**: Each batch will identify machinery components used in plastic machines and using CAD software prepare isometric drawings. The figures should be labeled and dimensioned using software.
e. **Digital Drawings:** Each batch will identify manual drawings of machinery components used in plastic machines and using CAD software create digital drawings using relevant software.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Drawing Practice for Schools and Colleges IS: SP-46	Bureau of Indian Standards	BIS, GOI, Third Reprint, October 1998, ISBN: 81-7061-091-2
2.	Engineering Drawing	Bhatt, N.D.	Charotar Publishing House, Anand, Gujarat, 2010, ISBN:978-93-80358-17-8
3.	Machine Drawing	Bhatt, N.D.; Panchal, V. M.	Charotar Publishing House, Anand, Gujarat, 2010, ISBN:978-93-80358-11-6

S. No.	Title of Book	Author	Publication
4.	Engineering Graphics with AutoCAD	Kulkarni D. M.; Rastogi A. P.; Sarkar A. K.	PHI Learning, New Delhi (2010), ISBN: 978-8120337831
5.	Essentials of Engineering Drawing and Graphics using AutoCAD	Jeyapoovan T.	Vikas Publishing House Pvt. Ltd. Noida, 2011. ISBN: 978-8125953005
6.	AutoCAD User Guide	Autodesk	Autodesk Press. USA, 2015
7.	AutoCAD 2016 for Engineers and Designers	Sham Tickoo	Dreamtech Press; Galgotia Publication New Delhi, Twenty Second edition, 2015. ISBN-13: 978-9351199113

14. SOFTWARE/LEARNING WEBSITES

a. http://www.mycadsite.com/tutorials/
b. http://tutorial45.com/learn-autocad-basics-in-21-days/
c. https://www.lynda.com/AutoCAD-training-tutorials/160-0.html
d. http://www.investintech.com/resources/blog/archives/5947-free-online-autocad-tutorials-courses.html
e. http://www.cad-training-course.com/
f. http://au.autodesk.com/au-online/overview
g. https://www.youtube.com/watch?v=yruPUj_61bw
h. https://www.youtube.com/watch?v=xquI8gcdwbs
i. https://www.youtube.com/watch?v=JTOP6TV4Mvw
j. https://www.youtube.com/watch?v=x7X25Xpa07o
k. https://www.youtube.com/watch?v=Si93Y36tUmY
l. https://www.youtube.com/watch?v=D8dPWKihkEo

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fourth**

Course Title : **Fundamental of Mechatronics**

Course Code : **22048**

1. RATIONALE

Rapid development in Technology and competitive economy has led to development of new trends in manufacturing Industry such as CNC Machines, Automation. FMS etc. which consists of combination of mechanical, electrical and electronic systems which is referred as Mechatronics. Diploma engineer in professional life has to operate and maintain systems being developed in the area of Mechatronics. In view of this, it is important for him to understand fundamental facts, concepts, principles and application of Mechatronics systems which enables him to work as technician to adopt an interdisciplinary approach of engineering while working on shop floor/industry.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Operate and manipulate mechatronics systems as per requirements.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify different instruments, sensor, actuators, microprocessor, software and mechanical components in mechatronics based systems.
b. Use sensor for different mechatronics applications.
c. Use transducers for different mechatronics based applications.
d. Use actuator for various mechatronics based applications.
e. Programme PLC for various applications.
f. Use microprocessor and microcontroller for various mechatronics based applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2	-	2	4	--	--	--	--	--	--	--	25#	10	25~	10	50	20

*(~): For the **practical only courses,** the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 15 marks) and*

micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 10 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

Legends: **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit. **ESE** - End Semester Examination; **PA** - Progressive Assessment, @ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment.

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

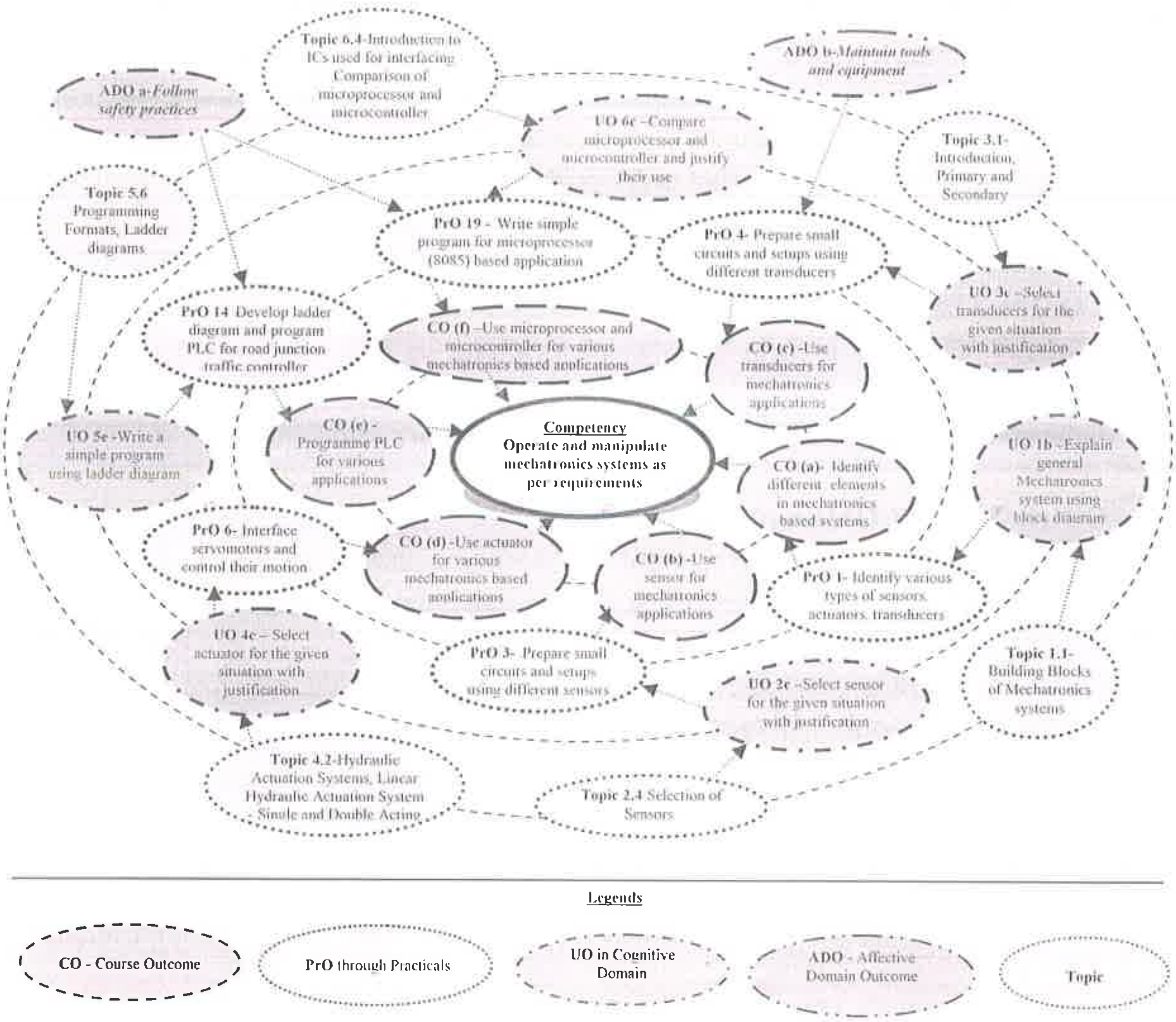


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Select sensors, actuators, transducers, PLC and Microcontrollers for given application with justification.	II, III, IV, V,VI	02*
2	Prepare small circuits using different sensors Proximity Sensor –NPN.NO.PNP, Limit Switch, Opto sensors, Pressure sensors, Motor-24V DC, interfacing facility with PLC used in Mechatronics systems	II, III,IV,V	02*
3	Verify the functions of Logic Gates for the given Ladder Diagram by using PLC	III, IV,V	02*
4	Prepare small circuits using different transducers like linear and rotary transducers with PLC	IV,V	02
5	Develop ladder diagram and program PLC for Timers and Counters	III,IV,V	02*
6	Prepare small circuits for door open and close application using different actuators with PLC.	III,IV,V	02
7	Develop ladder diagram and program PLC for Temperature control.	III,IV,V	02*
8	Build Electro-pneumatic circuits for given application.	III,IV, V	02*
9	Develop ladder diagram and program PLC for simulation of a pedestrian traffic controller.	III, IV, V	02*
10	Develop ladder diagram and program PLC for Lift / elevator control	III, IV, V	02*
11	Develop ladder diagram and program PLC for Washing machine control	III, IV, V	02
12	Develop ladder diagram and program PLC for Tank level control	III, IV, V	02
13	Develop ladder diagram and program PLC for Soft drink vending machine control	III, IV, V	02
14	Write a program for 8051 microcontroller for speed control of stepper motor.	IV,VI	02*
15	Develop a program for 8051 microcontroller for relay interfacing.	III,IV,VI	02
			30

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	PLC Trainer Kit with 12 DI.12 DO.2AI and 2AO with ladder and SCADA	3,4,6,12,13
2	Basic Pneumatic Trainer Kit with manual and electrical controls/ PLC Control	3,4
3	Electro-pneumatic Trainer kit	10,
4	Basic Hydraulic Trainer Kit	11
5	Hydraulics and Pneumatics Systems Simulation Software	12,13
6	BLDC, stepper motor and drive circuit sets.	5
7	AC servo and VFD trainer kit	5,
8	Real Time Temperature Controller	2,3
9	PID Controller and DC Motor Speed controller	17,18
10	Servo controller using Open/Closed loop control system	7,8
11	Pneumatic Power circuit system	9
12	Real Time Temperature Controller	17

S. No.	Equipment Name with Broad Specifications	PrO. No.
13	SCADA software (2000 points) with Siemens TIA portal free software educational bundle or equivalent Free Software	1,2,6
14	Pneumatic Power circuit system for Door close and open application, stamping application and raw material rejection system	6,9

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Basic Mechatronics System	1a. Compare with block diagram the features of the traditional and Mechatronics system for the given example 1b. Describe the basic elements of the given closed loop system. 1c. Identify sensor, actuators, microprocessor techniques, software and mechanical components in the given diagram of the mechatronics based system with justification.	1.1 Introduction, Need and Scope 1.2 Traditional V/s Mechatronics Approach, 1.3 Block diagram representation of General Mechatronics system showing various components with suitable example, 1.4 Control System - Open and Closed Loop Systems, Basic Elements of closed loop system,
Unit-II Transducers	2a. Classify the transducers. 2b. Select the relevant transducers for the given situation with justification	2.1 Introduction, Primary and Secondary Transducers, Working of Primary and Secondary Transducers, 2.2 Mechanical Device as Primary detectors, Electrical Transducers, Active and Passive Transducers, Analog and Digital Transducers.
Unit– III Sensors	3a. Classify the Sensors. 3b. Explain the working of the given sensor and Write specifications, features of the sensors. 3c. Select the relevant sensor for the given situation with	3.1 Introduction, Need of Sensors, Contact and Non - Contact Type of Sensors, Classification. 3.2 Working and Application of- Potentiometer Sensors, Strain Gauge Elements, Capacitive Elements, Eddy Current, Proximity Sensors, Inductive

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	Proximity Sensors, Light Sensors, Pressure Sensors, Pneumatic Sensors, Pyro electrical Sensors, Piezoelectric Sensors. 3.3 Selection of Sensors
Unit –IV Actuators	4a. Explain with sketches the working of the given Hydraulic actuator with sketch and block diagrams. 4b. Prepare the specifications and features of the given hydraulic, mechanical and electrical actuator. 4c. Select the relevant actuator for the given situation with justification.	4.1 Introduction and Classification of Actuators. Need and Scope. 4.2 Hydraulic Actuation Systems. Linear Hydraulic Actuation System - Single and Double Acting, Pneumatic Actuation Systems - Gear Motors and Vane Motors, 4.3 Electrical Actuation Systems - Electrical Systems Viz. Switching Devices, solenoid type Devices, Drive Systems, Mechanical Switches Viz. Debouncing, Keypads, Electro-Mechanical and Solid State Relays, Stepper Motors. 4.4 Selection of Actuaators
Unit-V Programmable Logic Controller	5a. Explain with sketches the working of the given PLC. 5b. Write specifications and features of the given PLC and power supply. 5c. Select the relevant PLC and power supply for the given situation with justification. 5d. Write a simple program using ladder diagram for the given situation.	5.1 Introduction, definition, Basic PLC functions, PLC block diagram, Difference between relay panel and PLC, 5.2 Power supply, input/output modules (analog, digital) concepts of sink/source, set/reset, latch/unlatch, 5.3 Selection of a PLC, Programming equipment, 5.4 Programming Formats, Ladder diagrams and sequence listing, PLC auxiliary commands and functions,
Unit-VI Microcontroller and Applications of Mechatronics Systems	6a. Explain the working of the microprocessor with sketches and block diagrams. 6b. Justify the use of D/A converters and A/D converters in the given application. 6c. Explain with sketches the working of the mechatronics devices in the given	6.1 Comparison of microprocessor and microcontroller 6.2 Introduction, Architecture-Pin Configuration of 8051 Microcontroller 6.3 Introduction to interfacing of D/A converters and A/D converters with 8051 microcontroller. 6.4Applications-Temperature control-Stepper motor control 6.4 Application of Mechatronics systems in

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	appliance.	Washing Machines,

Note: *To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Visit any nearby industry and prepare a list of mechatronics devices available with specifications.
b. Do internet survey to create small mechatronics circuits.
c. Prepare power point presentation or animation for understanding working of different sensors, actuators, PLC and transducers.
d. Simulate different mechatronic systems using LabView/ hydraulic and pneumatic software.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual mechatronics based systems and applications.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various pneumatic, hydraulic and mechatronic systems.

i. Use open source simulation software to model Pneumatic, Electro-Pneumatic and hydraulic circuits and ladder diagrams.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Design and testing of fluid power circuits to control
   i. Velocity
   ii. direction and
   iii. force of single and double acting actuators
b. Perform speed control of AC and DC drives.
c. Dissemble a digital weighing machine and understand how weight is measured.
d. Dissemble a digital thermometer and try to understand how temperature is measured.
e. Prepare a report on use of mechatronics elements in washing machine, lift, microwave oven, ATM etc.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechatronics	Bolton W.	Addison Wesley Longman Ltd., U.S.A. 1999, ISBN 9780582357051
2	Mechatronics	H.M.T.	McGraw-Hill Education, New Delhi, 2000, ISBN: 0074636435
3	Mechatronics Electronics in Production and Process	Dawson D.A., Burd N.C., Loader A.J.	Chapman-Hall, 1993, Taylor & Francis, ISBN 9780748757428
4	Introduction to mechatronics and Measuring Systems	Histand Michael B. Alciatore David G.	McGraw-Hill, New Delhi, 2003 ISBN 9780072402414
5	Mechanical Measurements and Instrumentation	Sawhney Puneet, Sawhney A.K.	Dhanpat Rai and Sons, 2013, New Delhi

Program Name : **Diploma in Automobile Engineering / Mechanical Engineering**

Program Code : **AE / ME**

Semester : **Fourth**

Course Title : **Theory of Machines**

Course Code : **22438**

1. RATIONALE

Knowledge of various mechanisms and machines is a pre-requisite for enabling a mechanical engineer to work in an industry. This course provides the knowledge of kinematics and dynamics of different machine elements and popular mechanisms such as four link mechanisms, cam-follower, belt-pulley, chain sprocket, gears, flywheel, brake and clutch to enable a diploma holder to carry out maintenance of these and it also serves as a prerequisite for course 'Elements of Machine Design' to be studied in later semester.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use principles of kinematics and dynamics in maintenance of various equipment.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify various links in popular mechanisms.
b. Select suitable mechanism for various applications.
c. Interpret the motion of cams and followers.
d. Recommend relevant belts, chains and drives for different applications.
e. Choose relevant brakes and clutches for various applications
f. Select suitable flywheel and governor for various applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment* ,@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

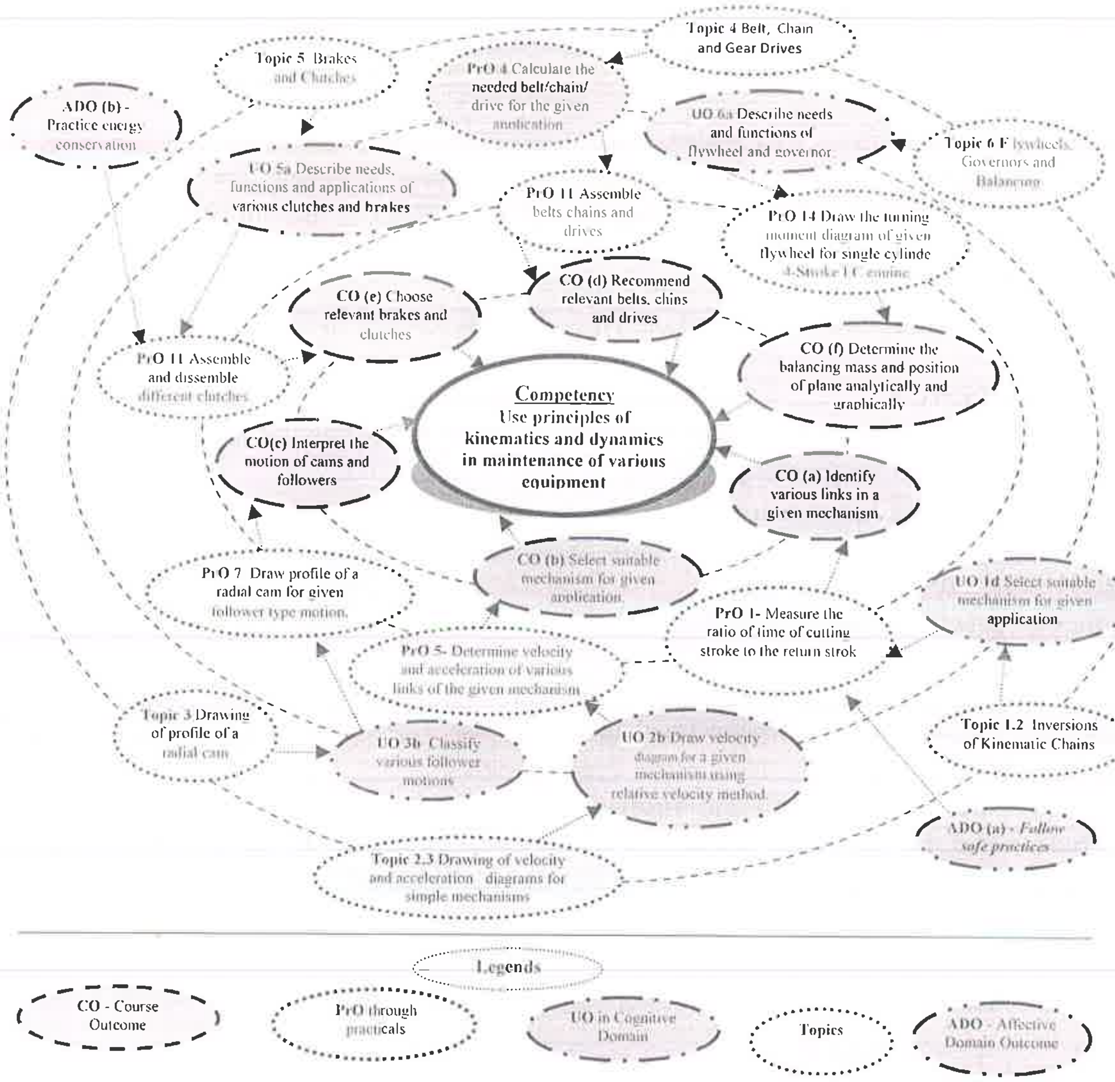


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure the ratio of time of cutting stroke to the return stroke in shaping machine by varying the stroke length. Following activities need to be performed: (Part I) a. Measuring dimensions of different links of given shaper machine b. Sketching	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	c. Labeling of sketch		
2	Measure the ratio of time of cutting stroke to the return stroke in shaping machine by varying the stroke length. Following activities need to be performed: (Part II) a. Measuring dimensions of different links of given shaper machine b. Sketching c. Labeling of sketch	I	02*
3	Estimate important kinematic data related to following mechanisms to sketch them. a) Bicycle free wheel sprocket mechanism b) Geneva mechanism	I	02
4	Estimate important kinematic data related to following mechanisms to sketch them. a) Ackerman's steering gear mechanism b) Foot operated air pump mechanism	I	02
5	Determine velocity and acceleration of various links of the given mechanism (any two) by relative velocity method for analysis of motion of links (Minimum 2 problems on A2 size drawing sheet).	II	04*
6	Determine velocity and acceleration in an I. C. engine's slider crank mechanism by Kleins's construction (Minimum 2 problems on A2 size drawing sheet).	II	02
7	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part I	III	02*
8	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part II	III	04
9	Estimate slip, length of belt, angle of contact in an open and cross belt drive.	IV	02*
10	Calculate breaking torque required in different breaks at different speeds and load situations.	IV	02
11	Assemble and dismantle different clutches. (Part I)	V	02*
12	Assemble and dismantle different clutches. (Part II)	V	02*
13	Measure radius and height of all types of governors for different rotational speeds, mass of balls and spring stiffness (in spring loaded governors)	V	02*
14	Perform balancing of rotating unbalanced system	VI	02*
	Total		**32**

Note:

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, all practicals are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report/sheets in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Working models of bicycle free wheel sprocket mechanism, geneva mechanism, Ackerman's steering gear mechanism and foot operated air pump mechanism, slider crang mechanism, elliptical trammel, skotch yoke mechanism, oldham's coupling, hooks joint, inversions of four bar mechanisms.	03, 04, 05, 06 and for demo in theory class for unit-I and II
2.	Working models of locomotive coupler, Beam engine, Pantograph, Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper, Scotch Yoke mechanism, Elliptical trammel and Oldham's Coupling.	03, 04, 05, 06 and for demo in theory class for unit-I and II
3.	Working models of various cam follower arrangements for demonstration.	07, 08

S. No.	Equipment Name with Broad Specifications	PrO. No.
4.	Working models with different belts in different arrangements.	09
5.	Working and cut section models of various types of brake assemblies.	For demo in theory class for unit-V
6.	Various types of clutch assemblies.	11
7.	Working models of various types of governors.	13
8.	Working models of a. various belt drives, b. chain and sprocket, c. various gear drives.	For demo in theory class for unit-IV
9.	Working Models of Gear trains - all types.(Simple, compound, reverted, epicyclical).	For demo in theory class for unit-IV
10.	Balancing Machines -Revolving masses, Reciprocating masses	14

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals and type of Mechanisms	1a. Identify various links in the given figure of the mechanism with justification. 1b. Describe with sketches the constructional details of the given type of mechanism 1c. Select suitable mechanism for the given application with justification. 1d. Select suitable material of the mechanism for the given application with justification.	1.1 **Kinematics of Machines:** Introduction to Statics; Kinematics, Kinetics, Dynamics; Kinematic links, joints, pairs, chain and its types; Constrained motion and its types, Inversion, Mechanism, Machine and Structure. 1.2 **Inversions of Kinematic Chains and their materials:** Four bar chain – Locomotive coupler, Beam engine and Pantograph. Single slider Crank chain – Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper; Double Slider chain - Scotch Yoke mechanism, Elliptical trammel, Oldham's Coupling.
Unit– II Velocity and Acceleration in Mechanisms	2a. Use analytical method (without derivation) to calculate the velocity and acceleration of given links in the given single slider crank mechanism 2b. Estimate velocity and	2.1 Concept of relative velocity and relative acceleration of a point on a link, angular acceleration, inter-relation between linear and angular velocity and acceleration. 2.2 Analytical method and Klein's construction to determine velocity and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	acceleration of any link at any instant in the given mechanism. 2c. Describe with dimensioned sketch of the given mechanism. 2d. Describe with velocity diagram for a given mechanism using relative velocity method. 2e. Describe with acceleration diagram for the given mechanism. 2f. Explain with velocity and acceleration diagram for the given mechanism using Klein's construction.	acceleration of different links in single slider crank mechanism. 2.3 Drawing of velocity and acceleration diagrams for simple mechanisms. Determination of velocity and acceleration of point on link by relative velocity method (Excluding Coriollis component of acceleration)
Unit– III Cams and Followers	3a. Identify the type of motion of follower in the given situation with justification. 3b. Describe with dimensioned sketch of the given cam and follower arrangement. 3c. Describe with cam profile for the given motion of knife-edge and roller follower with and without offset application using Graphical method.	3.1 Introduction to Cams and Followers. Cam and follower terminology. Classification of Cams and Followers. Applications of Cams and Followers. 3.2 Types of follower motions and their displacement diagrams -Uniform velocity, Simple harmonic motion, uniform acceleration and retardation. 3.3 Drawing of profile of a radial cam based on given motion of reciprocating knife-edge and roller follower with and without offset.
Unit-IV Belt, Chain and Gear Drives	4a. Calculate velocity ratio, belt tensions, slip and angle of contact in the given belt drive. 4b. Estimate power transmitted and condition for maximum power transmitted in the given belt drive for given data. 4c. Select suitable belt for the given application with justification. 4d. Calculate Train value and velocity ratio for the given simple, compound, reverted and epicyclic gear trains using spur and helical gears.	4.1 Belt Drives – Introduction to Flat belt, V-belt and its applications, materials used for flat and V-belts. Introduction of timing belt and pulley. Angle of lap, length of belt, Slip and creep. Determination of velocity ratio of tight side and slack side tension, centrifugal tension and initial tension, condition for maximum power transmission. Merits, demerits and selection of belts for given applications. 4.2 Chain Drives – Introduction to chain drives, Types of chains and sprockets, Methods of lubrication. Merits, demerits and selection of chains for given applications. 4.3 Gear Drives – Introduction to gear

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	4e. Select suitable gear for the given application with justification. 4f. Select suitable drives for the given application with justification.	drives, Classification of gears, Law of gearing, gear terminology, Types of gear trains, Train value and velocity ratio for simple, compound, reverted and epicyclic gear trains using spur and helical gears. Merits, demerits and selection of gear drives for given applications.
Unit-V Brakes and Clutches	5a. Calculate braking force, braking torque and power lost in friction in the given shoe and band brake for the given data. 5b. Explain with sketches the various parts of the given brakes with their functions and constructional details. 5c. Describe with sketches the needs, functions and applications of the given clutches. 5d. Explain with sketches the various parts of the given clutch with their functions and constructional details.	5.1 Introduction to Brakes – Types, Functions and Applications. 5.2 Construction and principle of working of i) Shoe brake, ii) Band brake iii) Internal expanding shoe brake iv) Disc Brake. 5.3 Braking force, braking torque and power for shoe and band brake. 5.4 Clutches-Uniform pressure and Uniform Wear theories. Introduction to Clutch - Types, Functions and Applications, Construction and principle of working of a. Single-plate clutch, b. Multi-plate clutch, c. Centrifugal Clutch d. Cone clutch e. Diaphragm clutch.
Unit –VI Flywheels, Governors and Balancing	6a. Explain with sketches the method of balancing a rotating mass as per the given conditions. 6b. Estimate the balancing mass and position of plane analytically and graphically in the given situation for the given data. 6c. Explain with sketches the turning moment diagram for the given single cylinder 4-Stroke I.C Engine for the given data.	6.1 Flywheel-Introduction to flywheel – need, function and application of flywheel with the help of turning moment diagram for single cylinder 4-Stroke I.C Engine. 6.2 Coefficient of fluctuation of energy, coefficient of fluctuation of speed and its significance. 6.3 Governors- Introduction, types, functions and applications, Terminology of Governors. Comparison of Flywheel and Governor. 6.4 Balancing- Need and types of balancing, Balancing of single rotating mass, Analytical and Graphical methods for balancing of several masses revolving in same plane.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals and type of Mechanisms	10	04	06	04	14
II	Velocity and Acceleration in Mechanisms	06	02	04	04	10
III	Cams and Followers	08	04	04	04	12
IV	Belt, Chain and Gear Drives	10	04	04	06	14
V	Brakes and Clutches	06	02	02	04	08
VI	Flywheels, Governors and Balancing	08	02	04	06	12
Total		**48**	**18**	**24**	**28**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journal of practicals.
b. Undertake micro-projects.
c. Compile information from internet related to various mechanisms/elements like piston, crank, connecting rod, cam, clutch, brake, flywheel, governor, or animation of mechanism etc. along with functions and areas of application of each.
d. List the mechanisms which you are using in your day to day life. Sketch any three from these.
e. List the different mechanisms used in a typical car.
f. Identify and measure the dimensions of Flywheel used in automobile engines, generators, punching and riveting machines.
g. Identify the type of clutches used in different automobiles and also the type of brakes in automobile and bicycle.
h. Visit the market and collect the data of items which are used in any mechanisms. Data includes specifications, cost, applications, etc. Also name the mechanism/s in which such item/s is/are used.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b. *'L' in item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various mechanisms.
f. Guide student(s) in undertaking micro-projects
g. Encourage students to refer different websites for deeper understanding of the course.
h. Monitor the performance of students in Lab.
i. Show models, education charts and videos, real life examples of various mechanisms.
j. Demonstration of real industrial parts and mechanisms used in different devices.
k. Demonstration of different real industrial parts, cams, power transmission elements through movies/animations.
l. Industrial visit, animations/movies, models of different types of governors.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare working model of any one mechanism using low cost materials.
b. Prepare animations of various mechanisms using free software's available on internet.
c. Market survey of belts for collecting specifications,.
d. Field survey to collect information about applications of timing belts.
e. Field survey to collect information about applications of flywheels and governors.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Theory of Machines	Rattan S. S.	McGraw-Hill Education, 1986 ISBN: 9780070591202
2	Theory of Machines	Khurmi R. S., Gupta J. K.	S. Chand Publications, New Delhi, 2015 ISBN: 9788121925242
3	Theory of Machines	Bevan Thomas	Pearson Education India, New Delhi, 1986, ISBN: 9788131729656

S. No.	Title of Book	Author	Publication
4	Theory of Machines and Mechanisms	Ballaney P.L.	Khanna Publisher, New Delhi, 2003, ISBN 9788174091222
5	A Text Book of Theory of Machines	Bansal R.K., Brar J. S.	Laxmi Publication, New Delhi, 2004, ISBN 9788170084181

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.iitm.ac.in/video.php?subjectId=112104121
b. http://www.technologystudent.com/gears1/gears7.htm
c. http://kmoddl.library.cornell.edu/model.php?m=20
d. http://www3.ul.ie/~kirwanp/whatisacamandfollowersyste.htm
e. http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-
f. Delhi/Kinematics%20of%20Machine/index.htm
g. http://elearning.vtu.ac.in/12/enotes/Des_Mac-Ele2/Unit6-RK.pdf
h. en.wikipedia.org/.../Canadian_Committee_for_the_Theory_of_Machines...
i. global.oup.com/.../theory-of-machines-and-mechanisms-978019537123...
j. www.tecquipment.com/Theory_of_Machines.aspx
k. www.researchgate.net/.../0094-114X_Mechanism_and_Machine_Theory
l. www.journals.elsevier.com/mechanism-and-machine-theory/
m. journalseek.net/cgi-bin/journalseek/journalsearch.cgi?field=issn...
n. site.iugaza.edu.ps/wp-content/.../IUGAZA%20TOM2012_CH1-2.pdf
o. www.iftomm.org/
p. www.wiziq.com/online-tests/44047-mechanical-theory-of-machine
q. www.cs.ubc.ca/~murphyk/Teaching/CS340-Fall07/infoTheory.pdf

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fourth**

Course Title : **Mechanical Engineering Measurements**

Course Code : **22443**

1. RATIONALE

Measurement activities are given prime importance in industry. The art of measurement plays an important role in all branches of engineering. With advances in technology, measurement techniques have also taken rapid strides, with many types of instrumentation devices, innovations, refinements. The course aims at making a Mechanical Engineering diploma holder familiar with the principles of instrumentation, transducers and measurement of non electrical parameters like temperature, pressure, flow, speed, force, torque for engineering applications.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use relevant analog and digital measuring devices in mechanical engineering related applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use relevant instrument for measuring displacement.
b. Use relevant instrument for measuring force and torque.
c. Use relevant pressure and temperature measuring instruments.
d. Use relevant instruments for measurement of flow.
e. Select relevant instruments for measurement of vibration and strain.
f. Select relevant instruments for speed and sound measurement.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment,* @ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

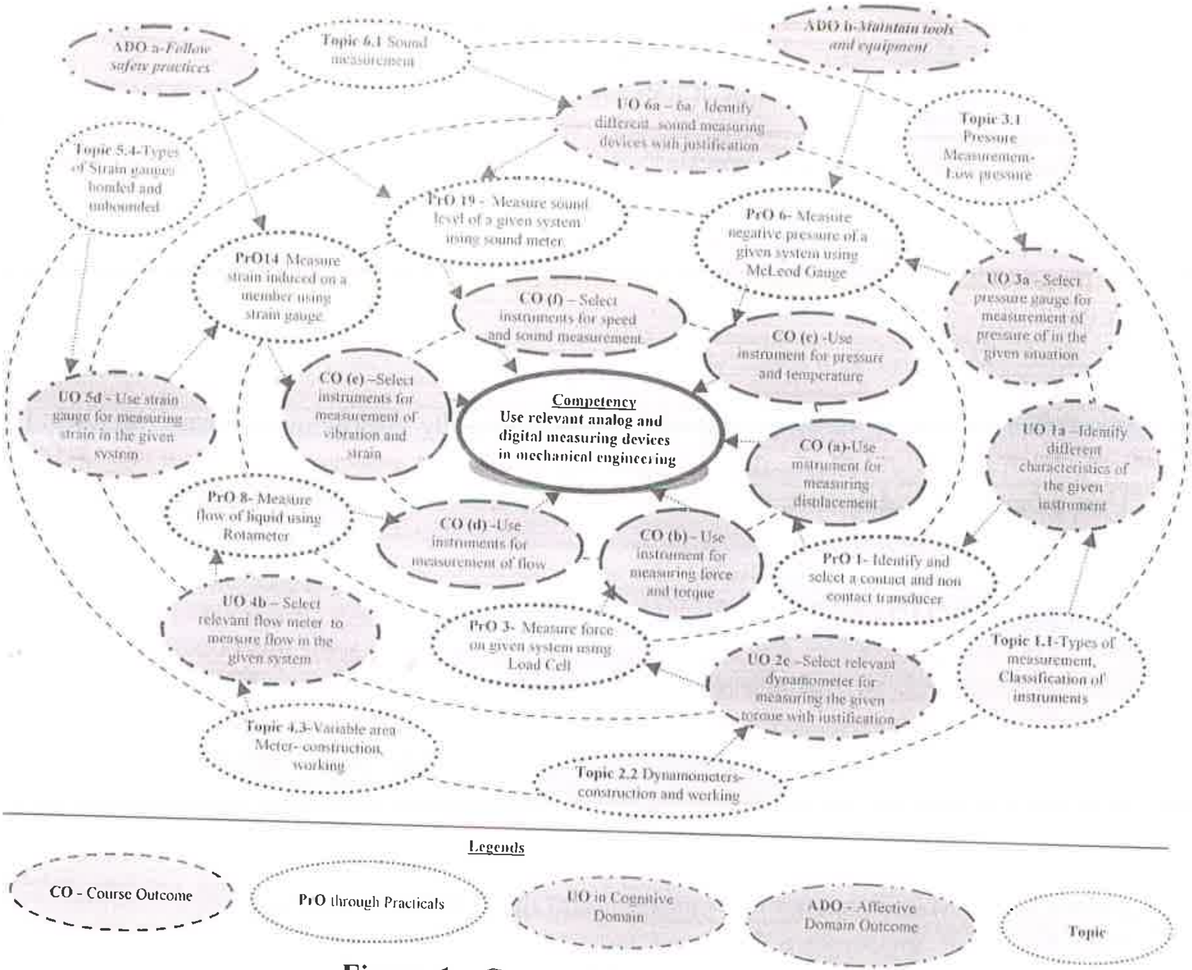


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify contact and Non-Contact Type Instruments	I	02*
2	Calibration of LVDT transducer for displacementMeasurement	II	02
3	Use Load cell to measure force on given system.	II	02*
4	Measure Force Using Eddy Current Dynamometer.	II	02
5	Calibration of Bourdon's Pressure gauge	III	02*
6	Measure Pressure using McLeod Gauge	III	02
7	Calibration of Thermocouple	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Measure flow of liquid by Rotameter	IV	02
9	Measure flow of liquid by Ultrasonic Flow meter	IV	02
10	Calibration of Stroboscope.	V	02*
11	Measure Speed of Rotating Machine using Inductive Pick up	V	02
12	Use of Vibration Meter for Measuring Vibration of Machine	V	02*
13	Use of Vibration Meter for Measuring Vibration of Structure	V	02
14	Use Strain gauge To measure Strain induced on member	V	02*
15	Use Psychrometer to measure Air properties	VI	02
16	Use Sound Meter to measure sound level of a given system	VI	02*
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	10
2	Handling of measuring instruments carefully while performing the practical.	10
2	Setting and operation	30
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	10
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs

according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Inductive transducer- measurement range -0 to 100 mm -Sensor -inductive (non linear) solenoid type on board with micrometer, micrometer screw guage assembly for displacement, bridge balance type circuit Display 3.5 digit digital display	1
2	Load cell – force measurement range 5- 50 N -sensor-4 arm bridge with strain guage capacity-2 kg, 3.5 digital display	2
3	Eddy Current Dynamometer Power rating: 0.18 KW to 55 KW Max Speed: 4,000 RPM; Torque Indicator: Spring Balance OR Digital Indicator with Zero, Span, Calibration presets; Max Torque: 100 KgM (1000 Nm); Speed Sensor: 60-Tooth wheel with Magnetic Speed Pick up Sensor Torque Sensor: Spring Balance with Pulley and rope, Load cell or Rotary Torque Sensor; Cooling: Self Cooled or FAN Cooled, to avoid Water Cooling hassles.	3
4	Sensor - Bourdon tube C type with LVDT Display 3.5 digit display for pressure/ displacement	4
5	McLeod guage with arrangement for high pump	4
6	Sensor- type k (Cr- Al)thermocouple, sensor assembly and water bath with heating arrangement Display3.5digit digital display	5
7	Rotameter trainer - Sensor -standard glass rotameter, process tank with motor pump Display- float position on graduated scale	6
8	Ultrasonic flow meter: 100 PPM OF 100 Microns in Size Paticulate or Bubbles Required,Battery Operated,Non-Invasive Clamp-On Transducer,Large Character Display; User Selected Velocity Units ,Measures Fluid Velocities from (0.10 to 9.00 MPS),100:1 Turndown Ratio,Pipe Sizes from 6.3 mm	7
9	Stroboscope- Range upto 5000 RPM display – LED digital	8
10	Inductive pickup for speed measurement- Sensor – inductive , variable speed motor arrangement, 3.5 digital display	9
11	FFT analyzer: Specifications:Vibration Velocity: 0.1 – 200 mm/s True RMS,Acceleration: 0.1 – 200m/s² Peak,Displacement: 0.5 – 2000 µm Peak – Peak,Resolution: 0.1 mm/s,Accuracy: ± 2% + 0.1 mm/s,Frequency response: 10 – 1khz,Power: Rechargeable battery Pack with charger,Display: 2 x 16 line back light dot matrix LCD,Operating Temp. Range: 0 – 55°C,Casing: ABS,Sealed Membrane key pad,Input Connectors: BNC Round,Size:200x100x40 mm	10
12	Strain gauge trainer (strain /force measurement)- Sensor-four arm bridge with strain gauge mounted on cantilever 2kg, Display 3.5digit digital display	11

41

S. No.	Equipment Name with Broad Specifications	PrO. No.
13	Sling Psycrometer: The Sling Psychrometer measures RH between 10 and 100% (for dry bulb temperatures between 30 and 100 °F) with an accuracy of ± 5%; Measurement Range :Dry/wet bulb temperature :25 to 120 °F or -5 to +50 °C (see ordering information); Relative humidity (RH) : 10 to 100%, for dry bulb temperature between 30 and 100 °F (-1 and 38 °C)	12
14	Sound meter: LCD backlight for clear reading. Wide measuring range: 30-130dB.Sound level measurement. in./Max./Lock current value. Hold the measurement data; Manual/auto shutoff. Equipped with sponge ball. Portable and easy to use suitable for sound quality control in factory, office, home, school and construction site.	13
15	Multi digital stratoscope cum tachometer for speed measurement- upto 5000 rpm	14

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to Measurement	1a. Identify different characteristics of the given instrument. 1b. Identify the error in the given instrument. 1c. Classify the transducers for the given application. 1d. Identify the given contact and non-contact transducer with justification.	1.1 Types of measurement, Classification of instruments, Static terms and characteristics- Range and Span, Accuracy and Precision, Reliability, Calibration, Hysteresis and Dead zone, Drift, Sensitivity, Threshold and Resolution, Repeatability and Reproducibility, Linearity. Dynamic characteristics- Speed of response, Fidelity and Dynamic errors, Overshoot. 1.2 Measurement of error- Classification of errors, environmental errors, signal transmission errors, observation errors, operational errors. 1.3 Classification of transducers, active and passive, contact non contact,mechanical electrical, analog digital.
Unit-II Displacement, Force and Torque Measurement	2a. Select the displacement measuring sensor for measurement of displacement in the given system with justification. 2b. Select the force measuring sensors for measurement of pressure in the given situtation with justification.	2.1 Specification, selection and application of displacement transducer. Capacitive transducer, Potentiometer, LVDT, RVDT. 2.2 Force Measurement System- characteristic of force measurement, creep curve for force transducer. 2.3 Force and Load Sensors- Types of Load cell, load cell applications,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2c. Select the relevant dynamometer for measuring the given torque with justification. 2d. Describe with sketches the procedure for measurement of displacement, force and torque using the given device.	construction and working of Quartz force sensor. Force rings. 2.4 Torque Measurement- Inline and Reaction Torque measurement 2.5 Torque sensors- construction and working of Slip ring. Rotary Transformer. Infrared sensor. FM Transmitter. 2.6 Dynamometers – construction and working of Transmission dynamometer. absorption dynamometer. Eddy current Dynamometer.
Unit– III Pressure and Temperature Measurement	3a. Select the pressure gauge for measurement of pressure in the given situation with justification. 3b. Choose the relevant instruments to measure temperature of the given system with justification. 3c. Select the relevant pyrometer for given application with justification. 3d. Describe with sketches the procedure for measurement of temperature and pressure using the given device.	3.1 Pressure Measurement- Low pressure gauges- McLeod Gauge, Thermal conductivity gauge. Ionization gauge, Thermocouple vacuum gauge. Pirani gauge. High Pressure gauge- Diaphragm. Bellows. Bourdon tube, Electrical resistance type. Photoelectric pressure Transducers, piezoelectric type. 3.2 Non-electrical methods- Bimetal , Liquid in glass thermometer and Pressure thermometer. 3.3 Electrical methods- RTD. Platinum resistance thermometer, Thermistor, Thermoelectric methods - elements of thermocouple, Seebeck series, law of intermediate temperature, law of intermediate metals. thermo emf Measurement. 3.4 Pyrometers- Working and Principle of Radiation and Optical Pyrometer.
Unit– IV Flow Measurement	4a. Identify the flow meter for the given situation with justification mentioning salient features. 4b. Select relevant flow meter to measure flow in the given system with justification. 4c. Describe with sketches the procedure for measurement of flow using the given Ultrasonic flow meter.	4.1 Types of flow meter. Selection criteria for flow meter. classification 4.2 Flow meters- application and construction of Orifice , venture tube, segmental wedges ,pitot tube, Dall Tube. 4.3 Variable area Meter- construction, working and principle of Rota meter, anemometer. 4.4 Positive Displacement Flow meter- construction. advantages and disadvantages of Coriolis flow meter, Oscillating piston flow meter.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Rotating vane flow meter. 4.5 Ultrasonic flow meter- application and construction of Doppler and Transit time ultrasonic flow meter.
Unit –V Vibration and Strain Measurement	5a. Select the relevant instrument for vibration measurement of given job with justification. 5b. Describe with sketches the use of FFT analyzer for measuring vibration of the given system. 5c. Identify the relevant strain gauges for measuring strain in the given system with justification. 4d. Describe with sketches the procedure for measurement of strain in the given system using strain gauge.	5.1 Concept of natural frequency, free body diagram and spring mass system. 5.2 Vibration measurement element-principle and working of velocity pickup ,Accelerometer, Inductive Pick Up, Capacitive Pick Up , Stroboscope. 5.3 Introduction to FFT Analyzer, working and application. 5.4 Types of Strain gauges- bonded and unbounded, gauge factor, strain gauge selection criteria. 5.5 Methods of strain measurement- Axial, bending, Torsional. 5.6 Construction of foil, semiconductor and wire wound strain gauge.
Unit–VI Miscellaneous Measurement Sound, speed and humidity measurements	6a. Identify the relevant sound measuring device for the given situation with justification and mentioning the salient features. 6b. Describe with sketches the use speed measuring instrument for the given system. 6c. Select the relevant instrument for measuring Humidity in the given system with justification. 6d. Describe with sketches the procedure for measurement of Humidity using the given device.	6.1 Sound measurement, principle of Electro dynamic microphone and Carbon microphone. 6.2 Speed measurement –working and principle of Eddy current generation type tachometer, incremental and absolute type, Mechanical Tachometers, Revolution counter and timer, Slipping Clutch Tachometer, Electrical Tachometers, Contact less Electrical tachometer. 6.3 Humidity measurement –working and principle of Hair hygrometer, Sling psychomotor.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Measurement	06	02	04	06	12
II	Force and Torque Measurement	10	02	04	06	12
III	Pressure and Temperature Measurement	08	02	04	06	12
IV	Flow Measurement	08	02	04	06	12
V	Vibration and Strain Measurement	08	02	04	04	10
VI	Miscellaneous Measurement	08	02	02	08	12
	Total	**48**	**12**	**22**	**36**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journal based on practical performed in measurement laboratory. Journal consist of drawing, observations , required measuring tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
   i. Measuring Tools and equipment in measurement laboratory.
   ii. Machineries in measurement laboratory
c. Undertake a market survey of local dealers for measuring equipments and prepare a report.
d. Visit to any Tool room and observe the working of inspection and testing department. also prepare a report consisting
   i. Different advanced Measuring Instruments
   ii. Different Measuring standards and Calibration process
   iii. Care and maintenance of measuring instruments observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Before starting practical, teacher should demonstrate the working of instrument.
g. Instructions to students regarding care and maintenance of measuring equipments.
h. Show video/animation films to explain functioning of various measuring Instruments
i. Teacher should ask the students to go through instruction and Technical manuals of instruments

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Predict and test the performance of sensors of various kinds, including strain gages, thermocouples, tachometers, displacement transducers, dynamometers, pressure gages and transducers.
b. Collect information of flow measuring devices.
c. Perfrom comparative study of different parameters of LVDT various contact sensors.
d. Perform comparative study of various non - contact sensors
e. Visit to automobile workshop and observe the various sensors used in car. also prepare report of the same i.e name ,use, location, function.
a. Visit the market and collect the sensor brochures with specifications of different manufactures.
b. Prepare a list of instruments used for vibration measurement and analysis.
c. Vist a power plant or manufacturing industry and identify situations where these sensors and instruments are used for predictive maintenance and condition monitoring.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechanical measurements and instrumentation	Rajput R.K.	S.K.Kataria and Sons, New Delhi, 2013, ISBN:978-93-5014-285-1
2	Mechanical Measurement and Control	Jalgaonkar R.V.	Everest Publishing House, New Delhi, 2010, ISBN-9788186314265.
3	Mechanical and Industrial Measurements	Jain R.K.	Khanna Publications, New Delhi, 2012, ISBN: 978-8174091912

S. No.	Title of Book	Author	Publication
4	Instrumentation Devices and Systems	Narang C.S.	Tata McGraw Hill Publications, New Delhi, 2012, ISBN: 978-0074633502
5	Instrumentation, Measurement and Analysis	Nakra B. C.; Chaudhary K.K.	Tata McGraw Hill Publications, 2010, New Delhi, ISBN:0070482969

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112106138
b. https://cosmolearning.org/video-lectures/pyrometry-cont
c. https://www.youtube.com/watch?v=VpmZjIsV4C4
d. www.youtube.com/watch?v=qNHZYAk9pI
e. https://www.youtube.com/watch?v=xcvNl1HHY9o
f. https://www.youtube.com/watch?v=DxdFiIDrFBc
g. https://www.youtube.com/watch?v=-_ZeUgVjajc
h. https://www.youtube.com/watch?v=iTjBPHtADA4
i. https://www.youtube.com/watch?v=I4h644S_64w
j. https://www.youtube.com/watch?v=XQT6RSNN9sA
k. https://www.youtube.com/watch?v=FgNAlKTTNtE
l. https://www.youtube.com/watch?v=sLZeR7RMGFA
m. https://www.youtube.com/watch?v=QGBRwXwxnuU
n. https://www.youtube.com/watch?v=jTbRMMgbnNU
o. https://www.youtube.com/watch?v=KeZ5CfPOlBc
p. https://www.youtube.com/watch?v=3hOVfbGSQ0c
q. https://www.youtube.com/watch?v=80sNyYPTXPA
r. https://www.youtube.com/watch?v=EWqThb9Z1jk
s. https://www.youtube.com/watch?v=j-u3IEgcTiQ
t. https://www.youtube.com/watch?v=CLEP5LQ-y0I

Program Name : Diploma in Mechanical Engineering

Program Code : ME

Semester : Fourth

Course Title : Fluid Mechanics and Machinery

Course Code : 22445

1. RATIONALE

Knowledge of fluid properties, fluid flow and fluid machinery is essential in all fields of engineering. Hydraulic machines have important role in water supply, irrigation, power generation and also in most of the engineering segments. This course is intended to develop the skills to estimate loss in pipes, efficiency of hydraulic machines like turbine, pumps etc., head on a pump and select a pump for a particular application, diagonose and rectify the faults in pumps and turbines, replace pressure gauges and other accessories on hydrauic machines turbines, and apply their knowledge in hydraulics to select appropriate devices like pressure gauges, valves, flow devices, pipes etc for different field applications.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain hydraulic machinery using knowledge of fluid mechanics.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use Manometers and Bourden gauge to measure pressure.
b. Use flow meters to measure the rate of flow.
c. Maintain flow through pipes.
d. Maintain the jet impact on various types of vanes for optimum efficiency.
e. Maintain hydraulic turbines.
f. Maintain hydraulic pumps.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment,* @ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

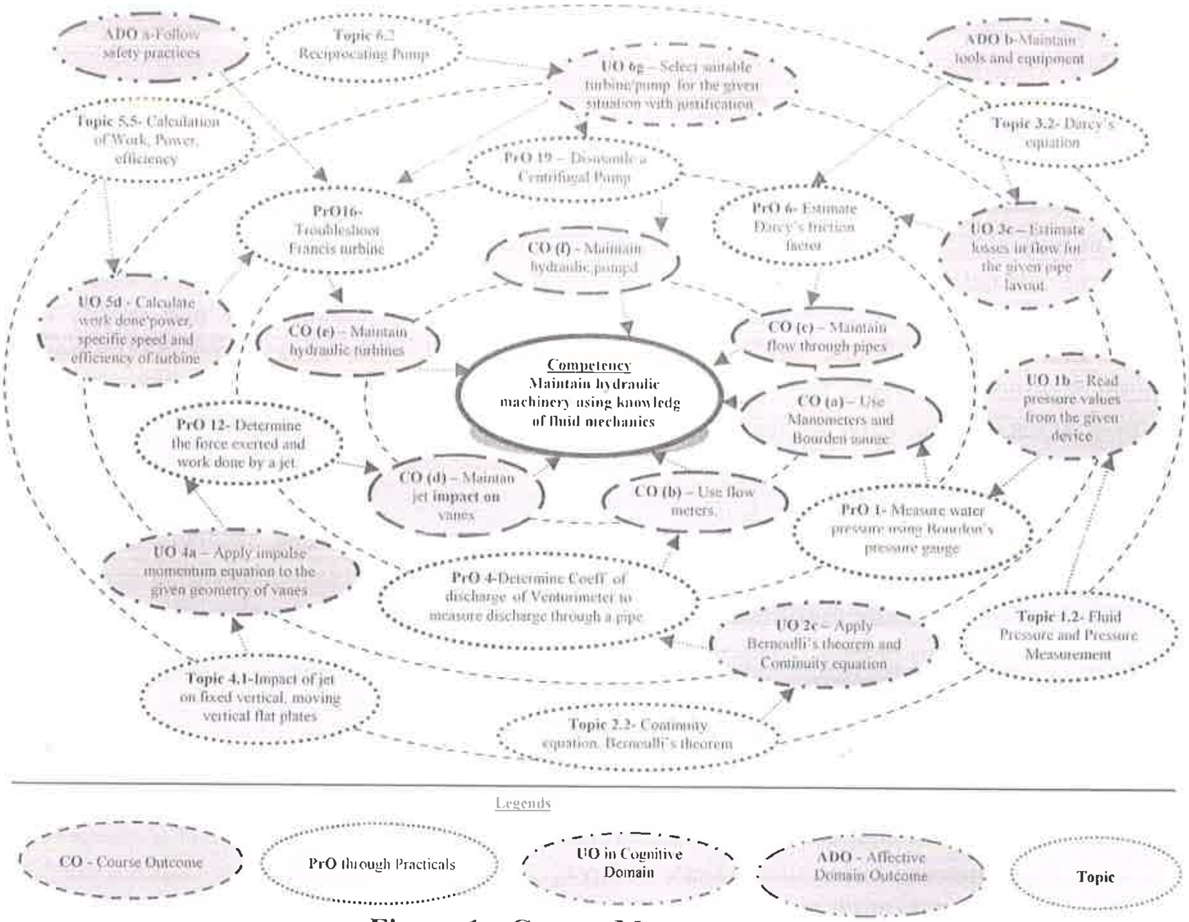


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use Bourdon's pressure gauge and U-tube Manometer to measure water pressure also Measure discharge of water using measuring tank and stop watch.	I	02*
2	Measure Total Energy available at different sections of a pipe layout	II	02
3	Use Venturimeter to measure discharge through a pipe	II	02*
4	Use Sharp edged circular orifice to measure discharge through a pipe	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
5	Estimate Darcy's friction factor 'f' in pipes of three different diameters for four different discharges	III	02
6	Determine frictional losses in sudden expansion and sudden contraction in pipe.	III	02*
7	Determine frictional losses in bend in pipe.	III	02
8	Determine frictional losses in elbow in pipe.	III	02
9	Determine the force exerted by a jet on flat plate	IV	02
10	Use Pelton wheel test rig to determine overall efficiency	V	02
11	Dismantle a Centrifugal pump.	VI	02*
12	Assemble a Centrifugal pump.	VI	02*
13	Determine overall efficiency of Centrifugal Pump	VI	02
14	Dismantle a Reciprocating pump	VI	02*
15	Assemble a Reciprocating pump	VI	02*
16	Determine overall efficiency of Reciprocating pump using Reciprocating pump test rig.*	VI	02*
17	Determine percent slip of Reciprocating pump.	VI	02
	Total		**34**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety and ethical practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.

f. Update yourself about the latest advancements happening in the field of fluid mechanics and machinery.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Bernoulli's theorem Apparatus.	1,3
2	Dead weight pressure gauge calibrater.	2
3	Flow measuring devices (Venturimeter/ orifice meter) Apparatus.	4
4	Hydraulic coefficient test rig.	5
5	Determination of major losses /minor losses in pipe fittings Apparatus.	6 to 11
6	Impact of jet test rig	12
7	Pelton wheel test rig.	13, 14
8	Francis turbine test rig	15
9	Turbine turbine test rig	16
10	Centrifugal pump test rig.	19 t0 21
11	Reciprocating pumps test rig.	22 to 25

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Properties of Fluid and Fluid Pressure	1a. Compare the given two fluids based on the given physical properties. 1b. Convert the pressure values from the chart of the given device and into the specified units. 1c. Choose the relevant pressure measuring device for the given situation with justification. 1d. Select the relevant pressure measuring devices for the given	1.1 Properties of Fluids: Density, Specific gravity, Specific volume, Specific Weight, Dynamic viscosity, Kinematic viscosity, Surface tension, Capillarity, Vapour, Pressure, Compressibility 1.2 Fluid Pressure and Pressure Measurement: Fluid pressure, Pressure head, Pressure intensity, Concept of absolute vacuum, gauge pressure, atmospheric pressure, absolute pressure; Simple and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	application with justification. 1e. Calculate fluid pressure, total pressure and centre of pressure on the given immersed body in the specified liquid and the given position.	differential manometers, Bourden pressure gauge; Total pressure, center of pressure on- regular surface immersed in given liquid in horizontal, vertical and inclined Positions.
Unit-II Fluid Flow	2a. Compare the types of fluid flow based on the given characteristic properties. 2b. Choose the relevant discharge measuring device for the given situation with justification. 2c. Apply Bernoulli's theorem and Continuity equation to the given discharge measuring device and data. 2d. Choose the relevant discharge measuring device for the given application with justification. 2e. Describe with sketches the procedure to calculate discharge using the given flow meter.	2.1 Types of fluid flows-Laminar, turbulent, steady, unsteady, uniform, non uniform, rotational, irrotational, one, two and three dimensional flow. 2.2 Continuity equation, Bernoulli's theorem. 2.3 Venturimeter – Construction, principle of working, coefficient of discharge, Derivation for discharge through venturimeter 2.4 Orifice meter – Construction, Principle of working, hydraulic coefficients. Derivation for discharge through Orifice meter 2.5 Pitot tube – Construction, Principle of Working
Unit– III Flow through Pipes	3a. Use laws of fluid friction for the given Laminar and turbulent flow. 3b. Use Darcy's equation and Chezy's equation for the given frictional losses. 3c. Estimate losses in flow for the given pipe layout. 3d. Calculate power transmitted and transmission efficiency for the given pipe layout and data.	3.1 Laws of fluid friction for Laminar and turbulent flow; Darcy's equation and Chezy's equation for frictional losses. 3.2 Minor losses in pipe fittings and valves; Hydraulic gradient line and total energy line. 3.3 Hydraulic power transmission through pipe 3.4 Water hammer phenomenon in pipes, causes and remedial measures.
Unit– IV Impact of Jet	4a. Apply impulse momentum equation to the given geometry of vanes and find equation for force and work done. 4b. Calculate force exerted by a jet, work done and efficiency for the given vane and data. 4c. Draw velocity diagram for the given curved vane with special reference to turbines. 4d. Draw velocity diagram for the given curved vane with special reference centrifugal pumps.	4.1 Impact of jet on fixed vertical, moving vertical flat plates. 4.2 Impact of jet on curved vanes with special reference to turbines and Pumps.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit –V Hydraulic Turbines	5a. Select the hydraulic turbine fo the given application with justification. 5b. Calculate work done, power, specific speed and efficiency of the given turbine and data. 5c. Describe with sketches the functioning of the given types of Draft tubes. 5d. Draw characteristic curves of the given turbine. 5e. Describe the procedure to troubleshoot the given type of hydraulic turbine with skethes.	5.1 Layout and features of hydroelectric power plant, surge tanks and its need. 5.2 Classification of hydraulic turbines and their applications. 5.3 Construction and working principle of Pelton wheel, Francis and Kaplan turbine. 5.4 Draft tubes – types and construction. Concept of cavitation in turbines. 5.5 Calculation of Work done, Power, efficiency of turbine.
Unit –VI Pumps	6a. Select the relevant hydraulic pumps fo the given application with justification. 6b. Calculate work required and efficiency of the given centrifugal pump ad data. 6c. Draw characteristic curves of the given pump. 6d. Calculate slip, efficiencies, and power required to drive the given reciprocating pump and data. 6e. Select the suitable pump for the given situation with justification. 6f. Describe the procedure to troubleshoot the given type of hydraulic pump with sketches.	6.1 Centrifugal Pumps: Construction, principle of working, priming methods and Cavitation; Types of casings and impellers; Static head Manometric head, Work done, Manometric efficiency, Overall efficiency. Numericals based on above parameters, NPSH, Performance Characteristics of Centrifugal pumps and its trouble shooting, Construction, working and applications of multistage pumps. Working principle and applications of Submersible pumps and Jet pump. 6.2 Reciprocating Pump: Construction, working principle and applications of single and double acting reciprocating pumps; Slip, Negative slip, Cavitation and separation. Use of Air Vessels; Indicator diagram with effect of acceleration head and frictional head; Pump selection criteria- head, discharge

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Properties of Fluid and Fluid Pressure	12	02	02	04	08
II	Fluid Flow	10	02	04	06	12
III	Flow through Pipes	10	02	04	06	12
IV	Impact of Jet	06	00	04	04	08
V	Hydraulic Turbines	12	02	04	08	14
VI	Pumps	14	04	04	08	16
	Total	**64**	**12**	**22**	**36**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Use various mechanical measuring instruments and equipments related to fluid mechanics and machinery.
d. Read and use specifications of the hydraulic machines and equipments.
e. Library / Internet survey of hydraulics and hudraulic machines
f. Prepare power point presentation or animation for understanding constructional details and working of different hydraulic machines.
g. Visit nearby shops to identify different PVC and GI pipe fittings. Collect manufacturing catalogues related to the same.
h. Visit nearby shops to identify different pumps. Collect manufacturing catalogues related to the same and compare their salient features.
i. Prepare a list of commercially available software related to computational Fluid dynamics (CFD).

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual domestic and industrial fluidic systems.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various fluid machinery and pipe line.
i. Use open source simulation software.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a pipe layout water suppy of your lab from supply reservoir and calculate the loss of head.
b. Prepare a chart of showing all the pressure and flow measuring devices.
c. Prepare a demonstration model of hydroelectric power plant.
d. Calculate running cost of your house hold pump and verify the electricity bill.
e. Gather information of hydroelectric power plants in Maharashtra, India and world.
f. Visit a hydroelectric power plant and write report.
g. Make a video to explain the Hydraulic power generation which could be understood by common man.
h. Select a pump for a coolant recirculation in lathe machine, Bore well pumps, pump at service station, pump used in water coolers, pump in purified water filter system with justification.
i. Download catalogue of pump manufacturer like kirloskar, cri,texmo,etc and compare their parameters.
j. Dissemble and assemble centrifugal pump for fault finding, troubleshooting and to identify wornout parts.
k. Prepare display chart of types of pipes on the basis of mareial, size and applications.
l. Study pressure gauges used by road side tyre worrks, blood pressure measurement by doctors., pressure gauges mounted on turbine test rig.
m. Visit to nearby pump manufacturing unit
n. Conduct market survey of pump suppliers and prepare report on technical specifications, area of applications, cost, material of different parts and maintenance procedure.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Hydraulics and Fluid Mechanics including Hydraulic Machines	Modi P.N. Seth S M	Standard Book House New Delhi, 2013. ISBN 978818940126
2	Fluid Mechanics and Hydraulic m/c	Bansal R. K.	Laxmi Publication Pvt. Ltd. New Delhi, 2013, ISBN 9788131808153
3	A text book of Fluid Mechanics and Hydraulic Machines	Rajput R. K.	S. Chand and Company Pvt. Ltd. New Delhi, 2000, ISBN 9789385401374
4	Fluid Mechanics and Hydraulic Machines: problems and solution	Subramanya K.	Tata McGraw-Hill Co. Ltd. New Delhi 2011, ISBN 9780070699809
5	Fluid Mechanics and Machinery	Ojha, Berndtsson, Chnadramouli	Oxford University Press, New Delhi 2000, ISBN 9780195699630
6	Introduction to Fluid Mechanics and Fluid Machines	Som S. K. , Biswas G.	Tata McGraw-Hill Co. Ltd. New Delhi 2005, ISBN 9780070667624
7	A Textbook of Hydraulics, Fluid Mechanics and Hydraulic Mechanics	Khurmi R. S.	S. Chand and Co. Ltd. New Delhi 2015, ISBN-13: 9788121901628
8	Hydraulic, fluid mechanics and fluid machines	Ramamrutham S.	Dhanpat Rai and Sons New Delhi 2011, ASIN: 8187433809
9	Fluid Mechanics	Streeter Victor, Benjamin Wylie E., Bedford K.W.	McGraw Hill Education; New Delhi, 2017,ISBN 978-0070701403
10	Hydraulic Machines	Jagdish lal	Metropolitan; 2008, ISBN-13: 9788120004221

14. SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses
b. www.learnerstv.com www.ni.com/multisim
c. https://www.youtube.com/watch?v=e6a2q9k2JCA
d. https://www.youtube.com/watch?v=5TTnFccqJEE
e. https://www.youtube.com/watch?v=3Gq3tR3fkM0
f. https://www.youtube.com/watch?v=UNBWI6MV_IY
g. https://www.youtube.com/watch?v=ljMVt7T4HQM
h. https://www.youtube.com/watch?v=wnOQMk7pKak
i. https://www.youtube.com/watch?v=IcJOkRZPNMI
j. https://www.youtube.com/watch?v=w7n0srAzm8g
k. https://www.youtube.com/watch?v=f9LY0-WP9Go
l. https://www.youtube.com/watch?v=tXLI-IeAynI

m. https://www.youtube.com/watch?v=qbyL--6q7_4
n. https://www.youtube.com/watch?v=3BCiFeykRzo
o. https://www.youtube.com/watch?v=0p03UTgpnDU
p. https://www.youtube.com/watch?v=BaEHVpKc-1Q
q. https://www.youtube.com/watch?v=oQqMrtc6kJQ

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fourth**

Course Title : **Manufacturing Processes**

Course Code : **22446**

1. RATIONALE

Diploma engineers require the knowledge of core principles of manufacturing processes to design, analyze and manufacture industrial equipments, transport systems, aircrafts, robots and others. This subject intends to help the students in performing various operations on Lathe. Drilling machine. Shaper. Slotter. Welding and Foundry shop. It gives insight of how the raw material gets converted into finished products using various manufacturing processes an parameters.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Produce components using conventional manufacturing processes.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Produce jobs using lathe and drilling machines.
b. Produce jobs using shaping and slotting operations.
c. Prepare product using different casting processes.
d. Prepare product using different forming processes.
e. Use joining process to produce jobs.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment.* @ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

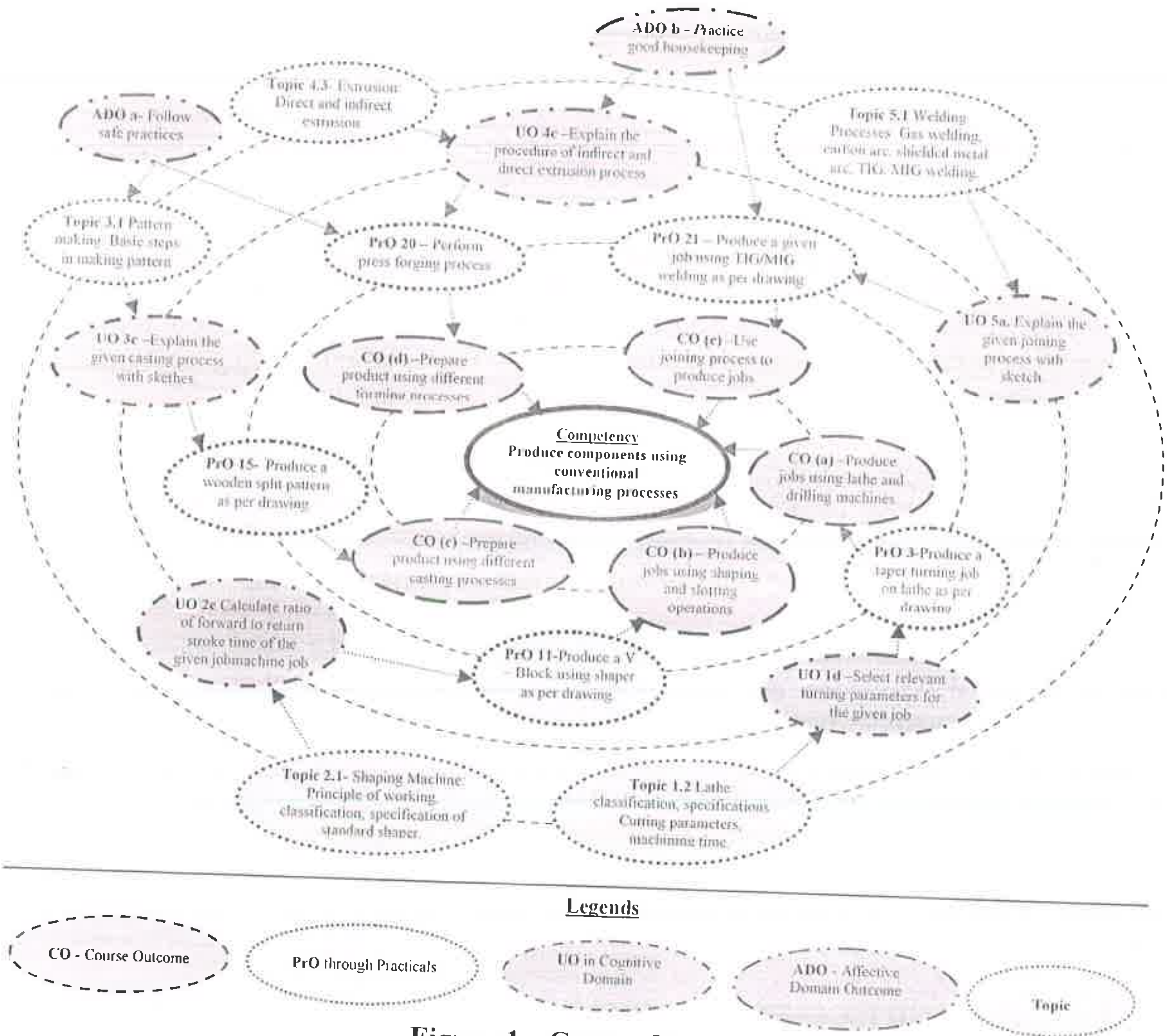


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/EXERCISES:

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Produce a plain turning job on lathe as per given drawing.	I	02*
2.	Produce a step turning job on lathe as per given drawing.	I	02
3.	Produce a taper turning job on lathe as per given drawing.	I	02
4.	Produce a turning job on lathe with knurling and chamfering operation as per given drawing	I	02*
5.	Produce an eccentric turning job on lathe as per given drawing	I	02
6.	Produce turning job on lathe with threading operation as per given drawing	I	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7.	Produce turning job on lathe with drilling and boring operations as per given drawing.	I	02*
8.	Use radial drilling machine to produce job with drilling, reaming, tapping and countersinking operation as per given drawing.	I	02*
9.	Produce drilling job on radial drilling machine with boring and spot facing operation as per given drawing.	I	02
10.	Use radial drilling machine to produce job with counterboring and counter-sunk operation as per given drawing.	I	02
11.	Produce a wooden solid pattern as per given drawing.	III	02
12.	Produce a mould by using solid pattern/split pattern as per drawing.	III	02*
13.	Produce a simple Job/product with the help of Hand Plastic molding machine as per given drawing.	III	02
14.	Produce a given job using TIG/MIG welding as per drawing.	V	02
15.	Perform soldering / brazing operation on the given job.	V	02*
	Total		**30**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
a.	Preparation of Job drawing, selection of material, tool and estimation of cutting parameters.	20
b.	Setup of machine, tool and Job	15
c.	Actual machining operation	20
d.	Inspection of Job using measuring instrument.	15
e.	Answer to questions on operations	10
f.	Submission of job and workshop diary in time.	10
g.	Safety precautions and good housekeeping	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/or a team member.
d. Maintain tools and equipment in good working condition.
e. Handle the machine and tools with care.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Center Lathe Machine (Length between centers : 2000 mm)	1 to 7
2	Radial drilling machine (Drill diameter : upto 40 mm)	8 to10
3	Shaping/Slotting machine (Maximum stroke length : upto 150 mm)	11to13
4	Pattern making, moulding and casting shop with necessary equipments.	14 to16
5	Plastic Hand Moulding Machine	17
6	Rolling mill made for Laboratory work	18
7	Hardness Tester with standard specification of Rockwell Hardness	18
8	Metallurgical Microscope ideal for examining Large and Single Side polished Metal samples	18
9	Extruder and extrusion dies	19
10	Feed system mechanism.	19
11	Forging press	20
12	Dies and punches for press forging.	20
13	Reheating furnace	20
14	TIG/MIG welding set up with suitable specification	21
15	Soldering machine	22

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-I Fundamentals of Machining and Machining Operations	1a. Identify different machining operations to be performed for the given job with justification. 1b. Explain with sketches the procedure of performing the given lathe machine operation on a job. 1c. Explain with sketches the procedure of performing the given Drilling machine operation on a job.	1.1 **Machining Process:** Mechanics of Chip formation, Single point cutting Tool and its geometry. Methods of Machining, Types of Chips, Principal elements of Metal Machining. 1.2 **Lathe:** classification, specifications of center lathe; Basic parts of center lathe and their functions; Lathe accessories: chucks (three jaw, four jaw, and magnetic chuck), mandrels, rests, face plates, centers, and angle

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	1d. Select the relevant turning and drilling process parameters for the given job with justification. 1e. Explain with sketches to measure cutting speed, feed, and depth of cut for the given job in turning and drilling operations.	plates; Lathe operations like facing, plain turning, taper turning, thread cutting, chamfering, grooving, knurling. Cutting tool nomenclature and tool signature. Cutting parameters – speed, feed, depth of cut and machining time. 1.3 **Drill Machine**: Classification, specifications of radial drilling machine. Basic parts of radial drilling machine, sensitive drilling and their functions. Drilling machine operations like drilling, reaming, boring, counter sinking, counter boring, spot facing. Cutting parameters - speed, feed, depth of cut and machining time.
Unit –II Shaping/ Slotting Machines.	2a. Explain with sketches the working of shaping and slotting machines with sketches. 2b. Select the relevant cutting speed, feed, depth of cut for the given job with justification. 2c. Calculate ratio of forward to return stroke time of the given shaping machine job. 2d. Explain with sketches the procedure to produce keyway by the given machine as per the given sketch.	2.1 **Shaping Machine**: Principle of working, classification, specification of standard shaper. Basic parts of standard shaping machine and their functions. Quick return mechanism. Different shaping operations. 2.2 **Slotting Machine**: Principle of working, classification, specification. Basic parts of Slotting machine and their functions.
Unit – III Casting Processes and Plastic Moulding :	3a. Design a pattern for the given job. 3b. Design a mould for the given the job. 3c. Explain with sketches the given casting process with skethes. 3d. Select the relevant furnace for the given raw material with justification. 3e. Select the relevant plastic moulding process for the given job with justification.	3.1 **Pattern making:** Basic steps in making pattern, types, materials and allowances. 3.2 Color coding of patterns 3.3 **Moulding**: Types of moulding sands, properties of sand, moulding methods, cores and core prints. Elements of gating system. Bench and floor moulding methods. 3.4 **Casting:** Safety practices / precautions in foundry shop. Furnaces, construction and working of cupola furnace, electric arc furnace. Centrifugal casting- Method and applications. Casting defects -

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Causes and remedies. 3.5 **Plastic:** Types of plastics; Plastic processing like Calendering and vacuum forming. 3.6 **Plastic moulding methods** – Compression moulding, Injection moulding, Blow moulding and Extrusion. Applications of plastic moulding methods.
Unit– IV Forming Processes	4a. Select the relevant forming process for the given component with justification. 4b. Identify the point of differences between forging, rolling and extrusion process with justification and sketches. 4c. Explain with sketches the given extrusion process as per the given job with sketches.	4.1 **Drop forging:** Introduction to forging. Upset forging, press forging, open die and closed die forging operations. 4.2 **Rolling:** Principle of rolling, hot and cold rolling. Types and applications of rolling mill. 4.3 **Extrusion:** Direct and indirect extrusion. Advantages, disadvantages, applications of extrusion processes.
Unit–V Joining Processes	5a. Explain with sketches the given joining process with sketch. 5b. Select the relevant joining process for the given job with justification. 5c. Select the relevant soldering/ brazing process for the given job with justification. 5d. Identify types of the welding defects in the figure given component with justification. 5e. Select the relevant fillers as per the job with justification.	5.1 **Welding Processes:** Gas welding, carbon arc welding, shielded metal arc welding, TIG welding, MIG welding, plasma arc welding, resistance welding types - spot, seam and projection. Electron beam welding, laser beam welding, welding defects. 5.2 **Introduction to soldering and brazing** Process, fillers, heating methods and applications.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of machining and Machining Operations	12	04	04	08	16
II	Shaping/Slotting Machines.	08	02	04	06	12
III	Casting Processes and plastic moulding	12	04	06	08	18

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
IV	Forming Processes	10	02	06	08	16
V	Joining Processes	06	02	02	04	08
	Total	**48**	**14**	**22**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Visit a Foundry shop and observe the Centrifugal/Investment/Die Casting process and identify the different defects on the surface of component.
b. Visit a plastic molding industry and collect information on types of molding machines, its specification and observe various activities performed in a molding process.
c. Visit an industry where the operation like drop forging, rolling and extrusion are carried out. Collect information on types these machines, their specification and observe various activities performed and characteristics of output product.
d. Visit a Industry/workshop to observe the process like seam, spot, TIG and MIG welding. Collect information on these machines, their specification and observe these processes critically to get information regarding various accessories (electrodes, current rating etc.) used in these processes.
e. Collect information of recent advancement in manufacturing processes, machines/tools/equipment and their specifications/manufacturer and application in the industries.
f. Collect information of various forming processes used in industries. Observe shape of input and output products and suggest suitable operation for various jobs.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

f. Demonstrate the different components of the machine to the students thoroughly before they start doing the practice.
g. Demonstrate trouble shooting practice to the students.
h. Encourage students to refer different technical websites, videos of manufacturing processes to have deeper understanding of the subject.

12. SUGGESTED MICROPROJECT:

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Prepare a cast product of different mechanical engineering drawing models with wax material.
b) Prepare various types of welding joints (with metal components). Display them on wall board.
c) Fabricate types of keys like sunk key, woodruff key, spline etc.
d) Prepare various types of patterns/ core/ core box etc with suitable material.
e) Prepare a model of Quick-Return Mechanism using wood material.
f) Prepare model Pulley and Belt drive system used in the lathe.
g) Prepare Model of Direct Extrusion process.
h) Prepare Hammer forging working Model.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Manufacturing Engineering Handbook	Hwaiyu Geng	McGraw Hill,New York, 2000, ISBN:9780071398251
2	Workshop Technology, Volume- I and II	Raghuvanshi B.S.	Dhanpat Rai Publications, New Delhi, 2009, ISBN 10:0470534915
3	Production Technology (Manufacturing Processes)	Sharma P.C.	S. Chand and Company, 2013, New Delhi, ISBN:9788721911146
4	Text book of Production Technology	Khanna O.P.	Dhanpat Rai Publications, New Delhi, 2010, ISBN :9788189928322
5	A text book of Foundry Technolgy	Khanna O.P.	Dhanpat Rai Publications, New Delhi, 2010, ISBN :9788189928346
6	Elements of workshop Technology-Volume I	Chaudhary Hajra S.K.	Media Promoters and Publishers Ltd., Mumbai, 2005

	and Volume II		ISBN : 9788185099156
7	Workshop Technology Volume- I and II	Bawa H.S.	McGraw-Hill Education, New Delhi, 2011. ISBN : 13:EBK0009651
8	Workshop Technology Part- I and II	Chapman W.	Taylor and Francis, New Delhi, 1995, ISBN:13:9780415503020
9	Materials and Processing in Manufacturing	Black J.T. Kosher Ronald A.	Wiley India Pvt.Ltd., New Delhi 1999, ISBN:9788126540464

14. LEARNING WEBSITES

a) http://nptel.ac.in
b) www.basicmechanicalengineering.com/lathe-machine-operations-basic-turning-
c) www.mechengg.net/2016/0peration-performed-on-shaping-machine.html
d) www.protolabs.com/injection-molding/plastic-injection-molding/
e) www.thelibraryofmanufacturing.com /forming_basics.html
f) www.themetalcasting.com/casting-process.html

Program Name : **Diploma in Production Engineering/Production Technology/ Mechanical Engineering/Civil Engineering/Electrical Engineering**

Program Code : **PG/PT/ME/CE/CR/CS/EE/EP/EU**

Semester : **Fourth**

Course Title : **Environmental Studies**

Course Code : **22447**

1. RATIONALE

The world today is facing the biggest challenge of survival. Degradation of ecosystem, depletion of natural resources, increasing levels of pollution pose major threat to the survival of mankind. The need of the hour, therefore, is to concentrate on the area of environmental aspects, which shall provide an insight into various environment related issues. Environmental studies are an interdisciplinary academic field that integrates physical, chemical and biological sciences, with the study of the environment. It provides an integrated, quantitative, and interdisciplinary approach to the study of environmental system & gives an insight into solutions of environmental problems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Diagnose and manage environment related issues**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Develop Public awareness about environment
b. Select alternative energy resources for Engineering Practice
c. Conserve Ecosystem and Biodiversity
d. Apply techniques to reduce Environmental Pollution
e. Manage social issues and Environmental Ethics as lifelong learning

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(#) Online Theory Examination.

(*): *Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.*

Legends: L*-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

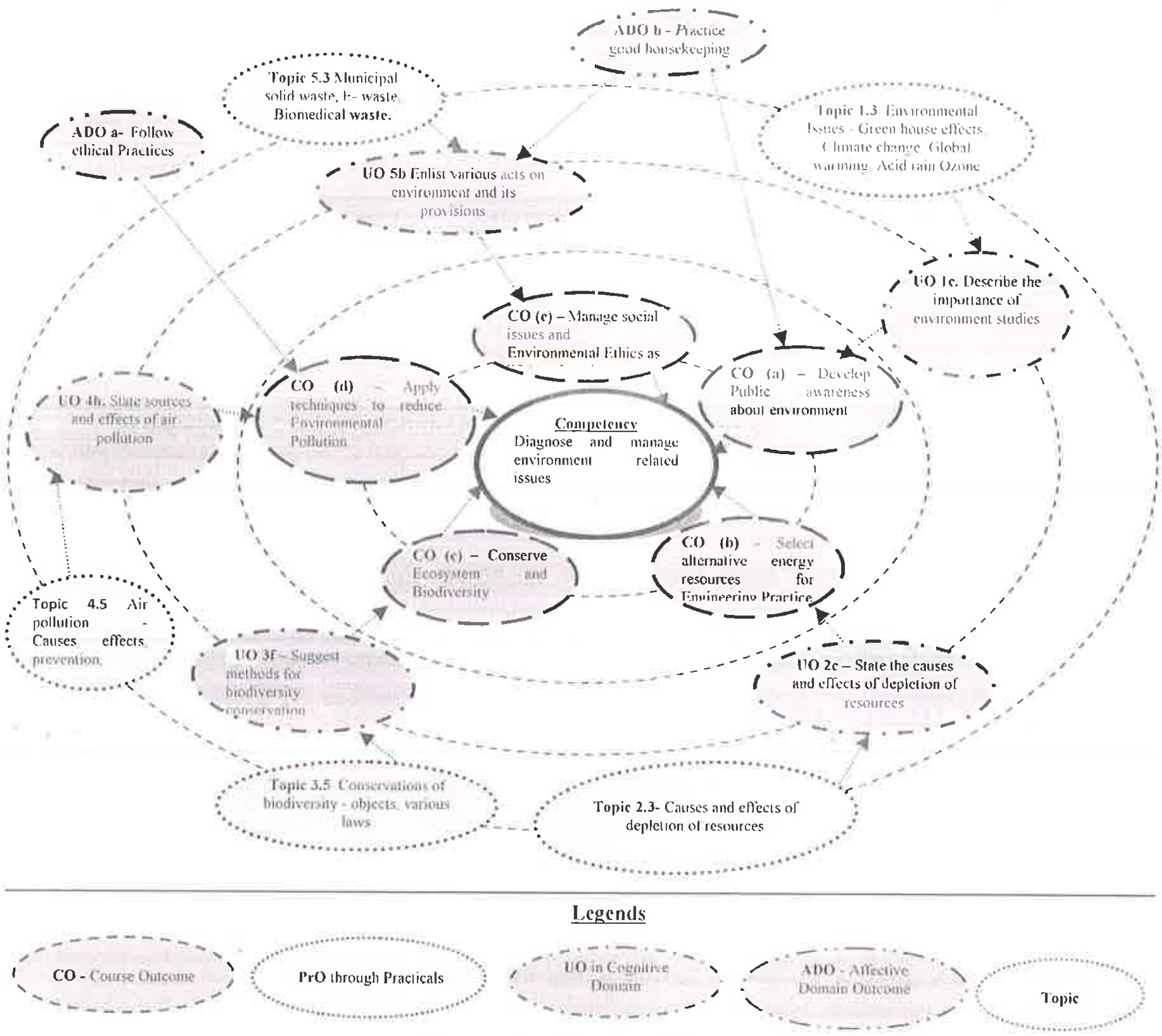


Figure 1 - Course Map

6. SUGGESTED EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	NIL		
	Total		

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student* *reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	NIL	
	Total	

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	NIL	-

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Environment	1a. Discuss the scope of Environment. 1b. Describe various types of environment 1c. Describe the importance of environment studies. 1d. Discuss about the need of public awareness about environment. 1e. Describe various	1.1 Definitions, need of environmental studies. 1.2 Segments of environment- Atmosphere, Hydrosphere Lithosphere, Biosphere. 1.3 Environmental Issues - Green house effects, Climate change, Global warming, Acid rain Ozone layer depletion, Nuclear accidents. 1.4 Concept of 4R (Reduce, Reuse,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	environmental issues.	Recycle and Recover). 1.5 Public awareness about environment.
Unit– II Energy Resources	2a. List various natural resources. 2b. Describe Renewable. Nonrenewable and Cyclic resources. 2c. State the causes and effects of depletion of resources. 2d. State advantages and disadvantages of forms of energy. 2e. Select appropriate solutions of efficient use of energy. 2f. State the impacts of overuse of natural resources.	2.1 Natural Resources - Forest Resources, Water Resources, Energy Resources. Land resources, Mineral resources. 2.2 Renewable, Non-renewable and Cyclic Resources. 2.3 Causes and effects of depletion of resources. 2.4 Energy forms (Conventional and non-conventional). 2.5 Present global energy use and future demands. 2.6 Energy conservation. 2.7 Over use of natural resources and its impacts on environment.
Unit- III Ecosystem and Biodiversity	3a. State the aspects and division of ecosystem. 3b. State the general characteristics and function of ecosystem. 3c. List levels of biodiversity. 3d. Enlist the endangered species. 3e. Describe value of biodiversity. 3f. Suggest methods for biodiversity conservation.	3.1 Ecosystem - Definition , Aspects of ecosystem, Division of ecosystem, General characteristics of ecosystem, Functions of ecosystem. 3.2 Biodiversity - Definitions, Levels, Value and loss of biodiversity. 3.3 Biodiversity assessment initiatives in India. 3.4 Threats and Hotspots of biodiversity. 3.5 Conservations of biodiversity - objects, various laws.
Unit– IV Environmental Pollution	4a. Define pollution. 4b. State the sources of pollution. 4c. State the effects of land pollution on environment and lives. 4d. State various units and their functions of water treatment plant. 4e. State the needs of water conservation. 4f. State the impacts of sewage. 4g. State various units and their functions of sewage treatment plant. 4h. State sources and effects of air pollution. 4i. Describe various methods to prevent air pollution. 4j. State sources and effects of noise pollution.	4.1 Definition of pollution, types- Natural & Artificial (Man- made). 4.2 Soil / Land Pollution – Causes and effects on environment and lives , preventive measures. 4.3 Water Pollution - Sources of water (surface and sub surface), sources of water pollution, effects on environment and lives, preventive measures, BIS water quality standards, flow diagram of water treatment plant, Water conservation. 4.4 Wastewater - Generation(domestic and industrial), Impacts, flow diagram of sewage treatment plant, CPCB norms of sewage discharge. 4.5 Air pollution - Causes, effects, prevention, Ambient air quality standards. 4.6 Noise pollution - Sources, effects,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	4k. Describe preventive measures for noise pollution. 4l. State characteristics of solid waste. 4m. State the impacts of solid waste. 4n. Describe incineration, RDF and sanitary landfilling. 4o. State the standards limiting/controlling values of various types of pollution.	prevention, noise levels at various zones of the city. 4.7 Municipal Solid Waste, Bio-medical waste and E-waste - Sources, generation, characteristics, effects, and methods to manage.
Unit-V Social Issues and Environmental Education	5a. Elaborate article (48-A) and (51-A (g)) 5b. Enlist various acts on environment and its provisions. 5c. State the roles and responsibilities of CPCB. 5d. Define sustainable development, and EIA. 5e. Describe rain water harvesting and groundwater recharge. 5f. Differentiate between formal and non formal education.	5.1 Article (48-A) and (51-A (g)) of Indian Constitution regarding environment, Environmental protection and prevention acts, CPCB and MPCB norms and responsibilities. The role of NGOs. 5.2 Concept of sustainable development, EIA and environmental morality. 5.3 Management Measures - Rain Water harvesting, Ground water recharge, Green Belt Development, Use of Renewable energy, water shed management, interlinking of rivers. 5.4 Role of information technology in environment and human health.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Environment	06	4	6	-	10
II	Energy Resources	10	4	8	4	16
III	Ecosystem and Biodiversity	08	4	4	4	12
IV	Environmental Pollution	16	8	8	4	20
V	Social Issues and Environmental Education	08	4	4	4	12
	Total	**48**	**24**	**30**	**16**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual*

distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Plant and adopt a tree in your nearby locality/Polytechnic campus and prepare report about its growth and survival after six months with photos.
b. Organize seminar on air pollutants of relevant MIDC area/vehicle
c. Organize poster exhibition about global warming and ozone depletion.
d. Visit a nearest water purification/effluent treatment plant.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use proper equivalent analogy to explain different concepts.
g. Use Flash/Animations to explain various topics.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a report on visit to PUC Center.
b. Visit a near by RO plant and prepare detail technical report
c. Prepare report on Household water filtration unit

d. Prepare a list of polluted natural resources which are responsible for pollution and collect information on how to manage them .
e. **Collection of Data from Hospital: Collect** everyday information on percentage of solid hazardous and toxic waste for two month
f. **Visit of Municipal Effluent Treatment Plant:** Visit effluent treatment plant and prepare report on waste management.
g. **Visit of Water Treatment Plant:** Visit water treatment plant and prepare report on various units of water treatment and its management.
h. **Preparation of report**: Prepare the chart of solid waste management showing effects on environment.
i. **And any other relevant topic related to course**

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Basic Environmental Sciences	Michael Allaby	Routledge Publication, 2nd Edition, 2000, ISBN: 0-415-21176-X
2	Environmental Science	Y. K. Singh	New Age International Publishers, 2006, ISBN: 81-224-2330-2
3	Environmental Studies	Erach Bharucha	University Grants Commission, New Delhi
4	Environmental Studies	Rajagopalan	Third Edition, Oxford University Press, USA, ISBN: 9780199459759, 0199459754
5	A text book of Environmental Science	Arvind Kumar	APH Publishing New Delhi
6	A text book of Environmental Studies	Shashi Chawla	Tata Mc Graw-Hill New Delhi

14. SOFTWARE/LEARNING WEBSITES

a. www.eco-prayer.org
b. www.teriin.org
c. www.cpcb.nic.in
d. www.indiaenvironmentportal.org.in
e. www.whatis.techtarget.com
f. www.sustainabledevelopment.un.org
g. www.conserve-energy-future.com

Maharashtra State Board of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechnical Engineering

Program Code : ME **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters **Duration : 16 Weeks**

Semester : Fifth **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme													Grand Total
								Theory							Practical						
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total		
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Management	MAN	22509	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	Power Engineering and Refrigeration	PER	22562	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
3	Advanced Manufacturing Processes	AMP	22563	4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
4	Elements of Machine Design	EMD	22564	4	-	2	6	4	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Elective (Any One)																				
5	Tool Engineering	TEN	22565	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Power Plant Engineering	PPE	22566	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Solid Modeling and Additive Manufacturing	SMA	22053	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
7	Industrial Training	ITR	22057	-	-	6	6	--	--	--	--	--	--	--	75#	30	75	30	150	60	150
8	Capstone Project Planning	CPP	22058	-	-	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20	50
			Total	**17**	-	**22**	**39**	--	**350**	--	**150**	--	**500**	--	**275**	--	**275**	--	**550**	--	**1050**

Student Contact Hours Per Week: **39 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks **: 1050**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**
- **Evalution of Industrial Training and its reports is to done after completion of Industrial Training. Credits of Industrial Training will not affect the framing of time table.**

Program Name : **Diploma in Mechanical Engineering / Plastic Engineering**

Program Code : **ME / PS**

Semester : **Fifth**

Course Title : **Solid Modelling and Additive Manufacturing**

Course Code : **22053**

1. RATIONALE

Mechanical, Plastic, Automobile and allied Industries need to build model based applications which are being developed using "**solid modeling software**". This course deals with concepts of solid modeling to enhance solid modeling skills of diploma students. This course will enable the students to inculcate solid modeling and additive manufacturing concepts and methodology to solve engineering problems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Develop 'Solid Models' of given machine components using any parametric CAD software.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Prepare 2D Drawing using sketcher workbench of any parametric CAD software.
b. Generate 3D Solid models from 2D sketch using Part workbench of any parametric CAD software.
c. Prepare assembly of part models using Assembly workbench of any parametric CAD software.
d. Generate orthographic views of 3D solid models/assemblies using drafting workbench of any parametric CAD software.
e. Plot a drawing for given part model/assembly.
f. Print components using 3D Printer/Rapid prototyping machine.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *– Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

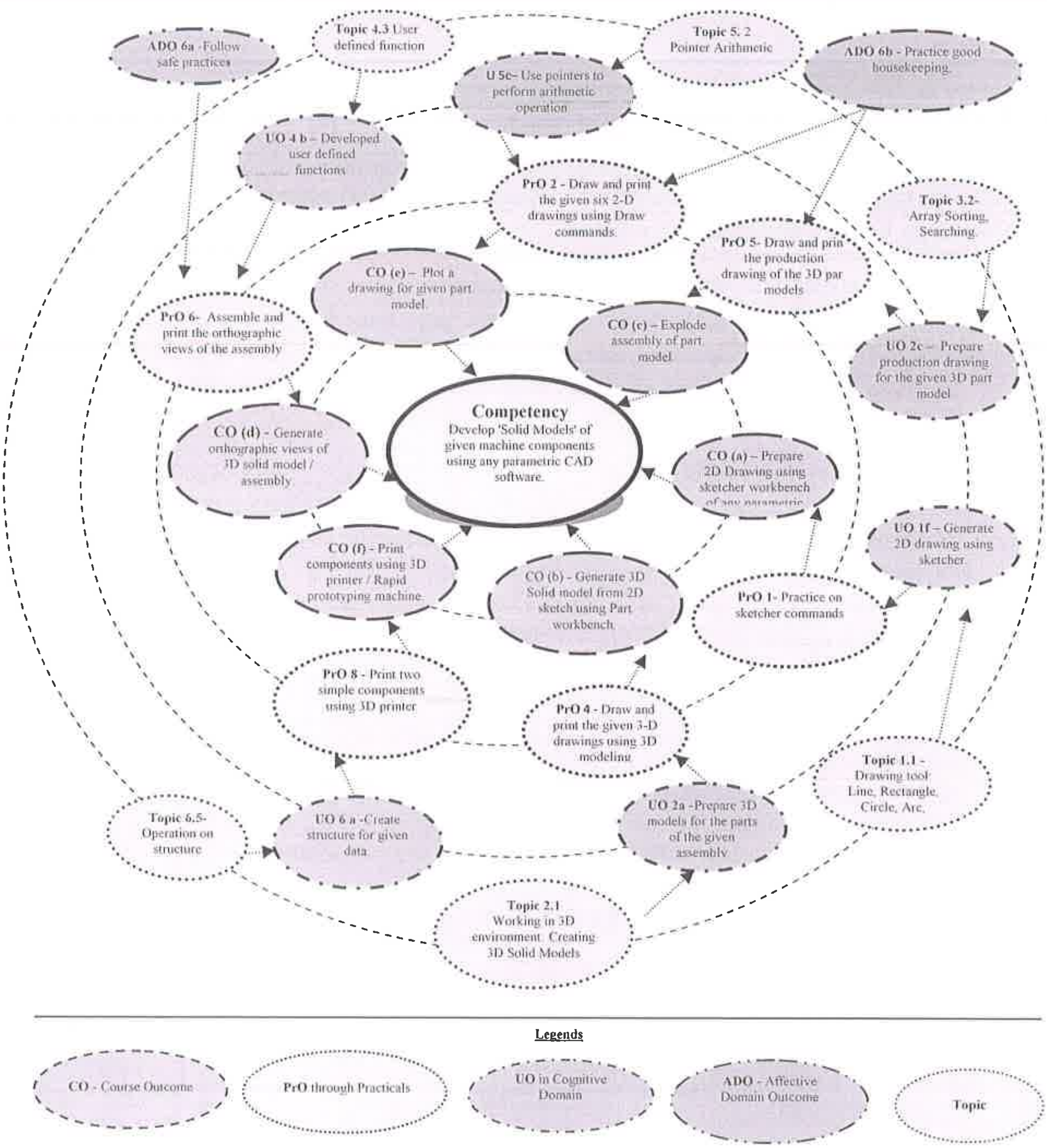


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare drawing template consisting of Name plate boundary lines and projection symbol.	I	02
2.	Draw and print two simple 2D geometries using sketcher commands	I, V	02*
3.	Draw and print two complex 2D geometries using sketcher commands	I, V	02
4.	Draw and print the given two simple 3-D drawings using 3D modeling commands	II, V	02*
5.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem-I)	II, V	02
6.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
7.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
8.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
9.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - I)	III, IV, V	02
10.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – I continued)	III, IV, V	02
11.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem - II)	II, V	02
12.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
13.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
14.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
15.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any	III, IV,	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	assembly consisting of at least five parts. (Problem - II)	V	
16.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – II continued)	III, IV, V	02
17.	Print simple component using 3D printer / Rapid prototyping machine.	VI	02
18.	Print a complex component using 3D printer / Rapid prototyping machine. (Problem – I)	VI	02
	Total		**36**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Use of proper commands	40
2	Completion of drawing with minimum size of model tree	20
3	Generation and printing of drawing views, tables, etc. and their arrangement on different sheet sizes.	20
4	Able to answer oral questions.	10
5	Completion of work in time.	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Handle solid modeling software carefully.
e. Plan for creation of solid model.
f. Demonstrate working as a leader / a team member.
g. Maintain software tools and equipment.
h. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year

- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Expt. Sr. No.
1	Hardware: Personal computer, (i3/ i5 or higher), RAM minimum 4 GB, A3 / A4 size printer / plotter. Display-wide Screen preferably.	For all Experiments
2	Operating system: Windows XP/Windows 7/ Windows 8/Windows 10 or higher.	
3	Software: Any parametric solid modeling software.	
4	3D printer / Rapid prototyping Machine.	17, 18

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Working in 2D environment.	1a. Describe the given sketcher commands. 1b. Demonstrate the given modify commands. 1c. Apply dimensioning and Constraints	1.1 Drawing tool: Line, Rectangle, Circle, Arc, Ellipse, Spline, etc. 1.2 Editing tool: Trim, Extend, Erase, Mirror, etc. 1.3 Modify tool: Chamfer, Fillet, Copy, Move, etc. 1.4 Linear, angular dimensions. 1.5 Dimensioning constraint and Geometrical constraint. 1.6 Drawing template: prepare drawing template consisting of Name plate boundary lines and projection symbol.
Unit– II Development of Solid Models.	2a. Prepare 3D models for the parts of the given assembly using different commands with minimum tree. 2b. Describe intersection of the given Solid. 2c. Prepare production drawing for the given 3D part model / assembly.	2.1 Working in 3D environment: Creating 3D Solid Models of simple machine parts. 2.2 Part tool: Extrude, Hole, Revolve, Rib, Sweep, Swept blend, Pattern, etc. 2.3 Part Editing tool: Trim, Extend, Erase, Mirror, 2.4 Part Modify tool: Chamfer, Round, Copy, Move, Draft, etc. 2.5 Intersect 2 solid components by inserting new body option. Boolean operations: Union, subtract, intersection.
Unit– III Computer aided	3a. Use of assembly tools to prepare assembly using given 3D solid models.	3.1 Assembly Drawing: Preparation of assembly drawing by using assembly command.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Assembly	3b. Use of explode command for the given assembly.	3.2 Exploded view: Explode the assembly.
Unit-IV Drafting of 3D assembly	4a. Use drawing module to create orthographic views for the given assembly. 4b. Generate Bill of material for given assembly Drawing.	4.1 Orthographic projections: Generate orthographic projections of the assembly. 4.2 Bill of material: Prepare part list table.
Unit –V Plotting	5a. Use different settings for plotting. 5b. Use printer to plot drawing on A3 or A4 size sheet.	5.1 Printer selection, paper size, orientation. 5.2 Page set up.
Unit-VI Additive Manufac turing	6a. Describe the process of Additive manufacturing. 6b. Study construction and working of 3D printer / Rapid prototyping machine. 6c. Describe materials use for 3D printer / Rapid prototyping machine.	6.1 Additive manufacturing: 3D printing, Rapid prototyping. 6.2 File format: STL (Stereo Lithography). 6.3 3D printer software: part import, orientation, processing and printing.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed in laboratory.
b. Give seminar on relevant topic.
c. Library/E-Book survey regarding 'Solid modeling' used in manufacturing industries.
d. Prepare power point presentation or animation for drafting/solid modeling/assembly/exploded view/3D printing.
e. List applications of 3D printing.
f. Visit to institute/industry having 3D printer/Rapid Prototyping machine.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the

development of the COs through classroom presentations (see implementation guideline for details).

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual design and additive manufacturing.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain 3D printing and Rapid prototyping manufacturing methods.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **2D drawing**: Each student will collect one or two drawings from the nearby industry/workshop and prepare a 2D drawing from it.
b. **3D model**: Each student will identify a small assembly from the institute workshop/laboratory. Measure the dimensions of each part and prepare sketches. Using sketches prepared 3D model of parts and assembly. Plot the assembly and detail drawings. (eg. Bench vice, Machine vice, Tool post, Couplings, Joints, Bearings etc.)
c. **3D printing/RPT**: Each student will visit a nearby institute/industry. Collect information regarding troubleshooting of 3D printer/Rapid prototyping machine and prepare a report.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	CATIA V5R17 for Designers	Sham Tickoo	Softcover, Cadcim Technologies
2	Pro/Engineer Wildfire for Designers	Sham Tickoo	Softcover, Cadcim Technologies
3	Solid Works For Designers Release 2006	Sham Tickoo	Softcover, Cadcim Technologies
4	Autodesk Inventor for Designers: Release 10	Sham Tickoo	Softcover, Cadcim Technologies

S. No.	Title of Book	Author	Publication
5	NX 4 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
6	Solid Edge V19 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
7			

14. SOFTWARE/LEARNING WEBSITES

a. http://www.solidworks.in/sw/products/3d-cad/3d-solid-modeling.htm
b. http://web.iitd.ac.in/~hegde/cad/lecture/L30_solidmod_basics.pdf
c. https://en.wikipedia.org/wiki/Solid_modeling
d. http://npkauto.com/solid-modeling/
e. https://www.youtube.com/watch?v=vjX4PDJcFOI
f. https://www.youtube.com/watch?v=5BDHS4FN2-
g. https://www.youtube.com/watch?v=JjKs-lePlPY

Program Name : **All Branches of Diploma in Engineering and Technology.**

Program Code : **CE/CR/CS/CH/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/ MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC**

Semester : **Fifth**

Course Title : **Capstone Project – Planning**

Course Code : **22058**

1. RATIONALE

According to the requirement of National Board of Accreditation (NBA), 'learning to learn' is an important Graduate Attribute (GA No.11). It is required to develop this skill in the students so that they continue to acquire on their own new knowledge and skills from different 'on the job experiences' during their career in industry. An educational 'project' just does that and may be defined as ***'a purposeful student activity, planned, designed and performed by a student or group of students to solve/ complete the identified problem/task, which require students to integrate the various skills acquired over a period to accomplish higher level cognitive and affective domain outcomes and sometimes the psychomotor domain outcomes as well'***. Projects mainly serve this purpose of developing learning-to-learn skills with an aim to develop the following attributes in the students:

a) Initiative, confidence and ability to tackle new problems
b) Spirit of enquiry
c) Creativity and innovativeness
d) Planning and decision making skills
e) Ability to work in a team and to lead a team
f) Ability of self directed learning which is required for lifelong learning
g) Persistence (habit of not giving up quickly and trying different solutions in case of momentary failures, till success is achieved)
h) Resourcefulness
i) Habit of keeping proper records of events and to present a formal comprehensive report of their work.

2. COMPETENCY

The course should be taught and implemented with the aim to develop the required course outcomes (COs) so that students will acquire following competency needed by the industry:

- **Plan innovative/creative solutions independently and/or collaboratively to integrate various competencies acquired during the semesters to solve/complete the identified problems/task/shortcomings faced by industry/user related to the concerned occupation.**

3. COURSE OUTCOMES (COs)

The following could be some of the major course outcomes depending upon the nature of the projects undertaken. However, in case of some projects few of the following course outcomes may not be applicable.

a) Write the problem/task specification in existing systems related to the occupation.
b) Select, collect and use required information/knowledge to solve the problem/complete the task.
c) Logically choose relevant possible solution(s).
d) Consider the ethical issues related to the project (if there are any).
e) Assess the impact of the project on society (if there is any).
f) Prepare 'project proposals' with action plan and time duration scientifically before beginning of project.

g) Communicate effectively and confidently as a member and leader of team.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
-	-	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. Capstones Project

One of the dictionary meaning is the 'crown' or the stone placed on top of the building structure like 'kalash on top of Temples and Mosques' or 'Cross on top of churches'. Capstone projects are culminating experiences in which students synthesize the competencies acquired over whole programme. In some cases they also integrate cross-disciplinary knowledge. Thus Capstone projects prepare students for entry into a career and can be described as a 'rite of passage' or 'minimal threshold' through which participants change their status from student to graduate. A capstone project therefore should serve as a synthesis — reflection and integration— to bridge the real-world preparatory experience to real life. Thus capstone project should have emphasis on integration, experiential learning, and real-world problem solving and hence these projects are very important for students. To develop the highly essential industry oriented skills and competencies in the students, the capstone projects are offered in the last two semesters to serve for following purposes:

a) Integrate the competencies acquired by the students in the previous and current semesters.
b) Provide opportunities for interdisciplinary work in tackling problems likely to be faced by them in industry which are exciting and challenging.

6. Capstone Project Planning

Students are supposed to find out a suitable project and prepare a detailed plan in fifth semester so that it can be executed smoothly in sixth semester. The main characteristic of any project whether small or big is that it requires simultaneous application of various types of skills in the different domains of learning. Moreover, project normally do not have a predefined single solution, in other words for the same problem different students may come up with different but acceptable solutions. Further, in the process of arriving at a particular solution, the student must be required to make a number of decisions after scrutiny of the information s/he has accumulated from experiments, analysis, survey and other sources.

The projects will have a detailed project proposal, which must be executed or implemented within the time allocated, simultaneously maintaining a logbook periodically monitored by the teacher. A detailed project report is to be prepared as project progresses, which has to be submitted after the project is over. For self assessment and reflection students have to also prepare a portfolio of learning.

During the guidance and supervision of the project work, teachers' should ensure that students acquire following ***learning outcomes*** (depending upon the nature of the project work some of these learning outcomes may not be applicable):

a) Show the attitude of enquiry.
b) Identify the problems in the area related to their programme.
c) Identify the information suggesting the cause of the problem and possible solutions.
d) Assess the feasibility of different solutions and the financial implications.

e) Collect relevant data from different sources (books/internet/market/suppliers/experts etc. through surveys/interviews).
f) Prepare required drawings and detailed plan for execution of the work.
g) Work persistently and participate effectively in group work to achieve the targets.
h) Work independently for the individual responsibility undertaken.
i) Ask for help from others including guide, when required.
j) Prepare portfolio to reflect *(chintan-manan)* on experiences during project work.
k) Prepare seminar presentations to present findings/features of the project.
l) Confidently answer the questions asked about the project.
m) Acknowledge the help rendered by others in success of the project.

If students are able to acquire these *learning outcomes*, then they would be able to acquire the COs as discussed in section 3.

7. Scopes of Projects

Scope of the project work should be decided based on following criteria:

a) Relation to diploma programme curriculum: When students intend to select topics for the project work they need to choose a project which relates well to their curriculum (It may be beyond curriculum, but it should relate to it) and requires implementation of theories already learnt and skills already possessed by them from the previous semesters.

b) Abilities possessed by the group of students: Projects should be chosen so that it can be completed mainly using students' problem solving capabilities and depth of learning. It is natural that highly motivated students or high achievers may come out with projects which are more complex and challenging. Teachers should guide students to choose challenging projects according to the students' ability.

c) Resources Available: Students and Guides should keep in mind the availability of resources while deciding the topic and the scope of the project. Some of the important resources which need consideration are:

i. Time available
ii. Raw Material/Components required
iii. Manufacturing/Fabrication equipment and tools required
iv. Testing/Measuring equipment and instruments required
v. Access to Journals (Library/Digital)
vi. Expertise for theoretical guidance (available in polytechnic, nearby institutes or nearby industries)
vii. Expertise and technology required for fabrication (if required)
viii. Software required.

An important aspect to be considered is to decide who will choose a project. The best practice is that teacher should guide students about the above factors to be considered for choosing the project and based on these factors students should do the ground work and identify the possible projects and teachers should work as only facilitator and Guide in final selection of the project title and its scope.

d) Suggested Type of Capstone Projects

In general, the projects that the students can take up could be of the following types;

i. Feasibility studies.
ii. Design projects
iii. Market surveys about raw material, components or finished products.
iv. Prototype (design, make, test and evaluate).
v. Advanced experimental work requiring the development of existing equipment to be used and developed.
vi. Field works: This could include surveys, using equipment, charting data and information from visual observation.

vii. Comparative Studies: Theoretical study of two systems/mechanisms/ processes in detail and comparing them on the basis of cost/energy conservation/impact on environment/technology used etc.
viii. Application of Emerging technology: Theoretical study of some emerging technology and feasibility of its application in some real life situation in detail.
ix. Fabrication of some equipment/machine etc.
x. Construction of some structure.
xi. Development of software or use of software for solving some broad-based problem.

8. GUIDELINES FOR UNDERTAKING A PROJECT

The selection of the *Capstone Project title* must have emphasis to the Elective courses/ Elective Group taken for the study and exam for 5th and 6th semester. The students will then work on the identified problem/task through a rigorous process of understanding and analyzing the problem, conducting a literature search, deriving, discussing (monitored by the guide every fortnight) and designing the ***Semester V 'Project Proposal'*** with the following ***sub-titles***:

a) Rationale (one page)
b) Introduction
c) Literature Survey
d) Problem Definition
e) Proposed Methodology of solving Identified problem
f) In-case some prototype has to be fabricated then its tentative design and procedure for making it should be part of the proposal.
g) Resources and consumables required.
h) Action Plan (sequential list of activities with probable dates of completion)

As soon as the 'Project Proposal' is approved by the teacher, the student will begin to maintain a dated ***'Project Logbook'*** for the whole semester. This is a sort of a 'weekly diary' indicating all the activities conducted by the student every week in the semester to complete the project. This *'project logbook'* should be got signed by the teacher at regular intervals for progressive assessment to match the project proposal. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the 'Project Report' at the end of the semester by him/her.

9. PORTFOLIO FOR SELF-DIRECTED LEARNING

To ensure that students acquire these outcomes, students should also be guided to prepare a **'Portfolio'**, so that they may reflect on their weaknesses/mistakes and learn from them. ***Students should also be encouraged to discuss with their guide and record not only technical problems but also problems related to group work, planning, execution, leadership in the team etc., so that students can also identify their weaknesses in affective domain and take remedial actions to overcome the same.*** If they wish, the students can also show their portfolio to their teachers (whom they trust) for obtaining teachers' comments on their reflection for pointing out their mistakes so that they can improve their performance.

'Portfolio' is the record of the reflection (thinking or *chintan-manan*) on experiences to which students undergo during the different stages of the project. In a portfolio, students record their critical experiences and reflect (think or do *chintan-manan*) on them in writing. This process of reflecting on the experiences make them learn from their mistakes and build on their strengths. To help students in reflection, a Portfolio format with reflective prompts (simple thought provoking questions) for different stages of the project is given as annexure B.

12.1 Purposes of Portfolio Preparation

Reflection by self is important since group work is so complex that it is difficult for teachers to appreciate the real problems amongst the students. In a portfolio, prompts (simple thought provoking questions) are given to trigger reflection on different aspects of project work. Prompts help the students to ask questions from themselves regarding different aspects of the project work and interpersonal relationships. Process of answering these questions forces students to think about behavioral problems and possible remedies/solution to deal with those problems. Portfolio preparation therefore helps in reflection on building the strengths and elimination of the weaknesses of the students pertaining to following qualities which the industry also need.

a) Plan properly for execution of given work.
b) Take appropriate decisions.
c) Arrange resources.
d) Work as member and leader of team.
e) Communicate properly.
f) Resolve the conflicts.
g) Manage the time well.
h) Have concern for ethical, societal and environmental issues.
i) Learn-to-learn from experiences.

It may be seen that these qualities are not directly related with the theoretical subject knowledge and can be developed only through real life experiences. Project work is one such type of experience where opportunity is available to develop all these qualities.

However, even during project work, emphasis of most of the students and teachers remains on development of the technical knowledge and skills while development of above qualities is neglected. Students can develop these qualities if they reflect (do thinking or *Chintan-Manan*) on their experiences from the point of view of these qualities and find out their own weaknesses and strengths. Because if somebody wants to improve his/her abilities then first step for that person is to have self awareness about his/her weaknesses and strengths.

Though portfolio preparation requires considerable time, it is essential, if we want to learn from the experiences and develop these qualities. Writing down reflections helps in better reflection as it is well known that when a person starts writing something he/she becomes more cautious about his/her view and evaluate those views before writing. Thus process of writing improves the quality of reflection or thinking. Moreover, if reflections on different stages of work are written down, over a period of time a large amount of reflection can be generated, and if this reflection is looked back, it may help in identifying some pattern of behaviour in individual which may be improved or rectified latter on as per requirement.

12.2 Guidelines for Portfolio Preparation and assessment

The main purpose of portfolio preparation is learning based on self-assessment and ***portfolio is not to be used for assessment in traditional sense.***

a) Each student has to prepare his/her portfolio separately. However, he/she can discuss with the group members about certain issues on which he/she wants to write in the portfolio.
b) For fifth semester and sixth semester, there will be only one portfolio but it will have two separate parts, first part for project planning (having two sections A and B) second part for project execution. (having two sections C and D)
c) Whatever is written inside the ***portfolio is never to be used for assessment***, because if teachers start giving marks based on whatever is written in the portfolio, then students would hesitate in true self-assessment and would not openly describe their own mistakes or shortcomings.

d) Some marks are allocated for portfolio, these marks are to be given based on how sincerely portfolio has been prepared and not based on what strengths and weaknesses of the students are mentioned in the portfolio.
e) Portfolio has to be returned back to the students after assessing it (assessment is only to see that whether portfolio is completed properly or not) by teachers. Because student is the real owner of the portfolio.
f) Students mainly learn during portfolio preparation, but they can further learn if they read it after a gap. And hence they are supposed to keep the portfolios with them even after completion of the diploma because it is record of their own experiences (it is like diary some people write about their personal experiences), because they can read it again after some time and can revise their learning (about their own qualities)

Even after completion of Diploma programme, students can continue to prepare portfolio related to different experiences in their professional and personal life and by refereeing back to old portfolios after a gap of some years, they can learn that how their personality has evolved over the years. They can also see a pattern of behaviour in their own personality which may be source of their weaknesses or strengths and they can take remedial measures based on this study of their portfolios.

Note

Since some sections of the portfolio are related with interpersonal relationships and student may find it difficult to write these experiences in English. Language should not be the barrier in reflection and hence students should be allowed to prepare the portfolio in their preferred language such as *Marathi* or *Hindi if they find it difficult to write in English.*

The amount and type of mistakes identified by students would not affect the marks received by the students. The total 7 Marks allocated for portfolio (4 marks for PA and 3 for ESE) are only for proper completion of the portfolio.

10. PROJECT REPORT

At the end of fifth Semester, the student will prepare a Semester V 'Project Report' with the following sub-titles:

- Certificate (in the Format given in this document as annexure A)
- Acknowledgements
- Abstract (in one paragraph not more than 150 words)
- Content Page
- Chapter-1 Introduction and background of the Industry or User based Problem
- Chapter-2 Literature Survey for Problem Identification and Specification,
- Chapter-3 Proposed Detailed Methodology of solving the identified problem with action plan
- References and Bibliography

Note: The report should contain relevant diagrams and figures, charts.

11. ASSESSMENT OF CAPSTONE PROJECT – PLANNING

Like other courses, assessment of Project work also has two components, first is progressive assessment, while another is end of the term assessment. The mentor faculty will undertake the progressive assessment to develop the COs in the students. They can give oral informal feedback about their performance and their interpersonal behaviour while guiding them on their project work every week. The following characteristics/ qualities informally or formally should be considered during different phases of the project work which will be assessed thrice as discussed in sub-section.

(A) Initial Phase

i. **Definition of the Problem**

a) Accuracy or specificity

b) Appropriateness with reference to desired course outcomes.

ii. **Methodology of Conduction the Project**

a) Appropriateness
b) Flexibility
c) Clarity

iii. **General Behaviour**

a) Initiative
b) Resourcefulness
c) Reasoning ability
d) Imagination/creativity
e) Self-reliance

(B) Intermediate Phase

i. **Performance of Student**

a) Ability to follow correct procedure
b) Manipulative skills
c) Ability to collect relevant information
d) Ability to observe, record & interpret
e) Ingenuity in the use of material and equipment
f) Target achievement

ii. **General Behaviour**

a) Persistence
b) Interest
c) Commitment
d) Confidence
e) Problem solving ability
f) Decision making ability
g) Initiative to act
h) Team spirit.
i) Sharing of material etc.
j) Participation in discussion
k) Completion of individual responsibilities

(C) Final Phase

i. **Quality of Product**

a) Dimensions
b) Shape
c) Tolerance limits
d) Cost effectiveness
c) Marketability
f) Modernity

ii. **Quality of Report**

a) Clarity in presentation and organization
b) Styles and language
c) Quality of diagrams, drawings and graphs
d) Accuracy of conclusion drawn
e) Citing of cross references
f) Suggestion for further research/project work

iii. **Quality of presentation**

a) Understanding of concepts, design, methodology, results, implications etc
b) Communication skills
c) Ability to draw conclusions and generalization

12. PROGRESSIVE ASSESSMENT (PA) GUIDELINES

15 Marks are allocated for the formal progressive assessment. However, following points need consideration during the three times of formal progressive assessment of the students at the end of 4th, 12th and 14th week.

a) ***Fortnightly monitoring*** by the mentoring teachers is necessary and marks given progressively (even the gradual chapter preparation) so that that students will not copy earlier reports or get things done or reports from the market. The ***students should not be awarded marks*** if they have not done on their own.
b) For progressive assessment at the end of 14th week, students should be asked to give the power point presentation before group of teachers and junior students (so that junior students may also get awareness about the capstone project work they have to carry out in future).
c) Although marks for *portfolio preparation* is to be given at the end of 14th week, students should be asked to bring their partly prepared portfolio (relevant sections prepared) also during their assessment at the end of 4th week and 12th week.
d) Marks for portfolio preparation should be based only on proper preparation of portfolio by writing answers to most of the prompts (self-questions to students) in the portfolio. These marks should not be based on the mistakes indicated by students in their working (while answering the prompts) and corrective actions taken by them.
e) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks if they have done enough efforts.)
f) ***Originality of the report*** (written in own words) would be given more importance rather than use of glossy paper or multi-colour printing.

12.1 Progressive Assessment (PA) Criteria

Allocation Criteria of the ***25 marks*** are for the Progressive Assessment (PA).

S. No.	Criteria	Marks
	First Progressive Assessment at the end of 4th week	
1	**Problem Identification/Project Title** (Innovation /Utility of the Project for industry/ User/Academia) marks to be also given based on (i) Accuracy or specificity of the scope and (ii) Appropriateness of the work with reference to desired course outcomes.	02
2	**Industrial Survey and Literature Review**: marks to be given based on extent/volume and quality of the survey of Industry / Society / Institutes/Literature/Internet for Problem Identification and possible solutions	02
3	**General Behaviour**: initiative, resourcefulness, reasoning ability, imagination/creativity, self-reliance to be assessed **Note:** Oral feedback on general behaviour may also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back/suggestions**	**00**
	Second Progressive Assessment at the end of 12th week	
4	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester	**03**

S. No.	Criteria	Marks
5	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	02
6	**Log book** (for work done in fifth semester, detailed and regular entry would be basis of marks)	02
7	**General Behaviour** (persistence, interest, confidence, problem solving ability, decision making ability, initiative to act, team spirit, sharing of material etc., participation in discussions, completion of individual responsibilities, leadership) **Note:** Oral feedback on general behaviour should also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back./suggestions**	00
	Third Progressive Assessment at the end of 14th week	
8	**Portfolio for Self learning and reflection** (marks based on amount of reflection and completion of the portfolio for work done in fifth semester)	**04**
9	**Final Report writing including documentation**. (marks based on: clarity in presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work) Report has to be prepared for work done in fifth semester and planning for sixth semester work.	**06**
10	**Presentation** (presentation skills including communication skills to be assessed by observing quality of presentations and asking questions during presentation and viva/voce) Report has to be prepared for work done in fifth semester and plan for sixth semester.	**02**
11	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**02**
	Total	**25**

13. END-SEMESTER-EXAMINATION (ESE) ASSESSENT GUIDELINES

The ***remaining 25 marks*** are for the end-semester-examination (ESE). And marks would be given according to following criteria. Moreover, the suggested evaluation scheme can be changed slightly by the external faculty according to nature of problem / project following University guidelines..

a) For each project, the one or two students from the concerned group of students should be asked to present the power point presentation before the external and internal (for about 10 minutes) and then external should ask the questions from each member of the group separately to ascertain the contribution made by each student.

b) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks commensurate with their efforts.)

c) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).

d) Originality of the report (written in own words, even if there are grammatical and spelling mistakes) would be given more importance rather than quality of printing and use of glossy paper (and preparing report by copy pasting from other reports).

Note: It is very common that people are not able to complete the project in time despite best of their efforts. (Please recall that how many times people are able to complete in time, personal projects such as building own house or professional projects such as developing the lab in the institute). So if students have put in enough genuine efforts but could not complete the project in time then we should consider it sympathetically and they should be given marks based on their efforts and they should get more marks as compared to students who have got their projects completed by taking major help from others/market.

13.1 End-Semester-Examination (ESE) Assessment Criteria.
Allocation Criteria of the ***25 marks*** are for the end-semester-examination (ESE)

S. No.	Description	Marks
1	**Problem Identification/Project Title** (innovation /utility of the project for industry/ user/academia) marks to be also given based on (i) accuracy or specificity of the scope and (ii) appropriateness of the work with reference to desired course outcomes.	**02**
2	**Industrial Survey and Literature Review** (marks to be given based on extent/volume and quality of the survey of industry / society / institutes/literature/internet for problem identification and possible solutions)	**02**
3	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester.	**02**
4	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	**02**
5	**Log book** (for work during fifth semester, marks to be given based on detailed and regular entry	**03**
6	**Portfolio for Self learning and reflection** (for work during fifth semester) Marks based on amount of reflection and completion of portfolio.	**03**
7	**Project Report including Documentation** (for work during fifth semester and planning for sixth semester) (marks based on: clarity in	**04**

S. No.	Description	Marks
	presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work)	
8	**Presentation** (presentation skills including communication skills to be assessed by observing the quality of presentations and asking questions during presentation and viva/voce) Presentation should be based on work done in fifth semester and planning for sixth semester.	**03**
9	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**04**
Total		**25**

14. SPECIAL TEACHING STRETAGIES (If any)

a) Teacher's should not spoon feed the students and let them try on their own at different stages of the project work and even first let them strive hard and only when efforts of students have failed, then teacher should guide them. Guidance should be in initially in the form of clues or hints rather than complete explanation, detailed explanation should be given only when students are not able to work based on clues/hints. The role of teacher should be limited to guide and facilitator

b) Teachers should guide students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) Teachers should ensure that students prepare the project plan in as much detail as possible, since this way only they would learn the importance of planning and how to do the detail planning. Teachers should allow students to proceed ahead only when they have detailed plan with them.

d) Teachers should motivate students to maintain log book and prepare portfolio. They should explain benefits of these activities to students and also train them in these activities, because most of them may be doing this first time.

e) Teachers should also encourage students to openly discuss their weaknesses and shortcomings in portfolio and teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them and their marks would not be affected by revealing their mistakes. Marks related to portfolio are awarded based only on the sincerity with which it is prepared and not based on strengths and weaknesses of students.

f) Teachers should continuously discuss with students about working of group and progress in the project and from this discussion should identify their personal qualities (both strengths and weaknesses) and suggest to them ways for improving those qualities.

g) Internal as well as external examiners should reward students for original work and efforts of students even if they are not fully successful or not able to complete the project in comparison to those students who have taken paid help from others to complete their project.

Annexure A

CERTIFICATE

This is to certify that Mr./Ms..

From ....College having Enrolment No: ....

has completed ***Report on the Problem Definition/ Semester V Project Report/ Final Project Report*** having title ....

individually/ in a group consisting of...................... persons under the guidance of the Faculty Guide.

....
The mentor from the industry for the project
Name: ....
Telephone:...

Annexure B

Portfolio for Self Directed Learning for Major Project Work

Name of Student:...

Semester:...............................Programme/Branch:...

Roll Number:...

Title of the Project:...

Name and Designation of Project Guide:...

Name of Polytechnic:...

Part A: Selecting the Project and Team (Answers to the following questions to be included in 'Portfolio' as Reflection related to formation of group and finalization of project topic).

Note: This section has to be prepared just after the finalization of the Project topic and formation of the Project Team .

1. How many alternatives we thought before finalizing the project topic?
2. Did we consider all the technical fields related to branch of our diploma programme?
3. Why we found present project topic as most appropriate?
4. Whether all the group members agreed on the present project topic? If not? What were the reasons of their disagreements?
5. Whether the procedure followed in assessing alternatives and finalizing the project topic was correct? If not, discuss the reasons.
6. What were the limitations in other alternatives of project topic?
7. How we formed our team?
8. Whether we faced any problem in forming the team? If yes, then what was the problem and how was it resolved?

9. Am I the leader of our project team? If yes, then why was I chosen? If not, why I could not become the project team leader?
10. Do I feel that present team leader is the best choice available in the group? If yes, then why? If not, then why?
11. According to me who should be the leader of the team and why?
12. Can we achieve the targets set in the project work within the time and cost limits?
13. What are my significant good/ bad sharable experiences while working with my team which provoked me to think? What I learned from these experiences?
14. Any other reflection which I would like to write about formation of team and finalization of project title, if any?

Part B: Reflection related to project planning (Answers to the following questions to be included in 'Portfolio' as reflection on planning)

Note: This section has to be prepared just after the finalization of the 'Project Proposal'.

1. Which activities are having maximum risk and uncertainty in our project plan?
2. What are most important activities in our project plan?
3. Is work distribution is equal for all project group members? If not? What are the reasons? How we can improve work distribution?
4. Is it possible to complete the project in given time? If not what are the reasons for it? How can we ensure that project is completed within time.
5. What extra precaution and care should be taken in executing the activities of high risk and uncertainty? If possible, how such risks and uncertainties can be reduced?
6. Can we reduce the total cost associated with the project? If yes, then describe the ways?
7. For which activities of our project plan, arrangement of resources is not easy and convenient?
8. Did we make enough provisions of extra time/expenditure etc. to carry out such activities?
9. Did we make enough provisions for time delays in our project activity? In which activities there are more chances of delay?
10. In our project schedule, which are the days of more expenditure? What provisions we have made for availability and management of cash?
11. Any other reflection which I would like to write about project planning?

Teacher Evaluation Sheet (ESE)
for
Capstone Project Planning

Name of Student: ....

Name of Programme... **Semester:** ....

Course Title and Code:...

Title of the Capstone Project: ....

A. POs addressed by the Capstone Project (Mention only those predominant POs)

a) ....
b) ....
c) ....
d) ....

B. COs addressed by the Capstone Project (Mention only those predominant POs)

a) ....
b) ....
c) ....
d) ....

C. OTHER LEARNING OUTCOMES ACHIEVED THROUGH THIS PROJECT

a) Unit Outcomes (Cognitive Domain)

i. ....
ii. ....
iii. ....
iv. ....

b) Practical Outcomes (in Psychomotor Domain)

i. ....
ii. ....
iii. ....
....
iv. ....
....

c) Affective Domain Outcomes

i. ....
ii. ....
iii. ....
iv. ....

D. SUGGESTED RUBRIC FOR ASSESSMENT OF CAPSTONE PROJECT

(please tick below the appropriate rating i.e. poor, average etc., for each characteristic to be assessed and give marks in the respective cell according to performance of student)

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
First Progressive Assessment (at the end of 4^{th} week)							

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
1	**Problem/Task Identification (Project Title)**	Relate to very few POs Scope of Problem not clear at all	i. Related to some POs ii. Scope of Problem/Task vague	i. Take care of at-least Three POs ii. Scope of Problem/task not very specific	i. Take care of more than three POs ii. Scope of problem/task very clear	**02**	
2	**Literature Survey /Industrial Survey**	Not more than ten sources (primary and secondary), very old reference	At-least 10 relevant sources, at least 5 latest	At –least 15 relevant sources, most latest	About 20 relevant sources, most latest	**02**	
	Second Progressive Assessment (at the end of 12th week)						
3	**Project proposal**	Methods are not appropriate, All steps not mentioned, Design of prototype not started (if applicable).	Appropriate plan but not in much detail. Plan B for critical activities not mentioned. Time line is not developed. Design of Prototype is not complete. (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, but clarity is not there in methods, time line is given but not appropriate. Design of prototype is not detailed (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, clarity in methods with time line, Detailed design of prototype (if applicable)	**02**	
4	**Execution of Plan in fifth semester (please write by hand about students performance in appropriate column)**					**02**	
5	**Log Book**	Entries for most weeks are missing. There is no proper sequence and details are not correct.	Entries for some weeks are missing, details are not appropriate, not signed regularly by the guide.	Entries were made every week but are not in detail. Signed and approved by guide every week	Entries were made every week in detail, signed and approved by guide every week	**03**	
	Third progressive Assessment at the end of 14th week						
6	Portfolio Preparation	Answer to only few of the 'questions from self' (prompts)	Answer to only about 50% of the 'questions from self'	Answer to most of the 'questions from self' (prompts) written. Some	Answer to nearly all the 'questions from self' (prompts) written in detail	**03**	

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
		written. Answers are not in much detail	(prompts) written. Answers are not in much detail	answers are not in much detail			
7	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions omitted, some details are wrong Nearly sufficient and correct details about methods, material, precautions and conclusion. but clarity is not there in presentation, not enough graphic description.	Detailed, correct and clear description of methods, materials, precautions and	Conclusions. Sufficient Graphic Description.	Very detailed, correct, clear description of methods, materials, precautions and conclusions. Enough tables, charts and sketches	**04**	
8	**Presentation**	Major information is not included, information is not well organized .	Includes major information but not well organized and not presented well	Includes major information and well organized but not presented well	Well organized, includes major information ,well presented	**03**	
9	**Defense**	Could not reply to considerable number of question.	Replied to considerable number of questions but not very properly	Replied properly to considerable number of question.	Replied to most of the questions properly	**04**	
					Total marks	**25**	

Any Other Comment:

....

....

Name and designation of the Faculty Member...**Signature**..............................

....

Program Name : **Diploma in Mechanical Engineering / Electrical Engineering Group / Chemical Engineering / Plastic Engineering**

Program Code : **ME / EE / EP / EU / CH / PS**

Semester : **Fifth**

Course Title : **Management**

Course Code : **22509**

1. RATIONALE

An engineer has to work in industry with human capital and machines. Therefore, managerial skills are essential for enhancing their employability and career growth. This course is therefore designed to provide the basic concepts in management principles, safety aspects and Industrial Acts.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use relevant managerial skills for ensuring efficient and effective management.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use basic management principles to execute daily activities.
b. Use principles of planning and organising for accomplishment of tasks.
c. Use principles of directing and controlling for implementing the plans.
d. Apply principles of safety management in all activities.
e. Understand various provisions of industrial acts.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(*#) Online Theory Examination.

(*): *Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the Cos.(*#): Online examination*

Legends: *L-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

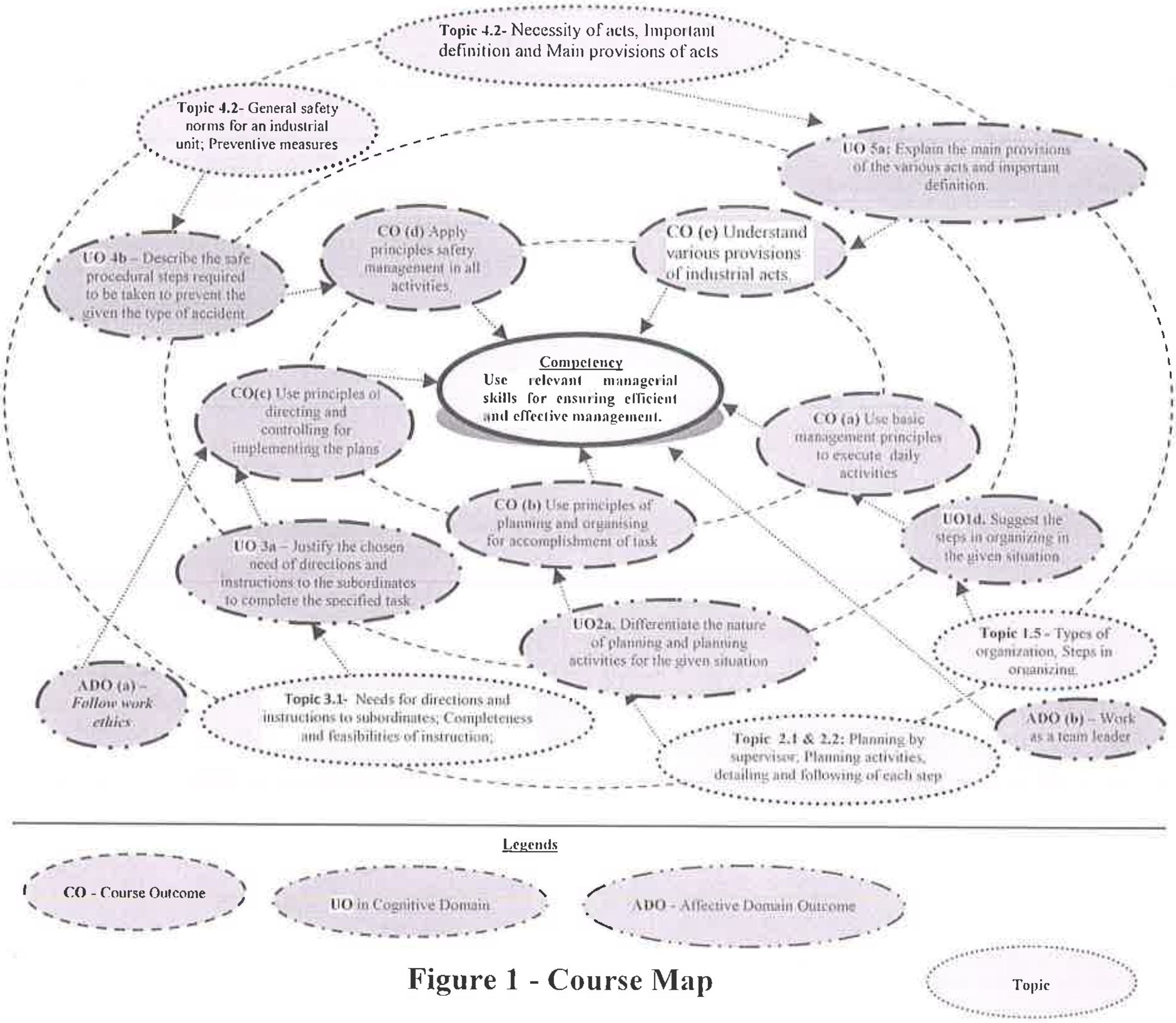


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

- Not applicable -

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

- Not applicable -

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to management concepts and managerial skills	1a. Differentiate the concept and principles of management for the given situation. 1b. Explain functions of management for given situation. 1c. Compare the features of the given types of planning 1d. Suggest the steps in organizing in the given situation. 1e. Suggest suitable type of organization for the given example. 1f. Identify the functional areas of management for the given situation 1g. Suggest suitable managerial skills for given situation with justification	1.1 Definitions of management, role and importance of management. 1.2 Management characteristics and principles, levels of management and their functions; management, administration and organization, relation between management and administration. 1.3 Functions of management: planning, organizing, leading/directing, staffing and controlling. 1.4 Types of planning and steps in planning 1.5 Types of organization, Steps in organizing 1.6 Functional areas of management. 1.7 Managerial skills.
Unit – II Planning and organizing at supervisory level	2a. Differentiate the nature of planning and planning activities for the given situation. 2b. Suggest the step wise procedure to complete the given activity in the shop floor. 2c. Prepare materials and manpower budget for the given production activity. 2d. Describe with block diagrams the organization of the physical resources required for the given situation. 2e. Describe the human needs to satisfy the job needs for the specified situation. 2f. List the tasks to be done by the concerned individuals for completing the given activity.	**Planning at supervisory level** 2.1 Planning by supervisor. 2.2 Planning activities, detailing and following of each step. 2.3 Prescribing standard forms for various activities. 2.4 Budgeting for materials and manpower. **Organizing at supervisory level** 2.5 Organizing the physical resources. 2.6 Matching human need with job needs. 2.7 Allotment of tasks to individuals and establishing relationship among persons working in a group
Unit– III Directing and Controlling at supervisory level	3a. Justify the chosen need of directions and instructions to the subordinates to complete the specified task. 3b. Select the feasible set of instructions to complete the given simple task, with justification 3c. Predict the possible mistakes for completing the given simple activity. 3d. Describe the managerial control	**Directing at supervisory level** 3.1 Needs for directions and instructions to subordinates; Completeness and feasibilities of instructions 3.2 Personal counselling advanced predictions of possible mistakes. 3.3 Elaborating decisions, laying disciplinary standards in overall working **Controlling at supervisory level**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	actions and remedial measures required to be taken for completing the given task successfully.	3.4 Managerial control; Understanding team and link between various departments in respect of process and quality standards; Steps in control process 3.5 Controlling methods; Control over the performance in respect of quality, quantity of production, time and cost. Measuring performance, comparing with standards, correcting unfavorable deviations.
Unit – IV Safety Management	4a. State the general safety norms required to be taken in the given case. 4b. Suggest preventive measures of plant activities in the given situation. 4c. Describe the safe procedural steps required to be taken to prevent the given the type of accident. 4d. Prepare a work permit in to conduct the given maintenance activity. 4e. Explain the causes of the specified type of accident in the given situation. 4f. Prepare the specifications of the firefighting equipment required for the given type of fire.	4.1 Need for safety management measures 4.2 General safety norms for an industrial unit; Preventive measures. 4.3 Definition of accident, types of industrial accident; Causes of accidents; 4.4 Fire hazards; Fire drill. 4.5 Safety procedure 4.6 Work permits.
Unit – V Legislative Acts	5a. Explain the purpose of the act 5b. Explain the main provisions of the various acts and important definition.	5.1 Necessity of acts, Important definition and Main provisions of acts. 5.2 Industrial Acts: a. Indian Factory Act b. Industrial Dispute Act c. Workman Compensation Act d. Minimum Wages Act

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to management	12	06	06	04	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	concepts and managerial skills					
II	Planning and organizing at supervisory level	08	04	06	04	14
III	Directing and controlling at supervisory level	08	04	06	04	14
IV	Safety Management	08	04	06	04	14
V	Legislative Acts	12	02	06	04	12
Total		**48**	**20**	**30**	**20**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Write assignments based on the theory taught in classrooms. Assignments consist of ten questions having long answers including charts, symbols, drawing, observations etc.
b. Prepare/Download information about various industrial acts.
c. Visit to any Manufacturing industry and prepare a report consisting of:
   i. Organization structure of the organization/ Dept.
   ii. Safety measures taken in organization.
   iii. Mechanism to handle the disputes.
   iv. Any specific observation you have noticed.
d. Give seminar on relevant topic.
e. Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.

g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Study of management principles applied to a small scale industry.
b. Study of management principles applied to a medium scale industry.
c. Study of management principles applied to a large scale industry.
d. Prepare case studies of Safety measures followed in different types of organization.
e. Study of measures to be taken for ensuring cyber security.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Management and entrepreneurship	Veerabhadrappa, Havinal	New age international publishers, New Delhi, 2014: ISBN: 978-81-224-2602-1
2	Principles of management	Chaudhry omvir Singh prakash	New Age international publishers, 2012, New Delhi ISBN: 978-81-224-3039-4
3	Industrial Engineering and management	Dr. O. P. Khanna	Dhanpath ray and sons, New Delhi
4	Industrial Engineering and management	Banga and Sharma	Khanna Publication, New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.versesolutions.com/
b. https://www.books.google.co.in/books?isbn=817758412X
c. https://www. www.educba.com › Courses › Business › Management

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Power Engineering and Refrigeration**

Course Code : **22562**

1. RATIONALE

Power producing and absorbing devices are essentials for mechanical engineering. It is necessary for mechanical engineering technologists to analyze working and plot the performance of devices like internal combustion engines, air compressors, gas turbines so that he will be able to operate them effectively in an industrial situation. This knowledge is also useful in selecting suitable prime mover for given application and to maintain and test the same. This course also gives basic exposure of refrigeration and air-conditioning equipment which play a vital role in maintaining controlled atmosphere in different domestic and industrial applications. A separate elective course on Refrigeration and Air-conditioning is also available in sixth semester for in-depth knowledge of the course.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain power engineering and refrigeration devices.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify different components of I C engines and its auxiliaries.
b. Test the performance of I C Engine.
c. Maintain reciprocating air compressors.
d. Identify different components of gas turbines and jet engines.
e. Test the performance of refrigeration and air-conditioning systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit,* ***ESE*** *-End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

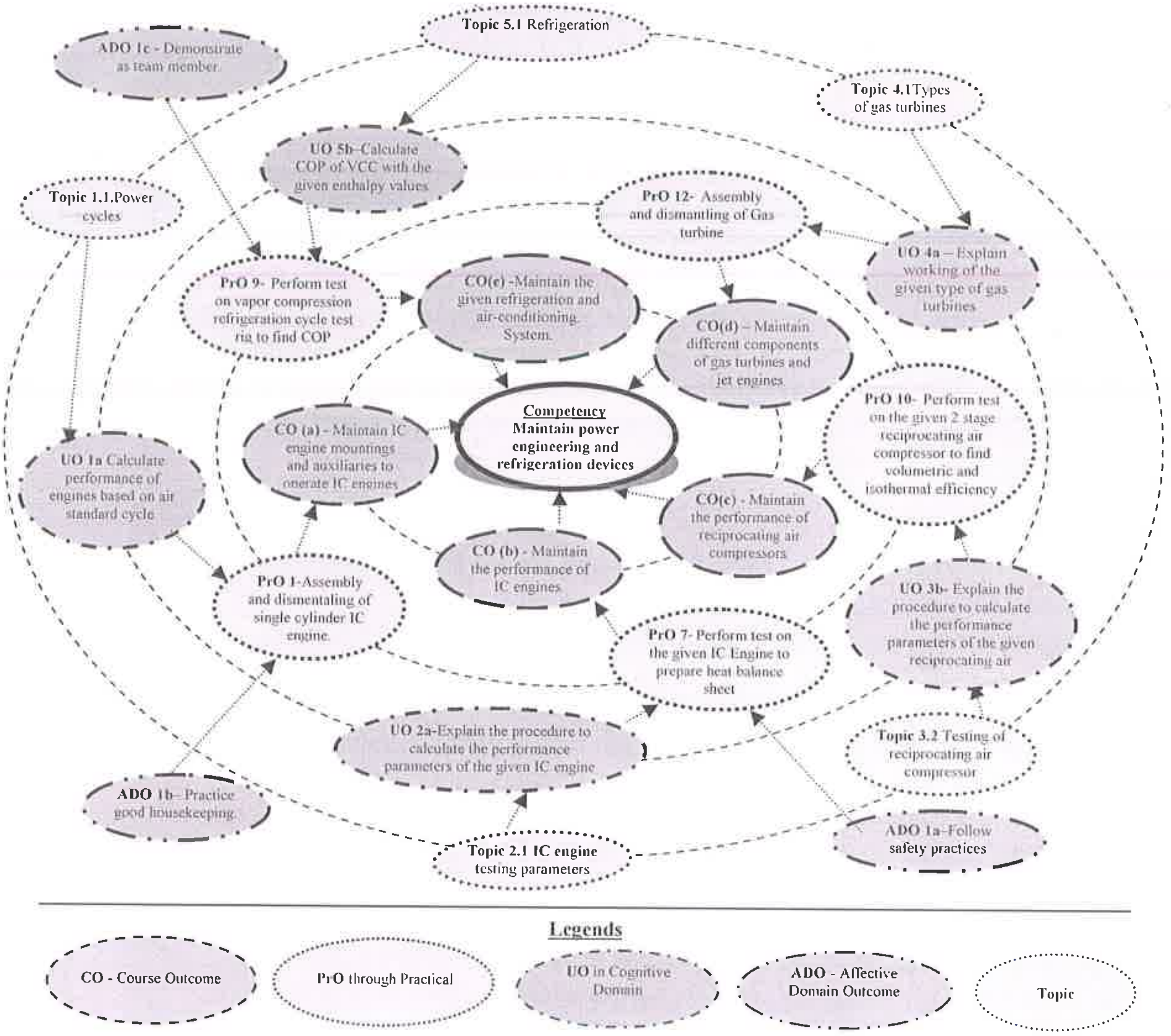


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Assemble/Dismantle single cylinder IC Engine. (Part-I)	I	02*
2	Assemble/Dismantle single cylinder IC Engine. (Part-II)	I	02*
3	Assemble/Dismantle multi cylinder IC Engine. (Part-I)	I	02
4	Assemble/Dismantle multi cylinder IC Engine. (Part-II)	I	02
5	Assemble/Dismantle inline/rotary fuel injection pump in a diesel engine.	I	02
6	Perform test on the given IC Engine to prepare heat balance sheet and plot performance characteristics. (Part-I)	II	02*
7	Perform test on the given IC Engine to prepare heat balance sheet and plot performance characteristics. (Part-II)	II	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Perform Morse Test on the given IC Engine to perform Morse Test.	II	02
9	Use exhaust gas analyzer to measurement and analyze pollutants in the given IC engine.	II	02
10	Perform diagnosis test on given IC engine using Engine Control Unit	II	02*
11	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-I)	III	02*
12	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-II)	III	02*
13	Assemble/Dismantle of Gas turbine model.	IV	02
14	Perform test on vapor compression refrigeration cycle test rig to find COP (Part-I)	V	02*
15	Trace the refrigerant flow of domestic refrigerator and measure temperatures at critical points for different settings of thermostat.	V	02
16	Assemble/Dismantle various components of domestic refrigerator.	V	02
17	Assemble/Dismantle various components of Water Cooler and Window/Split air conditioning units.	V	02
	Total		**34**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Preparing setup for experimentation	20
b.	Performing the practical and reading different instruments	20
c.	Measuring performance parameters	30
d.	Answer to sample questions	20
e.	Submit report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Work as a leader/a team member.
d. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Single cylinder IC engine suitable for assembly / dismantling with necessary tool set. (Engine complying latest Euro Norms)	1,2
2	Multi cylinder IC engine suitable for assembly / dismantling with necessary tool set. (Engine complying latest Euro Norms)	3,4
3	Inline / Rotary fuel pump of a latest version with necessary tool set.	5
4	Test rig on single cylinder IC engine. 3/5/7 HP petrol / diesel engine with required accessories.	6,7
5	Test rig on multi cylinder IC engine. 3/5/7 HP petrol engine with required accessories.	8
6	Exhaust gas analyzer 3/5 gas analyzer.	9
7	Engine Control Unit	10
8	Test rig on two stage reciprocating air compressor. Pressure and temperature gauges at suitable locations with manometer. Minimum ½ HP compressor motor.	11,12
9	Gas turbine and Jet engine models (working model or scrap turbine).	13
10	Charts and videos on construction and working of different components of gas turbines and jet engines.	23
11	Test rig on vapor compression cycle to find different COPs. ¼ to ½ HP compressor, pressure gauges and temperature gauges at suitable locations.	14, 15
12	Domestic refrigerator. Minimum 165 ltrs. Water cooler, Ice plant and Cold storage, Deep freezer (Actual working or scrap units)	16
13	Refrigeration tools required for repair and maintenance process of refrigeration and air-conditioning units	17
14	Window and split air-conditioner units, central air-conditioning unit. (Actual working or scrap units)	18,19
15	AxCYCLE Software: Thermodynamic Simulation Software for heat balance calculations of heat production and energy conversion cycles	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Internal Combustion Engines	1a. Calculate performance of given engine(s) based on corresponding air standard cycle. (Only Carnot and Otto Cycles) 1b. Explain with sketches valve timing diagrams for the given engine with sketches. 1c. Explain with sketch the	1.1 **Power cycles:** Engine terminology, working of 4 stroke engines, Carnot cycle, Otto cycle, diesel cycle, dual cycle, actual indicator diagrams for 4 stroke engines. 1.2 **Basic of IC Engines:** Working and comparison of four stroke and two stroke cycle engines and SI and CI

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
	construction and working of the given IC engine auxiliary (Turbo-Charger, Inline fuel injection pump, piezoelectric injectors, EGR, MPFI systems). 1d. Explain maintenance procedure of the given fuel injection pump, MPFI system and EGR and CRDI unit. 1e. Apply BS6 Norms to the given engine(s). 1f. State the procedure to undertake routine maintenance of the given IC engine	engines. 1.3 **IC Engines auxiliaries:** Valve timing diagrams, VVT-I engines – concept and arrangement, supercharging – objectives and advantages, Turbocharging, Variable Geometry Turbochargers, MPFI layout, various Sensors, rotary and inline fuel injection pump, piezoelectric injectors, EGR layout, viscous coupling for fan. 1.4 Common rail direct injection diesel engines (CRDI) controlled by electronic control unit. 1.5 Diagnostic tools used for fault finding of two wheelers. 1.6 List of Methods to reduce pollution in diesel engines as prescribed in BS6
Unit– II Testing of IC Engines and Emission Control	2a. Explain the procedure to calculate the performance parameters of the given IC engine. 2b. Explain the procedure to calculate indicated power of the given engine using Morse test. 2c. Explain procedure to measure emissions of exhaust gases in the given engine. 2d. Explain procedure to perform diagnosis using Engine Control Unit in the given engine. 2e. Explain methods to control exhaust emissions in the given engine.	2.1 **IC engine testing parameters**: IP, BSFC, components of heat balance sheet, thermal and mechanical efficiency, Morse test. 2.2 Combustion in IC engines, Octane Number (RON, MON) & Knock Resistance. 2.3 **Exhaust emissions and control:** Polluting emissions in IC engines, effects on environment, measurement of exhaust emissions, effect of air-fuel ratio on exhaust emissions (with graph), Euro IV and Euro VI norms for M and N1 vehicles, catalytic converter, SCR. 2.4 **Engine Control Unit (ECU):** working and diagnosis procedure.
Unit– III Air Compressors	3a. Explain with sketches working of the given compressor. 3b. Explain the procedure to calculate the performance parameters of the given compressor. 3c. Recommend the type of compressor for the given applications with justification. 3d. State the procedure to undertake routine maintenance of the given type of air compressor.	3.1 **Reciprocating compressors** – applications, working of single stage and two stage compressors with PV diagrams. Intercooling. 3.2 **Testing of reciprocating air compressors:** Pressure ratio, compressor capacity, FAD, volumetric efficiency, isothermal efficiency, numerical. Methods of energy saving. 3.3 **Rotary compressors:** Screw, centrifugal, Lobe type, vane type compressors and Axial flow compressors. Comparison of rotary with reciprocating.

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
Unit-IV Gas Turbines and Jet Propulsion	4a. Explain with sketches working of the given type of gas turbines. 4b. Identify different components of the given engine with justification. 4c. Explain with sketches the working of given rocket propulsion systems. 4d. State the procedure to undertake routine maintenance of the given gas turbine. 4e. State the procedure to undertake routine maintenance of the given propulsion engine.	4.1 **Types of Gas Turbines:** Constant pressure, open cycle and closed cycle gas turbines, Brayton cycle, applications, Aero derivative and heavy frame engines 4.2 **Jet propulsion:** Turbojet, Turboprop, engines. 4.3 **Rocket propulsion:** liquid and solid propellant systems.
Unit –V Refrigeration and Air-conditioning	5a. Sketch Carnot cycle and Vapor compression cycle (VCC) with the given type of PV, TS, PH diagrams. 5b. Calculate COP of Vapor compression cycle (VCC) for the given enthalpy values. 5c. Choose the refrigerant based on properties for given application with justification. 5d. Explain with sketches construction and working of the given components of vapor compression systems. 5e. Select suitable VCC component of the given refrigeration systems using ASHRAE Handbook with justification. 5f. Determine the given property(s) of the given air using psychrometric chart. 5g. Explain with sketches construction and working of the given refrigeration and air conditioner. 5h. State the procedure to undertake routine maintenance of the given type of air compressor.	5.1 **Refrigeration:** Unit of refrigeration, EER, SEER, Carnot cycle, Vapor compression cycle, sub cooling and superheating, components of vapor compression systems, refrigerant properties, concepts of GWP, ODP, TEWI, LCCP. 5.2 **Applications:** Specification, Working and construction of Domestic refrigerator, water cooler, ice plant and cold storage. 5.3 **Air-conditioning**: Definition, classification-comfort air conditioning, industrial air conditioning, applications . 5.4 **Psychrometry:** properties of air, psychrometric processes, psychrometric chart. 5.5 **Applications:** Specification, Working and construction of Window, split air-conditioner, central air-conditioning,

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Internal combustion engines	12	04	08	04	16

51

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
II	Testing of IC engines and emission control	12	04	04	08	16
III	Air compressors	08	02	04	08	14
IV	Gas turbines and Jet propulsion	04	02	02	04	08
V	Refrigeration and Air-conditioning	12	04	04	08	16
	Total	**48**	**16**	**22**	**32**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare a power point presentation on emission norms.
b) Make charts for performance characteristics of IC Engine.
c) Make a chart showing heat balance sheet format to display in laboratory.
d) Collect specifications of gas turbine based engines used for power generation and for jet engines.
e) Collect specifications of domestic refrigerators and window air-conditioners from manufacturer's websites.
f) Collect information on different tests actually used for IC engines.
g) Measure DBT and WBT using thermometer and calculate rest of the properties of air using psychrometric chart.
h) Prepare trouble shooting chart for domestic refrigerator / window air-conditioner
i) Prepare electrical trouble shooting chart for refrigeration system.
j) Prepare trouble shooting chart for IC engine.
k) Prepare seminar report on dual fuel and hybrid engines.
l) Visit an industry where air compressors are monitored online using SACDA or similar system. Write a report on the same.
m) Collect IC Engine fuel characteristics including information on RON and MON.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).

d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with power engineering system utility and equipment.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various working of compressor, gas turbine and refrigerant flow in refrigerator and air conditioner.
i) Show different parts of various refrigeration and air conditioning units.
j) Show constructional details of various Gas turbines, Jet Engines, Reciprocation and Rotary Compressors.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a) Display various components of MPFI system on wooden board with labels.
b) Prepare a report on OBD measurements.
c) Take sample of cooling load calculations sheet; list the components of cooling load along with percentage contribution of different loads in a refrigeration or air conditioning.
d) Display various parts of a hermetically sealed / open compressor on wooden board with labels.
e) Collect and display different gaskets required for a single cylinder /multi cylinder IC engine.
f) Prepare report on different types of lubricating oils, oil filters, coolants, for petrol engines wrt physical and chemical properties, cost, safety, disposal etc.
g) Make a working model of air compressor.
h) Prepare a step-by-step procedure for dismantling and assembly of multi cylinder IC engine. Tabulate different tools used in dismantling of IC engines against components for which these tools are used.
i) Collect information about electrical motor drives used in vehicles such as Tesla and Google's car.
j) Comparative study of hybrid vehicles and conventional vehicles.
k) Collect charts using internet regarding Combustion: combustion in SI engines, pre-ignition, detonation – concept, factors affecting detonation, Homogeneous Charged Compression Ignition Engine.
l) Collect working and constructional details of different types of Reciprocating and Rotary compressors.
m) Collect specifications, working and constructional details of different types of refrigeration and air conditioning units (Domestic refrigerator, water cooler, ice plant and cold storage, Window, split air-conditioner, central air-conditioning).

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Internal Combustion Engines	Mathur M. I.; Sharma R. P.	Dhanpatrai Publications (P) Ltd, New Delhi 2012, ISBN: 1234567144047
2	Thermal Engineering	Rajput R. K.	Laxmi Publications, New Delhi 2010, ISBN: 8131808041, 9788131808047
3	A Textbook of Internal Combustion Engines	Rajput R.K.	Laxmi Publications; Third edition, New Delhi, (2016) ISBN-13: 978-8131800669
4	IC Engines Combustion and Emissions	Pundir B. P.	Narosa Publishing House), New Delhi (2010) ISBN-13: 978-8184870879
5	Refrigeration and Air Conditioning	Khurmi R. S.; Gupta J. K.	S. Chand Publications, New Delhi (2016), ISBN: 978-81-219-2781-9
6	Thermal Engineering	Singh Sadhu, Pati Sukumar	Pearson Education; First edition, New Delhi, (2018) ISBN-13: 978-9352866687

14. SOFTWARE/LEARNING WEBSITES

a) https://jalopnik.com/how-variable-valve-timing-works-500056093
b) https://www.araiindia.com/pdf/Indian_Emission_Regulation_Booklet.pdf
c) http://www.fchart.com/ees/demo.php
d) http://industrial-ebooks.com/CBT_software/Aircompressor-Training91.php
e) https://www.gspteam.com/products.html

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Advanced Manufacturing Processes**

Course Code : **22563**

1. RATIONALE

Mechanical technologists (diploma holders) have to work with men, machines and materials. With the advancements, newer difficult to machine materials and complex shapes with high surface finish is the demand of the manufacturing sector. To machine these materials and also the complex geometries with very high surface finish the student must have the knowledge of non – conventional machining processes like EDM, ECM, LBM, PAM, WJM, EBM, WEDM and also the conventional machining like milling processes, gear manufacturing, grinding, surface finishing, Broaching, boring processes etc. This course is aimed to make them achiever the various outcomes required for the given jobs.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain the functioning of advanced manufacturing processes and equipment.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Maintain the non conventional machining process to produce complex and hard to machine components.
b. Produce components using milling machine.
c. Choose relevant machining process to produce gears.
d. Maintain CNC machine to produce components effectively.
e. Prepare CNC part programs for simple components.
f. Maintain the functioning of automated equipment.

4. TEACHING AND EXAMINATION SCHEME

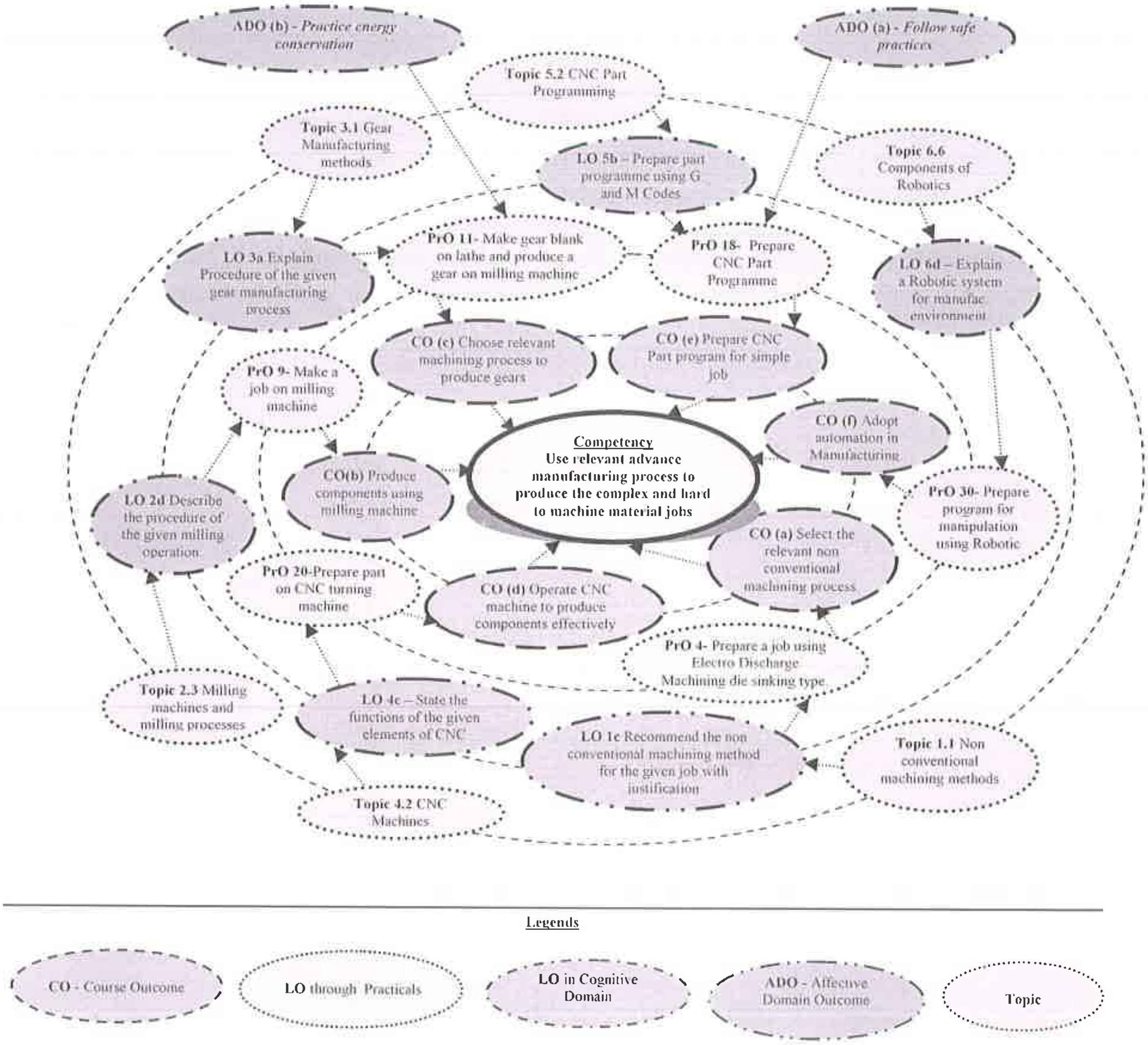
Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,*
ESE *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.



6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

For practical number 1 to 13 write a detailed report on the machine specification, tool and work piece specifications, criterion of selection of process and performance parameters, process carried out, set up, working principle with sketches and name of other industrial components produced using same process.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare a job using Abrasive Jet Machining/Observe the same in an industry(Part I)	I	02
2	Prepare a job using Abrasive Jet Machining/Observe the same in	I	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	an industry. (Part II)		
3	Prepare a job using Electro Discharge Machining die sinking type/Observe the same in an industry. (Part I)	I	02
4	Prepare a job using Electro Discharge Machining die sinking type /Observe the same in an industry. (Part II)	I	02
5	Prepare a job using Electro Discharge Machining wire cut type /Observe the same in an industry. (Part I)	I	02*
6	Prepare a job using Electro Discharge Machining wire cut type /Observe the same in an industry. (Part II)	I	02*
7	Prepare a job using Electro Chemical Machining/Observe the same in an industry. (Part I)	I	02*
8	Prepare a job using Electro Chemical Machining/Observe the same in an industry. (Part II)	I	02*
9	Make a job on milling machine which includes plain milling, slotting by using end mill cutter or slitting saw, or side and face milling cutter. (Part I)	II	02*
10	Make a job on milling machine which includes plain milling, slotting by using end mill cutter or slitting saw, or side and face milling cutter. (Part II)	II	02*
11	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part I)	II	02*
12	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part II)	II	02
13	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part III)	II	02
14	Prepare a job or assembly of jobs like Gear and shaft assembly, Shaft and keyway which involves operations like end mill, turning, grinding operations. (Part I)	III	02*
15	Prepare a job or assembly of jobs like Gear and shaft assembly, Shaft and keyway which involves operations like end mill, turning, grinding operations. (Part II)	III	02*
16	Operate CNC machines and try to change different parameters and controls to see their effect during machining. (Part I)	IV	02*
17	Operate CNC machines and try to change different parameters and controls to see their effect during machining. (Part II)	IV	02*
18	Prepare CNC part programme using G and M codes with ISO format for Simple contour milling of part. (Part-I)	V	02 *
19	Prepare part on virtual CNC machine simulator using part programme developed in PrO 18 and generate cycle time process sheet using CAM Software. (Part-II)	V	02*
20	Prepare part on CNC turning machine using part program developed in PrO 18. (Part-III)	V	02*
21	Prepare CNC part program using G and M codes with ISO format for Simple contour milling of part. (Part-I)	V	02*
22	Prepare part on virtual CNC machine simulator using part program developed in PrO 21 and generate cycle time process sheet using CAM Software. (Part-II)	V	02*

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
23	Prepare part on CNC turning machine using part program developed in Sr. no. 21. (Part-III)	V	02*
24	Prepare CNC part program using G and M codes with ISO format for Turning parts using canned cycle - with threading or drilling or other. (Part-I)	V	02
25	Prepare part on virtual CNC machine simulator using part program developed in PrO 24 and generate cycle time process sheet using CAM Software. (Part-II)	V	02
26	Prepare part on CNC turning machine using part program developed in PrO 24. (Part-III)	V	02
27	Import solid model into CAM environment of any CAM software and perform manufacturing simulation. (Part-I)	V	02
28	Prepare part on CNC turning machine using automatic part program developed in PrO 27. (Part-II)	V	02
29	Observe and use Flexible Machine Station in an industry	VI	02
30	Prepare a simple program for manipulation of standard components using Robotic arm	VI	02*
31	Observe the Robotics system in an industry	VI	02
	Total		**64**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Preparation of machine set up	20
b.	Actual machining operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1^{st} year
- 'Organising Level' in 2^{nd} year
- 'Characterising Level' in 3^{rd} year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No	Equipment Name with Broad Specifications	PrO. No.
1.	Abrasive Jet machining	1,2
2.	Electro Discharge Machine	3 to 6
3.	Electro Chemical Machine: Tool area 10mmx30mm or 15mmx20mm; Cross Head Stroke 40 mm; Supply Single phase 230 V. A.C.; Electrical Output Rating 0 - 100 Amps and voltage from 0 - 25 V DC; Tool Feed Rate In the range of 0.2 to 1 mm / min.; Machining Time 0 to 1999 seconds, variable through touch screen.; Display For voltage, output current; feed rate electrolyte temp; Protection For Current overload, short circuit; USB Port For data storage; pulsating facility On time 100 microseconds to 1 second variable, off time 100 microseconds to 1 second variable, plus amplitude 1v-10v variable; LCD display For forward and reverse, feed rate settings, feed rate; Tool Area 300 square mm;	7,8
4.	Lathe machine, turning tool, boring tool, Standard dial bore gauge. Minimum 500 mm between centre, with required set of work holding devices, cutting tools, accessories and tool holders	11 to 13,
5.	Milling machine, face milling cutter, side and face milling cutter, end mill cutter. Minimum 500 mm longitudinal traverse, with required indexing head, set of work holding devices, cutting tools, accessories and tool holders.	15
6.	Drilling Machine (Bench type, or Column type, or if possible Radial): Minimum 25 mm capacity, with required set of work holding devices, cutting tools, accessories and tool holders.	11,12,13,15
7.	CNC Turning 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC. (Suggested)	16 to 28
8.	CNC Milling 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC.(Suggested)	16 to 28
9.	CNC Simulation software and control pads (CAMLAB CNC Software, MasterCAM/NXCAM/, DONC CNC machine simulator, PRO, SWANSOFT, CAPSMILL and CAPSTURN IN cam software, DONCMILL AND DONCTURN software)	16 to 28
10.	PRO¬FICNC programming manuals and watch PROFICNC on https://youtu.be/3ghwlpmhwpm to integrated CNC machine with multiple industry standard CNC controllers like FANUC, SIEMENS, FAGOR AND	16 to 28

S. No	Equipment Name with Broad Specifications	PrO. No.
	MITSUBISHI.	
11.	Any Latest educational version of CAD/CAM integration software .	16 to 28
12.	Robotic Arm	31

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Non-Conventional Machining Processes	1a. Describe with sketches the working principle of the given non - conventional machining method and draw set up of the same. 1b. Describe advantages, limitations and applications of the given non - conventional machining method. 1c. Recommend the non conventional machining method for the given job with justification. 1d. Recommend the process parameters for the given job and non-conventional machining process with justification.	1.1 **Fundamentals of Non – conventional methods** – Needs and types of non – conventional methods. Importance of methods. 1.2 **Working principle, set up, process parameters of** – EDM, , WEDM ECM, PAM, AJM, USM, EBM and LBM. 1.3 **Advantages, limitations and applications of** - EDM, , WEDM ECM, PAM, AJM, USM, EBM and LBM.
Unit– II Milling Machines and Milling Processes	2a. Explain with sketches the working of the given milling machine. 2b. Draw sketches of the given milling machine parts and cutters. 2c. Describe the procedure of the given milling operation. 2d. Explain the procedure of the indexing for the given gear manufacturing	2.1 **Milling:** - Working Principle of milling machine, types of milling machines 2.2 **Milling cutters** – Different types of cutters used in milling, face milling cutter, end milling cutter, Staggered tooth milling cutter, side and face milling cutter, form milling cutters, metal slitting saw etc. 2.3 **Milling Processes** – Plain milling, face milling, side milling, end milling, Straddle milling, gang milling, slotting, slitting, Up milling and down milling 2.4 **Cutting Parameters** – Cutting speed, feed. 2.5 **Dividing head** – types, function of dividing head, method of indexing, index plates.
Unit– III Gear Manufactu	3a. Explain with sketches procedure of the given gear manufacturing	3.1 **Gear manufacturing methods** - Function and types of gears, gear manufacturing methods,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
ring	process. 3b. Draw sketches of the given gear hob, hobbing process or gear shaping process. 3c. Explain with sketches the given gear finishing process. 3d. Recommend the process parameters for the given gear manufacturing and finishing process with justifications.	3.2 **Gear hobbing –** Working principle, types of gear hobbing, advantages, limitations and applications of gear hobbing 3.3 **Gear shaping –** Gear shaping by pinion cutter, gear shaping by rack cutter, advantages, limitations and applications of both the methods and Comparison of gear hobbing and gear shaping 3.4 **Gear finishing methods –** Need of gear finishing, gear finishing methods, a) Gear shaving b) Gear grinding c) Gear burnishing d) Gear lapping e) Gear honing
Unit-IV Fundamentals of Computer Aided Manufacturing (CAM)	4a. State the functions of the given element(s) of the CNC Machine 4b. Select tool(s) and tool holder(s) used on a CNC machine for the given job with justification 4c. Explain the given work and tool holding and changing device(s) used on a CNC turning centre 4d. Explain the given work and tool holding and changing device(s) used on a CNC Machining centre	4.1 CAM concept, NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences. 4.2 CNC machines: Types, classification, working and constructional features Advantages, limitations and selection criteria. 4.3 Elements of CNC machines - Types, sketch, working and importance of: Slide ways; Re-circulating ball screw; Feedback devices (transducers, encoders); Automatic tool changer (ATC); Automatic pallet changer (APC); 4.4 CNC tooling : Tool presetting-concept and importance; Qualified tools- definition need and advantages; Tool holders- types and applications. 4.5 CNC turning centres: Types; Features; Axes nomenclature; Specification; Work holding devices -types, working and applications. 4.6 CNC machining centres: Types; Features; Axes nomenclature; Specification; Work holding devices-types, working and applications.
Unit V– CNC Part Programming	5a. Interpret the given CNC part programming code(s). 5b. Prepare part programme using G and M codes for the given job. 5c. Apply advanced CNC part programming features like canned cycle, do loop, subroutine etc. in the given	5.1 Definition and importance of various positions like machine zero, home position, work piece zero and programme zero. 5.2 CNC part programming: programming format and structure of part programme. 5.3 ISO G and M codes for turning and milling-meaning and applications of important codes.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	situation. 5d. Explain procedure for setting the given compensation(s) on the given CNC machine.	5.4 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation). 5.5 Simple part programming for milling using ISO format. 5.6 Importance, types, applications and format for: Canned cycles; Macro; Do loops; Subroutine; 5.7 CNC turning and milling part programming using canned cycles, Do loops and Subroutine. 5.8 Need and importance of various compensations: Tool length compensation; Pitch error compensation; Tool radius compensation; Tool offset. 5.9 Simple part programming using various compensations. 5.10 Virtual CNC machine simulators. Generation of generating shop documentation using a CAM software, cycle time sheets, tools list with tool layout, spindle utilization graphs, program for different control systems and different configuration of machines
Unit-VI Automation and Robotics	6a. Compare Fixed and flexible Automation on given parameters with justification. 6b. Justify the use of Group Technology for the given situation. 6c. Justify the use of FMS in a given situation. 6d. Explain a Robotic system used for a given manufacturing environment. 6e. Select different components of Robotics with justification.	6.1 Automation-Define, need of automation, high and low cost automation, examples of automations. 6.2 Types of Automation - Fixed (Hard) automation, programmable automations and Flexible automations (Soft).Comparison of types of automations. 6.3 Group Technology- concept, basis for developing part families, part classification and coding with example, concept of cellular manufacturing. Advantages and limitations. 6.4 Flexible Machining System- Introduction, concept, definition and need, sub systems of FMS, comparing with other manufacturing approaches. 6.5 Introduction to Robotics- definition of robot and robotics, advantages disadvantages and applications. 6.6 Components of Robotics manipulator, end effectors, actuators, sensors, controller, processor and software.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Non conventional Machining Processes	10	02	04	06	12
II	Milling Machines and Milling Processes	10	02	04	06	12
III	Gear Manufacturing	10	02	02	06	10
IV	Fundamentals of Computer Aided Manufacturing	10	02	04	06	12
V	CNC Part Programming	14	04	04	08	16
VI	Automation and Robotics	10	02	02	04	08
Total		**64**	**14**	**20**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

a. Prepare journal based on practical performed in measurement laboratory. Journal consist of drawing, observations, required measuring tools, equipments, date of performance with teacher signature.
b) Tabulate various cutting tools materials with main elements, properties and applications.
c) List process parameters for various machines (Each student will be given different machine).
d) Calculate RPM for lathe, milling cutter and drill spindle; based on given data. (Each student should be given different data for diameters and cutting speeds)
e) Prepare a report on at least one industrial component with its complete technical details covering the points like design criterion, features included with Dimensional/Geometric constraints, manufacturing resource requirements, challenges in controlling its quality and cost, etc.
f) Collect the technical details about all production facilities available at nearby industry/industries.
g) Visit or participate in the technical events, exhibition, conference, seminar etc.
h) Collect/download at least four different machine tool catalogues including at least one special purpose, non-conventional or advanced machine.
i) Collect/download at least one catalogue each of cutting tool, work holding device and tool holder.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate actual components and products with various concepts of advance machining processes.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various concepts of advance machining processes.
i) Demonstrate the process properly before students start doing the same.
j) Encourage students to refer different websites to have deeper understanding of the subject.
k) Observe continuously and monitor the performance of students in Lab.
l) Arrange the industrial visits in such a way that students are able to observe advance machining processes.
m) Encourage students to watch various videos on you tube or any particular website related to advance machining processes used to produce a component.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a list of industrial components which are produced through non conventional machining processes and describe the manufacturing procedure of the same in brief
b. Prepare a list of domestic and industrial components on which Lapping, honing, buffing, Electroplating, Galvanizing, metal spraying and powder coating are performed. For each process collect information about the material, machines and other resources required. Also prepare list of industries in your state doing these processes.

c. Manufacture any product like a small assembly of components which has been designed in the course Design of Machine Elements. Student will prepare the report on following.
   i. Prepare production drawings of the assembly and details.
   ii. Manufacture the parts.
   iii. Note down work holding devices, cutting tools and cutting parameters used for each part and each operations. Summarize this in tabular form.
   iv. On completion, present and share the experience of this mini project with photos/videos of mini project execution and with work distribution executed. Use power point presentation.

d. Produce job with various machining methods:
   i. Part should include plain/taper turning, knurling, threading, cylindrical/surface grinding, etc.
   ii. Sketch the production drawing of the part.
   iii. Outline the processes.
   iv. Calculate/select, set, observe and record the cutting parameters for each process.
   v. List the cutting tools and measuring instrument like vernier caliper, micrometer or gauge if any you have used. Also state specifications of each.
   vi. List the work holding devices you have used. Also state specifications of each.
   vii. Produce the part

e. Produce a complex job:
   i. Part should include shaping, milling, drilling, tapping, boring, slotting, surface grinding, cylindrical grinding, super finishing like lapping, polishing etc.
   ii. Select and sketch the production drawing of the part.
   iii. Outline the processes. Prepare process plan for the same.
   iv. Prepare workshop layout and route sheet.
   v. Produce the part, Calculate/select, set, observe and record the cutting parameters for each process.
   vi. List the cutting tools you have used. Also state specifications of each.
   vii. List the work holding devices you have used. Also state specifications of each.

f. Prepare a technical report on specifications, operating procedure, selection of operational parameters, details about tool/work holders used, machine setting, product details being manufactured for each method/machine like gear forming/generating, honing/lapping/buffing machine, Non-conventional machine, Jig boring machine, Broaching machine etc.
g. Visit a work shop which contains latest industrial Turret lathe, Capstan lathe, Single spindle automats, Automatic machines. Write a detail report on working of such machine or machines, parts produced, and other relevant information. Identify the jobs produced on such machines and draw the sketches of jobs.
h. Prepare a report on how to select parameters for machining Aluminum, Mild steel, Stainless steel and Inconel materials on CNC machine.
i. Comparative study of any two CNC turning centers or any two Vertical Machining centers and report the differences.
j. Comparative study of two different CNC systems for turning centers: Fanuc and Fagor using suitable virtual CNC machine simulator software.
k. Study and report 10 commonly used work piece materials and best grades of cutting tools that used to cut them efficiently.
l. Study machining process and reduce machining cycle time of parts from local CNC job shops.

m. Study of two different CNC systems for VMC: Siemens and MITSUBISHI M 70 with the help of CNC machine simulator software and furnish the report
n. Explore PRO¬FICNC programming manuals and watch PROFICNC on https://youtu.be/3ghwlpmhwpm to integrated CNC machine with multiple industry standard CNC controllers like FANUC, SIEMENS, FAGOR AND MITSUBISHI.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Manufacturing Science and Technology	Rao, K Vara Prasada	New Edge Publication, New Delhi, 2009, ISBN: 978-81-224-2759-2
2	Unconventional manufacturing processes	Singh M.K.	New Edge Publication, New Delhi, 2009, ISBN: 978-81-224-2244-3
3	A text book of Production Engineering	Sharma P.C.	S.Chand Publication, New Delhi 8th Edition 2012, ISBN 978812190116
4	Machine Tools Technology	Kandasami G. S.	Khanna Publishers, New Delhi, 2/e, 1989
5	Manufacturing ProcessesVol II	Bawa H.S.	McGraw Hill, New Delhi, ISBN - 0070583722
6	Fundamentals of Metal Machining and Machine Tools	Knight W. A., Boothroyd Geoffrey	McGraw-Hill Education, New Delhi, 2006, ISBN 1-57444-659-2
7	Production Technology	HMT, Banglore	McGraw-Hill Education, New Delhi, 2001, ISBN 13:978-0-07-96443-3
8	Advanced Machining Processes	Jain V. K.	Allied Publishers, Mumbai, 2009 ISBN 81-7764-294-4
9	CNC Machines.	Pabla B.S., Adithan M.	New Age International, New Delhi, 2014, ISBN: 9788122406696
10	Computer Numerical Control-Turning and Machining centres	Quesada Robert	Prentice Hall India, New Delhi, 2014 ISBN: 978-0130488671
11	CAD/CAM	Sareen Kuldeep	S. Chand, New Delhi, 2012 ISBN: 9788121928748
12	Introduction to NC/CNC Machines	Vishal S.	S.K. Kataria and Sons, New Delhi, 2010, ISBN: 978-8188458110
13	Computer Aided Manufacturing	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill, New Delhi, 2017 ISBN: 978-0074631034
14	CAD/CAM: computer aided design and manufacturing	Groover Mikell P, Zimmered W Emory	Prentice Hall, New Delhi, 2011 ISBN: 9780131101302

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

i. http://nptel.ac.in/video.php?subjectId=112105126
ii. http://nptel.ac.in/courses.php?disciplineId=112
iii. http://nptel.ac.in/courses/112104028/
iv. http://nptel.ac.in/courses/112105126/27
v. http://www.youtube.com/watch?v=bmooEZyivxo
vi. http://www.youtube.com/watch?v=mWy9awGv6so
vii. http://www.youtube.com/watch?v=mKES5Fyz9l0

viii. http://www.youtube.com/watch?v=BgGXQUeYNKw
ix. http://www.youtube.com/watch?v=eaeEn1Gs4aQ
x. http://www.youtube.com/watch?v=49GpJ7yhecg
xi. http://www.youtube.com/watch?v=XfYXelZ4IaY
xii. http://www.youtube.com/watch?v=SNWF_4jQ2pU
xiii. w.youtube.com/watch?v=pI1QGpmKqow
xiv. http://www.youtube.com/watch?v=N7NofmHWWPQ
xv. http://en.wikipedia.org/wiki/Microelectromechanical_systems
xvi. http://www.engineersgarage.com/articles/mems-technology
xvii. http://www.nptel.ac.in
xviii. http://www.youtube.com/watch?v=M3eX2PKM1RI
xix. http://www.youtube.com/watch?v=EHQ4QIDqENIandlist=PLBkq kLQO2nAt5MNLo eUhvkFS9M0p8y_1
xx. https://cadem.com/lms/
xxi. https://cadem.com/cncetc/
xxii. http://www.mtabindia.com
xxiii. http://www.swansoftcncsimulator.com
xxiv. https://goo.gl/4xvdhw https://goo.gl/fi4eqf
xxv. https://cadem.com/cncetc/
xxvi. https://youtu.be/3ghwlpmhwpm

Program Name : **Diploma in Mechanical Engineering / Production Engineering / Production Technology**

Program Code : **ME / PG/ PT**

Semester : **Fifth**

Course Title : **Elements of Machine Design**

Course Code : **22564**

1. RATIONALE

Design department of industry is one of the major job areas for Diploma Technicians. Fundamental knowledge of Applied Mechanics, Strength of Materials, Engineering Materials, Theory of Machines and Computer Aided Design and Drafting is essential. To enable a student to work there he should know how to design the simple machine elements. He should also be aware of usual design procedures, selection procedures, codes, norms, standards and guidelines for selection of appropriate material. This subject aims at developing analytical and selection abilities in the student to give solutions to simple engineering design problems using standard procedures.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Design simple machine components.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Select suitable materials for designing machine elements.
b. Design joints and levers for various applications.
c. Design the power transmission elements like shafts, keys and couplings.
d. Recommend the power screws and suitable fasteners for different applications.
e. Choose springs for various applications.
f. Select standard components with their specifications from manufacturer's catalogue.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	4	70	28	30*	00	100	40	25@	10	25	10	50	20

***(*):** Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.*

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

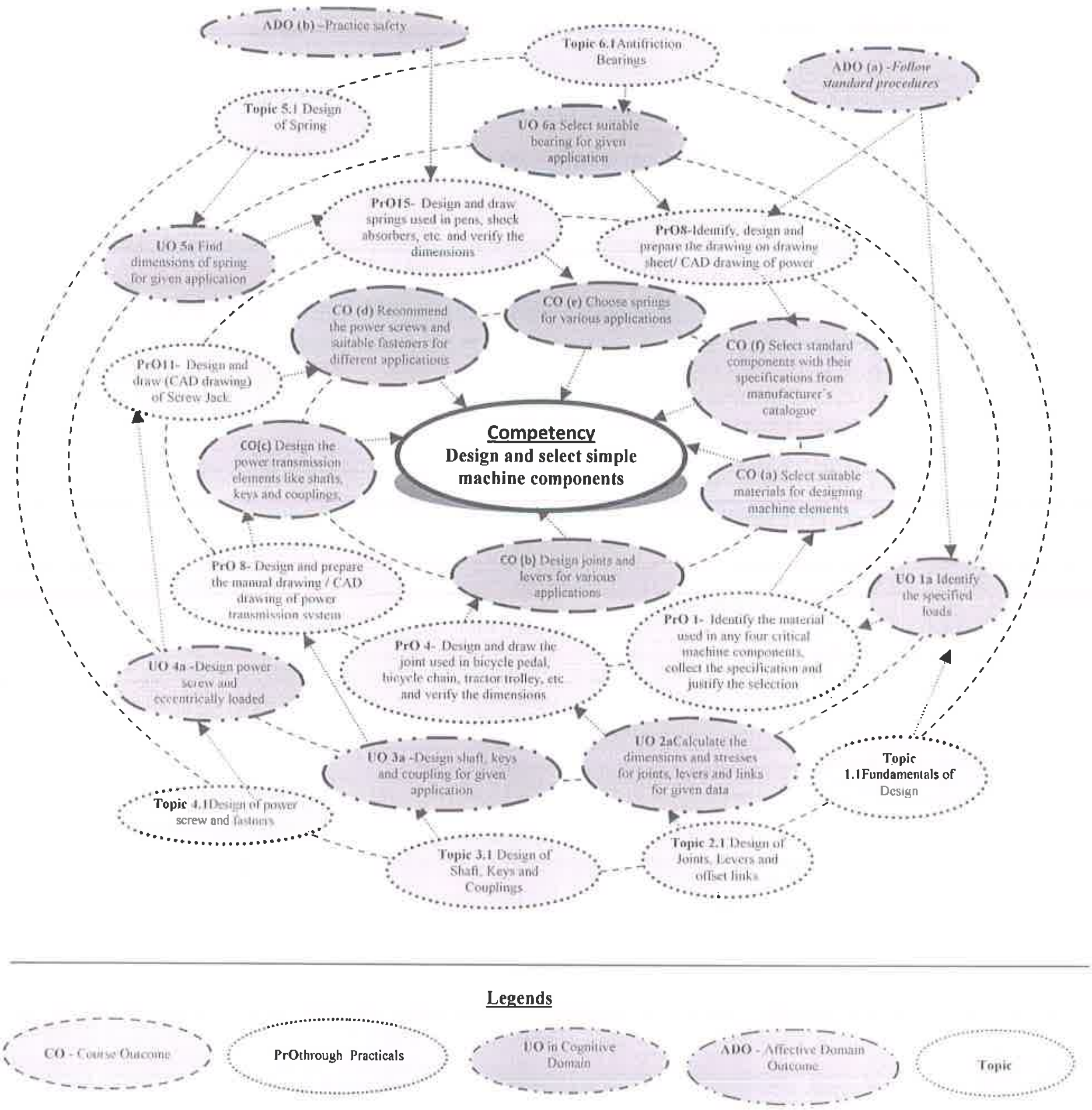


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the material used in any four critical machine components,	I	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	collect the specification of the materials and justify the selection. (group of 4 students)		
2	Draw various modes of failure for the machine components used in various laboratories/ workshops, under different loading conditions.	I	02
3	Use IS codes for design of any two machine elements. (ISO metric threads, Cast iron Flexible coupling, Keys, Screws, Bolts, Nuts, similar components). (Group of 4 students)	I	02*
4	Design and draw the joint used in bicycle pedal, bicycle chain, tractor trolley, rail wagons/coaches, and similar components and verify the dimensions. (Group of 4 students) (Part-I)	II	02
5	Design and draw the joint used in bicycle pedal, bicycle chain, tractor trolley, rail wagons/coaches and similar components and verify the dimensions. (Group of 4 students) (Part-II)	II	02
6	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions. (Part-I)	II	02*
7	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions. (Part-II)	II	02*
8	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shafts, keys, couplings, bearings, pulley and belt drive used in various machine like lathe machine, flour mills,sewing machine and transmission system in different machines and justify the dimensions. (Part-I)	III	02*
9	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shaft, keys, coupling, bearing, pulley and belt drive used in various machine like lathe machine, flour mills, sewing machine and transmission system in different machines and justify the dimensions. (Part-II)	III	02*
10	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shaft, keys, coupling, bearing, pulley and belt drive used in various machine like lathe machine, flour mills, sewing machine and transmission system in different machines and justify the dimensions. (Part-III)	III	02*
11	Design and draw (CAD drawing) of Screw Jack used for heavy vehicles, cars and other similar applications and verify the dimensions. (Part-I)	IV	02
12	Design and draw (CAD drawing) of Screw Jack used for heavy vehicles, cars and other similar applications and verify the dimensions. (Part-II)	IV	02
13	Design and draw fasteners used in civil structures (Railway platform shades, bridges. Eccentric loaded brackets), bridges, household electrical panels. column brackets and similar	IV	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	components and verify the dimensions. (Four design cases) (Part-I)		
14	Design and draw fasteners used in civil structures (Railway platform shades, bridges, Eccentric loaded brackets), bridges, household electrical panels, column brackets and similar components and verify the dimensions.(Four design cases) (Part-II)	IV	02*
15	Design and draw springs used in pens, shock absorbers, rocker arm spring, safety valve, bicycle/ two-wheeler side stand, railway buffers and similar components. (Four design cases) (Part-I)	V	02*
16	Design and draw springs used in pens, shock absorbers, rocker arm spring, safety valve, bicycle/ two-wheeler side stand, railway buffers and similar components and verify the dimensions. (four design cases) (Part-II)	V	02*
17	Design and draw Spur Gear used Agriculture machinery, Sugar Can Juice Machine and similar components and verify the dimensions. (One design case)	V	02
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Identification of loads and other boundary conditions	20
b.	Selection of material	20
c.	Apply suitable design procedure	20
d.	Identify exact mode of failure	10
e.	Neatness in drawing	20
f.	Answer to sample questions	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices in using drawing instruments and CAD workstations.
b. Follow neatness while preparing the drawings.
c. Practice good housekeeping.
d. Work as a leader/a team member.
e. Follow standard procedures and codes.
f. Use design data book and Manufacturer's catalogue.
g. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs

according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name	Specifications	PrO.S. No.
1	i) Cotter joint ii) Knuckle joint iii) Turn-Buckle	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	03
2	i) Foot, Hand, Bell-crank lever ii) Offset link	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	04
3	i) Pulley, Shaft, Keys and couplings. (all types) ii) Belt, Chain, Gear drive, Metallic rope.	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	05
4	Models of lead screw of lathe, feed screw of machine tools, clamping screws, toggle jack screw, screw jack.	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	06
5	Ball bearing-single, double row, angular contact and thrust, rolling contact bearings- cylindrical, taper roller, thrust, pedestal, journal, pivot bearing, Spur gear, Helical gears	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	05
6	Different Springs, Nut-Bolt, Standard sections	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	All
7	Wall charts for- Types of levers Types of joints Tolerance, surface finish, limits and fits. Helical springs Bolted joints Welded joints Bearing designation Various types of bearings	All charts should be plastic or acrylic coated –size 3ft x 3ft	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of	1a. Write general design procedure for the given component under static	1.1 Machine design philosophy and phases in design, design considerations.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Design	loading. 1b. Identify the specified loads and stresses for the given component with justification. 1c. Identify the materials for the given machine components with justification. 1d. Select the relevant standards and codes for design of the given component. 1e. Explain various modern design considerations in the given situation.	1.2 Types of loads, concept of stresses, bearing pressure, bending and torsion stresses, principal stresses, strain, stress-strain diagram. (Simple Numerical) 1.3 Factor of Safety, conditions for selection of F.S 1.4 Stress concentration meaning, causes and remedies. 1.5 Designation of materials as per IS and introduction to International standards, advantages of standardization, use of design data book, use of standards in design and preferred numbers series. 1.6 Concept of creep, Fatigue, S-N curve, Endurance limit. 1.5 Maximum principal stress theory and Maximum shear stress theory. 1.6 Modern Design considerations Ergonomics and aesthetic considerations in design. Ecology, social consideration and Concept of Product Design.
Unit– II Design of joints, Levers and offset links	2a. Write design procedure for the given joint(s), lever(s) and link(s). 2b. Sketch the given joint(s), lever(s), link(s) and their resisting sections. 2c. Calculate the dimensions and stresses for the given joints, levers and links for given data. 2d. Calculate the dimensions and stresses for the given C-clamp for given data.	2.1 Design of Cotter Joint, Knuckle Joint, 2.2 Turnbuckle. 2.3 Design of Levers:- Hand/Foot Lever and 2.4 Bell Crank Lever, 2.5 Lever for lever safety valve, 2.6 Design of Off-set links, C-clamp, Overhang Crank
Unit– III Design of Shaft, Keys and Coupling s	3a. Write design procedure for the given shaft, keys and couplings. 3b. Sketch the given shaft, key(s) and coupling(s). 3c. Design the given shaft, key and coupling for given application. 3d. Select the given shaft, keys and coupling for given application from manufacturer's catalogue/ design handbook with	3.1 Types of shafts, Shaft materials, Standard sizes. Design of solid and hollow shafts based on strength and rigidity criteria. 3.2 Design of hollow and solid shaft for combined bending and twisting moments and considering the effect of shock and fatigue. ASME code of design for line shafts supported between bearings with one or two pulleys in between or one overhung pulley. 3.3 Types of keys, effect of keyway on the strength of shaft, design of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	rectangular and square sunk key. 3.4 Types of couplings, Design of muff coupling, flanged couplings (protected and unprotected) and Bushed pin type flexible coupling.
Unit-IV Design of Power screws and Fasteners	4a. Write strength equations for the given screw and nut combination. 4b. Sketch the given type of Jack. 4c. Design the given power screw and eccentrically loaded bolted joint for given data. 4d. Calculate the length of weld for the given application. 4e. Recommend the type of fasteners for the given situation based on catalogue with justification.	4.1 Basic concepts of power screw Thread Profiles used for power Screws, relative merits and demerits of each, Self locking and overhauling properties, Torque required to overcome thread friction, efficiency of power screws, types of stresses induced. 4.2 Design of Screw Jack, Toggle Jack (only screw and nut). 4.3 Stresses in Screwed fasteners, bolts of Uniform Strength, Design of Bolted Joints subjected to eccentric loading. 4.4 Design of parallel and transverse fillet welds, axially loaded symmetrical Section.
Unit –V Design of Springs	5a. Identify the type of spring used in the given application. 5b. Choose suitable material for spring with justification and write specification. 5c. Sketch the given type of spring. 5d. Write design procedure of the given type of helical compression/tension spring. 5e. Find dimensions of spring for the given application.	5.1 Classification and Applications of Springs, Spring - terminology, materials specifications. Stresses in helical tension and compression springs, Wahl's correction factor, Deflection of springs. Energy stored in springs. 5.2 Design of Helical tension and compression springs subjected to concentric applied loads like I.C. engine valves, weighing balance, railway buffers. 5.3 Leaf springs - construction and applications.
Unit-VI Selection of Antifriction Bearings and Gears	6a. Identify the given type of bearing. 6b. Explain the procedure of designing and selection of the given type of bearing. 6c. Select suitable bearing for given application from manufacturer's catalogue with justification. 6d. Select suitable Spur Gear for given application from manufacturer's catalogue with	6.1 Classification of Bearings – Sliding contact and rolling contact. 6.2 Terminology of Ball bearings – life load relationship, basic static load rating and basic dynamic load rating. 6.3 Selection of ball bearings using manufacturer's catalogue 6.4 Design of spur gear using Lewis and Buckinghams equation (Simple Numerical), selection of gears from standard sizes.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	

Note:*To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Design	14	04	04	06	14
II	Design of Joints, Levers and Offset links	12	02	04	06	12
III	Design of Shafts, Keys and Couplings	14	02	04	08	14
IV	Design of Power screws and Fastners	10	02	04	06	12
V	Design of Springs	08	02	04	04	10
VI	Selection of Antifriction Bearings and Gears	06	02	02	04	08
Total		**64**	**14**	**22**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

a. Prepare journal of practicals.
b. Undertake micro-projects.
c. Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
d. Collect different types of springs and write applications of the same.
e. Collect different types of used bearings and make display model and their application.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.

c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual failure and machine elements.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various failure modes.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.
k. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually***undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Take any day to day life component, find load, stresses and also prepare chart/model for the same.
b. Make models of various joints and levers highlight resisting sections of different elements.
c. Make models of various shafts, keys and pulleys highlight resisting sections.
d. Make models of various couplings highlight resisting sections of different elements.
e. Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
f. Prepare model of eccentrically loaded bolted and welded joint and highlight the maximum loaded section.
g. Prepare list of different types of bearings used in a bike and write their specifications and basis for selection.
h. Prepare list of different types of Gears used in Agriculture machinery, Sugar can juice machine, gear boxes of two and three wheelers and similar machines, write their specifications and basis for selection.
i. Prepare list of different types of levers and springs used in a bike, bicycle, Auto Rickshaw, Moped and write their specifications and basis for selection.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Design of Machine Elements	Bhandari V. B.	McGraw-hilleducation India pvt. limited, New Delhi, 2017, ISBN-13:978-9339221126
2	Machine Design	Khurmi R. S. and Gupta J. K.	S. ChandNew Delhi, 2005, ISBN 10:8121925371 ISBN13:9788121925372
3	Machine Design	Jindal U. C.	Pearson Education India New Delhi, 2010, ISBN13: 9788131716595
4	Machine Design	Pandya and Shah	CharotarPublishing house pvt. Ltd. Anand, Gujarat, 2015, ISBN-13:9789385039102
5	Mechanical EngineeringDesign	Shigley	McGraw-hilleducation India pvt. limited, New Delhi, 2017, ISBN-13:978-9339221638
6	Design Data Book	PSG	PSG College ofTechnology Coimbatore, 2012, ISBN-10: 8192735508
7	IS Codes: IS 4218: 1967 ISO Metric Threads IS 2693: 1964 Cast Iron Flexible Couplings IS 2292: 1963 Taper keys and Keyways IS 2293: 1963 Gib Head Keys and Keyways IS 2389: 1963 Bolts. Screws, Nuts and Lock Nuts IS 4694: 1968 Square threads IS 808: 1967 Structural Steel SKF/NBC Catalogue for Bearings	ISO	Indian Standard Bureau New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112105124/
b. https://www.youtube.com/watch?v=CLeLFUrvO2g
c. www.machinedesignonline.com
d. www.engineeringtoolbox.com
e. https://www.youtube.com/watch?v=N5SckoiTDxA
f. https://www.youtube.com/watch?v=GfbcxJmjn9s
g. http://www.ignou.ac.in/upload/Unit-5-60
h. https://sizes.com/numbers/preferred_numbers.htm
i. www.robot-and-machines-design.com/en/articles/mech
j. http://www.youtube.com/flangedcoupling
k. http://www.youtube.com/screwjack

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Tool Engineering (Elective)**

Course Code : **22565**

1. RATIONALE

Tools are basic component required for any machining process. The quality and efficiency of any machining operation basically depends upon quality of tools which in turn depends upon the proper shape, size and material of the tools. Productivity and quality of machining operations may further be enhanced by proper and quick mounting of tools and jobs on machines using suitable Jigs and Fixtures. Therefore, this course attempts to develop abilities in students to select a tool of proper size and shape for required machining operation. The design of basic cutting tools, jigs and fixtures are also dealt with in this course.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use different types of tools, dies, jigs and fixtures to machine simple components.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Interpret geometries of various cutting tools.
b. Use relevant cutting tool insert and tool holders for different machining operations.
c. Use relevant locating and clamping devices for components.
d. Use relevant Jig and Fixture for components and machining operations.
e. Use relevant Press tools and Press tools operations.
f. Use relevant Die for bending and forging simple components.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

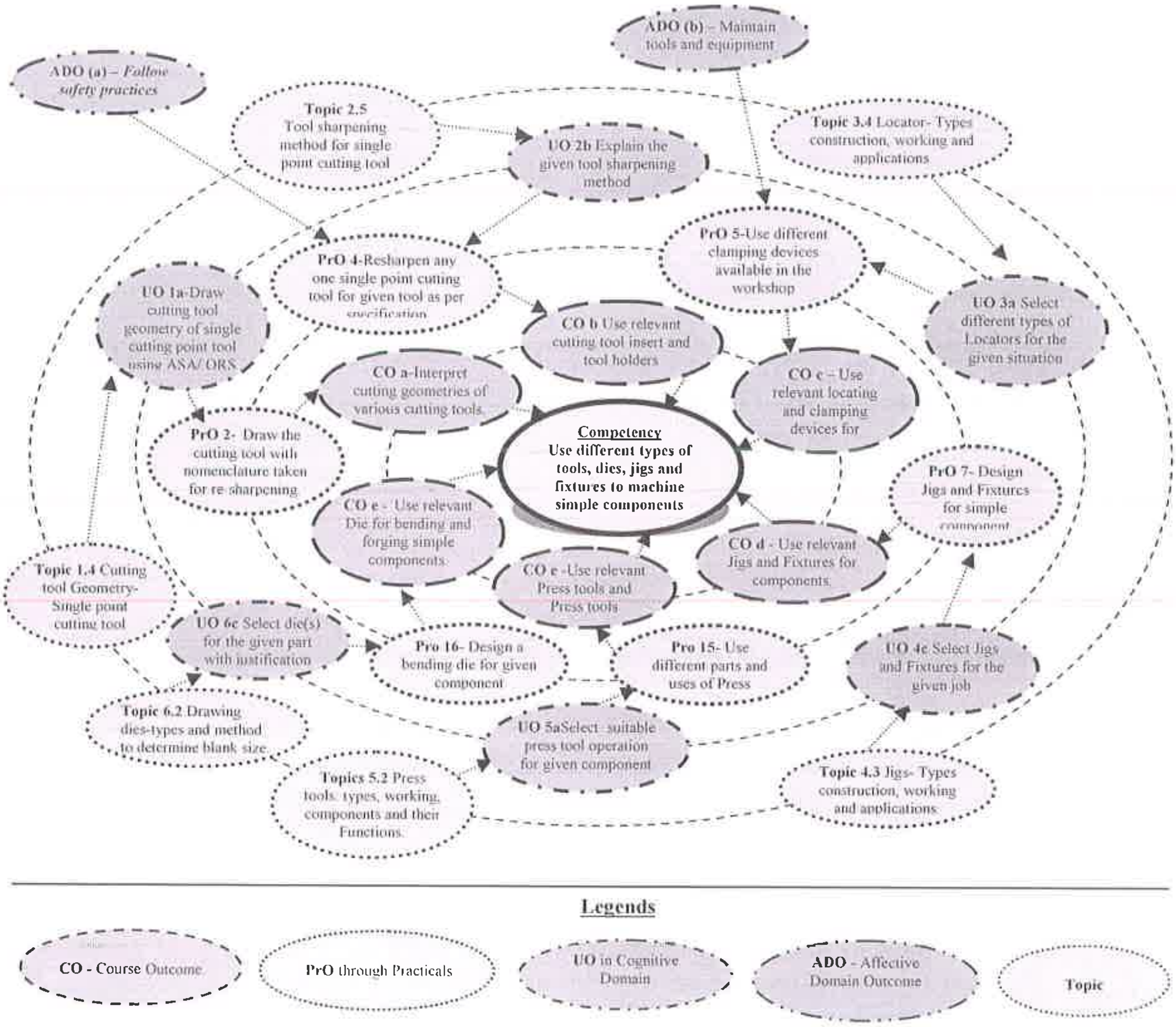


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the use of different types of tools, and their designation systems.	I	02*
2	Draw the cutting tool with nomenclature taken for re-sharpening.	I	02
3	Use different tool holders and their use with specific applications.	II	02*
4	Re-sharpen any one Single Point Cutting Tool as per given specification.	II	02
5	Use different clamping devices and their use available in the workshop.	III	02
6	Use different locators and their use available in the workshop	III	02
7	Design a Jig and Fixture for machining of a given simple component. (Part-I)	IV	02*
8	Design a Jig and Fixture for machining of a given simple component. (Part-II)	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Draw assembly and detail drawing of the designed Jig.	IV	02*
10	Draw assembly and detail drawing of the designed Fixture.	IV	02*
11	Design a progressive cutting die for a simple component.	V	02
12	Draw assembly and detail drawing of the designed progressive cutting die. (Part-I)	V	02
13	Draw assembly and detail drawing of the designed progressive cutting die. (Part-II)	V	02
14	Prepare Strip layout of simple component.	V	02*
15	Use different parts and uses of Press.	V	02*
16	Design a bending die for given component.	VI	02*
17	Draw bending die indicating all parts and dimensions.	VI	02
18	Estimate blank size for Deep Drawing a simple component.	VI	02
	Total		**36**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of Result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Single point cutting tool- 2 Qty	1,4,5
2	Drill – M12/M16/M20 size	1
3	Grinding Machine- Grinder Size 100 mm min.	1,4,5
4	Tool holders- Milling Cutter mandrill, Drill tool holder, Tool post of Lathe machine (Qty one each)	2
5	Clamping devices for drilling machine, Milling machine, Chucks (Qty one each)	5
6	Different Press tools	13

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Basics of Tool Engineering	1a. Classify the given cutting Processes. 1b. Estimate cutting forces in the given simple numerical problem situation. 1c. Draw cutting tool geometry of single cutting point tool using given ASA or ORS system. 1d. State the shear angle required for the given job with justification	1.1 Principles in tool engineering. 1.2 Mechanics of Metal cutting: requirements of tools. 1.3 Cutting forces – Merchant circle, types of chips, chip thickness ratio, shear angle. Shear angle- concept, need and method to give shear angle on punch and die. 1.4 Types of metal cutting process - orthogonal, cutting 1.5 Cutting tool Geometry- Single point cutting tool
Unit– II Cutting Tool Material and Holding Devices	2a. List the different properties and composition of the given tool material(s). 2b. Interpret ISO designation of the given tool insert. 2c. Select tool holders and inserts for the given component and machining operation with justification. 2d. Explain the given tool sharpening method(s).	2.1 Cutting tool materials - types, composition, properties and applications. 2.2 Carbide inserts -types, ISO -designation and Applications. Other inserts like CBN and PCBN. 2.3 Tool holders for turning, milling machines and CNC machines. 2.4 ISO designations of Tool holders. 2.5 Tool sharpening method for single point cutting tool.
Unit-III Locating and Clamping devices	3a. Explain principle of location with reference to the given work piece. 3b. Calculate the Degrees of freedom in the given situation. 3c. Select different types of Locators for the given	3.1 Concept, definition locating and clamping. 3.2 Use of locating and clamping principles on shop floor. 3.3 Degree of freedom concept and importance. 3.4 Locator- Types construction, working and applications. 3.5 Clamping devices - Types construction,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	situation with justification. 3d. Select different types of Clamping devices for the given situation with justification.	working and applications 3.6 Fool proofing and ejecting techniques.
Unit –IV Jigs and Fixtures	4a. Differentiate between given type of jig and fixture. 4b. Select the relevant Jigs for the given component with justification. 4c. Select the relevant fixtures for the given component with justification 4d. Explain the design procedure for the given Jig and fixture.	4.1 Concept, definition of jigs and fixtures. difference between jigs and fixtures. 4.2 Jigs- Types construction, working and applications. 4.3 Fixtures - Types construction, working and Applications. 4.4 Design considerations and procedure for Jigs and Fixtures.
Unit-V Press Tool design	5a. Select suitable press tool operation for the given simple press tool component with justification. 5b. Calculate press tonnage and centre of pressure for the given press tool component. 5c. Prepare scrap strip layout for the given press tool component. 5d. Design progressive cutting die for the given simple press tool component.	5.1 Press working processes-types, sketches and Applications. 5.2 Press tools: types, working, components and their Functions. 5.3 Concept, meaning, definitions and calculations of press tonnage and shut height of press tool. Shear action in die cutting operation. 5.4 Centre of pressure: Concept, meaning, definition, Methods of finding and importance. 5.5 Die clearance: Concept, meaning, definition, Reasons, effects and methods of application. 5.6 Cutting force: Methods to calculate and methods of reducing. 5.7 Scrap strip layout: - Concept, importance, method to prepare, and determining percentage stock utilization. 5.8 Types, working, and applications of stock stop, pilots, strippers and knockouts. 5.9 Cutting dies-types and applications. 5.10 Design of progressive cutting die: a) Sketch the component. b) Prepare scrap strip layout. c) Calculate tonnage. d) Determine centre of pressure. e) Determine dimensions of punches, die block and die shoe. f) Prepare sketch of stripper plate. g) General assembly sketch of punches arrangement, die block, die shoe and stripper plate.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-VI Bending, Drawing and Forging Dies	6a. Calculate bend radius, bend allowance and spring back for the given simple part. 6b. Draw labeled sketch of the given die(s). 6c. Select die(s) for the given part with justification.	6.1 Bending dies - a) Types and Parts and functions of bending die. b) Definition, calculations and factors affecting bend radii, bend allowance and spring back. c) Method to compute bending pressure.: Types, sketch, working and applications of bending dies. 6.2 Drawing dies-types and method to determine blank size for drawing operation, Types, sketch, working and applications of drawing dies (embossing, curling, bulging, coining, swaging and hole flanging). 6.3 Forging dies- terminology, types, sketch, working and application

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Tool Engineering	06	02	02	04	08
II	Cutting Tool Material and holding devices	06	02	02	04	08
III	Locating and Clamping devices	06	02	04	04	10
IV	Jigs and Fixtures	08	02	04	06	12
V	Press Tool design	12	04	06	10	20
VI	Bending, Drawing and Forging Dies	10	02	04	06	12
Total		**48**	**14**	**22**	**34**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

a. Visit any industry and collect information related to tool engineering practices.
b. Prepare journal based on practical performed in Tool Engineering laboratory. Journal consists of drawing, observations, required materials, tools, equipments, date of performance with teacher signature.

c. Prepare/Download specifications of followings:
   i. Tools and equipment in Tool engineering laboratory.
   ii. Machineries in Tool Engineering laboratory
d. Undertake a market survey of local dealers for tools, equipments; machineries and raw material and prepare a report.
e. Visit to any press tool industry and prepare a report consisting of
   i. Types of press
   ii. Types of dies
   iii. Types of operations
   iv. Types of fool proofing arrangement
   v. Safety precautions observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.
i. Guide student(s) in undertaking micro-projects.
j. Arrange visit to nearby industries for understanding various tool engineering operations
k. Show video/animation films to explain tool design processes.
l. Use different instructional strategies in classroom teaching.
m. In respect of item no.10 above the teachers need to ensure to create opportunities and support sustem for such co-curricular activities.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Preparation of Wax/Rubber model of various dies/single point cutting tools.
b. Collect various Carbide inserts as per ISO specification.
c. Measure press capacity of any press available in industry or nearby industry.
d. Design simple Clamming devices/Jigs/Fixtures/locating for simple jobs.
e. Collect specifications of different Jigs and fixtures.
f. Sketch different jigs /fixtures/clamping devices available in institute workshop.
g. Identify and restrict degree of freedom of a given component for designing a clamping/locating device for a given machining operation.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Fundamentals of Electrical Networks	Gupta, B.R, and Singhal Vandana	S.Chand and Co., New Delhi, 2005 ISBN: 978-81-219-2318-7
2	Tool Design	Donaldson Cyrll	Mcgraw Hill Education, 2000 ISBN: 9780070153929, 0070153922
3	Tool Engineering, Jigs and Fixture	Atkins Albert	McGraw-Hill, 1922 ISBN/ASIN: 1151454966
4	Fundamentals of Tool Engineering Design	Basu S. K.	Oxford Ibh, 1979 ISBN 812040016X, 9788120400160
5	Tool Engineering and Design	Nagpal G. H.	Khanna Publication, 2003 ISBN : 817409203X
6	Machine tool and Tool Design	Sharma P. C.	S.Chand Publishing, 2012 SBN: 9788121923620,

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=Mn9jpqI8rao
b. https://www.youtube.com/watch?v=bUrp8JMRwx4andvl=en
c. https://www.youtube.com/watch?v=qaG_vxsfLUg
d. https://www.youtube.com/watch?v=EgTzD_8dUFc
e. https://www.youtube.com/watch?v=CrWxJ58la1E
f. https://www.youtube.com/watch?v=Pb20Rkx25yA
g. https://www.youtube.com/watch?v=Hp7UC5ite5M
h. https://www.youtube.com/watch?v=lcrK2Po8fJI
i. https://www.youtube.com/watch?v=_E1GCE2dDcY
j. https://www.youtube.com/watch?v=7yzvno4AvKw
k. https://www.youtube.com/watch?v=yoUxqeAN0So
l. https://www.youtube.com/watch?v=_r7djWX8X34
m. https://www.youtube.com/watch?v=Us7kjBmRL-Q
n. https://www.youtube.com/watch?v=S9qzJat3Mzk
o. https://www.youtube.com/watch?v=I71YrXafg0o
p. https://www.youtube.com/watch?v=wulJZzORm3wandpbjreload=10
q. https://www.youtube.com/watch?v=i5ZGSMXw5nU
r. https://www.youtube.com/watch?v=WJ_VlWd0EsA
s. https://www.youtube.com/watch?v=93-VH01ACB4
t. https://www.youtube.com/watch?v=MtNTFvP0uAI
u. https://www.youtube.com/watch?v=eqKa2gv9Kx0
v. https://www.youtube.com/watch?v=m8EoGASM0SI
w. https://www.youtube.com/watch?v=til4UOBTRg0

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Power Plant Engineering (Elective)**

Course Code : **22566**

1. RATIONALE

Electrical power is the main resource for any type of industry. Economic growth of the nation essentially results into growth in power sector. Various conventional power plants such as Hydro, Steam, Gas, Diesel, Nuclear power plants are employed for power generation. Most of the power plants use mechanical engineering equipment and components. Hence, this course attempts to provide the basic knowledge of the components, operation and maintenance of power plants to the students and would also acquaint them with the latest technological advances taking place in this sector.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain power generation systems related to mechanical engineering.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify various components of Hydro, Steam, Gas, Diesel power plants.
b. Select high pressure Boiler for power generation capacity of plants.
c. Identify components of Steam, Diesel and Gas turbine power plants.
d. Measure waste heat recovery in a typical thermal power plants.
e. Identify components of Nuclear power plants.
f. Estimate economic parameters of power plants.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

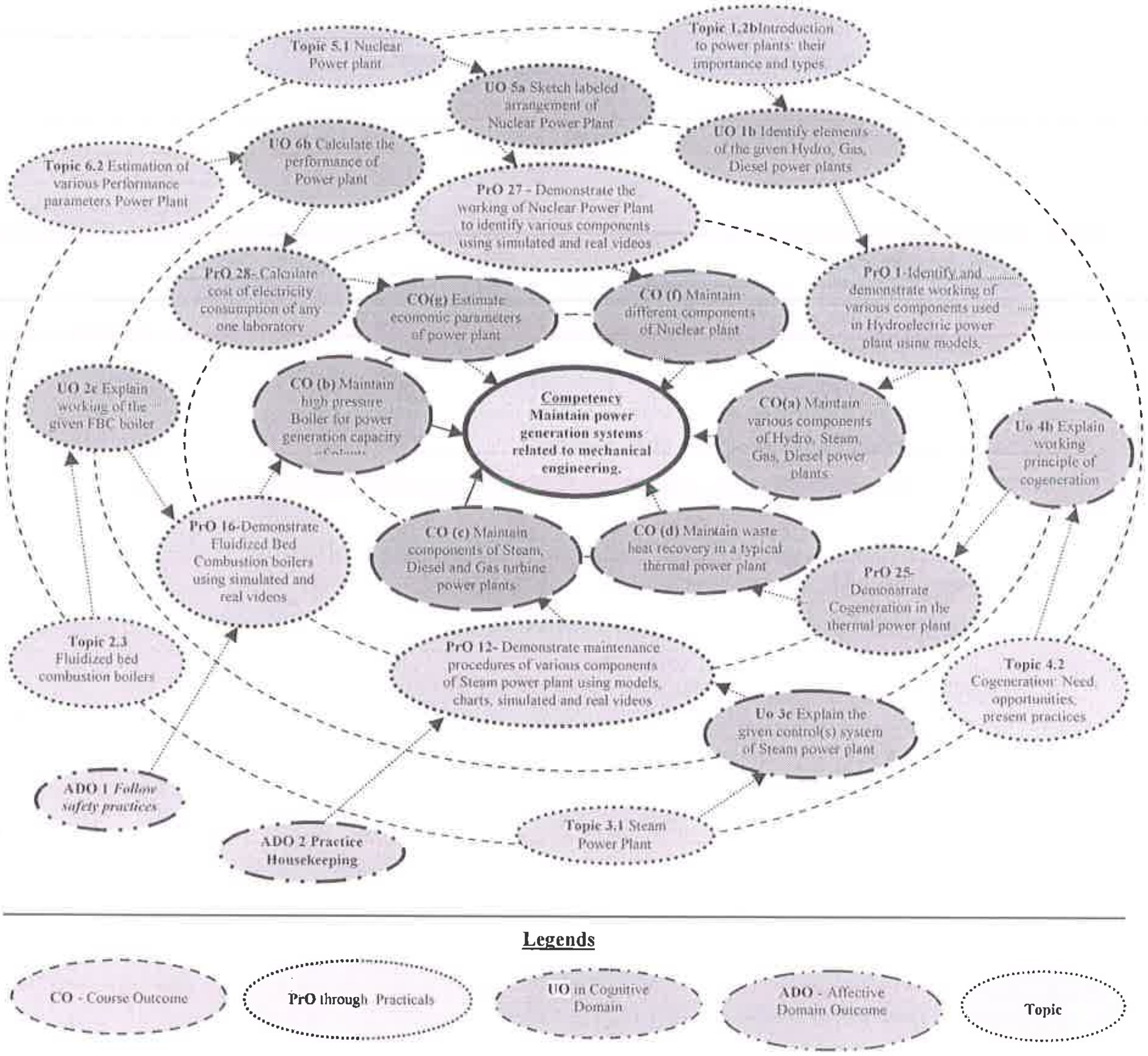


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Identify various components used in Hydroelectric power plant using models, charts, simulated and real videos.	I	02*
2	Maintain various components of Hydroelectric power plant using models, charts, simulated and real videos.	I	02
3	Identify various components used in Gas turbine power plant using models, charts, simulated and real videos.	I	02
4	Identify various components used in Gas turbine power plant using models, charts, simulated and real videos.	I	02
5	Maintain Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant	I	02*
6	Identify and demonstrate working of various components used in	I	02

	Diesel engine power plant using models, charts, simulated and real videos.		
7	Identify various components used in Diesel engine power plant using models, charts, simulated and real videos.	I	02
8	Maintain component like Diesel engine, Air filters, Super chargers, Engine starting system, Fuel system, Lubrication system, Cooling system, Governing system etc.of Diesel engine power plant	I	02*
9	Identify various components used in Diesel generating set using models, charts, simulated and real videos.	I	02
10	Maintain a typical small size Diesel generating set used in houses or shops	I	02*
11	Identify various components used in Steam power plant using models, charts, simulated and real videos.	III	02*
12	Maintain condenser, economizer etc. components of Steam power plant.	III	02*
13	Maintain working of any two types of High pressure Boilers using models, charts, simulated and real videos on High pressure Boilers.	II	02*
14	Maintain Fluidized Bed Combustion boilers using models, charts, simulated and real videos.	II	02*
15	Maintain the working of electro static precipitators using model, charts, simulated and real videos.	II	02
16	Maintain temperature and feed water control system using model, charts, simulated and real videos.	II	02*
17	Prepare model diagram of steam power plant by selecting various components for a given load. (Part-I)	III	02
18	Prepare model diagram of steam power plant by selecting various components for a given load. (Part-II)	III	02
19	Develop maintenance procedure for preventive and predictive maintenance of a typical Hydro Power Plant and its components.	I	02
20	Develop maintenance procedure for preventive and predictive maintenance of a typical Diesel power plant and its components.	I	02*
21	Develop maintenance procedure for preventive and predictive maintenance of typical FBC boilers and its components.	II	02*
22	Develop maintenance procedure for preventive and predictive maintenance of a typical High-pressure boiler and its components	II	02
23	Develop maintenance procedure for preventive and predictive maintenance of a typical Steam Power Plant and its components.	III	02*
24	Develop maintenance procedure for preventive and predictive maintenance of a typical Gas Power Plant and its components.	III	02
25	Demonstrate the concept of Cogeneration in the given thermal power plant using model, charts, simulated and real videos.	IV	02*
26	Maintain Trigeneration in the given thermal power plant using model, charts, simulated and real videos.	IV	02
27	Maintain the working of Nuclear Power Plant to identify various components using models, charts, simulated and real videos.	V	02*
28	Calculate cost of electricity consumption of any one Laboratory. (Part-I)	VI	02*
29	Calculate cost of electricity consumption of any one Laboratory. (Part-II)	VI	02*
	Total		32

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical needs to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Arrangement of available equipment / test rig or model	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of practicals, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Working Model of Hydro power plant- Small Turbine (capacity-0.25KW),lighting system as a load (min.10 bulbs of various capacity)	01
2	Model of gas power plant including all major components	02
3	Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant	04
4	5 KVA Diesel Generating set.	11
5	Working model of Steam Power plant- oil fired Boiler (min Capacity-0.5KW), Reaction steam Turbine, Surface Condenser, generator, power distribution system to power bank.	04,08,12

S. No.	Equipment Name with Broad Specifications	PrO. No.
6	Condenser, economizer etc. components of Steam power plant.	14
7	Working model of Loffler Boiler	05,12
8	Working model of Benson Boiler	05,12
9	Working model of Electro static Precipitator	07,12
10	Model of FBC Boiler	06,12
11	Working model of Feed water control system	04,08,12
12	Temperature sensor and temperature sensing system	04,08,12
13	Model of Nuclear Power plant	09
14	AxCYCLE Software:Thermodynamic Simulation Software for heat balance calculations of heat production and energy conversion cycles.	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Introduction to Power Plants	1a. Explain energy conversion in the given power plant. 1b. Identify elements of the given Hydro, Gas, Diesel power plant(s). 1c. Explain preventive procedure of the given power plants. 1d. Explain predictive maintenance procedure of the given power plants.	1.1 World and national scenario of demand and supply of energy. 1.2 Introduction to power plants: their importance and types. 1.3 Hydroelectric power plant: Classification, General arrangement, operating principle, advantages and limitations, Maintenance. 1.4 Diesel power plant: Introduction, components, advantages and limitations, Diesel generating set, Maintenance.
Unit– II High Pressure Boilers	2a. Explain with sketches of the working of the given type of boiler 2b. Compare the salient features of the given types of high pressure boilers. 2c. Explain Preventive maintenance of the given High pressure boilers. 2d. Explain Predictive maintenance of the given High pressure boilers.	2.1 High Pressure Boilers – Classification. 2.2 Construction and principle of working of Lamont boiler, Benson boiler, Loeffler boiler, Velox boiler, Schmidt Hartman boiler, Ramsin boiler 2.3 Fluidized bed combustion boilers (FBC): principle, need, types, various arrangement, control system and advantages over other boiler systems. 2.4 Comparison of various types of boilers 2.5 Indian Boiler Regulation Act 2.6 Maintenance procedure of major components of high pressure and FBC boilers
Unit-III Steam and Gas Power Plants	3a. Explain with sketches the given Fuel handling system. 3b. Identify various elements of the given Steam power plant and its control system. 3c. Explain with sketches the given control(s) system of	**Steam Power Plants** 3.1 Steam power plant: Introduction, components, advantages and limitations 3.2 Fuel handling systems in power plants: types, components 3.3 Electro-Static Precipitators 3.4 Control systems of power plant –

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Steam power plant. 3d. Identify the given Component(s) of Gas Power Plant. 3e. Explain preventive maintenance of the given major component of given turbine power plants. 3f. Explain predictive maintenance of the given major component of given turbine power plants	Elements, Types, desirable characteristics. 3.5 Steam temperature control and feed water control systems. 3.6 Maintenance procedure of major components of Steam power plant. **Gas Turbine Power Plants** 3.7 Open and close cycle with constant pressure gas turbine power plant 3.8 Components of gas turbine power plant 3.9 Methods to improve the thermal efficiency of a simple open cycle constant pressure gas turbine power plan 3.10 Advantages of gas turbine power plant over others. 3.11 Maintenance procedure of major components of Gas turbine power plants.
Unit –IV Waste Heat Recovery, Cogeneration and Trigeneration	4a. Explain the need of waste heat recovery of the given thermal power plants. 4b. Explain with sketches working principle of cogeneration and trigeneration in the given thermal power plant.	4.1 Waste heat recovery in thermal power plants: Need, opportunities, present practices 4.2 Cogeneration: Need, opportunities, present practices 4.3 Trigeneration: Need, opportunities, present practices
Unit-V Nuclear Power Plants	5a. Sketch labeled arrangement of the given nuclear power plant. 5b. Explain with sketches working of the given reactors. 5c. Compare the calorific values of the given types of fuels. 5d. Interpret the regulations for nuclear power plants.	5.1 Nuclear power plant: Classification, General arrangement, operating principles 5.2 Nuclear Fuels and Reactors 5.3 Advantages and limitations 5.4 Introduction to regulating agencies and regulations: Atomic Energy Regulatory Board (AERB), International Atomic Energy Agency (IAEA)
Unit-VI Economic Analysis of Power Plants.	6a. Estimate Cost of Electricity in the given situation using simple numerical problems. 6b. Calculate performance parameters for the given power plant using simple numerical problems.	6.1 Estimation of production cost of electrical energy in various types of power plants. 6.2 Estimation of various Performance parameters. 6.3 Factors affecting choice of a power plant.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Power plants	08	02	04	06	12
II	High Pressure Boilers	08	02	04	06	12
III	Steam and Gas Power Plants	10	02	04	08	14
IV	Waste Heat Recovery, Cogeneration and Trigeneration	06	02	02	04	08
V	Nuclear Power Plants	08	02	04	06	12
VI	Economic Analysis of Power Plants	08	02	04	06	12
Total		48	**12**	**22**	**36**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journal based on practical performed in Power Plant Engineering laboratory. Journal consists of drawing, observations, required equipment, date of performance with teacher signature.
b) Prepare/Download the specifications of followings:
   i. Power plant equipment.
   ii. Steam power plant equipment and elements.
   iii. Gas turbine power plant equipment and elements.
   iv. Hydro power plant equipment and elements.
   v. Diesel power plant equipment and elements.
c) Visit to any Power plant and prepare a report consisting of
   i. Various advanced systems
   ii. Various standards
   iii. Maintenance of components of power plant observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with power plant system and equipments.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various components, operation and maintenance of power plants.
i) Before starting practical, teacher should demonstrate the working of power plant.
j) Instructions to students regarding care and maintenance of measuring equipments.
k) Show video/animation films to explain functioning of various power plants
l) Teacher should ask the students to go through instruction and Technical manuals

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a) Collection of information of control systems of power plant.
b) Collection of information about nearby cogeneration plant.
c) Comparative study of various parameters of performance evaluation of a power plant.
d) Measure operating parameters of Boiler using appropriate instruments.
e) Maintenance of a diesel generator set (DG set).
f) Collect information regarding preventive, predictive and breakdown maintenance of various power plants.
g) Develop maintenance procedure for preventive and predictive maintenance of a typical Hydro Power Plant and its components.
h) Develop maintenance procedure for preventive and predictive maintenance of a typical Diesel power plant and its components.
i) Develop maintenance procedure for preventive and predictive maintenance of typical FBC boilers and its components.
j) Develop maintenance procedure for preventive and predictive maintenance of a typical High-pressure boiler and its components
k) Develop maintenance procedure for preventive and predictive maintenance of a typical Steam Power Plant and its components.
l) Develop maintenance procedure for preventive and predictive maintenance of a typical Gas Power Plant and its components.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Power Plant Engineering	Nag, P. K.	Tata McGraw Hill India, 2007 ISBN: 9789339204044
2	Power Plant Technology	El-Wakil M. M.	McGraw Hill Education, (India).

S. No.	Title of Book	Author	Publication
			2010 ISBN: 9780070702448
3	Power Plant Engineering	Raja, A. K.	Prentice Hall, 2006 ISBN : 9788122418316
4	A Text Book of Power Plant Engineering	Sharma, P. C. and Nagpal	McGraw Hill Education, (India) ISBN : 9789350143841
5	Steam and Gas Turbine and Power plant Engineering	Yadav, R	Central Publication house ISBN : 9788185444352

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=-hooifWJ1jY
b. https://www.youtube.com/watch?v=Uhjhufhg3Xk
c. https://www.youtube.com/watch?v=_UwexvaCMWA
d. https://www.youtube.com/watch?v=_AdA5d_8Hm
e. https://www.youtube.com/watch?v=ChvI2v85fsU
f. https://www.youtube.com/watch?v=IdPTuwKEfmA
g. https://www.youtube.com/watch?v=XjbczcFNrNU
h. https://www.youtube.com/watch?v=0rsPFdkwR0
i. https://www.youtube.com/watch?v=gDVukHOxURc
j. https://www.youtube.com/watch?v=02p5AKP6W0Q
k. https://www.youtube.com/watch?v=FXBqvLWxbr0
l. https://www.youtube.com/watch?v=dCPfHifMbOk
m. https://www.youtube.com/watch?v=b6-n0pFu5d4
n. https://www.youtube.com/watch?v=iUXHzYLgrB0
o. https://www.youtube.com/watch?v=ZssGiY6rfYE
p. https://www.youtube.com/watch?v=F01AFJe2j2A
q. https://www.youtube.com/watch?v=c6wDRQMD-YE
r. https://www.youtube.com/watch?v=ks-G4FYVtg
s. https://www.youtube.com/watch?v=H6EClYcfXKw
t. https://www.youtube.com/watch?v=KmYbupS4u-k
u. https://www.youtube.com/watch?v=rEJKiUYjW1E
v. https://arupatan.in/info/959/coal_mill_operation_power_plant/
w. https://www.youtube.com/watch?v=KmYbupS4u-k

Maharashtra State Board of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechnical Engineering

Program Code : ME — **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters — **Duration : 16 Weeks**

Semester : Sixth — **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme													Grand Total
								Theory							Practical						
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total		
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Emerging Trends in Mechanical Engineering	ETM	22652	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	Industrial Hydraulics and Pneumatics	IHP	22655	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
3	Automobile Engineering	AEN	22656	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Industrial Engineering and Quality Control	IEQ	22657	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Elective (Any One)																				
5	Computer Integrated Manufacturing	CIM	22658	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Refrigeration and Air Conditioning	RAC	22660	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Renewable Energy Technology	RET	22661	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Enterprenureship Development	EDE	22032	2	-	2	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40	100
7	Capstone Project Execution and Report Writing	CPE	22060	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
			Total	17	-	14	31	--	350	--	150	-	500	--	200	--	200	--	400	--	900

Student Contact Hours Per Week: **31 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **900**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

➢ **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME/PG/PT/AE**

Semester : **Sixth**

Course Title : **Emerging Trends in Mechanical Engineering**

Course Code : **22652**

1. RATIONALE

Over the coming years, technological developments such as Robotics, IOT, Artificial intelligence, smart controls are likely to have a significant impact on the world of work and employment as well as to trigger far reaching changes. Looking towards the era in Technology advancement, Mechanical/Automobile/Production Engineering offers addition of new Dynamic subjects and new versions of core subjects. Diploma Mechanical/Automobile/Production Engineers should be familiar with new technologies from the fields of Automobile Engineering, Energy Management, Advanced Manufacturing Processes, Agriculture and Farm Machines and many more. This Dynamic course will give insight to the recent practices adopted by the Mechanical Industries and awareness of these techniques will enhance career opportunities of Diploma Mechanical/Automobile/Production Engineers.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Relate basic principles of Mechanical Engineering with Recent Technologies available in Industry.**
-

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify different New Systems available in Automobile.
b. Apply Heat engineering principles in process Boilers and waste heat Recovery systems used in Process Industry
c. Cite examples of Modern manufacturing Technology in industry
d. Use different standards for energy Management and Audit of a given system.
e. Select recent agricultural equipment for pre and post harvesting.
f.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

***(*)**: Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 MULTI CHOICE QUESTION tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.*
***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

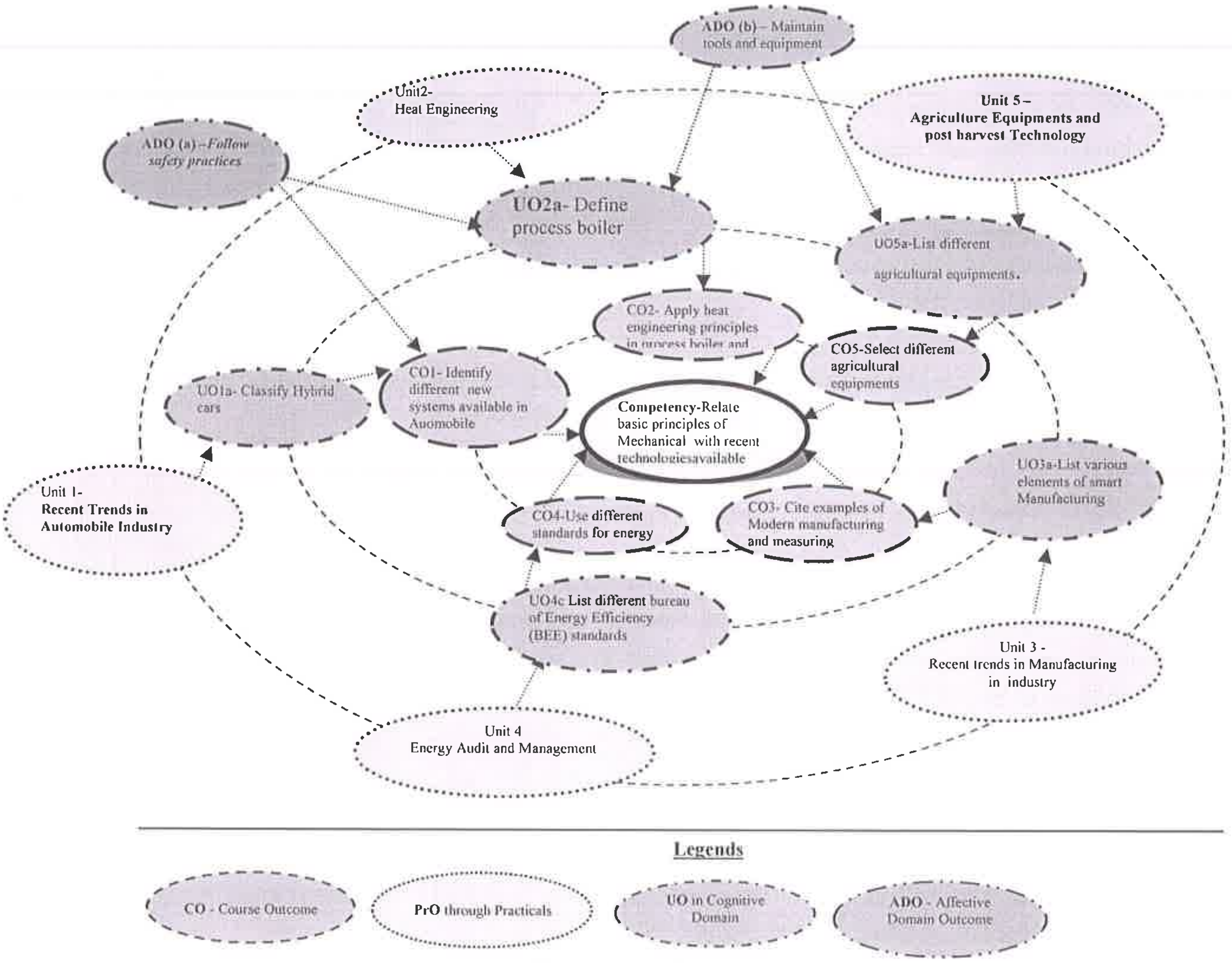


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	NA		

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*
ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	NA	

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1styear
- 'Organizing Level' in 2ndyear
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	LCD Projector	-

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I **Recent Trends in Automobile Industry**	1a. Classify Hybrid cars 1b. List different batteries used in E-Vehicles 1c. Name different safety systems used in given vehicle.	1.1 Hybrid cars-manufactures, Types- Micro Hybrid, Mild Hybrid, Full Hybrid, Series hybrid, Parallel Hybrid 1.2 E-vehicles- Manufacturers, specifications, Types of Batteries, Li-ion batteries, Sodium Nickel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Chloride Batteries ,Sodium Sulphor Batteries, Fuel Cell, Charging- Charging Methods and Modes. Issues with e-vehicles 1.3 Safety in Automobile- Air bags, Automatic Emergency Braking, Adaptive Cruise Control, Electronic stability programmer, Anti Collision system, Active Passive Integration system.
Unit– II Process Engineering	2a. Define process boiler 2b. State principles of ultra-super critical boilers. 2c. List commerciality viable waste heat recovery devices.	2.1 Process Boilers-Steam and Condensate loop in process industries 2.2 Introduction to ultra-super critical Boilers. 2.3 Hyperbolic cooling towers. 2.4 Waste heat recovery-process industry
Unit –III Recent Trends in Manufacturing in industry	3a. List various elements of smart Manufacturing 3b. Interpret the Automation in Mechanical Industry 3c. List Different types of Automation 3d. Select Robot for given application 3e. Compare 4 D printing technology with 3D printing technology. 3f. Describe the importance of 3-D scanning with reverse engineering.	3.1 **Smart Manufacturing Technology** introduction, Elements and applications 3.2 **Automation**: Need, Basic elements of automated systems, automation principles and strategies, Benefits. 3.3 **Types of automation:** fixed, programmable, flexible, hard and soft automation. 3.4 **Industrial robotics**: robot anatomy, robot control systems, end effectors, sensors in robotics, industrial Robot applications 3.5 4-D printing Technology- Printing Techniques, 3D scanning Technology- Function, ,Applications
Unit-IV Energy Audit and Management	4.a List different bureau of Energy Efficiency (BEE) standards. 4.b Describe methods of Energy Monitoring and Targeting 4.c Identify steps for conducting Energy Audit.	4.1 Standards and labelling standard(HVAC) 4.2 Energy Monitoring and Targeting. 4.3 Energy Management and Audit
Unit-V Agriculture Equipment and post harvest Technology	5.a Explain working of different agricultural equipment. 5.b Name different elements of Cold Chain 5.c List the features of NCAP	5.1 Tillers, Sowing and planting equipment, Weeding Machines, Spraying Machines, Harvesting, Post harvesting Machineries 5.2 Elements of Cold chain 5.3 National Cooling Action Plan (NCAP)

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Recent Trends in Automobile Industry	14	06	10	04	20
2	Process Engineering	06	02	06	02	10
3	Recent Trends in Manufacturing in industry	14	06	10	04	20
4	Energy Audit and Management	08	02	06	02	10
5	Agriculture Equipment and post-harvest Technology	06	02	06	02	10
	Total	**48**	**18**	**38**	**14**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Visit any industry and collect information of recent trends in Industry.
b. Undertake a market survey of local dealers for agricultural equipments, machineries, HVAC equipments and prepare a report.
c. Visit to any Industrial press shop and prepare a report consisting
   i. Safety precautions observed.
   ii. Identify problems related to energy conservations faced by industry

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.

h. Observe continuously and monitor the performance of students in Lab.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.
k. Guide student(s) in undertaking micro-projects.
l. Arrange visit to nearby industries for understanding various tool engineering operations
m. Show video/animation films to explain tool design processes.
n. Give Micro projects.
o. Use different instructional strategies in classroom teaching.
p. In respect of item no.10 above the teachers need to ensure to create opportunities and pursue for such co-curricular activities.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projcets arc given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare energy audit report of any one Lab rotary.
b. Collect data with respect to safety systems available in Modern cars
c. Identify different heat losses in Furnace available in workshop.
d. Compile the different products manufactured by 4-D printing Technology
e. Prepare report of pre and post harvesting using recent agricultural equipment
f. Collect information of District cooling.
g. Collect information of Robotics
h. Visit the local industry nearby and study the manufacturing systems. Thereby prepare the low cost automation plan for improvement in the productivity and quality of the industry

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Electric and Hybrid Vehicles	Tom Denton	IMI (Institute of Motor Industry) ISBN-13: 978-1138842373 ISBN-10: 1138842370
2	The Electric car	M H Westbrook	IET,2001, ISBN-0852960131
3	Hybrid, Electrical and Fuel Cell Vehicles	Jack Erjavec	Cengage Learning,2012 ISBN-1285415051
4	Boilers for Power and process	Kumar Rayaprole	CRC Press,2009, ISBN-1420075373
5	Steam generators and	V Ganpathy	CRC press,

S. No.	Title of Book	Author	Publication
	Waste heat Boilers		ISBN 1482247127
6	Introduction to process Technology	C.E Thomas	Cengage Learning,2009 ISBN 1435454251
7	Industry 4.0 Smart manufacturing for the future	William MacDougall	Germany trade and Investe,2014
8	Energy Management and Conservation	K V Sharma	I K International Publishing House Pvt ltd, 2011, ISBN- 9381141290
9	Energy Management, Audit and Conservation	B K De	Vrinda Publication, Indiana University,2007, ISBN-8182810930
10	Farm Tools and Equipments for Agriculture	Surendra Singh	New India Publishing,2015 ISBN-9385516221
11	Cold storage, cold chain, ware houses	NPCS Board of Consultant	3rd Edition,2018 ,NIR project consultancy services, Delhi ISBN-978-93-81039-66-3
12	4 D Printing- the next generation technology	Dirk Schreder	ISBN-13-978-8963495
13	Additive Manufacturing to 3 D/4D Printing 1	J D Andre	John Eiley & Sons,2017 ISBN 1119437393
14	Automation, Production Systems, and Computer Integrated Manufacturing	Groover, Mikell. P.	PHI, ISBN-13: 978-8120334182
15	Computer based Industrial Control	Kant, Krishna.	PHI Learning ISBN 13: 9788120339880

SOFTWARE/LEARNING WEBSITES

1. https://www.youtube.com/watch?v=MdFWgat9ddA(Agri Equipments)
2. https://www.chargepoint.com/about (Electrical Vehicle)
3. http://www.plugndrive.ca/ev-models (Electrical vehicle)
4. http://www.oorja.in/what-is-radiant-cooling/types-of-radiant-cooling-systems/(Cold Chain)
5. https://www.beeindia.gov.in/content/standard-labeling (Energy audit)
6. www.beestarlabel.com/ 9energy audit)
7. htttps:// Four-dimensional product/about (4 Dprinting)

Program Name : **Diploma in Mechanical Engineering**
Program Code : **ME**
Semester : **Sixth**
Course Title : **Industrial Hydraulics and Pneumatics**
Course Code : **22655**

1. RATIONALE

Hydraulic and pneumatic operated machines and equipment are widely used in various industries due to its versatility and adaptability to automation. Mechanical engineering technologists are required to maintain such systems in different segments of industries. This competency needs the knowledge of construction and working of different components of hydraulic and pneumatic systems. This course will give the students, the basic skills and knowledge to use and maintain different types of hydraulic systems and pneumatic systems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use different types of hydraulic and pneumatic systems for engineering applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Identify various components of hydraulic & pneumatic systems.
b) Select pump and actutators for given fluid operated system.
c) Select appropriate control valves for given fluid operated system.
d) Select compressor and appropriate accessories for given fluid operated system.
e) Develop different hydraulic circuits for given simple application.
f) Develop different pneumatic circuits for given simple application.

4. TEACHING AND EXAMINATION SCHEME

<table>
<tr><th colspan="3">Teaching Scheme</th><th rowspan="4">Credit (L+T+P)</th><th colspan="13">Examination Scheme</th></tr>
<tr><th rowspan="3">L</th><th rowspan="3">T</th><th rowspan="3">P</th><th colspan="7">Theory</th><th colspan="6">Practical</th></tr>
<tr><th rowspan="2">Paper Hrs.</th><th colspan="2">ESE</th><th colspan="2">PA</th><th colspan="2">Total</th><th colspan="2">ESE</th><th colspan="2">PA</th><th colspan="2">Total</th></tr>
<tr><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th></tr>
<tr><td>3</td><td>-</td><td>2</td><td>5</td><td>3</td><td>70</td><td>28</td><td>30*</td><td>00</td><td>100</td><td>40</td><td>25#</td><td>10</td><td>25</td><td>10</td><td>50</td><td>20</td></tr>
</table>

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

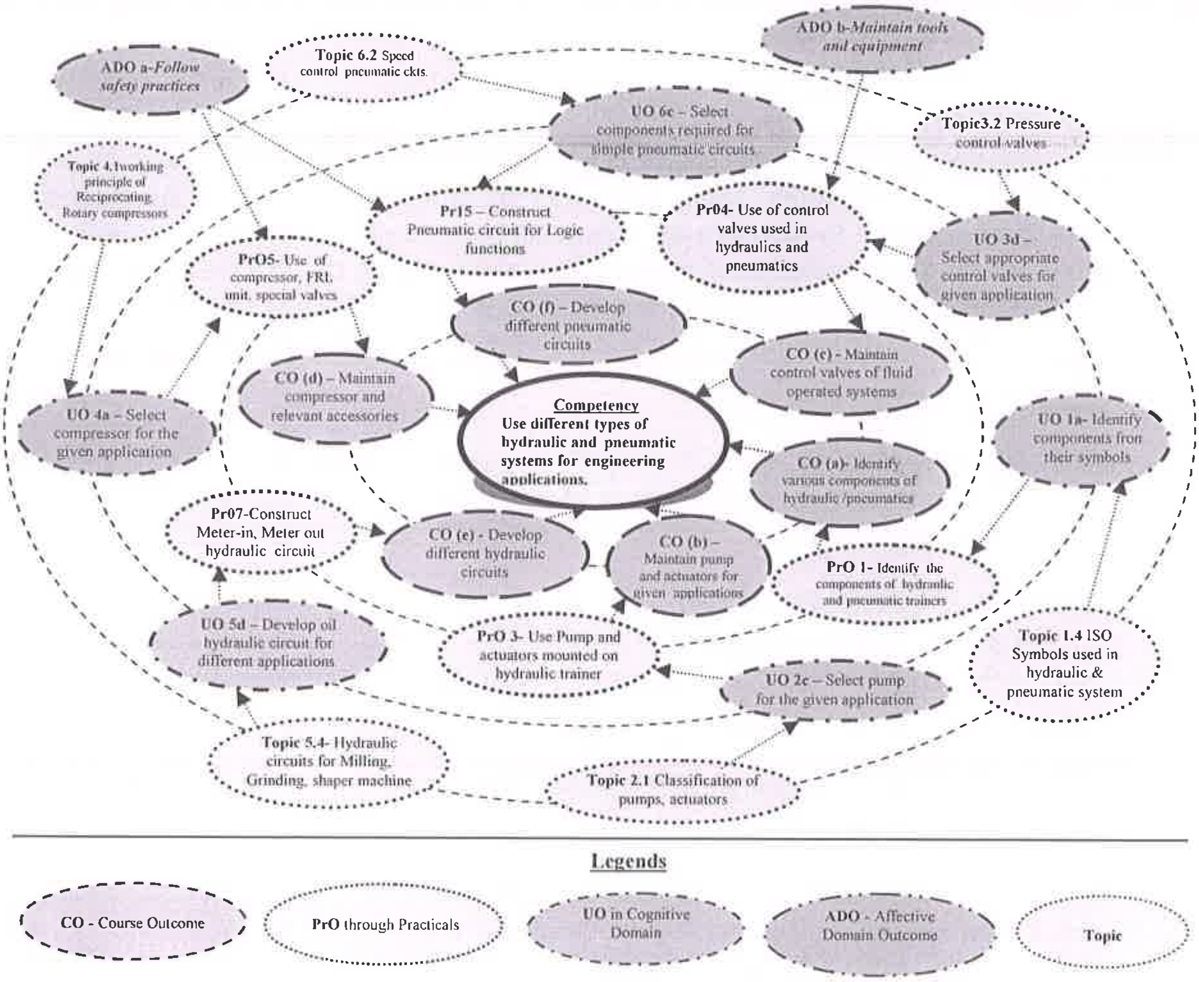


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the components of hydraulic and pneumatic trainers.	I	02*
2	List and draw ISO symbols used in hydraulic and Pneumatics.	I	02
3	Use Pump and actuators mounted on hydraulic trainer.	II	02
4	Use of control valves used in hydraulics and pneumatics.	III	02*
5	Use of compressor, FRL unit, special valves and accessories of pneumatics.	IV	02
6	Construct and actuate hydraulic circuit for SAC and DAC, hydromotor	V	02
7	Construct and actuate Meter-in, Meter out hydraulic circuit.	V	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Construct and actuate any suitable sequencing hydraulic circuit.	V	02
9	Develop circuit for simple machine tool applications such as milling machine, shaper machine, grinding machine	V	02*
10	Construct pneumatic circuits using Pneumatic simulation software	V	02
11	Construct and actuate Pneumatic circuit for SAC, DAC, Air motor	VI	02*
12	Construct and actuate speed control Pneumatic circuits.	VI	02
13	Construct and actuate indirect (pilot) control Pneumatic circuit.	VI	02*
14	Develop any suitable sequencing Pneumatic circuit.	VI	02
15	Construct and actuate Pneumatic circuit for Logic functions (AND/OR/TIME DELAY)	VI	02*
16	Construct Hydraulic circuits using Hydraulic simulation software	VI	02*
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1^{st} year

- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Cut sections of pumps, valves, cylinders, motors, accumulators, filters, etc	1,2,3
2	Hydraulic trainer with transparent /actual working components.	1,4,6,7,8,9
3	Pneumatic trainer with transparent/ actual working components.	4,5,12,13,14,15,16
4	Working / actual models of pumps, cylinders, valves, other components	1,2,3
5	Single /Multistage Reciprocating Compressor (pressure 0-10 bar)	4,5,12,13,14,15
6	Hydraulic and pneumatic simulation software	10,16
7	Electro-Pneumatic trainer	16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Introduction to Hydraulic and Pneumatic Systems	1a. Sketch the labeled general layout of the given type of Hydraulic system. 1b. Identify the given component(s) from their symbols. 1c. List the types of components in the given simple oil hydraulic circuits. 1d. List the desired properties of oil used in the given type of hydraulic system. 1e. Describe the general routine maintenance procedure of the given hydraulic/pneumatic system. 1f. List different Safety precautions required for handling Industrial hydraulics and pneumatics systems.	1.1 General layout of oil Hydraulic Maintain Pneumatic system. 1.2 Applications, Merits, limitations and oil hydraulic systems and Pneumatics systems. 1.3 Properties of fluids, ISO and SAE grades of oil. 1.4 ISO Symbols used in Hydraulic , Pneumatic system. 1.5 Hazard and Safety in Industrial hydraulics and pneumatics
Unit– II Pumps and Actuators	2a. Classify the given types of pumps with justification. 2b. Compare given two types of pumps on the basis of the given criteria. 2c. Select relevant pump for the given application with justification. 2d. Classify given types of actuators with justification. 2e. Describe with sketches the construction of the given actuator(s).	2.1 Classification of pumps. 2.2 Construction and working of Gear, Vane, Screw, piston pumps (axial and radial). 2.3 Performance characteristics and Selection of Pumps. 2.4 Classification of Hydraulic and Pneumatic actuators. 2.5 Construction and working of Linear and rotary actuators

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2f. Select the relevant actuator for the given application with justification. 2g. Describe the routine maintenance procedure of the given type of pump/actuator.	(Motors).
Unit-III Control Valves	3a. Classify the given types of valves with justification. 3b. Describe with sketches the construction of the given valve(s). 3c. Describe the actuation method of the valves for the given application. 3d. Select relevant control valve for the given application with justification. 3e. Describe the routine maintenance procedure of the given type of valve.	3.1 Classification of Control valves. 3.2 Pressure control valves- relief, unloading, sequence, counter balance, pressure reducing valves. 3.3 Direction control valves- Check valve, 2/2,3/2,4/2,4/3,5/2,5/3 D.C. Valves used in Hydraulics and Pneumatics. 3.4 Standard centre positions, Methods of actuation. 3.5 Flow control valves- Non-compensated, Pressure and temperature compensated.
Unit –IV Compressor, Pneumatic Components and Accessories in Fluid System	4a. Select the relevant compressor for the given application with justification 3f. Describe with sketches the construction of the given valve(s). 4b. List various accessories required in the given hydraulic/pneumatics. 4c. Select the relevant accessories for the given type of hydraulic/ pneumatic system with justification.	4.1 Types, construction, working principle of Reciprocating Maintain Rotary compressors. 4.2 Construction, working principle of FRL unit, Dual (twin) pressure valve, Shuttle valve, Quick exhaust valve, Time delay valve. 4.3 Accessories: Oil reservoir, pipes, hoses, fittings, oil filters, air filters, seals and gaskets, intensifiers, accumulators, heat exchanger, muffler.
Unit-V Oil Hydraulic Circuits	5a. Describe with sketches the construction of the given hydraulic circuit 5b. Explain with sketches the working of the given oil hydraulic circuit. 5c. Select the relevant components required for given simple hydraulic circuit with justification. 5d. Develop with sketches the oil hydraulic circuit for the given application. 5e. Describe the routine maintenance procedure of the given oil hydraulic circuit.	5.1 Simple oil hydraulic circuits - Single and Double Acting Hydraulic cylinders, motors. 5.2 Speed control Meter-in, Meter-out, Bleed Off circuit. 5.3 Regenerative, counterbalance, sequencing circuits, synchronizing, two pump unloading. 5.4 Hydraulic circuits for Milling machine, Grinding machine, Shaper machine, slotting machine. 5.5 Remedies and fault detection in Pneumatic circuits

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-VI Pneumatic Circuits	6a. Describe with sketches the construction of the given pneumatic circuit 6b. Explain with sketches the working of the given oil pneumatic circuit. 6c. Select the relevant components required for given simple pneumatic circuit with justification. 6d. Develop with sketches the oil pneumatic circuit for the given application. 6e. Explain Maintenance procedure for Hydraulics and Pneumatics system	6.1 Direct/Indirect Control of Single and Double Acting Air cylinders, motors. 6.2 Speed control circuit for cylinders and motors. 6.3 Sequencing circuits, Logic AND/OR circuits, Time delay circuits, piston continuous back and forth. 6.4 Simple Hydro-pneumatic applications. 6.5 Simple Electro-Pneumatic circuits. 6.6 Remedies and fault detection in Pneumatic circuits 6.7 Maintenance of hydraulic and Pneumatic systems

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Hydraulic and Pneumatic Systems	04	02	02	02	06
II	Pumps and Actuators	08	04	04	04	12
III	Control Valves	12	04	08	04	16
IV	Compressor, Pneumatic Components and Accessories in Fluid system	08	04	04	04	12
V	Oil Hydraulic Circuits	08	**00**	04	08	12
VI	Pneumatic Circuits	08	02	02	08	12
	Total	**48**	**16**	**24**	**30**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journal based on practical performed in Industrial fluid power laboratory. Journal consists of drawing, observations, required measuring tools, equipments, and date of performance with teacher signature.
b) Power Point Presentation on hydraulic and Pneumatic brakes by group of two/three students. (Duration:10 minutes)
c) Power Point Presentation on accessories used in hydraulics and pneumatics by group of two/three students. (Duration:10 minutes)
d) Prepare report of market survey of suppliers for fluid powered Earth moving equipments like JCB, Mahindra Earth master by group of four students.
e) Prepare chart on full imperial drawing sheet for ISO Symbols used in hydraulic Maintain pneumatic system by group of two students.
f) Prepare chart on full imperial drawing sheet for classification of pumps and actuators by group of two students.
g) Prepare Seminar/presentation on types of oil filters by group of two/three students. (Duration:10 minutes)
h) Prepare display chart on types of seals and gaskets (actual/ used samples) used in hydraulics.
i) Prepare visit report of any automobile service station to observe use of pneumatic hand tools.
j) Prepare visit report of construction sites to observe use of earth moving equipment /Other hydraulic /pneumatic equipments for automation.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Before starting practical, teacher should demonstrate the working of instrument.
g) Instructions to students regarding care and maintenance of measuring equipments.
h) Show video/animation films to explain functioning of various measuring Instruments
i) Teacher should ask the students to go through instruction and Technical manuals of instruments

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Market survey of oil used in hydraulic system (Manufacturers, specifications, trade names, cost, packing size) (field-based/ Internet based)
b) Prepare working model of hydraulic crane using waste injections used by Doctors. (laboratory-based)
c) Prepare report of agriculture equipments working on hydraulics and pneumatics. (field-based)
d) Prepare report of specifications of Hydraulic power pack and Pneumatic service unit (FRL Unit) (Internet based)
e) Collect technical specifications of Gear pumps, Vane pumps/other pumps (Internet based).
f) Prepare visit report to observe use of Pneumatic system used by Dentist. (field-based)
g) Prepare visit report on automobile vehicle cleaning service station to observe the hydraulic actuator and system used. (field-based)
h) Prepare display board by collecting sample of pipes and pipe fittings with specifications of different manufactures. (New/Worn-out) (workshop-based)
i) Prepare a tabulated summary for types of pipes available in market. (Summary includes type, specification, size range, material, rate and applications). (workshop-based)
j) Prepare report on specifications, sketches of Linear actuators and mounting methods. (Internet based).
k) Prepare report on working of hydraulic jack and its system. (Industry application based)
l) Prepare prototype working model of hydraulically operated hospital bed. (Industry application based)
m) Prepare demonstration model of telescopic cylinder using PVC pipes. (workshop-based)
n) Develop working model of automation of bench vice used in carpentry/fitting shop. (workshop-based)
o) Prepare report of various pneumatic hand tools and its attachments. (Internet based).
p) Prepare cut section model of any hydraulic/pneumatic component. (laboratory-based)
q) Prepare report of hydraulic system used in Universal testing machine available in Strength of material laboratory. (laboratory-based)
r) Prepare report of construction and working of hydraulic press used in nearby machine/fabrication shop. (field-based)
s) Prepare visit report of service centre for common faults and remedies of hydraulic equipments. (field-based)
t) Prepare Hydraulic circuit layout with identification of all the components of a hydraulic circuit of heavy earth moving machineries/road construction machineries.
u) Prepare report of any actual pneumatic system used in low cost automation systems, material handling systems, etc.
v) Prepare visit report of any one mobile hydraulic system such as in earth moving equipment or any one stationary hydraulic system such as in any machine tool.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Oil Hydraulic system- Principles and maintenance	Majumdar, S.R.	McGraw Hill, New Delhi, (2002), ISBN: 9780074637487
2	Pneumatics Systems Principles and Maintenance	Majumda,r S.R.	McGraw Hill, New Delhi, (1996), ISBN-978-0-07-460231-7
3	Fluid Power with applications	Esposito, Anthony	Pearson Education, Inc New Delhi (2003), ISBN 81-7758-580-0
4	Hydraulics and Pneumatics	Stewart, Harry	Taraporewala Publication, (1984) ISBN:978-0672234125
5	Pneumatic Controls	Joji, B.	Wiley India Pub. New Delhi, (2008) ISBN:978-8126515424
6	Hydraulics Maintain Pneumatics A Technicians Maintain Engineers Guide	Parr, Andrew	Butterworth-Heinemann Publisher, (1991), ISBN: 9780080966755
7	Industrial Hydraulics Manual	------	Vickers Systems International (Company Manual), (2010), ISBN 9780978802202
8	Product Catalogue of FESTO	-----	Company catalogue

14. SOFTWARE/LEARNING WEBSITES

a) www.cesim.com/simulations
b) Hydraulic Pumps: https://en.wikipedia.org/wiki/Hydraulic_pump
c) Hydraulic Pumps: www.hydraulicspneumatics.com/.../HydraulicPumpsM/.../TechZone-HydraulicPumps.
d) Animation of Hydraulic pumps: https://www.youtube.com/watch?v=Qy1iV6EzNHg
e) Animation of Hydraulic pumps: https://www.youtube.com/watch?v=pWuxYnqYDnk
f) Eaton Pump assembly: https://www.youtube.com/watch?v=sEVTIRYHoGg
g) Video lectures of IIT Faculty: http://nptel.ac.in/courses/112105047/
h) Lecture series and notes by IIT faculty: http://nptel.ac.in/courses/112106175/
i) Pneumatic control valves animation: https://www.youtube.com/watch?v=XAItnsUcES0
j) Control valve symbol generation: https://www.youtube.com/watch?v=yIot4shcOkE
k) Animation of D.C Valve: https://www.youtube.com/watch?v=jsMJbJQkGTs
l) Animation of 4/2,4/3 D.C Valves: https://www.youtube.com/watch?v=CQPwvWXbV3w
m) Animation of Hydraulic cylinder: https://www.youtube.com/watch?v=bovfDsAYSbc
n) Telescopic cylinder animation: https://www.youtube.com/watch?v=icaqvfAtccY
o) Pneumatic cylinder: https://www.youtube.com/watch?v=MmYpzgh6Gok
p) Speed control hydraulic circuit: https://www.youtube.com/watch?v=4eCuPVxezzY

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Automobile Engineering**

Course Code : **22656**

1. RATIONALE

Automobile sector has been helping the world for the overall development and it has been creating wage and self employment opportunities both in public and private sectors. A Mechanical engineering technologist should have an overall understanding of various aspects of Automobile Systems. This course provides a broad knowledge about the different vehicle layouts, transmissions and controls, electrical and electronics systems, vehicle safety and security, features of Motor Vehicle Acts along with automobile maintenance systems. This knowledge will be helpful to the students in co-relating various automobile systems with each other and provide good practical input with theoretical knowledge for technological advancement of the industry/society.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Interpret the required automotive component based on the analysis of the automobile specifications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Prepare vehicle layouts with chassis specification.
b. Interpret power flow diagrams of transmission systems.
c. Select suitable braking and steering systems for different applications.
d. Select suspension system for different applications.
e. Prepare simple electrical-electronic circuits for automobile systems.
f. Select service tools for relevant service operation in automobile shops.

4. TEACHING AND EXAMINATION SCHEME

<table>
<tr><th colspan="3">Teaching Scheme</th><th rowspan="4">Credit (L+T+P)</th><th colspan="13">Examination Scheme</th></tr>
<tr><th rowspan="3">L</th><th rowspan="3">T</th><th rowspan="3">P</th><th colspan="7">Theory</th><th colspan="6">Practical</th></tr>
<tr><th rowspan="2">Paper Hrs.</th><th colspan="2">ESE</th><th colspan="2">PA</th><th colspan="2">Total</th><th colspan="2">ESE</th><th colspan="2">PA</th><th colspan="2">Total</th></tr>
<tr><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Min</th></tr>
<tr><td>3</td><td>-</td><td>2</td><td>5</td><td>3</td><td>70</td><td>28</td><td>30*</td><td>00</td><td>100</td><td>40</td><td>25#</td><td>10</td><td>25</td><td>10</td><td>50</td><td>20</td></tr>
</table>

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

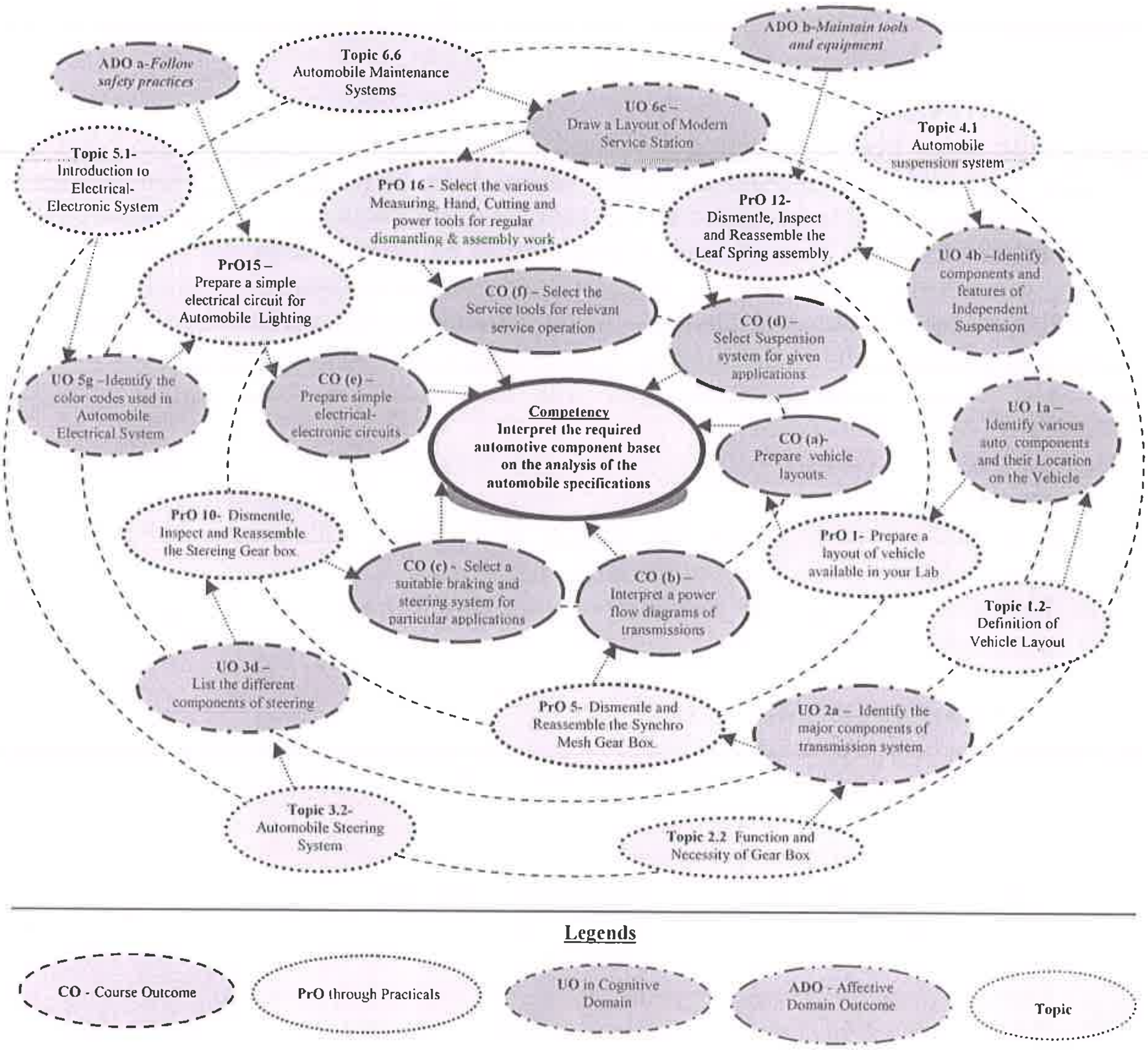


Figure 1: Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare a layout of vehicle available in your Laboratory.	I	02*
2	Dismantle, inspect and reassemble the Single Plate Clutch. (Coil Spring Type/Diaphragm Type)	II	02
3	Dismantle/Assemble the Multiplate Clutch.	II	02*
4	Dismantle/Assemble the Centrifugal Clutch.	II	02
5	Dismantle/Assemble the Synchro Mesh Gear Box.	II	02*
6	Dismantle/Assemble the Propeller shaft Assembly.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Dismantle/Assemble the Differential Assembly.	II	02*
8	Dismantle/Assemble the Drum/Disc Brake.	III	02
9	Dismantle/Assemble the Steering Gear box. (Rack and Pinion/Recirculating Type/Worm and Wheel)	III	02
10	Dismantle/Assemble the Power Steering system. (Hydraulic/Electronic Type)	III	02
11	Dismantle/Assemble the Leaf Spring assembly.	IV	02*
12	Dismantle/Assemble the Wheel and Tyre assembly.	IV	02
13	Test a Lead Acid Battery for Open Voltage and Specific Gravity.	V	02*
14	Dismantle/Assemble the Distributor used in Battery Ignition System.	V	02*
15	Prepare a simple electrical circuit for Automobile applications like Lighting/Horn/Wiper/Flasher/Indicators/Gauges etc.	V	02
16	Maintain given simple automobile component using various Service Tools.	VI	02*
	Total		**32**

Note:

i. *For Practical Nos. 2,3,4,5,8,9,10,12 students should rectify the particular troubles in respective system with probable causes and remedies for the same and prepare a Trouble Shooting Chart.*

ii. *For Practical Nos. 1,6,7,10,11,13,14 students should identify the various components of respective system and state their functions and location.*

iii. *A suggestive list of PrO's is given in the above table. More such PrO's can be added to attain the CO's and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

iv. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of practical set up	10
2	Handling of service tools carefully while performing the practicals	20
3	Select the sequence of operation of dismantle and assembly	20
4	Safety measures and standard practices	10
5	Inspection, record keeping and reassembly	10
6	Identify the Probable Causes of the Troubles	10
7	Prepare the Trouble shooting chart with causes and remedies	10
8	Submission of the practical report with conclusion	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1styear
- 'Organisation Level' in 2ndyear
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of practicals, as well as aid to procure equipment by authorities concerned.

S. No	Equipment Name with Broad Specifications	PrO. No.
1	Any Two/Four Wheel drive (2WD/4WD) Vehicle	1
2	Working Model of Coil Spring Single Plate Clutch used in Cars	2
3	Working Model of Diaphragm Spring Type Single Plate Clutch used in Cars	2
4	Working Model of Multiplate Clutch used in Scooter/Motor cycles	3
5	Working Model of Centrifugal Clutch used in Mopeds	4
6	Working Model of Synchro Mesh Gear Box used in four wheelers	5
7	Propeller Shaft Assembly along with two U-joints and one slip joint	6
8	Working Model of Differential Assembly of four wheeler	7
9	Working Model of Drum Brake (Mechanical/Hydraulic Linkage)	8
10	Working Model of Disc Brake (Hydraulic Linkage)	8
11	Working Model of Rack and Pinion Steering Gear used in cars	9
12	Working Model of Recirculating Ball Type Steering Gear Box	9
13	Working Model of Worm and Wheel Steering Gear Box	9
14	Working Model of Hydraulic/Electronic Power Steering System	10
15	Working Model of Semi Elliptical Leaf Spring with shackle and Shock ups	11
16	Tyre Removing Tool Kit/Tyre Remover Tyre Inflator: 12 V Air Compressor Pump	12
17	Air Compressor: AC Single Phase, Air Cooled, Capacity: 160- 500 Litre, Speed: 690-925 RPM, Power: 2 to 20 HP, Working Pressure: 10.5-12 Kg/cm^3	
18	12 Volt Lead Acid Battery in Working Condition, 7-50 AH	13
19	Voltmeter, Ammeter, Cell Tester, Multi Meter	13
20	Hydrometer for Specific Gravity Test. (For Large and Small Battery with a Sp. Gravity range of 1.100-1.300, 77°F)	13
21	Working Model of Distributor used in Battery Ignition System.	14
22	Working Model of Auto. Electrical System (2/4 Wheeler) (Model consists; *Electrical Circuit*-Horn, Buzzer, Starting, Ignition, Earthing etc. *Lighting Circuit*-Head, Tail and Side Lamps, Indicators/Flashers, Parking Light)	15
23	Minimum 02 sets of Automobile Service Tool Kit preferably with Trolley. *(Service Tool Kit:* It includes Cutting Tools, Hand Tools, Measuring Tools, Power Tools, Torque Wrenches, Bearing Pullers.)	1,2,5,16
24	Axle Stand/ Scissor/ Hydraulic Screw Jack (Capacity of 4 to 50 Ton)	1,2,5,16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to Automobiles	1a. Identify various automobile components and their location on the given vehicle. 1b. Describe with sketches the the function of the given part of the specified automobile chassis/frame/ body 1c. Select relevant type of alternative fuel for the given application with justification. 1d. Draw labeled vehicle layout of the given vehicle.	1.1 Automobile: Definition, Classification of Automobiles, Major Components of Automobiles with their Function and Location 1.2 Vehicle Layout: Definition Significance of Vehicle Layout, Different types of Vehicle layouts (FEFWD, FERWD, RERWD, 4WD), Advantages, Disadvantages, Applications and Comparisons of Different types of vehicle layouts. 1.3 Function of Chassis, Frame and Body: Requirement of Chassis, Frame and Body, Load acting on Frame, Classification of Chassis Frames with advantages, disadvantages and applications (Conventional, Unitized Body, Sub Frame), Basic Body Nomenclature. 1.4 Significance of Body Streamlining: Need and Importance of aerodynamic Aspects, Basic terms related with Car Aerodynamics (e.g. Drag, Lift, Skin Friction, Form Drag, Wake, Coefficient of Drag) 1.5 Alternative Fuels: LPG and CNG: Need, Fuel Characteristics, Construction and Working, Advantages, Limitations; Layout of Electric Vehicles: Need, Working , Advantages, Limitations. Hydrogen as fuel.
Unit-II Automobile Transmission Systems	2a. Identify the major components of the given transmission system. 2b. Select type of transmission for the given application with justification. 2c. Explain with sketches the working principle of the given overdrive with labelled diagram. 2d. Differentiate the features of the given two components based on the specified criteria. 2e. Explain the working principle of Differential for the given vehicle.	2.1 Function and Necessity of Clutch: Requirement of Clutch, Classification of Clutch, Working Principle of Clutch, Construction and Working of Single Plate (Coil Spring and Diaphragm), Multiplate Clutch and Centrifugal Clutch. 2.2 Function and Necessity of Gear Box Manual Transmission: Classification of Gear Box, Construction and working of Constant Mesh and Synchro Mesh Gear Box with power flow diagrams. 2.3 Semi Automatic Transmission: Function, Construction and Working of Overdrive, Automatic Transmission: Fluid Flywheel: Function, Construction and Working of Fluid Flywheel;

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2f. Interpret power flow diagram of the given transmission system.	Torque Converter: Function, Construction and Working of Torque Converter; Epicyclic Gear Train: Function, Construction and Working of Epicyclic Gear Train. 2.4 Propeller Shaft Assembly: Function, Necessity and Types of Propeller Shaft, Function and ncccssity of Universal and Slip Joint. 2.5 Final Drive: Function and Necessity of Final Drive, Differential, Working Principle, Construction and Working of Differential. 2.6 Axles: Significance of Live and Dead Axle, Function and Requirement of Front Axle, Types of (Front) Stub axle, Function, Construction and Working of Semi Floating and Fully Floating Rear Axle.
Unit– III Automobile Control Systems	3a. Sketch the labelled layout of the given type of Braking System. 3b. Explain with sketches the working of the given ABS. 3c. Explain with sketches the terms related to Steering System 3d. Explain with sketches the working principle of the given type of Steering gearbox for the given vehicle. 3e. Select relevant braking systems for the given application with justification. 3f. Select relevant steering systems for the given application with justification.	3.1 Automobile Braking System: Function and Requirement of Braking System: Principle of Braking, Basic Terms related to Braking (Stopping Distance, Braking Efficiency, Fading of Brakes) 3.2 Types of Braking System: Layout, Construction, Working of Drum, Disc, Hydraulic and Air Brakes. 3.3 Master Cylinder, Wheel Cylinder, Tandem Master Cylinder, Significance and general procedure of Bleeding of Brake. 3.4 Review of Anti lock braking System: Layout of ABS, Pressure Modulation, Types of ABS. 3.5 Automobile Steering System: Function and Requirements of Steering System: Basic Terms related to Steering (Steering Ratio, Turning Radius, Understeering and Oversteering), Basic Components of Steering Linkages. 3.6 Types of Steering Gear Boxes: Construction and Working of Rack and Pinion, Recirculating Ball Type Steering Gear Box, Necessity and Principle of Power Steering, Construction and Working of Hydraulic and Electronic Power Steering. 3.7 Steering Geometry: Necessity of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Steering Geometry, Significance and ranges of Caster (Positive, Negative), Camber (Positive, Negative), Toe-in, Toe out, King Pin Inclination (KPI), Steering Axis Inclination (SAI)
Unit– IV Automobile Suspension, Wheels and Tyres	4a Define the given terms related to the given suspension system. 4b Explain with sketches the working principle of the given type of Suspension System for the given vehicle. 4c Explain with sketches the working principle of the given type of Shock Absorbers/Air Suspension. 4d Select relevant procedure, tool and equipment for Wheel Alignmnet and Balancing for the given vehicle with justification. 4e Describe with sketches the terms related to Wheel alignment/wheel balancing. 4f Select relevant suspension systems for the given application with justification.	4.1 Automobile Suspension System: Function and Requirement of Rigid Suspension System: Basic Terms Related with Suspension System: (Jounce, Rebound, Sprung and Unsprung Weight, Spring Rate, Elasticity), Types and Constructional Features of Leaf Springs,. 4.2 Function and Requirement of Independent Suspension System: Advantages of Front Wheel Independent Suspension, Construction and Working of Mac-Pherson Strut Type, Wishbone Type Suspension system. 4.3 Shock Absorbers and Air Suspension: Layout, Construction and Working of Air Suspension, Function and Types of Shock Absorber, Principle of Hydraulic Shock Absorber, Construction and Working of Telescopic Shock Absorber, Constructional Features and working of Gas Filled Shock Absorber. 4.4 Wheels, Rims and Tyres: Function, Necessity and Requirement of Wheel, Rim and Tyres: Types of Wheels, Rims and Tyres, Construction and Working of Different Types of Wheels, Rims and Tyres. 4.5 Tyre Economy: Consideration in Tyre Tread Design, Factors affecting to Tyre Life, Tyre Wear and Rotation, Tyre Designation. 4.6 Wheel Alignment and Balancing: Purpose of Wheel Alignment, Procedure of Wheel Alignment, Purpose of Wheel Balancing, Significance of Static and Dynamic Balancing, Procedure for Static and Dynamic Balancing.
Unit –V Automobile Electrical and Electronics Systems	5a Define the given terms related to the automobile electrical system. 5b Select the relevant battery for the given	5.1 Introduction to Electrical-Electronic System: Basic Electrical-Electronics Principles (Current, Voltage, Resistance, Electricity, Magnetism, Electromagnetism, Induction,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	application. 5c Explain wit sketches the working principle of the given electrical component of the vehicle. 5d Differentiate between the given two terms related to the automobile electrical system. 5e Select the relevant sensors and actuators for the given application with justification. 5f Prepare simple electrical/electronic circuits for given type of automobile.	Rectification etc.) Basic Electrical-Electronics Components used in automobiles with their conventional symbols. 5.2 Battery: Function and Requirements of Battery, Types of Battery, Principle of Lead Acid Battery, Construction and Operation of Lcad Acid Battery, Significance of Battery Rating and Battery Capacity, Battery Open Volt and Specific Gravity Test, Salient Features of Maintenance Free Battery. 5.3 Starting System: Function and Requirement of Starting System, Components of Starting System, Construction and Working of Standard Bendix Drive. 5.4 Charging System: Function and Requirement of Charging System, Components of Charging System, Construction and Working of Alternator. 5.5 Ignition System: Function and Requirement of Ignition System, Types of Ignition System, Construction and Working of Battery Ignition, Magneto Ignition and Electronic Ignition System with advantages, disadvantages, applications. . 5.6 Lighting System: Function and Requirements of Lighting Systems, Types of Lights, Necessity and Importance of Cable Color Codes, Wiring Harness. 5.7 Miscellaneous: A Brief Review of Different types of Gauges, Windscreen wiper, Function and Location of Major Sensors and Actuators used in Automobile Electronics.
Unit–VI Motor Vehicle Act, Road Safety and Garage Practices	6a. Explain the meaning of the given Road Traffic signs. 6b. Draw labeled layout of a Modern Service Station for the given situaton. 6c. Differentiate between the given two terms related to the motor vehicle act. 6d. Describe with sketches the the function of the	6.1 Introduction and Objectives of Motor Vehicle Act: Salient Features of M. V. Act 1988 and Central Motor Vehicle Rules 1989. 6.1.2 Types and Significance of Traffic Signs, Important Transport Terms (Definitions) in M. V. Act (Motor Vehicle, Motor Cycle, HGV, MGV, LGV, Public Service Vehicle, Transport Vehicle, Driver, Passenger, Accident)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	specified type of passenger comfort/safety component. 6e. Select the relevant service tools for relevant service operation in automobile shops with justification.	6.2 Organization Structure of Motor Vehicle (RTO) Department, Duties and Responsibilities of RTO, AIMV. 6.3 Passenger Comfort and Safety: Function and requirements of Passenger Safety System. Features of Air Bags, Seat Belts, Collapsible Steering Column. 6.4 Automobile Maintenance Systems: Significance of Garage, Workshop, Service Station, Dealership. 6.5 Types of Maintenance, Need and importance of Record Keeping, List of Records to be kept in Service Stations 6.6 Site selection and amenities/facilities required to set up your own Garage/Service Station, Role and Responsibilities of Service Manager, Service Supervisor, Customer Care Manager in Service Stations.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Automobiles	08	02	04	04	10
II	Automobile Transmission Systems	10	02	04	08	14
III	Automobile Control Systems	08	02	02	06	10
IV	Automobile Suspension, Wheels and Tyres	08	02	04	06	12
V	Automobile Electrical and Electronics Systems	08	02	04	08	14
VI	Motor Vehicle Act, Road Safety and Garage Practices	06	02	04	04	10
	Total	**48**	**12**	**22**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Attend, observe and Prepare a brief report for Computerized Wheel alignment of vehicles with various types of suspension and steering system at nearby service station.
b) Attend, Observe and Prepare a brief report for Computerized Wheel Balancing of Vehicles with static and dynamic conditions at nearby service station.
c) Apply for the Learner's Licence. Fill online form and appear for Virtual Driving Test at RTO Office. Prepare a brief report on "Procedure of Issuing Driving Licence by RTO".
d) Visit to nearby Authorised Service station preferabaly Four Wheelers/Heavy Vehicles and observe the organization structure, Different sections, Modern Tools and Equipments used, Records to be kept, Work Profile of Diploma Engineer in Service Station, and prepare a visit report with schematic layout and concluding remarks.
e) Visit to nearby MSRTC Divisional Workshop/Depot, observe the organization structure, Work profile of Diploma Engineer, different Sections and systems, Service activities at Workshop and prepare a brief report with schematic layout and concluding remarks.
f) Conduct a PUC test of 2/4 Wheeler on exhaust gas analyser according to M. V. Act and prepare a brief report on "Automobile Emission Norms in India".
g) Visit to 2/3/4 Wheeler Automobile Manufacturer's, observe the Organization Structure, Diffferent Sections, Work Profile of Diploma Engineer, Safety precautions to be followed and prepare a detail report with schematic layout.
h) Attend an expert talk of RTO Officials in your city/town arrange by Department/Institute for your Class on following Topics;
    i. Road Safety and Security:Challenges and Opportunity
    ii. Motor Vehicle Act 1988 and CMV Rules 1989
    iii. Career Opportunities to Mechanical Engineer in RTO Department.
    iv. Disaster Management at Road Accidents.
    v. Traffic Offences and penalties as per M.V. Act.
i) Try to attend the event of "Indian Auto Expo" joiltly organized by the Automotive Component Manufacturers Association (ACMA), Confederation of Indian Industry (CII) and Society of Indian Automobile Manufacturers (SIAM)]. Observe the various new production launches, their features and concepts behind design and technical specifications. Prepare a detailed report on visit and share the experience with collegues.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Before starting practical, teacher should demonstrate the working of System.

g) Instructions to students regarding care and maintenance of Model/Equipment.
h) Show video/animation films to explain functioning of various Automobile Systems.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Prepare a chart of Symbolic representation of different electrical-electronic components used in automobiles. (e.g. Earthing, Fuse, Circuit Breaker, Capacitor, Resistor, Coil, Switch, Diode, Motor, Semi conductor etc.)
b) Collect information of Chassis Specifications of different vehicles.
c) Perfrom comparative study of different alternative fuels available in India.
d) Visit to Modern Service Station and Prepare a Layout indicating various sections, Specialized Equipments, Machines and basic ameneties provided.
e) Prepare a case study on following topics related with Transport Management through Group Discussion:
   i. Current Public Transport Scenerion in India
   ii. RTO Policies for enhancing Road Safety
   iii. Importance of Metro Rail in Rapid transiotion System
   iv. Review of worldwide effective Rapid Transition Systems
   v. *(E.g. BRT System in Bogota, Singapore, Japan,Malesiya)*
   vi. Traffic crisis in Metro Cities: Causes and Cures
   vii. Role of Motor Vehicle Department in Transport Management
f) Information Search and Market Survey through Magazines like Overdrive, Autocar, Auto India, internet surfing and site visits on following topics:
   i. Automobile Manufacturers in India.
   ii. Aerodynamic Optimization in Automobiles.
   iii. Current (Indian/Worldwide) Automobile Market of 2/4 Wheeler Industry.
   iv. Upcoming vehicles on alterntive fuel sources in Indian Auto Industry.
   v. Adaptive Suspension System
   vi. On Board Diagnostics Systems (OBD-I/II)
g) Prepare a Chart of road traffic signs in categories of Mandatory, Cautionary, Informatory. Display it to your Departmnet/Institute and make aware to your collegues for the same.
h) Prepare a simple Automobile Lighting Circuit (2/4 Wheeler) Display and indicates the relevant cable color codes on it.
i) Information Search and Market Review on "Different types of Automobile Service tools and Specialized Equipment and Machines" used in Modern Service Stations.
a. Prepare a report on Electric and Hybrid vehicles.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A Text Book of Automobile Engineering	Rajput R. K.	Laxmi Publications Pvt. Ltd., New Delhi, (2008) ISBN: 97881170089919
2	Automobile Engineering	Kamaraju Ramakrishna	PHI Learning Pvt. Ltd., New Delhi, (2012) ISBN: 9788120346109.
3	Automobile Engineering (Vol I and II)	Dr. Kirpal Singh	Standard Publishers, New Delhi. (2004) ISBN: 9788180141034.
4	Automotive Mechanics	Crouse W.H., Anglin D.W.	Tata McGraw Hill Publications, Delhi (1965) ISBN: 978007070148215
5	Motor Vehicle Act, 1988	CMV Rules	Eastern Book Company, Mumbai, (1989) ISBN: 8171771629.
6	Compendium of Transport Terms	CIRT, Pune	Central Insttute of Road Transport, (2007) CIRT Publications, Bhosari Pune
7	The Drivers Manual	Pasricha P.S.	Nasha Publications, (1994) Mumbai
8	Road Safety Guide	Pasricha P.S.	Nasha Publications, (1991) Mumbai
9	Automobile Electrical and Electronic Systems	Tom Denton	Elsevier Butterworth Heinemann, Oxford/ Routledge, (2013) ISBN: 9780750662192.
10	Indian Journal of Transport Management (Quarterly Published Journal)	IJTM, CIRT, Pune	Central Institute of Road Transport (CIRT), CIRT Publications, Bhosari, (1876, starting year) Pune ISSN: 0972-5695.

14. SUGGESTED VIDEOS AND LEARNING WEBSITES:

a) http://nptel.ac.in/courses. *(NPTEL)*
b) https://www.araiindia.com/Draft_AIS_Standards.asp. *(ARAI, Pune)*
c) http://www.cirtindia.com/testing_universalTyreTestingMachine.html. *(CIRT, Pune)*
d) www.pcra.org/pages/view/220. *(PCRA, New Delhi)*
e) https://www.saeindia.org/. *(SAE India)*
f) https://transport.maharashtra.gov.in/1161/Road-Signs. *(RTO, M. V. Department, M.S.)*
g) https://msrtc.maharshtra.gov.in/. *(MSRTC, M.S.)*
h) https://www.howstuffworks.com.
i) https://www.youtube.com/watch?v=Y1zbE21Pzl0. *(Automatic Transmission)*
j) https://www.youtube.com/watch?v=u_y1S8C0Hmc. *(Automatic Transmission)*
k) https://www.youtube.com/watch?v=wCu9W9xNwtI. *(Manual Transmission)*
l) https://www.youtube.com/watch?v=vOo3TLgL0kM. *(Manual Transmission)*
m) https://www.youtube.com/watch?v=aNGA5Ejq8A4. *(Differential)*
n) https://www.youtube.com/watch?v=VFu-6tckyc8. *(Rear Axle)*
o) https://www.youtube.com/watch?v=IrBE8k9rIr8. *(Radial and Tubeless Tyre)*
p) https://www.youtube.com/watch?v=mLCG1_ecC3g. *(Tubeless Tyre)*
q) https://www.youtube.com/watch?v=wKwvObmidh0. *(Repair of Tubeless Tyre)*
r) https://www.youtube.com/watch?v=LCMs-7K8nLk. *(Alloy Wheels)*
s) https://www.youtube.com/watch?v=hnsvkpOP8_g. *(Alloy and Cast Wheel)*
t) https://www.youtube.com/watch?v=F6ZZ_U_Fl1Y. *(Wheel Alignment)*
u) https://www.youtube.com/watch?v=1k6Yh6FhHvE. *(Wheel and Tyre Animation)*
v) https://www.youtube.com/watch?v=bg92_ytLm0M. *(Tyre Protector)*
w) https://www.youtube.com/watch?v=LffD2xx-7uw. *(Repair of Tubeless Tyre)*

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Industrial Engineering and Quality Control**

Course Code : **22657**

1. RATIONALE

In any mechanical industry, industrial engineering integrates men, machines, materials, method of production, information, and energy to make a product and hence enhance productivity by eliminating wastefulness in production processes. Mechanical engineering technologists needs to determine the standardized process, time for its completion known as work and time study, measuring the output in terms of productivity, evaluation of jobs, workers and determining the wages and incentives, measurement of quality of product. Total Quality Control is an effective system of integrating quality development, quality maintenance and quality improvement efforts of the various groups in industry, so as to enable production and services at most economical level which tends towards full customer satisfaction. Understanding of fundamental principles of industrial engineering and quality control helps a technologists in maximizing efficiency within a company by finding the best use of people, equipment, and facilities..

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Apply Industrial Engineering and Quality Control techniques for assuring quality of products and services.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Apply work study techniques to optimize manufacturing processes.
b) Prepare the detailed sequence of operations for manufacturing of components.
c) Apply Ergonomic principle for designing simple mechanical component .
d) Interpret the data obtained from the different quality control processes.
e) Interpret control charts for variable and attribute data.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:* *L*-Lecture; *T* – Tutorial/Teacher Guided Theory Practice; *P* - Practical; *C* – Credit, *ESE* - End Semester Examination; *PA* - Progressive Assessment**

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

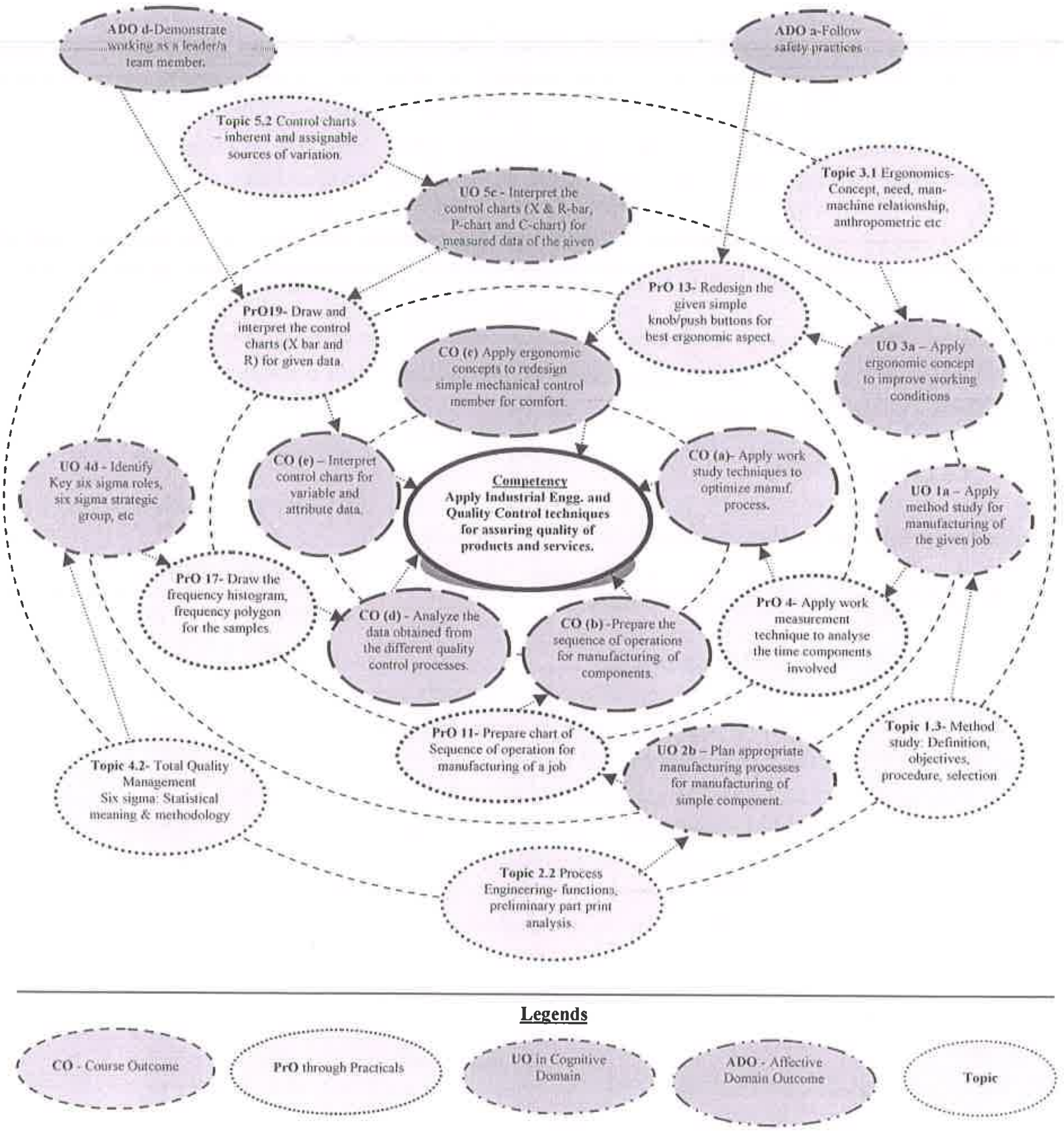


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Apply method study approach Analyze the motions involved in machining operation of the given job	I	02*
2	Apply work measurement technique to analyze the time components involved machining operation of given job using stop watch.	I	02*
3	Calculate standard time for all the operations involved in step turning process.	I	02
4	Prepare motion chart of given activity using standard symbols of therbligs (max 18).	I	02
5	Prepare supply chain chart in day-to-day situation like supply of Cold drink/tooth paste/any grocery item.	II	02*
6	Prepare supply chain management chart for online purchase of goods/products.	II	02
7	Prepare detailed process plan for manufacturing of Hexagonal Nut/Hexagonal headed bolt/Stud/Wing Nut/Plain Washer.	II	02*
8	Prepare chart of Sequence of operation for manufacturing of simple job like manufacturing of hexagonal nut & bolt/ Manufacturing of V-Block on shaper machine.	II	02
9	Prepare Chart of sequence of operation for Single or Double riveted lap joint/Single riveted butt joint (single strap).	II	02*
10	Use Ergonomic principle for given component .	III	02*
11	Prepare and analyze steps to solve the given problem in institute/industry using quality circle concept.	IV	02*
12	Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.	V	02
13	Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability for $\pm 3\sigma$ or $\pm 6\sigma$.	V	02*
14	Draw and interpret the control charts (Xbar and R) for given data.	V	02
15	Draw and interpret the control charts (P-chart and C-chart) for given data.	V	02*
	Total		**30**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Stop Watch Timing capacity:23hrs, 59mins and 59.99secs, Accuracy: ±3 seconds/day	1,2,3,4,5,6
2	Digital Video Camera for Micro Motion Analysis with following specification (i) ISO 100-12800 (ii) Focal length f = 3.5-5.6 (iii) 24.2 MP (iv) lenses 18-55mm.	1,2,3,4,5,6
3	Steel Rule for Length Measurement Range 0-5 feet	4,5,6 ,10,11.12
4	Digital/manual Vernier Caliper Range 0-150 mm, L.C. 0.02mm	10,11,12
5	Digital / manual Screw thread Micrometer, Range 0-25 mm, L.C. 0.01mm	10,11,
6	Digital / manual Screw Thread Micrometer Range 25-50mm, L.C. 0.01mm	10,11,
7	Display Wall chart showing X bar Chart and R CHART	13.14.15
8	Display Wall chart showing "C Chart"	13,14,15
9	Display Wall chart showing Therbilgs with minimum 18 symbols	7
10	Standard samples like steel balls, bearings, turning operation jobs, gear samples for sample measurement	13,14,15
11	Different types of Ergonomic Charts	7

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Work Study (Method Study and Work Measurement)	1a. Apply method study for manufacturing of the given job. 1b. Apply time study for manufacturing of the given job. 1c. Select relevant recording techniques for the given process with justification. 1d. Prepare relevant types of charts for the given process using the given recording techniques. 1e. Calculate standard time for the given activity using work measurement.	1.1 Industrial Engineering: Definition, Need, Objectives and Scope 1.2 Work study: Method study(Motion Study) and Time study(Work Measurement) 1.3 Method study: Definition, objectives, procedure, selection of work 1.4 Recording Techniques: - Process Charts – Outline process chart, Flow process chart, Two Handed process chart/Simo Chart, multiple activity Chart, Flow diagram, String diagram, Therbligs, Travel chart. 1.5 Work Measurement – Objectives, procedure, Time Study, Time Study Equipment. Stop Watch Time Study, Allowances, Calculation of Standard Time.
Unit– II Process Engineering	2a. Apply principles of supply chain management in the given industrial/domestic application. 2b. Plan appropriate manufacturing processes for manufacturing of the given simple job/component. 2c. Sketch precedence diagram for the given simple manufacturing task using line balancing concept. 2d. Apply CPM for the given project of the specified industry. 2e. Prepare the detailed sequence of operations for manufacturing the given component.	2.1 Production: Concept, factors of production, Supply Chain Management, 2.2 Process Engineering- functions, preliminary part print analysis, Selecting and planning manufacturing process; determining manufacturing sequence 2.3 Line Balancing: Heuristic approach of line balancing 2.4 Critical Path Method (CPM) and its application related to Project completion.
Unit-III Ergonomics	3a. Apply ergonomic concept to improve working conditions in the given industrial environment(s). 3b. Apply ergonomics principle to given simple component. 3c. Use ergonomic principle for	3.1 Ergonomics- Concept, need, man-machine relationship, anthropometric and functional anatomy data, 3.2 Ergonomic in design of control members – push button, knobs, levers, cranks, hand wheel. 3.3 Ergonomic considerations applied to

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	designing different controls and displays	types and location of display. 3.4 Compatibility in the design of control members.
Unit –IV Quality Control and Inspection	4a. Prepare quality characteristics chart which contribute to fitness for use of the given job/ component. 4b. List steps to solve the given problem in the industry using quality circle concept with justification. 4c. Identify Key six sigma roles , six sigma strategic group, Master Black Belt and Black Belt as coaches for the given industrial situation. 4d. Prepare cause and effect diagram/ Pareto chart/Scatter diagram for solving the given problem for root cause analysis. 4e. Select the type of inspection to be carried out at various stages of process/ product layout for the given situation relevant to industry with justification. 4f. Interpret the data obtained from the given quality control processes.	4.1 Meaning of quality of produce and services, Quality characteristics, Quality of design, Quality of conformance, Quality of performance, Concept of reliability, Cost, Quality assurance, Cost of rework and repair, Quality and Inspection, Quality Circle 4.2 Total Quality Management; Six sigma: Statistical meaning and methodology, Six sigma Black Belt concept. 4.3 KAIZEN, POKA-YOKE, 5S Techniques. 4.4 Introduction of ISO 9000, ISO-14000. 4.5 Quality Economics: Cost of quality, Value of quality, Economics of quality confirmation, Cost of quality appraisal, prevention, external and internal failure cost. Quality function deployment: Basic concept and areas of application. 4.6 Various Q-C tools: Cause-and-effect diagram (fishbone or Ishikawa diagram),Check sheet, Histogram, Pareto chart and Scatter diagram. 4.7 Inspection Definition and meaning, Difference between Inspection and quality control, Classification of Inspection –(i) Process Inspection (ii) Final Inspection (iii) Raw Material (finished/semifinished) Inspection (iv) Tool and Gauge Inspection. Role of Quality Control Inspector/supervisor.
Unit-V Statistical Quality Control	5a. Calculate mean, mode and median for the given sample(s) including the frequency histogram, frequency polygon. 5b. Represent the given data through normal distribution curve after calculating the standard deviation (σ), variance, range to determine the process capability. 5c. Interpret the control charts (X and R-bar, P-chart and C-chart) for measured data of the given sample(s). 5d. Prepare Single/Double	5.1 Basics of Statistical concepts, Meaning and importance of SQC. 5.2 Variable and attribute Measurement. Control charts – inherent and assignable sources of variation. Control charts for variables – X and R charts, control charts for attributes p, np, C charts. 5.3 Process capability of machine (±3σ or ±6σ), Cp and Cpk calculations. 5.4 Acceptance Sampling Concept, Comparison with 100% inspection, Operating Characteristics Curve, 5.5 Different types of sampling plans, sampling methods.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	sampling plan for the given Lot size (N), Sample size(n), acceptance number(c) 5e. Interpret control charts for the given variable and attribute data.	5.6 Merits and demerits of acceptance sampling.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Work Study (Method Study and Work Measurement)	12	02	04	06	12
II	Process Engineering	08	02	04	06	12
III	Ergonomics	06	02	04	06	12
IV	Quality Control and Inspection	10	02	04	10	16
V	Statistical Quality Control	12	02	04	12	18
	Total	**48**	**10**	**20**	**40**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Collect examples related to improvements which can be implanted in manufacturing using concepts of ergonomics.
b) Explain with suitable examples of your choice interaction between human and machine (any machine). Explain the procedure of evaluation of this interaction w.r.t. ergonomics.
c) Prepare Wall Chart of 3 Sigma and Six Sigma Curves and Compare number of defectives/rejection in parts per million (PPM).
d) Prepare list of National/international industries working on principle of Six Sigma Technique.
e) Visit any production industry. Collect the actual data from production and quality control department. Calculate mean, mode and median for the collected data.
f) Prepare a wall chart using standard 18 Therblings, state meaning of each symbol

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Before starting practical, teacher should demonstrate the working of instrument.
g) Instructions to students regarding care and maintenance of measuring equipments.
h) Show video/animation films to explain functioning of various measuring Instruments
i) Teacher should ask the students to go through instruction and Technical manuals of instruments

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Calculate the predermine time and total time required for the delivery of food (pizza/Burger) from fast food centers available in your city or town. Prepare sequence of activity and represent with Therbligs.
b) Prepare the list on World class industries using Six sigma Technique at present. and write detail report on any one of industry.
c) Visit any manufacturing Industry and observe analyse actual Quality Control practices.
d) Visit any manufacturing local/nearby Industry and observe the working of type of inspection practices carried out and prepare a report.
e) Visit any manufacturing local/nearby Industry and observe the various statistical Quality controls techniques carried out. Prepare related chart.
f) Visit any manufacturing local/nearby Industry and observe the various sampling plan followed by the industry. Draw the same sampling plan.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Oil Hydraulic system- Principles and maintenance	Majumdar, S.R	Tata McGraw Hill, New Delhi, (2002), ISBN: 9780074637487
2	Industrial Engineering and management	Khanna, O.P.	Dhanapat Rai Publications(P) Ltd., New Delhi, (1980), ISBN-10: 818992835X
3	Statistical Quality Control	Mahajan, M.	Dhanpat Rai and Sons, New Delhi, (2006) ISBN-10: 817700039X
4	Statistical Quality Control	Montgomer,y Douglas C.	Wiley India Pvt. Ltd., New Delhi, (2009), ISBN:9781118146811
5	Total Quality Management	Besterfield, Dale, H.	Pearson New Delhi, (2011) ISBN-13: 9780130993069
6	A Guide to the Ergonomics of Manufacturing	Heylander, Martin	East West Press, Taylor and Fransis, UK, (1997) , ISBN 0748401229
7	Ergonomics : Man in his Working Environment :	Murrell, K. F.	Chhapman and Hall Ltd., U.S.A. (2012), ISBN 13: 9780412219900
8	Ergonomics at Work	Oborn, David J.	John Wiley and Sons, New York , (1982), ISBN-10: 0471909424
9	Motion and Time Studies	Ralph, M. Barnes	John Wiley and Sons, UK, (2009), ISBN-9788126522170
10	Hand Book of Industrial Engg	Gavriel, Salvendy	John Wiley and Sons, UK, (2001) ISBN-10: 0471502766
11	Six Sigma Project Management: APocket Guide	Lowenthal, J. N	Milwaukee, WI: ASQ Quality Press. (2001), Lowenthal, J. N ISBN: 087389-519-3
12	The Six Sigma Handbook.	Pyzdek, T.	McGraw-Hill, New York, (2018) ISBN-13: 978-0071372336

14. SOFTWARE/LEARNING WEBSITES

a) https://nptel.ac.in/courses/112107143/8
b) https://www.youtube.com/watch?v=SRV27U2LBf0
c) https://www.youtube.com/watch?v=I2Oz5cyr9qs
d) https://www.ifm.eng.cam.ac.uk/research/dstools/quality-function-deployment
e) https://www.pinterest.com/pin/342696471431684777/
f) https://www.simplilearn.com/reasons-to-do-six-sigma-certification-article
g) https://www.youtube.com/watch?v=ZUZKtzhivQo
h) https://www.youtube.com/watch?v=4zrbfsAdEw0
i) https://www.youtube.com/watch?v=ENSb6BsM_q8
j) http://www.safetycare.com/en/shop/ergonomics-2/

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Computer Integrated Manufacturing (Elective-II)**

Course Code : **22658**

1. RATIONALE

Diploma Engineers need to acquire the knowledge of computer integrated Manufacturing (CIM) after getting conversant with conventional manufacturing methods. This subject encompasses entire range of product development and manufacturing activities with the help of different software packages. The course intends to help the students to work on Group Technology, Material Requirement Planning and collection of factory data system.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use of computer integrated manufacturing (CIM) technology in current manufacturing system.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Prepare Computer Aided Design (CAD)/ Computer Aided Manufacturing (CAM)/(CIM) product cycle different products cycle.
b) Apply CAM and CIM practices.
c) Apply business function software in CIM.
d) Apply networking in CIM.
e) Use of Flexible Manufacturing System (FMS) and Automation concepts in industries.
f) Use of Robotics technology in industries.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

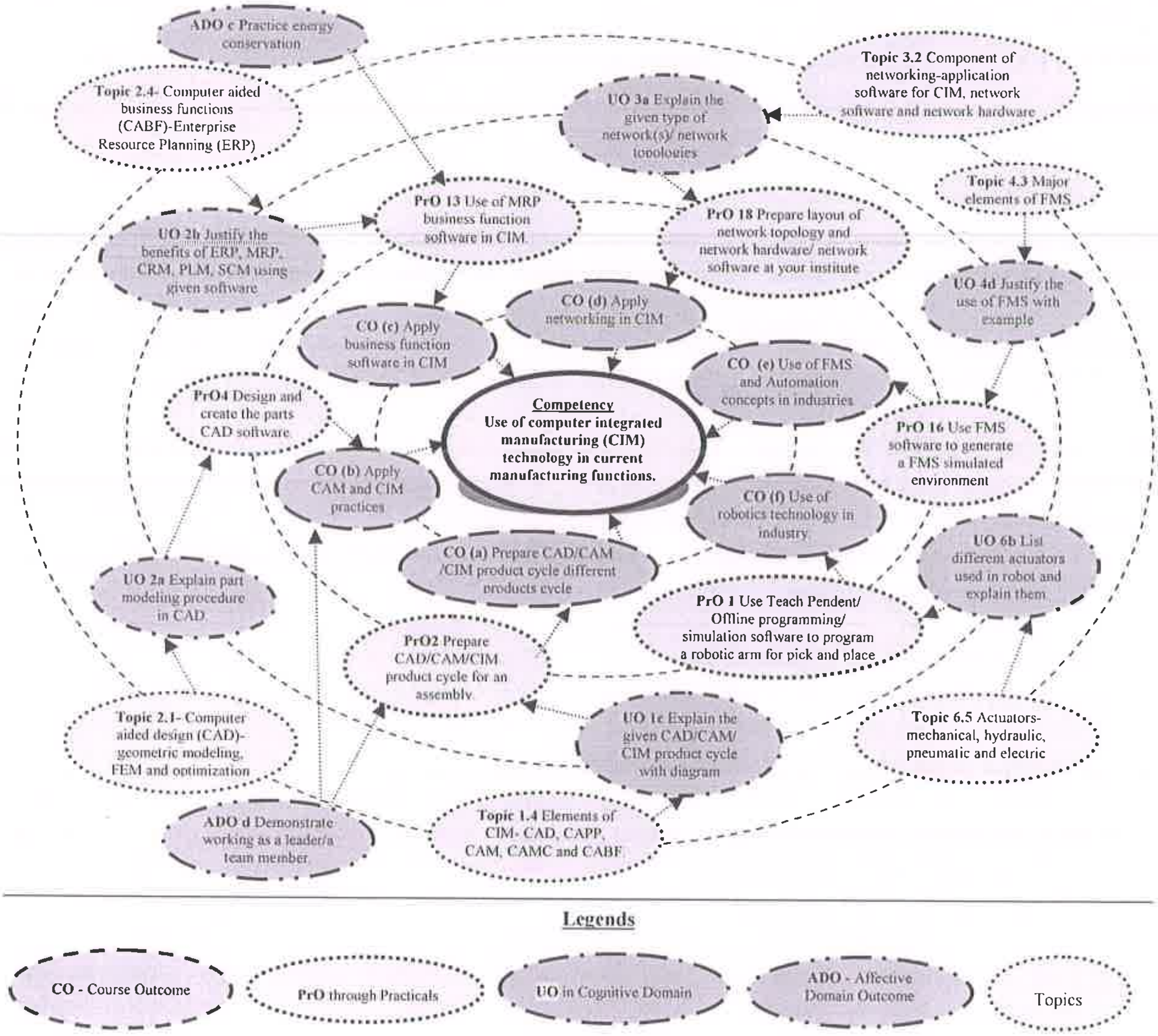


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare traditional product cycle for any one of the assembly.	I	2*
2	Prepare CAD/CAM/CIM product cycle for PrO1 assembly.	I	2*
3	Use of CRM (Customer Relation Management) software for maintaining customer relationship.	II	2
4	Design and create the individual parts of PrO1 assembly by using geometric modeling workbench of CAD software.	II	2*
5	Optimizing, evaluate and design review of parts modeled under PrO3 using any CAD/CAE software.	II	2*
6	Create drawings of parts modeled under PrO3 using drafting workbench of CAD software.	II	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Generate bill of material (BOM) and other data of PrO4 using CAD software.	II	2
8	Prepare Computer aided process plan for the selected part using variant type of CAPP (Computer Aided Process Planning) software.	II	2
9	Generate sample program for any part and verify tool path by simulation using CAM software.	II	2*
10	Generate tool path movement by Interfacing part program or manual part program to CNC machine.	II	2*
11	Inspection of part using CAQC software (Computer Aided Quality Control) by CMM/other system.	II	2
12	Use MRP (Material Resource Planning) software for CIM of and assembly.	II	2*
13	Use PLM (Product Life Management) software for CIM related to any product.	II	2*
14	Use Supply Chain Management software for CIM related to any product.	II	2
15	Prepare layout of network topology and network hardware/ network software at your institute place.	III	2*
16	Establish networking between two CNC machines, computers and supported peripherals of your institute to exchange manufacturing data and produce a simple component.	III	2*
17	Observe actual/video film of FMS system and identify various elements of FMS and its nature of controlling by computer.	IV	2*
18	Generate part family code for a machine component using Opitz/MICLASS methods.	IV	2*
19	Observe actual / video film of automation system and identify various elements, type of automation and its nature of controlling by computer.	V	2*
20	Use FMS simulation software to generate a Flexible Manufacturing System simulated environment to control and program Automatic storage and Retrieval system (ASRS), linear shuttle conveyor, Interfacing of CNC lathe/milling and with loading unloading.	V	2
21	Build Electro-Hydraulic circuits for given application and interfacing it to PLC using Electro-Hydraulic Training kit.	V	02*
22	Observe actual / video film of robotics system and identify various element, type of robot, it configurations and its nature of controlling by computer.	VI	2*
23	Use Teach Pendent/Offline programming/simulation software to program a robotic arm to perform pick and place and stacking of objects (2 programs)	VI	2*
	Total		**46**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup/simulated environment	40
2	Effective use of related software/hardware.	20
3	Correlation with the real/industrial situation	10
4	Observations/survey and collection of information.	10
5	Answer to sample questions.	10
6	Submit report in time.	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1styear
- 'Organisation Level' in 2ndyear
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Computers minimum 4GB RAM and above	2,3 to 22
2	MRP/ ERP/ CRM/SCM and PLM software (1 + 10 user)	2,3,12,13,14
3	Database Management system Software (1 + 10)	2,3,12,13,14
4	Educational networking licensed CAD software (1 + 20 user)	2 & 4 To 7
5	Educational networking licensed CAM software (1 + 20 user)	2 & 4 To 7
6	CNC Milling Machine	9,10,15,16
7	CNC lathe machine	9,10, 15,16
8	Educational networking licensed CAQC software (Computer Aided Quality Control) or CMM/other system	11
9	Flexible Manufacturing System (FMS) model	20
10	Educational networking licensed FMS simulation software	20
11	Previous final year students sample projects containing low cost automation system.	All
12	Educational programmable robotics arm to manipulate objects.	22
13	Educational networking licensed Robotic system simulation software	22

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to CIM	1a Explain the traditional product cycle with diagram and show all elements on it. 1b Explain advantages and benefits of the given CIM system. 1c Explain the given CAD/CAM/CIM product cycle with diagram and show elements on it. 1d Compare the given traditional product cycle with its counter CAD/CAM /CIM product cycle.	1.1 **Traditional product cycle diagram**-role of marketing, R&D, design, PPC, quality control and sales departments. Disadvantages and limitations of traditional product cycle. 1.2 **Current production needs-** production rate, quality, accuracy, repeatability, flexibility, survival. 1.3 **CIM**-concept, advantages and benefits of CIM. 1.4 **Elements of CIM-** computer aided design (CAD), computer process planning (CAPP), computer aided manufacturing control (CAMC), and computer aided business function (CABF). 1.5 **CAD/CAM/CIM product cycle diagram-** customer, marketing, computer aided design (CAD), computer aided process planning (CAPP), computer aided manufacturing control (CAMC), computer aided business function (CABF).
Unit– II Product Cycle Development through CIM	2a Explain part modeling procedure in CAD for the given component. 2b Explain analysis, optimization and evaluation for the given part using any CAE software. 2c Explain automated drafting procedure for the given component using any CAD software. 2d Differentiate given two methods of CAPP justifying with suitable examples 2e Explain the procedure of computerized part program generation for the given part using any CAM software. 2f Explain the procedure of part program interfacing to the given	2.1 **Computer aided design (CAD)**-geometric modeling, finite element analysis and optimization, evaluation and design review (CAE), concept of concurrent engineering, and list of software for CAE, simulation, automated drafting and generation of report. 2.2 **Computer aided process planning (CAPP)-** concept of CAPP, structure of processes planning software, methods of CAPP-variant, generative. Computerized material resource planning (CMRP), computerized work scheduling. 2.3 **Computer aided manufacturing control (CAMC)** – to generate computer program in machining. Interfacing part program to CNC. Computerized control monitoring and control, computer aided quality control (CAQC). Programmable logic control (PLC), software list like SCADA etc. 2.4 **Computer aided business functions (CABF)**-Enterprise Resource Planning (ERP)-role of ERP in business, advantage and applications of ERP softwares. Material Resource Planning (MRP)- role of MRP in business, advantage and benifits.MRP

	CNC machine. 2g Justify the benefits of ERP, MRP, CRM, PLM, SCM using the given corresponding software.	softwares. Customer Relationship Management (CRM) - role of CRM in business, advantage and applications.CRM software. 2.5 Product Lifecycle Management (PLM) - role of PLM in business, advantage and applications. PLM software. 2.6 Supply Chain management (SCM)- role of SCM in business, advantage and applications. SCM software.
Unit– III CIM Hardware, Software, Networking & Data Base Management System(DBMS)	3a. Explain the given type of network(s) and network topologies with diagram. 3b. Explain the given application software, network software, and network hardware with its purpose. 3c. State need of the given DBMS for the specified situation. 3d. Explain with sketches the given type of database.	3.1 **CIM networking**-types of network and its characteristics', applications. Types of network topologies-star, bus and ring topology. 3.2 **Component of networking**-application software for CIM, network software and network hardware. 3.3 **Data Base Management System (DBMS)**-data base types - hierarchical data base, network data base, relational data base, object oriented data base. Functions of data base management system. Advantages of DBMS.
Unit– IV Group Technology and Flexible Manufacturing System	4a. Justify the concept of Group Technology and its benefits for the given situation. 4b. Classify the FMS based on Flexibility for the given types of layouts. 4c. Compare the given two manufacturing systems based on the given criteria with examples. 4d. Justify the use of FMS for the given situation with example.s	4.1 **Group Technology**-concept, basis for developing part families, part classification and coding with example, concept of cellular manufacturing. Advantages and limitations. 4.2 **Flexible Manufacturing System-** Introduction, concept, definition and need, sub systems of FMS, comparing with other manufacturing approaches. 4.3 **Major elements of FMS**-workstations, material handling and storage system, computer control system and human resource. 4.4 **Classification based on flexibility**-dedicated FMS, random order. 4.5 **Classification based on types of layouts-** inline layout type, rotary layout, rectangular layout, loop layout type ladder layout type. 4.6 Applications and benefits of FMS, advantages and disadvantages of FMS.
Unit– V Automation	5a. Explain the main elements of the given automation system. 5b. Explain the given types of automations with respect to their characteristics.	5.1 **Automation**-Define, need of automation, high and low cost automation, examples of automations. 5.2 **Elements of automation** – power source, control unit and feedback control. 5.3 **Types of automations**- Fixed (Hard)

	5c. Justify the need of automation for the given situation. 5d. Explain the kind of strategies to be considered while designing automation in industry for the given situation.	automation, programmable automations and Flexible automations (Soft).Comparison of types of automations. 5.4 **Strategies in automation-** simplification, specializations of operations, multiple operations, integration of work stations, increased flexibility, automated material handling storage system, on line inspection, on line monitoring, processes control and optimization, control of plant operations and computer integrated manufacturing.
Unit–VI Robotics	6a. Explain with sketches the function of the specified actuators used in a robot. 6b. Explain given types of grippers used in robot with diagram. 6c. Explain with sketches the function of the given sensors used in a robot. 6d. Justify the use of Robot in the given industrial situation.	6.1 **Introduction to robotics-** definition of robot and robotics, advantages disadvantages. 6.2 **Basic components of robot**-manipulator, end effectors, actuators, sensors, controller, processor and software. 6.3 **Robot joints**-linear, orthogonal, rotational, twisting and revolving. 6.4 **Degree of freedom of robot**-vertical, radial, rotational traverse, wrist pitch, wrist yaw wrist roll. 6.5 **Actuators**-mechanical, hydraulic, pneumatic and electric. 6.6 **End effectors**-grippers and types. 6.7 **Robot sensors**-classification of sensors. 6.8 **Basic configuration of robot-** Cartesian, cylindrical, polar(spherical) 6.9 **Applications of robot**-loading unloading, material handling, processing operations, assembly and inspection.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to CIM	06	02	04	04	10
II	Product Development through CIM	12	04	04	06	14
III	CIM Hardware, Software, Networking and Data Base Management System (DBMS)	08	02	04	06	12
IV	Group Technology and Flexible manufacturing System	08	02	04	06	12
V	Automation	06	02	04	04	10
VI	Robotics	08	02	04	06	12
Total		**48**	**14**	**24**	**32**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journals based on practical performed in laboratory.
b) Follow the safety precautions.
c) Use various software and equipment related to CAD/CAM/CIM/CAE/CAPP
d) Read and use specifications various software and equipment related to CAD/CAM/CIM/CAE/CAPP
e) Library / Internet survey of CAD/CAM/CIM/CAE/CAPP/FMS.
f) Prepare power point presentation or animation for GT/FMS/CIM/PLM
g) Perform Market survey of business function such as flipkart /amazon service etc.
h) Visit Industries and Companies consisting CIM, FMS, automation and robot system.
i) Survey any one of the company and study of its product cycle and compare it with CIM product cycle.
j) Visit any industry to understand total CIM product cycle functions.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Arrange visit to nearby industries for understanding CIM functions.
g) Show video on films to explain functioning of CIM/FMS/automation/robot technology.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more

COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Collect information of any one of the company and compare every step with CIM product cycle.
b) Prepare a report related to suggestions to control business function according to CIM product cycle.
c) Collect information of advanced techniques related with quality control from nearby industry
d) Collect the different ERP, MRP PLM, SCM, DBMS and CRM software names, company name, product name and its features.
e) Perform web search and prepare a report on latest advancements and industrial practices in India and abroad in the field of CAD/CAM/CAPP/CAE/CIM/FMS/ ERP, MRP/PLM/SCM/DBMS and CRM.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Automation Production System and Computer Integrated Manufacturing	Groover. Mikell P.	Pearson Education, Canada, (2018), ISBN-978-93-325-4981-4
2	CAD/CAM/CIM	Radhakrishnan. P.	New Age International Publisher, New Delhi, (2008) ISBN-97-81-224-3980-9
3	Computer Aided Manufacturing	Rao. P. N.	McGrawhill Education, New Delhi, (2010) ISBN- 9780074631034
4	Principles of computer Integrated Manufacturing	Kant. S.	PHI Learning, New Delhi, (1995), ISBN-10: 812031476X
5	Cim: Principles of Computer- Integrated Manufacturing	Waldner. J. B.	John Wiley & Sons Inc. UK, (1992), ISBN- 9780471934509

14. SOFTWARE/LEARNING WEBSITES

a) http://nptel.ac.in/courses/112102103/17
b) http://nptel.ac.in/courses/112107077/module5/lecture2/lecture2.pdf
c) http://www.intelitek.com/pdf/DS01_BU_CIM-A_100761.pdf
d) https://nptel.ac.in/courses/112103174/module1/lec2/3.html
e) https://www.researchgate.net/publication/231832221_FMS_in_CIM_Flexible_Manufacturing_Systems_in_Computer_Integrated_Manufacturing
f) https://www.researchgate.net/post/What_are_the_differences_among_flexible_manufacturing_system_FMS_computer_integrated_manufacturing_CIM_and_totally_integrated_automation_TIA
g) http://www.me.nchu.edu.tw/lab/CIM/www/courses/Computer%20Integrated%20Manufacturing/Chapter2%20-CIM-introduction.pdf
h) https://brainmass.com/business/kaizen/cad-cae-cam-cim-fms-manufacturing-47731
i) http://www.alphace.ac.in/downloads/notes/me/10me61.pdf
j) http://www.me.nchu.edu.tw/lab/CIM/www/courses/Computer%20Integrated%20Manufacturing/Chapter2%20-CIM-introduction.pdf

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Refrigeration and Air Conditioning (Elective-II)**

Course Code : **22660**

1. RATIONALE

The 21st century predicts revolutionary developments in Heating, Ventilation and Air Conditioning. Considering the wide and increasing use of Heating, Ventilation and Air Conditioning for domestic, commercial and industrial applications and the challenges put in it is absolutely necessary that Diploma Engineers should learn these systems. They should know the processes, equipment, systems of Heating, Ventilation and Air Conditioning with their functioning, maintenance, repairs and measures to meet the current demand.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain refrigeration and air-conditioning systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use refrigeration systems for given application.
b. Use relevant refrigerants for different applications.
c. Select different refrigeration components for given refrigeration system.
d. Select different air conditioning components for given air-conditioning system
e. Determine cooling loads for Air-conditioning systems.
f. Select relevant tools for maintaining air conditioning systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

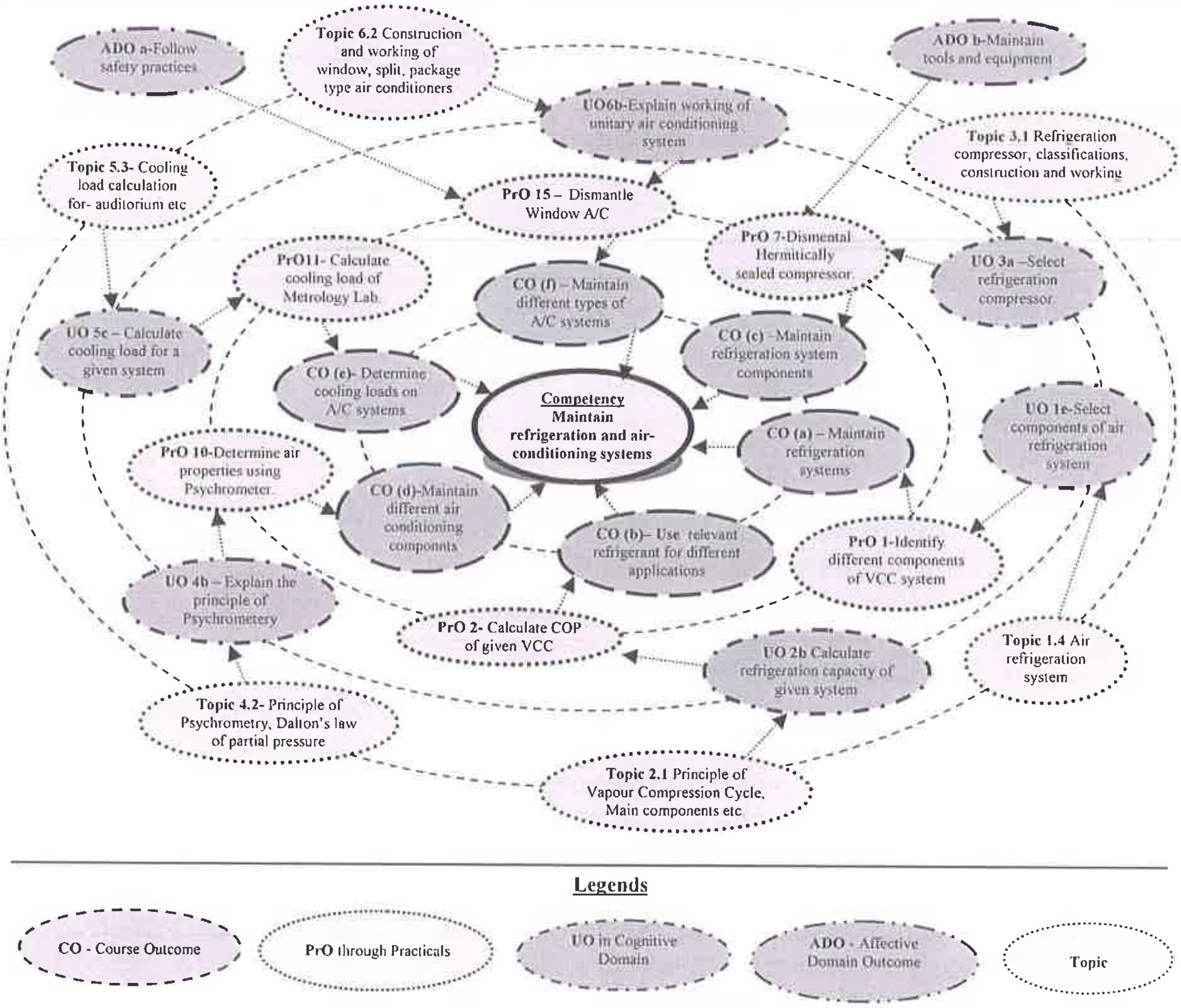


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify different components of Vapour compression cycle with their specification.	I	02*
2	Troubleshoot VCC system for Refrigerant leakage.	II	02
3	Charge the VCC system.	II	02
4	Identify the different components of House hold refrigerator with specification.	II	02
5	Dismantle Hermitically sealed compressor.	III	02*
6	Assemble Hermitically sealed compressor.	III	02*
7	Dismantle and assemble defrosting system of Household refrigerator.	III	02
8	Determine air properties using Psychrometer.	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Calculate cooling load of Institute's Metrology laboratory.	V	02*
10	Identify different components of Unitary Air conditioner with specifications.	VI	02
11	Dismantle the Window Air conditioner.	VI	02
12	Troubleshoot the Window Air conditioner.	VI	02*
13	Assemble Split Air conditioner.	VI	02
14	Troubleshoot the split Air conditioner.	VI	02*
15	Perform piping operations like tube/pipe cutting, swedging, brazing. insulation	VI	02
16	Dismantle Air conditioner of a car.	VI	02
17	Troubleshoot Air conditioner of a car	VI	02*
18	Assemble Air conditioner of a car.	VI	02
	Total		**36**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Vapour compression Test rig consisting of Hermitically sealed compressor 1TR capacity, Air cooled condenser, Expansion devices like TEV and capillary tube, Evaporator coils.	1,2
2	Water cooler test rig up to 100 liters capacity	1,3
3	Testing equipment like halide torch	4,5
4	Charging system, Vacuum pump, Charging kit	4,5
5	Household refrigerator test rig	6
6	Hermitically sealed compressor	7,8
7	Psychrometer digital	9,10,11,12,13
8	Anemometer	9,10,11,12,13
9	Window air conditioner	14,15
10	Split air conditioner	14,15
11	Window/split air conditioner test rig 1.5 Tr capacity	17

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Refrigeration	1a. Calculate COP of Carnot and Bell colemen cycle for the given condition 1b. Explain with sketches the significance of the given diagram 1c. Draw the PV and TS diagram for the given criteria 1d. Select components of air refrigeration system for given application with justification.	1.1 Necessity of Refrigeration, Unit of Refrigeration, concept of COP (actual and Theoretical) 1.2 Reversed Carnot cycle and its representation on PV and TS diagram 1.3 Bell colemen cycle and its representation on PV and TS diagram with simple numerical. 1.4 Air refrigeration system, component of air refrigeration system, Its applications
Unit-II Refrigeration Cycles and Refrigerants	2a. Calculate Actual and theoretical COP of given Vapour compression cycle. 2b. Calculate the refrigeration capacity for the given system 2c. Select relevant application of Multistage VCC for	2.1 Principle of Vapour Compression Cycle, Main components, Representation on P-H and T-S diagram, conditions- dry compression, effect of superheating, effect of undercooling, Calculation of Refrigeration capacity and Power required. Multistage Vapour Compression Refrigeration system, its

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given system with justification. 2d. Select relevant Refrigerant for given application with justification.	necessity, advantages and applications. 2.2 Vapour Absorption Cycle, principle, its component, working of Aqua – Ammonia Vapour absorption system, working of Li-Br absorption system, Electrolux refrigerator- working, main components, applications. Comparison between Vapour Compression system. and Vapour absorption system 2.3 Refrigerants, desirable properties, classification, designation of refrigerant, selection of refrigerant for relevant applications, System vaccumisation Charging processes, leak testing methods and process. 2.4 Montreal protocol, Kyoto protocol. Concept of Ozone Layer Depletion, Green House effect, Global warming, Eco friendly Refrigerants. 2.5 Applications of Refrigeration, House hold refrigerators, Water coolers, name of Manufacturers and their products with capacity.
Unit– III Refrigeratio n System Components	3a. Select relevant Refrigeration compressor for given refrigeration system with justification. 3b. Select relevant condenser for given refrigeration system with justification. 3c. Select relevant evaporator for given refrigeration system with justification. 3d. Select relevant Expansion device for given refrigeration system with justification. 3e. Explain the working of specified auxiliary devices used in refrigeration system 3f. Describe the process to maintain the given refrigeration systems component.	3.1 Refrigeration compressor, classifications, construction and working of hermitically sealed compressor, open type compressor, rotary compressors-centrifugal, Screw and Scroll compressors and their applications. 3.2 Condensers- classifications, working of air and water-cooled condensers, evaporative condensers, comparison and applications. 3.3 Evaporators- Classification- working of finned type, bared tube, plate type, flooded, shell and tube type evaporators, their applications. Chillers- Direct expansion and flooded type chillers, working and applications. 3.4 Expansion device- classifications, capillary tube, automatic expansion valve, Thermostatic expansion valve, selection, working and application. 3.5 Other components- Drier, Solenoid valve, Thermostatic switch, defrosting devices, working and applications.
Unit– IV Basics of Air Conditionin	4a. Explain the principle of Psychrometry for the given situation	4.1 Air conditioning- necessity, types of air conditioning- comfort air conditioning, industrial air conditioning, applications.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
g	4b. Represent the given psychrometric processes in Psychrometric chart 4c. Select relevant auxiliary components for given air conditioning system. 4d. Describe the procedure to maintain the given air conditioning component.	4.2 Principle of Psychrometry, Dalton's law of partial pressure, air properties. 4.3 Psychrometric processes, Representation of processes on Psychrometric. chart. Types and construction of Psychrometers. 4.4 Components used for air conditioning- Humidifiers, dehumidifiers, filters, heating and cooling coils.
Unit –V Cooling Load Calculation	5a. List human comfort conditions 5b. Identify the relevant sources of heat gain for the given situation with justification. 5c. Calculate cooling load for the given situation.	5.1 Comfort condition, heat exchange by human body with environment, factors affecting on human comfort. 5.2 Calculation of Sensible and Latent heat gain sources. 5.3 Cooling load calculation for- auditorium, Metrology laboratory, class room.
Unit –VI Air Conditionin g Systems	6a. Classify Air conditioning system 6b. Explain working of Unitary air conditioning system 6c. Explain the constructional features of central air conditioning 6d. Select relevant components for given air distribution system 6e. Select the insulating material for given air conditioning system. 6f. Describe the procedure to maintain the given type of air conditioning system.	6.1 Classification of air conditioning system- Summer and winter, Year around air conditioning, construction, application, comparison. 6.2 Construction and working of window, split, package type air conditioners. 6.3 Central air conditioning- types, direct and indirect central air conditioning construction, capacity, application. 6.4 Concept of air handling unit, air distribution system- closed perimeter system, extended perimeter system, radial duct system, losses in ducts, construction and application of supply, return and make up ducts, grills diffusers, types of fans and blowers. 6.5 Insulation- purpose, types of insulation, material and their properties. 6.6 Introduction to Automobile Air conditioning system.

Note*: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Refrigeration	06	02	02	04	08
II	Refrigeration cycles and Refrigerants	12	02	06	12	20
III	Refrigeration system components	08	02	02	06	10
IV	Basics of Air conditioning	06	02	02	06	10

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
V	Cooling load calculation	06	02	02	04	08
VI	Air Conditioning system	10	02	04	08	14
	Total	**48**	**12**	**18**	**40**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journals based on practical performed in laboratory.
b) Follow the safety precautions.
c) Use various mechanical measuring instruments and equipment related to Heating, Ventilation and air conditioning
d) Read and use specifications of the Refrigeration and air conditioning equipment.
e) Library / Internet survey of HVAC systems
f) Prepare power point presentation or animation for understanding constructional details and working of different Centralised air conditioning systems.
g) Visit nearby malls/auditoriums/commercial complex/Dairy/Cold storages/Ice cream factory/Ice plant/Cinema Theaters to identify different components of Refrigeration and air conditioning system.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with actual domestic and industrial Refrigeration and air conditioning systems.
g) Use proper equivalent analogy to explain different concepts related to Psychrometry.
h) Use Flash/Animations to explain various applications of Refrigeration and air conditioning.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Prepare a duct layout of your institute building from AHU
b) Prepare a chart of showing all the components of house hold refrigerator.
c) Prepare a demonstration model of cold storage.
d) Calculate Refrigeration capacity of split air conditioner.
e) Collect different air outlet devices used in Central air conditioning system
f) Download catalogue of Refrigeration compressors.
g) Prepare display chart of types of refrigerant used in commercial and Industrial applications.
h) Visit to nearby Central air conditioning plant/Malls/Showrooms and collect information regarding air conditioning
i) Conduct market survey of household refrigerators, make, capacity, arrangement, features, commercial terms etc.
j) Conduct market survey of window air conditioner make, capacity, arrangement, features, commercial terms etc.
k) Collect information of automobile air conditioning of different vehicles.
l) Comparative study of various types of compressors with detailed specification & market survey.
m) Comparative study of various types of condensers with detailed specification & market survey.
n) Comparative study of various types of evaporators with detailed specification & market survey.
o) Comparative study of various types of expansion devices with detailed specification & market survey.
p) Study of different types of refrigerants with properties, designation, selection & applications.
q) Comparative study of different types of central air-conditioning system with detailed specification and visit analysis report. (viz. AHU,FCU,VAV)

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Refrigeration and Air conditioning	Khurmi R. S.	S Chand publication, New Delhi, (2008), ISBN-10: 8121927811

S. No.	Title of Book	Author	Publication
2	Refrigeration and Air conditioning	Arora C. P.	Tata McGrawHill Publication, New Delhi, (2009), ISBN-13-978-07-008390-5
3	Basic Refrigeration and Air conditioning	Ananthnarayan P. M.	Tata McGrawHill Publication, New Delhi, (2013), ISBN- 9781259062704
4	Refrigeration and Air conditioning	Sapali S. N.	PHI publication, New Delhi, (2013) ISBN - 9788120348721
5	Refrigeration and Air conditioning	Prasad Manohar	New Age International, New Delhi, (2011), ISBN- 9788122414295
6	Refrigeration and Air conditioning	Ameen Ahmdul	PHI Publication, New Delhi, ISBN - 9788120326712
7	Principles of refrigeration	Dossat R. J.	John Wiley and Sons Ltd, UK, (2009) ISBN 978-0130272706

14. SOFTWARE/LEARNING WEBSITES

a) www.youtube.com/watch?v=52P0KbTNvok
b) www.youtube.com/watch?v=OXIZhqypNUI
c) www.youtube.com/watch?v=cobFAMZDS0o&start_radio=1&list=RDcobFAMZDS0o
d) www.youtube.com/watch?v=cobFAMZDS0o&list=RDcobFAMZDS0o&index=1
e) www.youtube.com/watch?v=Ll8Ku-mFQxE
f) www.youtube.com/watch?v=yQGFmBBvw1g&t=134s
g) www.youtube.com/watch?v=GSWt0zjLgIY
h) www.youtube.com/watch?v=PL0vU02QC4w
i) www.youtube.com/watch?v=lMqoKLli0Y4
j) www.youtube.com/watch?v=oSLOHCOw3yg
k) www.youtube.com/watch?v=6UMqdD6ejZQ
l) www.youtube.com/watch?v=7FxltQ41bZc

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Renewable Energy Technologies (Elective-II)**

Course Code : **22661**

1. RATIONALE

Use of renewable sources of energy is the need of the hour. Solar, Wind, micro-hydro and Bio-fuel systems have become reality now and the share of these systems in global energy market is increasing day by day. India has set high targets of employing renewable sources of energy for all possible applications to reduce the dependency on the fossil fuels. This has increased the demand of trained manpower for installation, operation and maintenance of various systems and equipment used in Solar, wind, micro-hydro and bio-fuel systems. This segment has huge potential for innovative solutions and opportunities for self-employment also. This course aims at equipping the technologists in installation, operation and maintenance of various mechanical equipment and systems used in Solar, Wind, Micro-hydro and bio-fuel systems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain the mechanical components of renewable energy systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Maintain mechanical components of solar thermal systems.
b) Maintain mechanical components of solar PV systems.
c) Maintain mechanical components of wind turbines.
d) Maintain mechanical components micro hydro turbines.
e) Maintain mechanical components of Biomass plants.
f) Maintain mechanical components hybrid renewable energy system.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

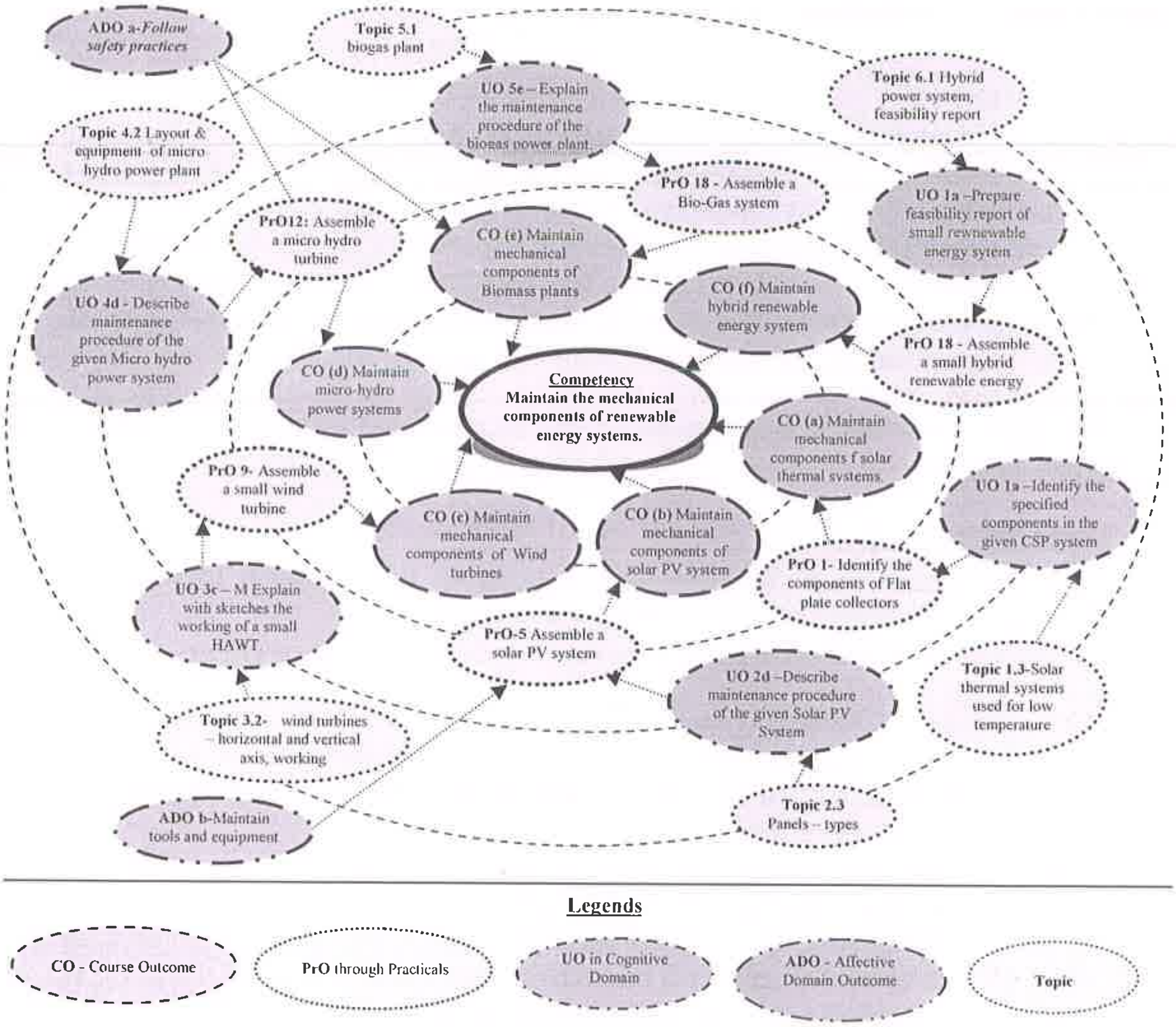


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the components of solar Flat plate collector.	I	02*
2	Identify the components of evacuated tube solar thermal system.	I	02
3	Identify the components of Solar dryer system.	I	02
4	Use pyranometer for measurement of solar radiation flux density.	I	02*
5	Assemble a solar PV system with and without battery connection	II	02*
6	Measure heat output, Maximum power, power output efficiency of solar PV panel.	II	02*
7	Simulation software to calculate PV energy output.	II	02
8	Use vane anemometer for measurement of different locations for	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	site selection for wind mill.		
9	Assemble/dismantle a horizontal axis small wind turbines.	III	02*
10	Assemble/dismantle a vertical axis small wind turbines.	III	02
11	Measure the output power of the turbine, rotation speed of the turbine, wind speed, system voltage and system current.	III	02
12	Assemble/dismantle a micro hydro power system.	IV	02
13	Measure Power output, flow and head for micro hydro power system.	IV	02
14	Assemble/dismantle a biogas power system.	V	02*
15	Assemble/dismantle a biomass gassifier power system.	V	02*
16	Assemble/dismantle a wind-solar hybrid system	VI	02*
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year

- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Poly crystalline/Mono crystalline solar PV panel 20W X	1,2
2	Solar dryer system.	3
3	Solar Cooker	4
4	Solar water heater (flat plate/tube type) -50 Ltrs.	3
5	Pyranometer any make available in the market.	5
6	Vane anemometer any make available in the market	8
7	3-bladed Geared Wind Turbine: 5/10/20/30 kW, Upwind with 20/30 m hydraulically operated tilt-up/tilt-down tubular tower or whichever lowest rating that is available in the market	9,10,11,12,13
8	Wind (1kW) - Solar PV (1kW) Hybrid System	16,17
9	Smokeless Chulhas, Burners, Heaters and Engines.	18
10	Voltmeter, Ammeter	1 to 21
11	Bio gas plant for lab	18

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Solar Thermal Systems	1a. Identify specified components in the given CSP system. 1b. Select CSP for the given application with justification. 1c. Select Solar Dryer system for a given application with justification. 1d. Describe with sketches the maintenance procedure of the given CSP	1.1 Alternative energy sources: primary, secondary and tertiary energy. 1.2 Classification of solar thermal systems 1.3 Concentrated Solar Power (CSP) systems– Flat plate collectors, parabolic collectors, parabolic dish collector, solar tower. 1.4 Domestic-Water heating systems; Commercial-Heating systems used for process heating Installation- standard procedure, precautions, Plumbing – piping, Valves. 1.5 Maintenance: Routine maintenance, procedure for domestic and commercial water heater systems. • Failure maintenance – Major causes, remedies. 1.6 Solar dryers – Classification, construction, working and applications commercial, agro-products, domestic. 1.7 Choice of a system for a given Application-technical and financial criteria used for selection.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-II **Solar Photovoltaic Systems**	2a. Identify the specified components in the given rating of the solar PV system. 2b. Explain with sketches the working of the solar PV system 2c. Select Solar Photovoltaic systems for a given situation with justification. 2d. Describe maintenance procedure of the given Solar PV System.	2.1 Classification of Solar Photovoltaic systems – Grid connected, Off-grid, stand-alone systems. 2.2 PV cells – types, merits and demerits 2.3 Panels – types. 2.4 Battery and other accessories – types, rating, methods of selection 2.5 Recent trends and promotional schemes – Net metering. 2.6 Installation, commissioning and maintenance of Solar Roof Top systems, Stand-alone street light.
Unit– III **Wind Energy Systems**	3a. Explain with sketches of the working of the small HAWT. 3b. Explain with sketches the working of VAWTs 3c. Prepare the specifications of the specified type of small wind turbine 3d. Describe with sketches the functions of the given components of the large wind power plant 3e. Describe the procedure to undertake routine maintenance of small wind turbines. 3f. Describe the procedure to maintain large wind turbines.	3.1 Types of wind energy systems -- large and small, commercial and domestic, grid connected and stand-alone. 3.2 Small Horizontal axis wind turbines (HAWTs): construction, working, specifications and maintenance procedure 3.3 Small veritcal axis wind turbines (VAWTs): construction, working, specifications and maintenance procedure 3.4 Large Horizontal axis wind turbines:: construction, working and maintenance procedure
Unit– IV **Micro Hydro Power Systems**	4a. Explain with sketches the construction and working of specified type of micro-hydro power systems. 4b. Identify various components in the give Micro hydro power systems. 4c. Select micro-hydro systems for a given situation with justification. 4d. Describe maintenance procedure of the given type of Micro power system(s).	4.1 Micro hydro power systems: Classification, Layout, construction and working. 4.2 Installation-procedure, precautions. 4.3 Operating procedures. 4.4 Maintenance of Micro hydro power systems.
Unit –V **Bio-energy Systems**	5a. Identify various components in the given type of biomass power system. 5b. Describe with sketches the	5.1 Classification of bio-fuels- biogas, biodiesel. 5.2 Biomass power plants – bio-gas plants, gasifiers, digestors, bio-diesel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	construction of the specified biomass power plant 5c. Explain with sketches the working of the specified biomass power plant 5d. Describe the procedure of installation of the given Bio-Gas plants. 5e. Describe the maintenance procedure of the given biomass power plant	plants: Layout, construction and principle of working and specification for small power plant of all these 5.3 Installation and maintenance procedure of Bio gas plant. 5.4 Applications of various bio-fuels Domestic – heating, cooking, Commercial – process heating, power generation 5.5 Systems used for utilization of bio-fuels – smokeless Chulhas, burners, heaters and engines.
Unit–VI Renewable Energy Hybrid Systems and Feasibility Studies	6a. Prepare layouts of the given hybrid power systems. 6b. Describe the different performance parameters related to the given Wind-Solar PV hybrid system. 6c. Describe the procedure to test the performance of the given Wind-Solar PV hybrid system. 6d. Prepare project feasibility report for installation of renewable energy systems.	6.1 Types of hybrid system: wind- solar, wind-biogas, solar-biogas: Specification, construction and specification of all these 6.2 Power output of hybrid system. 6.3 Installation-procedure, precautions, Operating procedures of Wind-Solar PV hybrid system. 6.4 Choice of systems –technical and commercial feasibility assessment, costing of renewable energy systems.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Solar Thermal Systems	10	02	04	08	14
II	Solar Photovoltaic Systems	08	02	04	06	12
III	Wind Energy Systems	08	02	04	06	12
IV	Micro Hydro Power Systems	08	00	04	06	10
V	Bio-energy Systems	08	02	04	06	12
VI	Renewable Energy Hybrid systems and feasibility studies	06	02	04	04	10
Total		**48**	**10**	**24**	**36**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews. Participate in field visits to understand actual operation / working of following:

a) Flat plate collector used for domestic water heating application.
b) Flat plate collector used for process heating in commercial / industrial organization.
c) Stand-alone solar photovoltaic lighting Grid connected solar PV power plants
d) Grid connected wind power plants
e) Hybrid plants
f) Bio-gas plants (domestic or commercial)
g) Smokeless Chulhas

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with actual renewable energy based appliances and devices.
g) Use proper equivalent analogy to explain different concepts related to these renewable energy conversions.
h) Use Flash/Animations to explain function and construction of Flat plate collector used for domestic water heating application and used for process heating in commercial / industrial organization, Stand-alone solar photovoltaic lighting plant, Grid connected wind mill plant, Hybrid plants.
i) Arrange field or industrial visits to see manufacturing/working of renewable energy systems.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Prepare a feasibility report and present it (Group of max 3 students) for employing renewable energy system for any given situation where fossil fuels are used. Following guidelines may be followed.
   i. Various distinctly different industrial or household situations should be visited by the group.
   ii. Annual requirement of total energy for the situation (visited by the respective group) should be estimated using a survey and questionnaire technique.
   iii. Appropriate choice of renewable energy technology should be made based on the availability of local resources.
   iv. The budget required for the installation of the renewable energy system should be estimated by using prevalent market prices of various components and installation costs.
b) The feasibility report should be prepared using various financial parameters such as Return on Investment (ROI) and payback period.
c) Prepare small working models of already existing/improved/new Horizontal/vertical wind turbine, Flat plate collector used for domestic water heating application and used for process heating in commercial / industrial organization, Stand-alone solar photovoltaic lighting plant, Grid connected wind mill plant, Hybrid plants, Wind-Solar PV hybrid system, Smokeless Chulhas, Burners, Heaters and Engines, Biogas plant.
d) Prepare a report for selection of Solar lightning system for a small colony or your institute campus.
e) Prepare a small Solar charger/Solar car/Solar fan/Solar torch/Solar cooler/Solar street light etc.
f) Visit to a commercial or industrial solar water heating installation of at least 500 liters per day capacity and write a report about collector layout, piping and fittings and measurement of performance of the system.
g) Compare constructional details and performance of conventional FPC and evacuated tube FPC.
h) Prepare a layout of solar water heating system for domestic/commercial use. Comprises of plumbing, insulations, control valves and support systems in bad weather conditions.
i) Study various types of solar dryer designs and select best suited dryer for a given application.
j) Study of PV cells : classification - monocrystalline, polycrystalline, thick film, thin film, amorphous, organic.; energy generation mechanism; applications.
k) Study construction and working of horizontal axis wind mill or to visit a nearest wind farm and write a report.
l) Visits to a biogas plant or biomass gasification facility

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Solar Photovoltaic: A Lab Training Module	Solanki, Singh Chetan, Arora, Brij M., Vasi Juzer, Patil, Mahesh B.	Cambridge University Press, New Delhi, (2009), ISBN: 9789382264590
2	Solar Photovoltaic: Fundamentals, Technologies and	Solanki, Singh Chetan	PHI Learning, New Delhi, (2009), ISBN: 9788120351110

S. No.	Title of Book	Author	Publication
	Application		
3	Solar Energy	Sukhatme S.P., Nayak J.K.	Tata McGraw, New Delhi, (2010), ISBN: 9781259081965
4	Introduction to Photovoltaics	Balfour John R., Shaw Michael L., Jarosek Sharlave	Jones and Bartlett Publishers, Burlington, (2011), ISBN: 9781449624736
5	Solar Cells and Their Applications	Fraas Lewis M., Partain Larry D.	Wiley, UK, (2010), ISBN: 9780470446331
6	Concentrating Solar Power Technology	Lovegrove K., Stein W.	Woodhead Publishing, (2012), ISBN:9781845697693
7	Wind Power in Power Systems	Ackermann Thomas	John Wiley and Sons, UK, (2012) ISBN: 9781119942085
8	Renewable Energy Sources and Emerging Technologies	Kothari D.P. Singal K.C.	Prentice Hall India Learning Private Ltd., New Delhi, (2011), ISBN: 9788120344709
9	Solar Energy : Fundamentals and Applications	Garg H. and Prakash J.	McGraw Hill Education, New Delhi, (2017), ISBN: 978-0074636312
10	Introduction to Bioenergy	Nelson Vaughn C., Kenneth L. Starcher	CRC press, UK, (2015) ISBN 9781498716987

14. SOFTWARE/LEARNING WEBSITES

Solar thermal

a. https://mnre.gov.in/file-manager/UserFiles/pdf/Students%20Workbook%20-%20Solar%20Thermal%20System.pdf
b. http://www.climatetechwiki.org/technology/solar-thermal-hot-water
c. http://nptel.ac.in/courses/112105050/m1l1.pdf
d. http://nptel.ac.in/courses/108105058/15
e. https://www.youtube.com/watch?v=mpHZWYpKDJg

Solar photovoltaic

f. https://www.nrel.gov/workingwithus/re-photovoltaics.html
g. https://mnre.gov.in/solar-photovoltaic-systems
h. https://www.renewableenergyworld.com/solar-energy/tech/solarpv.html
i. https://www.youtube.com/watch?v=jxOvCnQfj_8
j. http://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/notused/Non-Conventional%20Energy%20Systems(28-05-07)/pdfs/chap04.pdf
k. https://www.youtube.com/watch?v=Fuyq6WrM1EA

Wind power

l. https://www.energy.gov/energysaver/buying-and-making-electricity/small-wind-electric-systems
m. http://synergyfiles.com/2015/04/small-scale-vs-large-scale-wind-turbines/
n. https://www.nrel.gov/workingwithus/re-wind.html
o. https://www.youtube.com/watch?v=JJDylOtr5yA
p. https://www.youtube.com/watch?v=NbZepCQUQTg
q. http://nptel.ac.in/courses/108108078/pdf/chap6/teach_slides06.pdf
r. http://nptel.ac.in/courses/108107028/module1/lecture1/lecture1.pdf

Micro, hydro power systems

s. http://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/what-is-the-difference-between-micro-mini-and-small-hydro/
t. https://www.youtube.com/watch?v=eXljm_axyu0
u. http://nptel.ac.in/courses/108108078/pdf/chap5/teach_slides05.pdf
v. http://nptel.ac.in/courses/105105110/pdf/m5l01.pdf
w. https://www.youtube.com/watch?v=JBrdUoU2uTE
x. https://www.youtube.com/watch?v=i9yCpuiMze0

Bio energy systems

y. https://www.youtube.com/watch?v=DKvzVlN-sOQ
z. https://www.bioenergyconsult.com/biomass-energy-systems/
aa. https://mnre.gov.in/bio-energy
bb. http://nptel.ac.in/courses/108108078/7
cc. http://nptel.ac.in/courses/102104057/3
dd. http://nptel.ac.in/courses/102104057/
ee. http://nptel.ac.in/courses/102104057/5
ff. http://nptel.ac.in/courses/102104057/4

Program Name : **Diploma in Computer Engineering Group/ Diploma in Mechanical /Chemical Engineering /Diploma in Electronics Engineering Group/ Diploma in Fashion & Clothing**

Program Code : **CO/CM/CW/DC/EJ/ET/EN/EX/EQ/IE/ME/CH**

Semester : **Sixth**

Course Title : **Entrepreneurship Development**

Course Code : **22032**

1. RATIONALE

Globalisation, liberalization and privatization along with revolution in information technology have opened up new opportunities transforming lives of masses. In this context, there is immense opportunity of establishing manufacturing, service, trading, marketing and consultancy enterprises by diploma engineer. Our fast growing economy provides ample scope for diploma engineers to succeed as an entrepreneur. Entrepreneurship requires distinct skill sets which are attempted to be developed through this course. To begin with, this course aims to develop the competency and the related outcomes in order to start small enterprises.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Develop project proposals to launch small scale enterprises.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify your entrepreneurial traits.
b. Identify the business opportunities that suits you.
c. Use the support systems to zero down to your business idea.
d. Develop comprehensive business plans.
e. Prepare plans to manage the enterprise effectively.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2	-	2	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40

@ : Internal examination

*(~): For the **practical only courses,** the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e.30 marks) and micro-project assessment (seen in section 11) has a weightage of 40% (i.e.20 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

***Legends:** L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

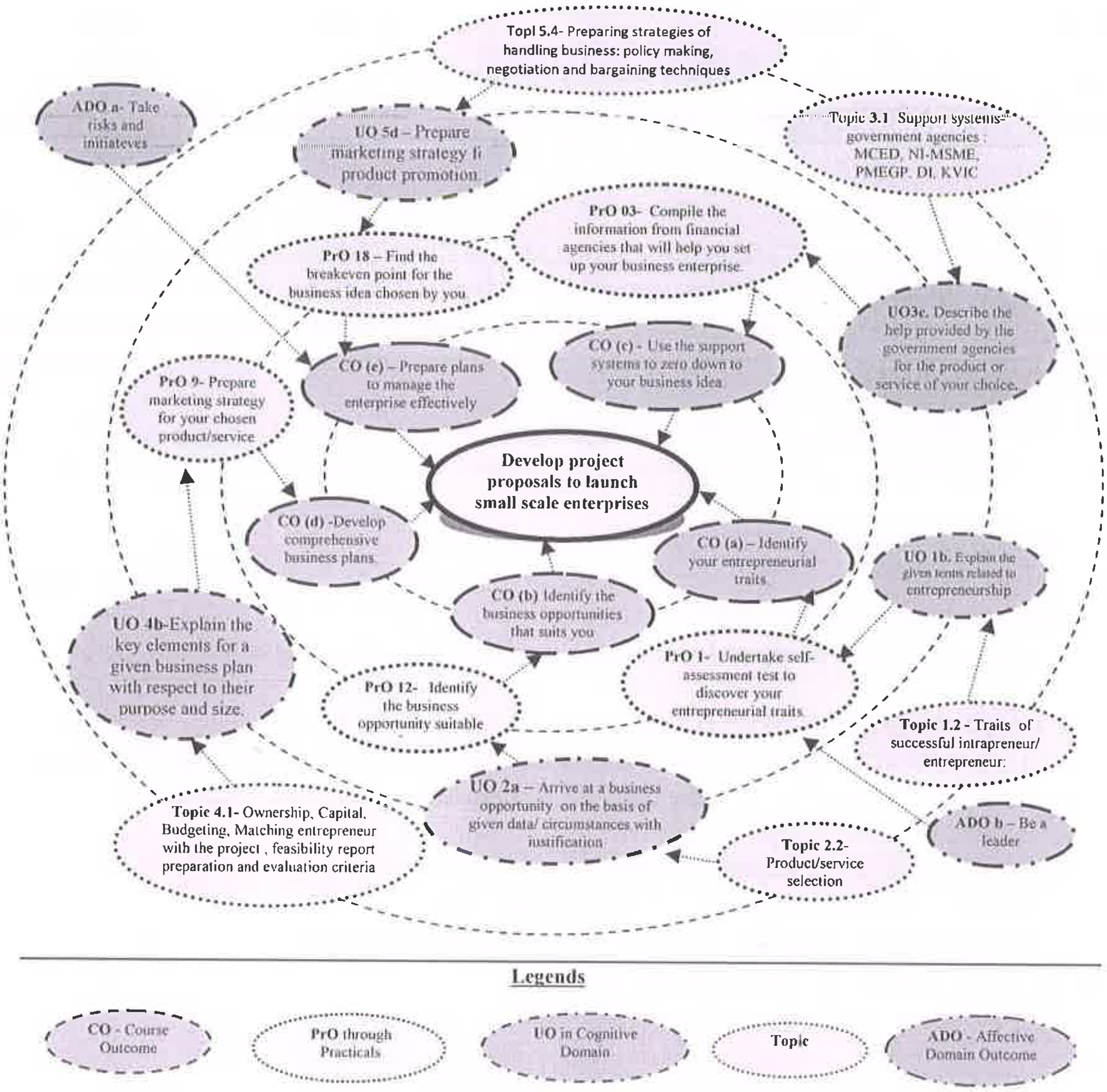


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Submit a profile summary(about500words) of a successful entrepreneur indicating milestone achievements.	I	02*
2	Undertake SWOT analysis to arrive at your business idea of a product/service.	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Generate business ideas(product/service) for intrapreneurial and entrepreneurial opportunities through brainstorming.	II	02*
4	Undertake self-assessment test to discover your entrepreneurial traits.	II	02*
5	Identify the business opportunity suitable for you.	II	02
6	Arrange an exhibition cum sale of products prepared out of waste.	II	02
7	Survey industries of your stream, grade them according to the level of scale of production, investment, turnover, pollution to prepare a report on it.	II	02*
8	Visit a bank/financial institution to enquire about various funding schemes for small scale enterprise.	III	02*
9	Collect loan application forms of nationalise banks/other financial institutions.	III	02*
10	Compile the information from financial agencies that will help you set up your business enterprise.	III	02*
11	Compile the information from the government agencies that will help you set up your business enterprise.	III	02*
12	Prepare Technological feasibility report of a chosen product/service.	III	02*
13	Prepare financial feasibility report of a chosen product/service.	III	02*
14	Craft a vision statement and enabling mission statements for your chosen enterprise.	III	02
15	Prepare a set of short term,medium and long term goals for starting a chosen small scale enterprise	III	02*
16	Prepare marketing strategy for your chosen product/service.	IV	02*
17	Compile information about various insurance schemes covering different risk factors.	IV	02
18	Organize a funfair of your class and write a report of profit/loss	V	02
19	Find the breakeven point for the business idea chosen by you.	V	02
20	Arrange a discussion session with your institute's pass out students who are successful entrepreneurs.	V	02
21	Prepare a business plan for your chosen small scale enterprise	V	02*
	Total		**42**

Note:

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

Sample Products that can be manufactured under SME

1. Badges cloth embroidered and metals

2. Bags of all types i.e. made of leather, cotton, canvas and jute etc. including kit bags, mail bags, sleeping bags and water-proof bag
3. Bandage cloth
4. Basket cane (Procurement can also be made from State Forest Corpn. and State Handicrafts Corporation)
5. Bath tubs of plastic
6. Battery Charger
7. Belt leather and straps
8. Bolts and Nuts
9. Boot Polish
10. Brooms
11. Domestic Brushes of different types
12. Buckets of all types of plastic
13. Button of all types
14. Chappals and sandals
15. Cleaning Powder
16. Cloth Covers for domestic use
17. Cloth Sponge
18. Coir mattress cushions and matting
19. Cotton Pouches
20. Curtains mosquito
21. Domestic Electric appliances as per BIS Specifications: Toaster Electric, Elect. Iron, Hot Plates, Elect. Mixer, Grinders Room heaters and convectors and ovens
22. Dust Bins of plastic
23. Dusters Cotton all types except the items required in Khadi
24. Electronic door bell
25. Emergency Light (Rechargeable type)
26. Hand drawn carts of all types
27. Hand gloves of all types
28. Hand numbering machine
29. Hand Pump
30. Hand Tools of all types
31. Handles wooden and bamboo (Procurement can also be made from State Forest Corpn. and State Handicrafts Corporation)
32. Haver Sacks
33. Honey
34. Invalid wheeled chairs.
35. Iron (dhobi)
36. Lamp holders
37. Letter Boxes
38. Nail Cutters
39. Oil Stoves (Wick stoves only)
40. Paper conversion products, paper bags, envelops, Ice-cream cup, paper cup and saucers and paper Plates
41. Pickles, Chutney and Pappads
42. Pouches for various purposes
43. Safe meat and milk
44. Safety matches
45. Safety Pins (and other similar products like paper pins, staples pins etc.)
46. Shoe laces

47. Sign Boards painted
48. Soap Liquid
49. Spectacle frames
50. Steel Chair
51. Umbrellas
52. Utensils all types

Sample Services that can be offered under SME

1. Marketing Consultancy
2. Industrial Consultancy
3. Equipment Rental & Leasing
4. Typing Centres
5. Photocopying Centres (Zeroxing)
6. Industrial photography
7. Industrial R & D Labs.
8. Industrial Testing Labs.
9. Desk Top publishing
10. Advertising Agencies
11. Internet Browsing/Setting up of Cyber Cafes
12. Auto Repair, services and garages
13. Documentary Films on themes like Family Planning, Social forestry, energy conservation and commercial advertising
14. Laboratories engaged in testing of raw materials, finished products
15. 'Servicing Industry' Undertakings engaged in maintenance, repair, testing or electronic/electrical equipment/ instruments i.e. measuring/control instruments servicing of all types of vehicles and machinery of any description including televisions, tape recorders, VCRs, Radios, Transformers, Motors, Watches.
16. Laundry and Dry Cleaning
17. X-Ray Clinic
18. Tailoring
19. Servicing of agriculture farm equipment e.g. Tractor, Pump, Rig, Boring Machines.
20. Weigh Bridge
21. Photographic Lab
22. Blue printing and enlargement of drawing/designs facilities
23. ISD/STD Booths
24. Teleprinter/Fax Services
25. Sub-contracting Exchanges (SCXs) established by Industry Associations.
26. Coloured or Black and White Studios equipped with processing laboratory.
27. Ropeways in hilly areas.
28. Installation and operation of Cable TV Network:
29. Operating EPABX under franchises
30. Beauty Parlours
31. Creches.

S. No.	Performance Indicators	Weightage in %
1	Leadership skills	20
2	Team work	20
3	Lateral/creative thinking	10
4	Observations and recording	10
5	Self learning	20

S. No.	Performance Indicators	Weightage in %
6	Answer the sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Seminar Hall equipped with conference table,chairs and multimedia facilities	All
2	Modern desktop Computer with internet connection.	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (In cognitive domain)	Topics and Sub-topics
Unit – I Entrepreneurship Development - Concept and Scope	1a. Describe the procedure to evaluate your entrepreneurial traits as a career option for the given product to be manufactured or services to be rendered. 1b. Explain the given terms related to Entrepreneurship	1.1 Entrepreneurship as a career 1.2 Traits of successful intrapreneur/ entrepreneur: consistency, creativity, initiative, independent decision making, assertiveness, persuasion, persistence, information seeking, handling business communication, commitment to work contract, calculated risk taking. 1.3 Entrepreneurship : scope in local and

Unit	Unit Outcomes (In cognitive domain)	Topics and Sub-topics
	1c. Describe the salient features of the resources required for starting the specified enterprise. 1d. Identify the characteristics for a given type of enterprise.	global market. 1.4 Intrapreneur and entrepreneur 1.5 Types of enterprises and their features : manufacturing, service and trading. 1.6 Steps in setting up of a business.
Unit – II Entrepreneurial Opportunities and selection process	2a. Arrive at a business opportunity on the basis of given data/circumstances with justification. 2b. Describe the scheme(s) offered by the government for starting the specified enterprise. 2c. Suggest a suitable place for setting up the specified enterprise on the basis of given data/circumstances with justification. 2d. Suggest the steps for the selection process of an enterprise for the specified product or service with justification. 2e. Describe the market study procedure of the specified enterprise.	2.1 Product/Service selection: Process, core competence, product/service life cycle, new product/ service development process, mortality curve, creativity and innovation in product/ service modification / development. 2.2 Process selection: Technology life cycle, forms and cost of transformation, factors affecting process selection, location for an industry, material handling. 2.3 Market study procedures: questionnaire design, sampling, market survey, data analysis 2.4 Getting information from concerned stakeholders such as Maharashtra Centre for Entrepreneurship Development[MCED], National Institute for Micro, Small and Medium Enterprises [NI-MSME], Prime Minister Employment Generation Program [PMEGP], Directorate of Industries[DI], Khadi Village Instries Commission[KVIC]
Unit – III Support Systems	3a. Describe the support system required for the specified enterprise. 3b. Describe the help provided by the government agencies for the specified product/service. 3c. Describe the help provided by the non-governmental agencies for the specified product/service. 3d. Compute the breakeven point for the specified	3.1 Categorisation of MSME, ancillary industries 3.2 Support systems- government agencies: MCED, NI-MSME, PMEGP,DI, KVIC 3.3 Support agencies for entrepreneurship guidance, training, registration, technical consultation, technology transfer and quality control, marketing and finance. 3.4 Breakeven point, return on investment and return on sales.

Unit	Unit Outcomes (In cognitive domain)	Topics and Sub-topics
	business enterprise, stating the assumptions made.	
UNIT IV **Business Plan Preparation**	4a. Justify the importance of the business plan for the given product/service. 4b. Explain the key elements for the given business plan with respect to their purpose/size 4c. Prepare the budget for the given venture. 4d. Prepare the details of the given component of the given startup business plan.	4.1 Sources of Product for Business : Feasibility study 4.2 Ownership, Capital, Budgeting, Matching entrepreneur with the project , feasibility report preparation and evaluation criteria 4.3 Business plan preparation
Unit –V **Managing Enterprise**	5a. Justify the USP of the given product/ service from marketing point of view. 5b. Formulate a business policy for the given product/service. 5c. Choose the relevant negotiation techniques for the given product/ service with justification. 5d. Identify the risks that you may encounter for the given type of business/enterprise with justification. 5e. Describe the role of the incubation centre for the given product/service.	5.1 Unique Selling Proposition [U.S.P.]: Identification, developing a marketing plan. 5.2 Preparing strategies of handling business: policy making, negotiation and bargaining techniques. 5.3 Risk Management: Planning for calculated risk taking, initiation with low cost projects, integrated futuristic planning, angel investors, venture capitalist. 5.4 Incubation centres: Role and procedure.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Develop two products from household waste (attach photographs).
b. Download product development and innovative films from internet.
c. Prepare a collage for 'Traits of successful entrepreneurs'.
d. Invite entrepreneurs, industry officials, bankers for interaction.
e. Identify your hobbies and interests and convert them into business idea.

f. Convert you project work into business.
g. Choose a product and design a unique selling preposition, brand name, logo, advertisement (print, radio, television), jingle, packing, packaging, label for it.
h. Develop your own website. Share your strengths and weakness on it. Declare your time bound goals and monitor them on the website.
i. Choose any advertisement and analyse its good and bad points.
j. Decide any product and analyse its good and bad features.
k. Select any product and prepare its cost sheet.
l. Choose any product and study its supply chain.
m. Arrange brainstorming sessions for improvement of any product.
n. Study schemes for entrepreneurship promotion of any bank.
o. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
p. Open a savings account and build your own capital.
q. Organise industrial visit and suggest modifications for process improvement.
r. Interview at least four entrepreneurs or businessman and identify Charms of entrepreneurship and Traits of successful entrepreneurs.
s. Analyse case studies of any two successful entrepreneurs.
t. Perform a survey and identify local resources available for setting up of an enterprise.
u. Engage in marketing of products.
v. Carry out a demand supply gap analysis for a particular product.
w. Organise a prototype development competition.
x. Arrange fairs, events in the institute and try for sponsorships.
y. Select any performance criteria and continuously compete with yourself.
z. On any performance criteria continuously compete with others.
aa. Foresee your dream and make a long term plan for its accomplishment.
bb. Dream for something unique and make a write-up.
cc. Read articles, books on creativity.
dd. Using morphological analysis technique, reduce cost or increase quality of a product.
ee. Conduct a market survey for a project. Collect data on machinery specifications, price, output/hr, power consumption, manpower requirement, wages, raw material requirement, specification, price, competitor's product price, features, dealer commissions, marketing mix.
ff. Prepare a business plan and organize a business plan competition.
gg. Select a social cause, set objectives, plan and work for its accomplishment.
hh. Videograph as many as possible from the above and upload on your website, YouTube, facebook.

10. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs/UOs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

e. Use Flash/Animations to explain various maintenances techniquies.
f. Guide student(s) in undertaking micro-projects.
g. Instructors should emphasise more on deductive learning. Students should learn to recognise, create, shape opportunities, and lead teams for providing economic-social value to society.
h. Business simulations should be used to enhance behavioural traits of successful intrapreneurs and entrepreneurs amongst students. Emphasis should be on creating entrepreneurial society rather than only setting up of enterprise.
i. They must be encouraged to surf on net and collect as much information as possible.
j. Each student should complete minimum twenty activities from the suggested list. Minimum possible guidance should be given for the suggested activities.
k. Students should be promoted to use creative ideas, pool their own resources, finish their presentation, communication and team skills.
l. Alumni should be frequently invited for experience sharing, guiding and rewarding students.
m. Display must be arranged for models, collages, business plans and other contributions so that they motivate others.

11. SUGGESTED MICRO-PROJECTS

One Business Plan as a micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he should submit it by the end of the semester to develop the industry oriented COs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation in the middle of the semester and one at the end of the semester before submission of the project proposal incorporating the concepts taught during semester. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

a. Choose any advertisement and analyse its good and bad points.
b. Decide any product and analyse its good and bad features.
c. Select any product and prepare its cost sheet.
d. Choose any product and study its supply chain.
e. Arrange brainstorming sessions for improvement of any product.
f. Study schemes for entrepreneurship promotion of any bank.
g. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
h. Open a savings account and build your own capital.
i. Organise industrial visit and suggest modifications for process improvement.

12. SUGGESTED LEARNING RESOURCES

S. No.	Title of Books	Author	Publication
1	The Entrepreneurial Instinct : How Everyone Has the Innate Ability to Start a Successful Small Business	Mehta, Monica	McGraw-Hill Education, New Delhi, 2012, ISBN 978-0-07-179742-9
2	Entrepreneurship	Hisrich, R. D.	McGraw-Hill Education, New Delhi, 2013 ISBN-13: 978-1259001635
3	Part I Readings in Entrepreneurship Education	Sareen, S.B.	Entrepreneurship Development Institute of India (EDI), GOI,

S. No.	Title of Books	Author	Publication
			Ahmedabad, 2016; ISBN: 978-0078029196 ..
4	Reading Material of Entrepreneurship Awareness Camp	Gujral, Raman	Entrepreneurship Development Institute of India (EDI), GOI, 2016 Ahmedabad,
5	Product Design and Manufacturing	Chitale, A K	PHI Learning, New Delhi, 2014; ISBN: 9788120348738
6	Entrepreneurship Development Small Business Entrepreneurship	Charantimath, Poornima	Pearson Education India, New Delhi; ISBN: 9788131762264
7	Entrepreneurship Development: Special edition for MSBTE	CPSC, Manila	Tata Mc-Graw Hill, New Delhi,
8	Entrepreneurship and Small Business Management	Khanka, S.S.	S.Chand and Sons, New Delhi, ISBN: 978-93-5161-094-6
9	Entrepreneurship Development	S, Anil Kumar	New Age International, New Delhi, ISBN: 9788122414349

13. SUGGESTED SOFTWARE/LEARNING WEBSITES

1	MCED Books links	http://www.mced.nic.in/UdyojakSpecial.aspx?linktype=Udyojak
2	MCED Product and Plan Details	http://www.mced.nic.in/allproduct.aspx
3	The National Institute for Entrepreneurship and Small Business Development Publications	http://niesbud.nic.in/Publication.html
4	Courses : The National Institute for Entrepreneurship and Small Business Development	http://niesbud.nic.in/docs/1standardized.pdf
5	Entrepreneur.com	https://www.entrepreneur.com/lists
6	GOVT. SPONSORED SCHEMES	https://www.nabard.org/content1.aspx?id=23andcatid=23andmid=530
7	NABARD - Information Centre	https://www.nabard.org/Tenders.aspx?cid=501andid=24
8	NABARD – What we Do	http://www.nabard.org/content1.aspx?id=8andcatid=8andmid=488
9	Market Review	http://www.businesstoday.in/markets
10	Start Up India	http://www.startupindia.gov.in/pdffile.php?title=Startup%20India%20Action%20Planandtype=Actionandq=Action%20Plan.pdfandcontent_type=Actionandsubmenupoint=action
11	About - Entrepreneurship Development Institute of India (EDII)	http://www.ediindia.org/institute.html
12	EDII - Centres	http://www.ediindia.org/centres.html
13	EDII - Publications	http://www.ediindia.org/publication.html
14	Business Plans: A Step-by-Step Guide	https://www.entrepreneur.com/article/247574
15	The National Science and Technology Entrepreneurship Development Board (NSTEDB)	http://www.nstedb.com/index.htm

16	NSTEDB - Training	http://www.nstedb.com/training/training.htm
17	Tata Exposures	http://www.tatasocial-in.com/project-exposure
18	Ministry Of Micro, Small And Medium EnterpriseS	http://www.dcmsme.gov.in/schemes/TEQUPDetail.htm
19	List of Business Ideas for Small Scale Industry	https://smallb.sidbi.in/%20/thinking-starting-business/big-list-business-ideas-small-business
20	Thinking of Entrepreneurship	https://smallb.sidbi.in/entrepreneurship-stage/thinking-entrepreneurship
21	List of services for Small Scale Industry	http://www.archive.india.gov.in/business/Industry_services/illustrative.php
22	NSIC Schemes and Services	http://www.nsic.co.in/SCHSERV.ASP

Program Name : **All Branches of Diploma in Engineering and Technology.**

Program Code : **CE/CR/CS/CH/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/ MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC**

Semester : **Sixth**

Course Title : **Capstone Project – Execution & Report Writing**

Course Code : **22060**

1. RATIONALE

This course on 'Capstone Project–Execution and Report Writing' is the continuation of the previous semester course on 'Capstone Project–Planning'. So, in this semester, the students are to implement the detailed Capstone Project Plan, which they have prepared in the preceding semester. Therefore, to successfully complete this Capstone Project by the end of this semester, it is necessary to incorporate the suggestions of the guide/examiners of the preceding semester. Hence, it is of utmost importance for the student to again re-capitulate and comprehend the importance, concept and need of the 'Capstone Projects' which are well explained in the 'Capstone Project–Planning' course in the previous semester.

Often, the jobs in the industry, which the diploma holders will come across when they join it and will be in the form of small or large projects. Such projects are generally an integration of the various types of skills which cut across the three major domains of learning i.e. cognitive, psychomotor and affective domain which must have acquired during their journey from first semester to the last semester. Hence, it is essential that students are also given an opportunity to do large projects which require more time compared to the micro-projects in order to develop and integrate the highly essential industry oriented competencies and associated skills in the students. Therefore, in this semester the 'Capstone Project – Execution and Report Writing' will continue to integrate some more additional competencies along with those in the previous semester and hence build up greater confidence to face such situations in the world of work.

2. COMPETENCY

The course should be taught and implemented with the aim to develop the required course outcomes (COs) so that students will acquire following competency needed by the industry:

- **Implement the Capstone Project Plan to solve the identified problem/task faced by industry/user related to the concerned occupation by integrating the various types of skills acquired during the programme.**

3. COURSE OUTCOMES (COs)

Depending upon the nature of the projects undertaken, the following could be some of the major course outcomes that could be attained, although, in case of some projects few of the following course outcomes may not be applicable.

a) Implement the planned activity individually and/or as team.
b) Select, collect and use required information/knowledge to solve the identified problem.
c) Take appropriate decisions based on collected and analysed information.
d) Ensure quality in product.
e) Incorporate energy and environment conservation principles.
f) Consider the ethical issues related to the project (if there are any).
g) Assess the impact of the project on society (if there is any).
h) Communicate effectively and confidently as a member and leader of team.

i) Prepare project report after performing due plagiarism check using appropriate tools.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. Course details

As the implementation of the Capstone project progresses and which has to be submitted at the end of project work, one of the outputs of this course is a detailed ***Project Report*** that is continuously prepared by the student. There will also be regular progressive assessment by the teacher as per the criteria no 7 on the basis of rubrics mentioned in **Appendix –C** and in the formats as shown in **Appendix-B** and also for the end-of-semester examination.

5.1 Guidelines for Capstone Project–Execution and Report Writing

a) The students would like to revise the 'Capstone Project – Plan' based on the feedback received in the fifth semester examination.

b) This revised 'Capstone Project – Plan' would be again approved by the project guide. As soon as the revised plan is approved by the teacher, the student will begin to work according to it and would also continue to maintain a dated ***'Project Diary'*** for the whole semester. This is a sort of a 'weekly diary' indicating all the activities conducted by the student every week in the semester to complete the project. This 'Project Diary' should be got signed by the teacher at regular intervals for progressive assessment. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the ***Final Project Report*** at the end of the semester by him/her.

6. Project report

During the final Semester, the student will prepare a 'Project Report' in continuation with the activities conducted in fifth semester under Project Planning having following sub-titles:

Suggested contents of the Project report

- Title page (with name of team members and mentor teacher)
- Certificate (in the Format given in this document as annexure A)
- Acknowledgements (this may need revision at the end of the final semester)
- Abstract (in one paragraph not more than 150 words)
- Content Page

<u>Chapters</u>

1. Chapter–1 Introduction (background of the Industry or User based Problem/Task)
2. Chapter–2 Literature Survey (to finalise and define the Problem Statement)
3. Chapter–3 Scope of the project
4. Chapter–4 Methodology
5. Chapter-5 Details of designs, working and processes

6. Chapter-6 Results and Applications
7. Chapter-7 Conclusions And future scope
8. Appendix (if any)
9. References and Bibliography

Note:

i. The report should contain as many diagrams, figures and charts etc as relevant for the project.

ii. Originality of the report (written in own words) would be given more importance rather than quality of printing and use of glossy paper or multi-colour printing

7. ASSESSMENT OF PROJECT WORK

Project work has two components, first is Progressive Assessment (PA), while another is End Semester Examination (ESE).

7. 1. Progressive Assessment (PA) Guidelines and Criteria

Project guide is supposed to carry out this assessment. It is a continuous process, during which for developing desired qualities in the students, faculty should orally give **informal feedback** to students about their performance and interpersonal behaviour while guiding them on their project work every week. Following criteria should be considered while assessing students informally or formally during different stages of the project work.

The following factors need consideration for both Capstone Project-Planning and Capstone Project-Execution and Report Writing.

a) Students should be assessed during the project work so that students can also get feedback for further improvement.

b) It should be kept in mind that project work is mainly experiential learning and it is not the research work, so emphasis should be on work based learning or learning from experience and development of attitudes and skills as mentioned in course outcomes. So focus of assessment should also be on learning from the process of completing project work rather than on novelty or innovation in the project work.

c) For progressive assessment at the end, students should be asked to give the power point presentation before group of teachers and junior students (so that junior students may also get awareness about the major project work they have to carry out in future)

d) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks if they have done enough efforts.)

e) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking some help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).

f) Originality of the report (written in own words) would be given more importance.

g) The Project Guide will assure the quality of project done by his group.

Criteria of Marks for PA for Capstone Project -Execution and Report Writing.

S. No.	Criteria	Marks
1	**Project Proposal /Identification**	10
2	**Punctuality and overall contribution**	
3	**Project Diary**	
4	**Execution of Plan during sixth semester**	20
5	**Project Report including documentation**	15
6	**Presentation**	05
	Total	**50**

7.2 END SEMESTER EXAMINATION (ESE)

Evaluation shall be carried out according to following criteria. For each project, students from the concerned group should be asked to make presentation of their project , in front of the external and internal examiners which should be followed by question answer session to ascertain the contribution made by each student.

Criteria of Marks for ESE for Capstone Project -Execution and Report Writing

S. No.	Criteria	Marks
1	Project Proposal	05
2	Punctuality and overall contribution	
3	Project diary	
4	Execution of Plan during sixth semester	10
5	Project Report including documentation	10
6	Presentation	10
7	Question and Answer	15
	Total	**50**

8. SPECIAL TEACHING STRETAGIES (If any)

a) Teacher's should not spoon feed the students and let them try on their own at different stages of the project work and even first let them strive hard and only when efforts of students have failed, then teacher should guide them. Guidance should be in initially in the form of clues or hints rather than complete explanation, detailed explanation should be given only when students are not able to work based on clues/hints. The role of teacher should be limited to guide and facilitator

b) Teachers should help students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) ***Teachers should come out of the mindset that there should be compulsorily some innovation and novelty in the project work. Because as discussed earlier, project is mainly opportunity for work based or experiential learning, the aim of which is to develop higher order cognitive skills and attitudes. Project at diploma level is not research or innovation.*** The main thing teachers have to ensure is that students choose a task or problem for their project work which is challenging but according to their capability i.e. a task which they can complete on their own without getting it done from market.

d) Teachers should ensure that students prepare the project plan in as much detail as possible, since this way only they would learn the importance of planning and how to do the detail planning. Teachers should allow students to proceed ahead only when they have detailed plan with them.

e) Teachers should motivate students to maintain project document project diary and project report. They should explain benefits of these activities to students and also train them in these activities, because most of them may be doing this first time.

f) Project Guide should ensure that students submit chapter of report one by one to him/her as per schedule and should check the content of the chapters. The Project guide should monitor that schedule is maintained and report writing is not left till last few weeks. It should not be a problem since first three chapters of the report should have been written in fifth semester itself.

g) Teachers should also encourage students to openly discuss their weaknesses and shortcomings .Teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them.

h) Teachers should continuously discuss with students about working of group and progress in the project and from this discussion should identify their personal qualities (both strengths and weaknesses) and suggest to them ways for improving those qualities.

i) Internal as well as external examiners should reward students for original work and efforts of students even if they are not fully successful or not able to complete the project in comparison to those students who have taken paid help from others to complete their project.

Appendix–A

CERTIFICATE

This is to certify that Mr./Ms...

from ....Institute having Enrolment No: ....

has completed project of final year having title ....,.... during the academic year20__-20__. The project completed by individually/ in a group consisting of...................... persons under the guidance of the Faculty Guide.

....

....

Name & Signature of Guide: ....

Telephone:...

Appendix–B

PROGRESSIVE ASSESSMENT (PA) OF CAPSTONE PROJECT – EXECUTION AND REPORT WRITING

Evaluation Sheet for Internal Assessment

Name of Student: ....

Name of Programme... **Semester: Sixth**

Course Title: Capstone Project : Execution and Report Writing **Code:22060.**

Title of the Capstone Project: ....

....

A. **POs addressed by the Capstone Project** (Mention only those predominant POs)

a) ....

b) ....

c) ....

d) ....

B. **COs addressed by the Capstone Project** (Mention only those predominant POs)

a) ....

b) ....

c) ....

d) ....

C. **OTHER LEARNING OUTCOMES ACHIEVED THROUGH THIS PROJECT**

1. **Unit Outcomes (Cognitive Domain)**

a) ....

b) ....

c) ....

d) ....

2. **Practical Outcomes (in Psychomotor Domain)**

a) ....

b) ....

c) ....

d) ....

3. **Affective Domain Outcomes**

a) ....

b) ....

c) ....

d) ....

PROGRESSIVE ASSESSMENT (PA) Sheet		
S. No.	**Criteria**	**Marks**
1	Project Proposal /Identification	10
2	Punctuality and overall contribution	
3	Project Diary	
4	Execution of Plan during sixth semester	20
5	Project Report including documentation	15
6	Presentation	05
	Total	**50**

Appendix–B

Suggested Rubric for Capstone Project – Execution and Report Writing

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent
1	**Problem/Task Identification (Project Title)**	Relate to very few POs Scope of Problem not clear at all	i. Related to some POs ii. Scope of Problem/Task vague	i. Take care of at-least Three POs ii. Scope of Problem/task not very specific	• Take care of more than three POs ii. Scope of problem/task very clear
2	**Literature Survey /Industrial Survey**	Not more than ten sources (primary and secondary), very old reference	At-least 10 relevant sources, at least 5 latest	At –least 15 relevant sources, most latest	About 20 relevant sources, most latest
3	**Project proposal**	Methods are not appropriate, All steps not mentioned, Design of prototype not started (if applicable).	Appropriate plan but not in much detail. Plan B for critical activities not mentioned. Time line is not developed. Design of Prototype is not complete. (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, but clarity is not there in methods, time line is given but not appropriate. Design of prototype is not detailed (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, clarity in methods with time line, Detailed design of prototype (if applicable)
4	**Project Diary**	Entries for most weeks are missing. There is no proper sequence and details are not correct.	Entries for some weeks are missing, details are not appropriate, not signed regularly by the guide.	Entries were made every week but are not in detail. Signed and approved by guide every week	Entries were made every week in detail, signed and approved by guide every week
5	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions	Detailed, correct and clear description of methods, materials, precautions and	Conclusions. Sufficient Graphic Description.	Very detailed, correct, clear description of methods, materials, precautions and conclusions. Enough tables,

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent
		omitted, some details are wrong			charts and sketches
6	**Presentation**	Major information is not included, information is not well organized .	Includes major information but not well organized and not presented well	Includes major information and well organized but not presented well	Well organized, includes major information ,well presented
7	**Defense**	Could not reply to considerable number of question.	Replied to considerable number of questions but not very properly	Replied properly to considerable number of question.	Replied to most of the questions properly

Appendix C
Suggestive Project Diary format

Week no:
Activities planned:
Activities Executed:
Reason for delay if any
Corrective measures adopted
Remark and Signature of the Guide