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.

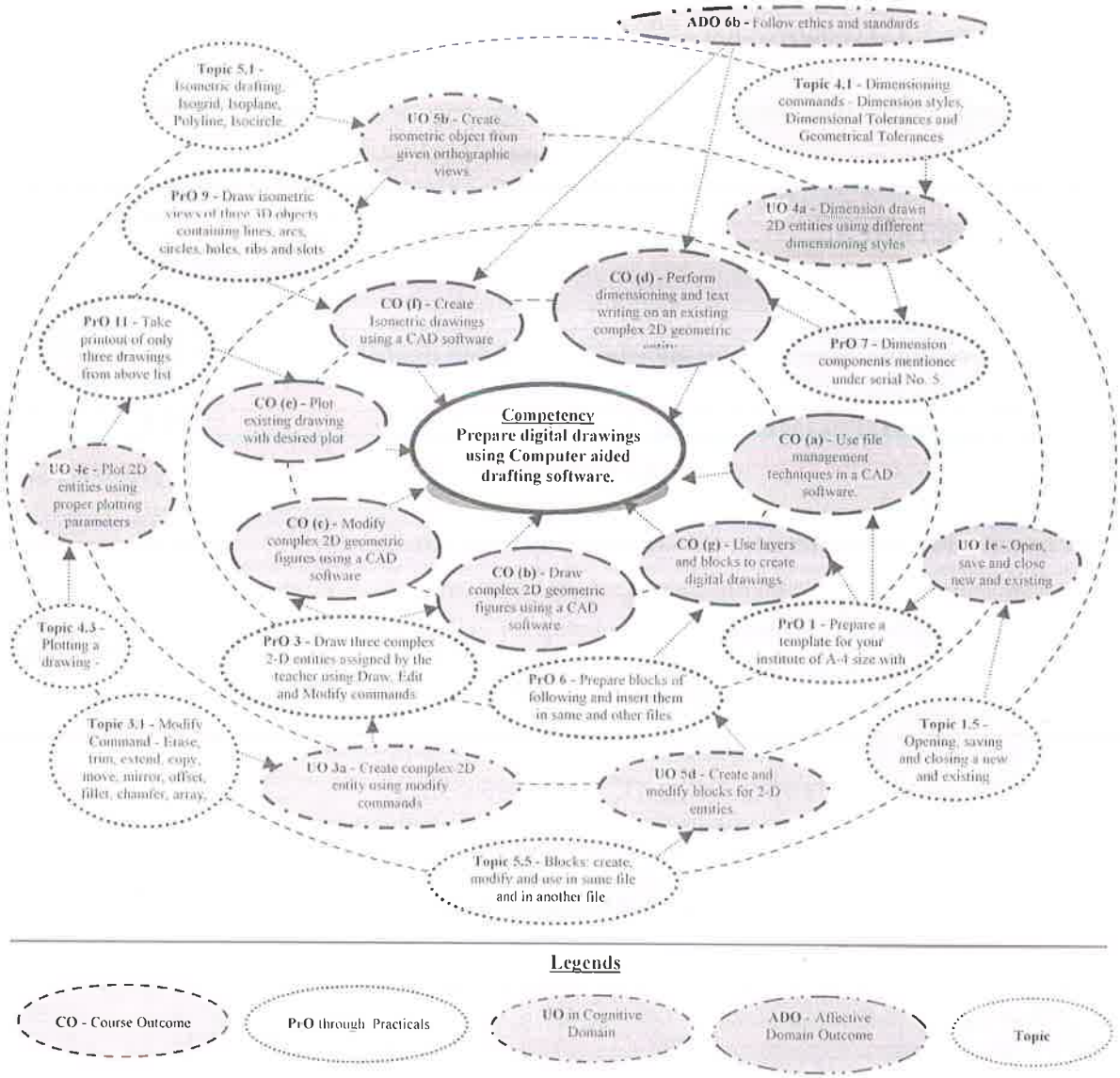

Figure 1 - Course Map

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		

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.

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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.

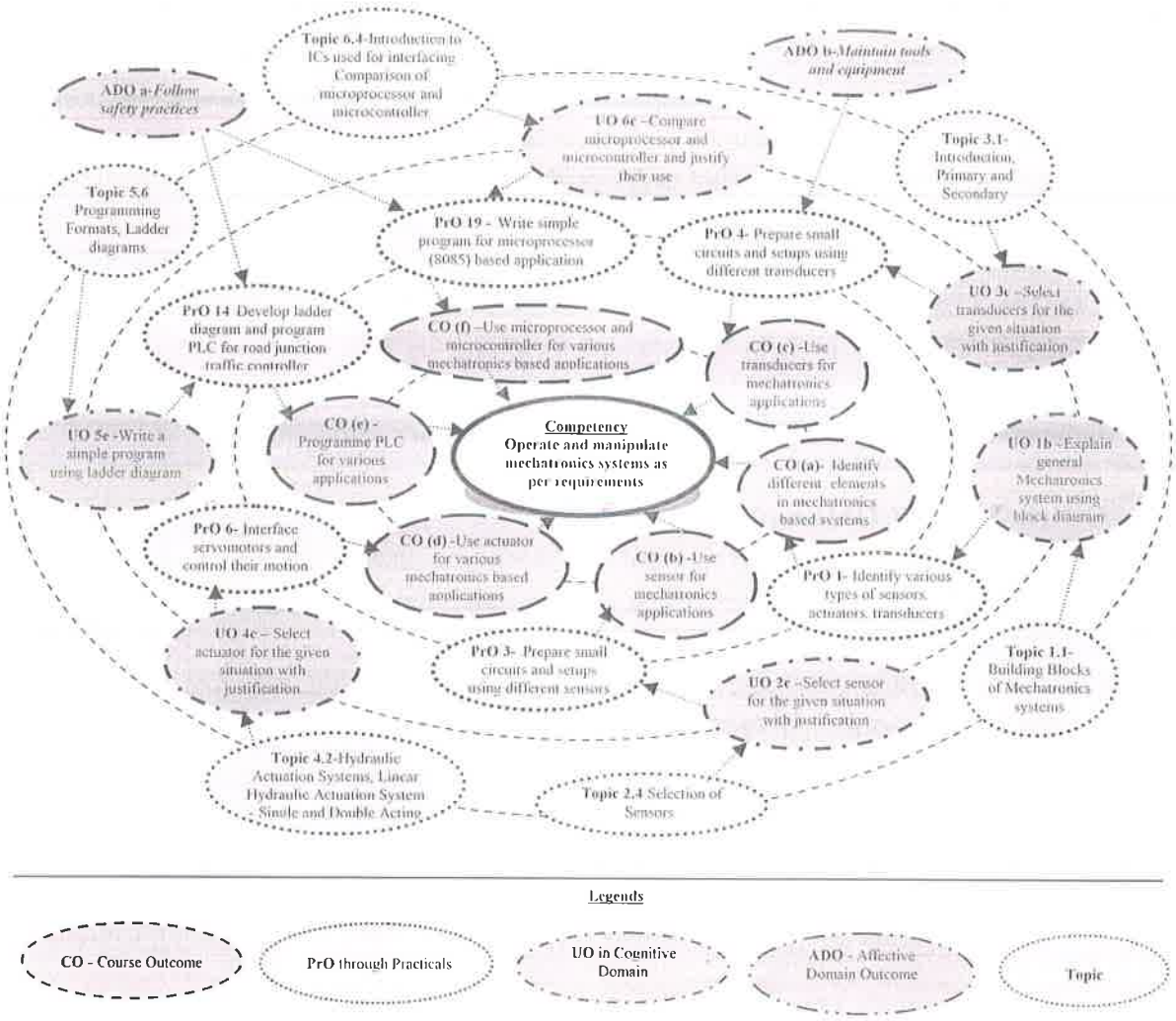

Figure 1 - Course Map

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	
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.

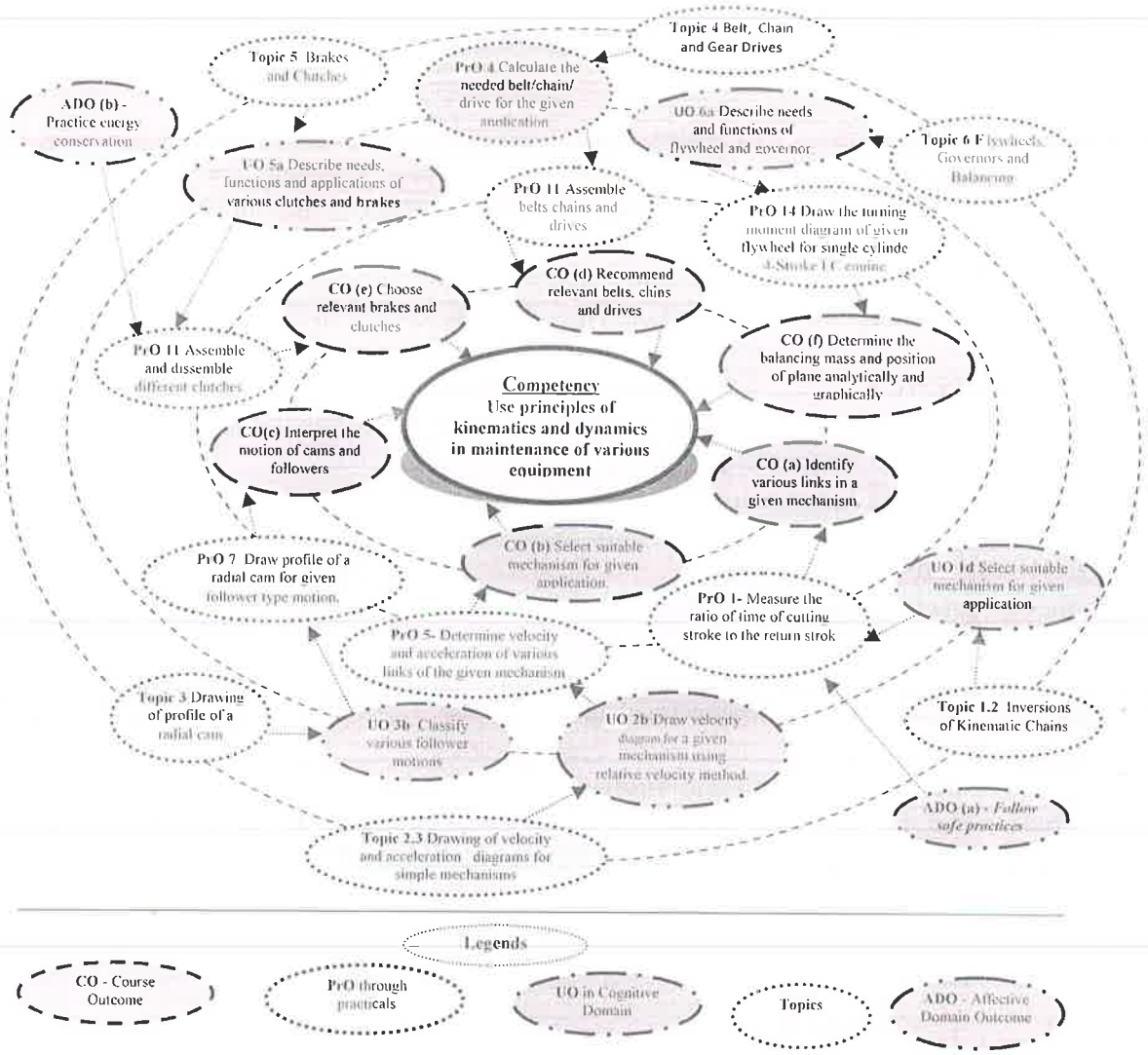

Figure 1 - Course Map

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					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			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.

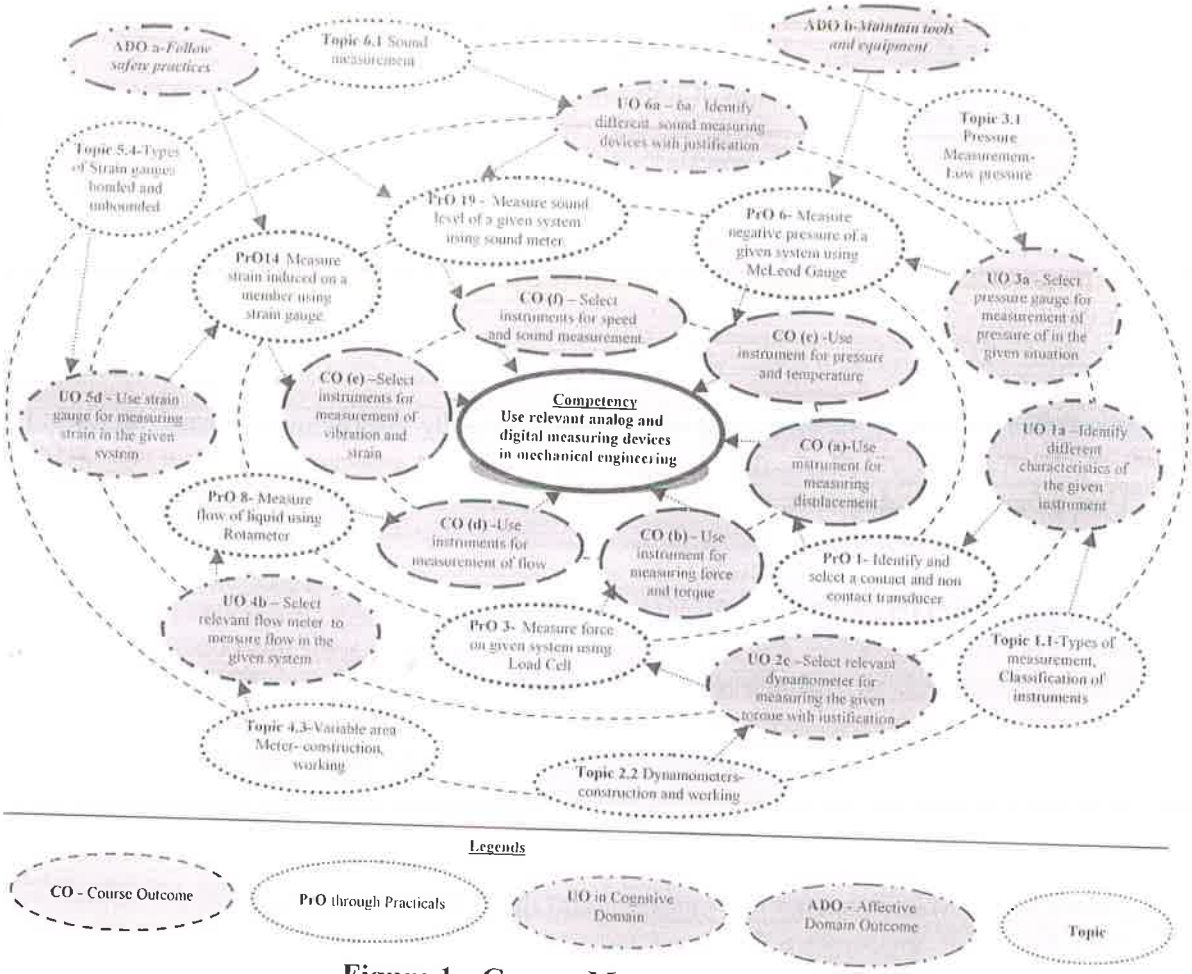

Figure 1 - Course Map

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,Scaled 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

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=qNIIZYAk9pI
e. https://www.youtube.com/watch?v=xcvNl1HHY9o
f. https://www.youtube.com/watch?v=DxdFilDrFBc
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				
				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	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.

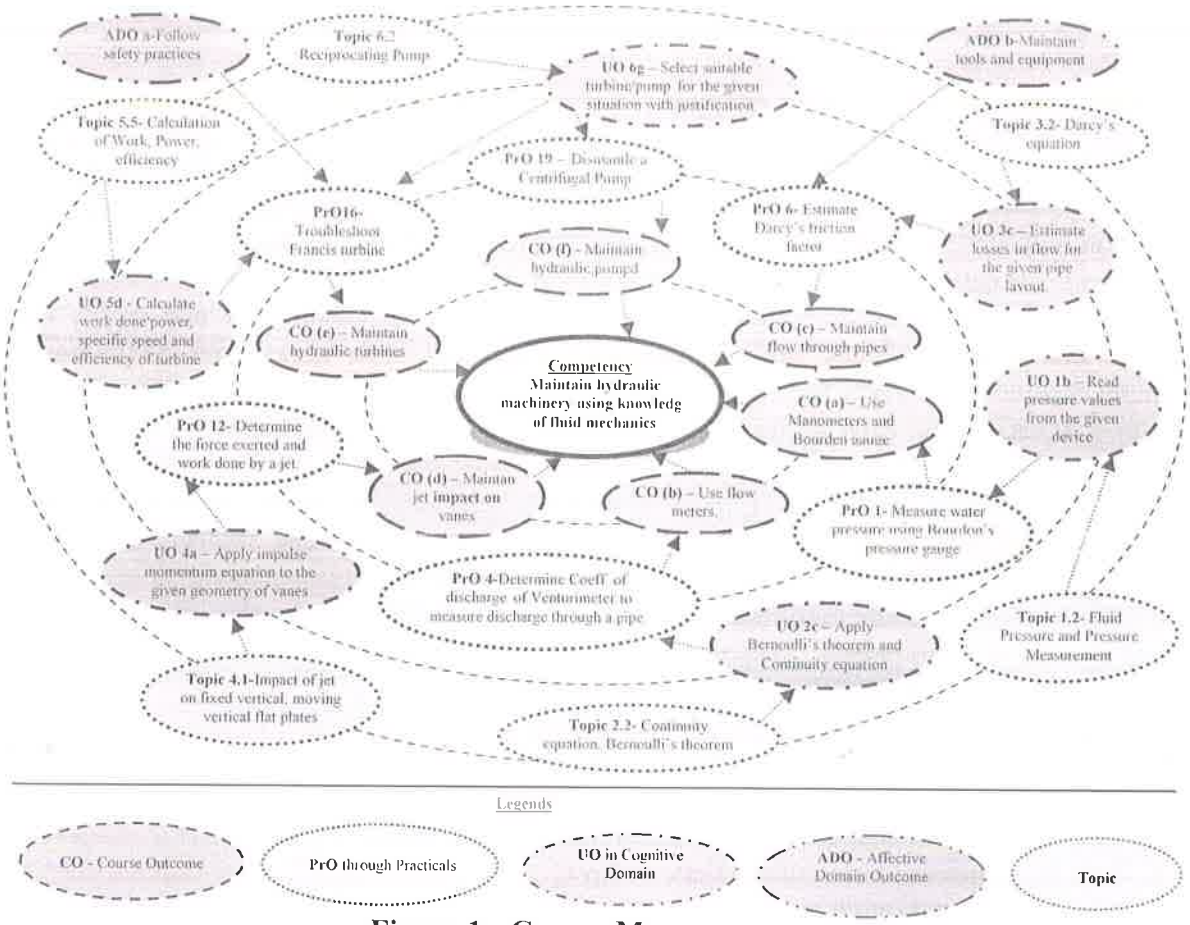

Figure 1 - Course Map

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.

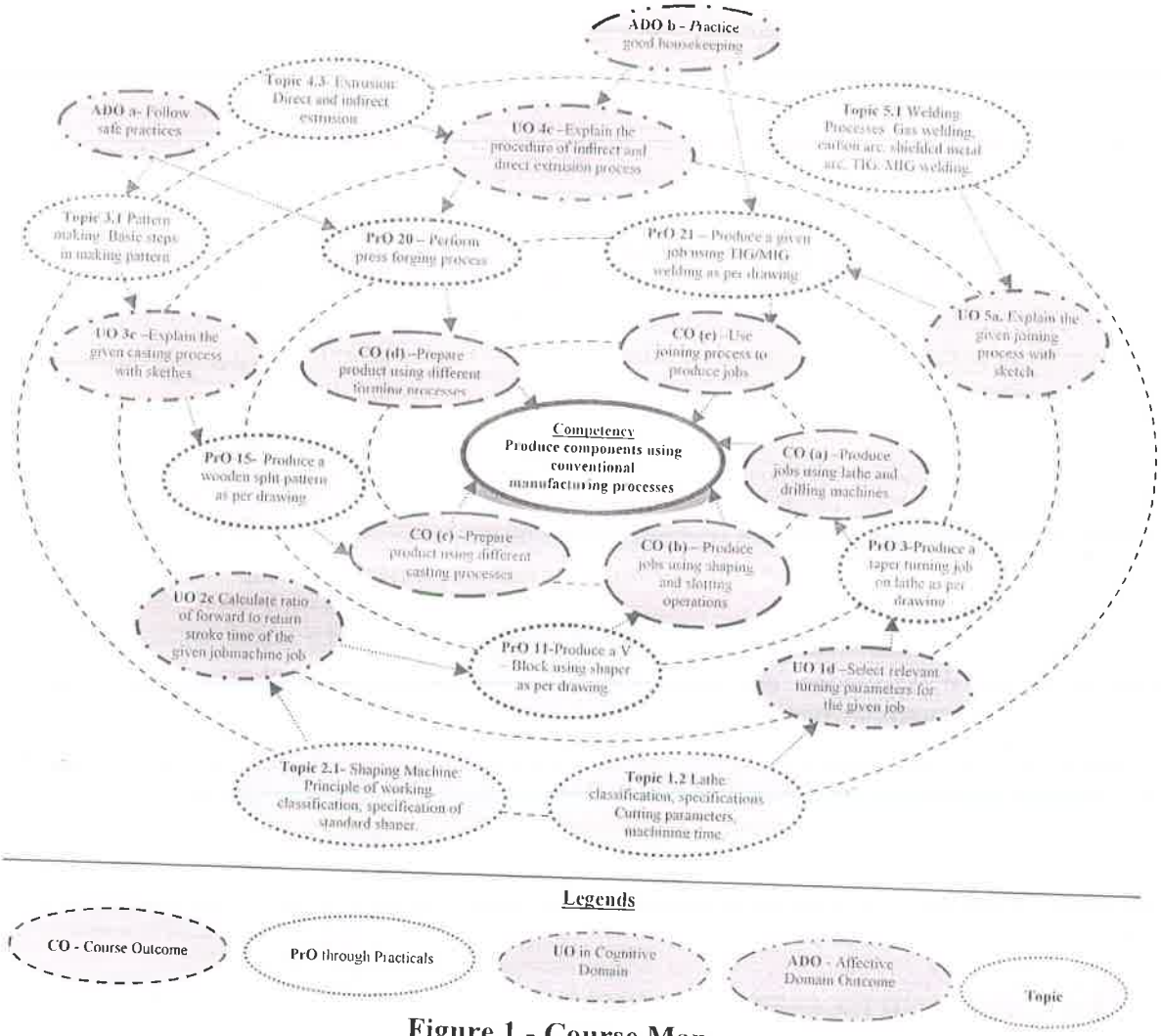

Figure 1 - Course Map

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.

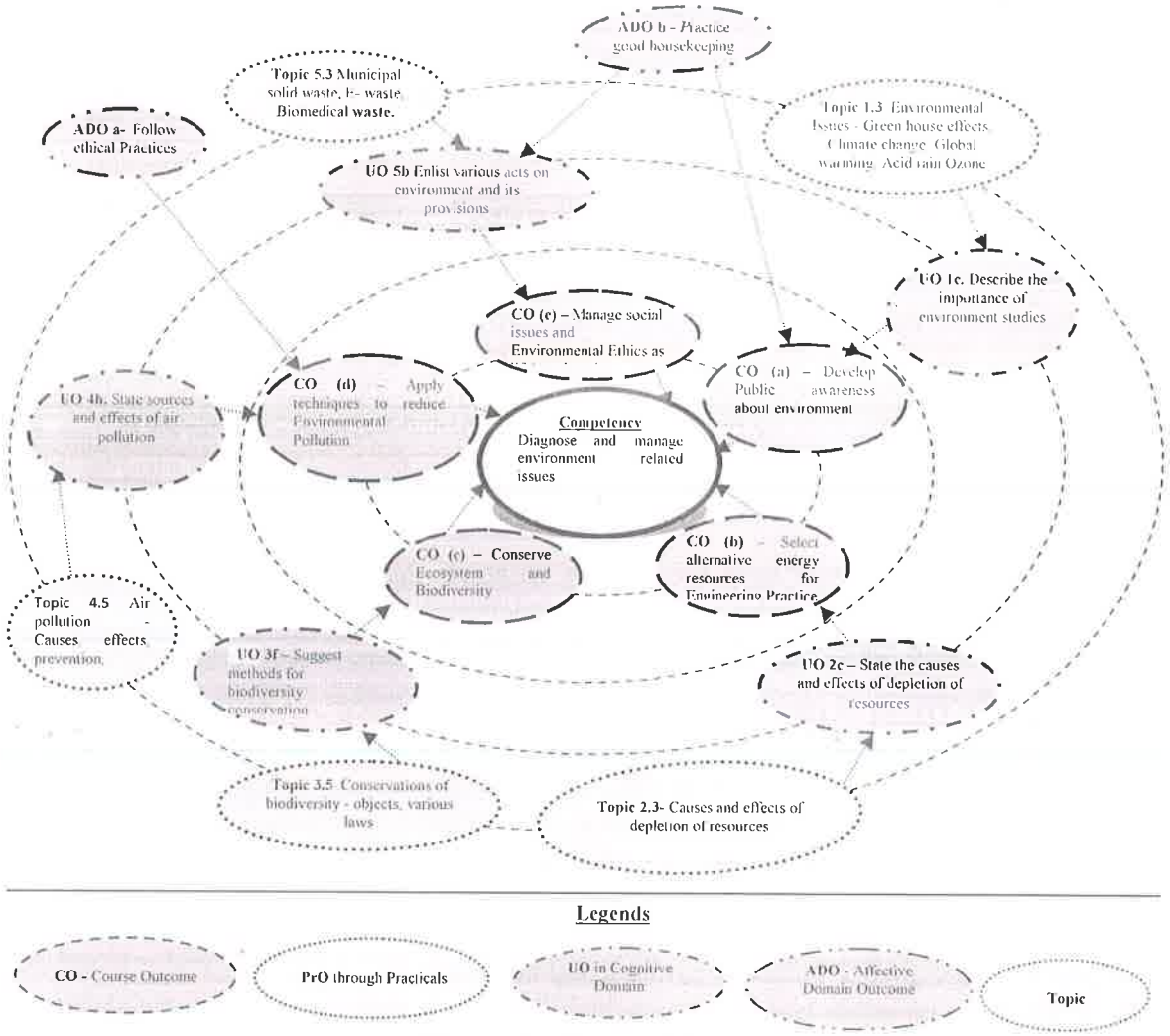

Figure 1 - Course Map

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