Maharashtra State Board of Technical Education, Mumbai

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

Program Name : Diploma in Mechnical Engineering

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

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

Semester : Fifth **Scheme - I**

S. N.	Course Title	Course Abbrev iation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
								Theory						Practical						
				L	T	P		Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total	
									Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Management	MAN	22509	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	Power Engineering and Refrigeration	PER	22562	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
3	Advanced Manufacturing Processes	AMP	22563	4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
4	Elements of Machine Design	EMD	22564	4	-	2	6	4	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Elective (Any One)																				
5	Tool Engineering	TEIN	22565	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Power Plant Engineering	PPE	22566	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Industrial Training	ITR	22049	-	-	6	6	--	--	--	--	--	--	--	75#	30	75~	30	150	60	150
7	Capstone Project Planning	CPP	22050	-	-	2	2	--	--	--	--	--	--	--	25@	10	25~	10	50	20	50
8	Solid Modeling and Additive Manufacturing	SMA	22053	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
			Total	**17**	**-**	**22**	**39**	--	**350**	--	**150**	--	**500**	--	**275**	--	**275**	--	**550**	--	**1050**

Student Contact Hours Per Week: **39 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **1050**

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

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

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

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

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**
- **Evalution of Industrial Training and its reports is to done during this semester. Credit of Industrial Training will not affect the framing of time table.**

MSBTE – Final Copy Dt. 29.03.2019

Program Name : **Diploma in Mechanical Engineering / Electrical Engineering Group / Chemical Engineering / Plastic Engineering**

Program Code : **ME / EE / EP / EU / CH / PS**

Semester : **Fifth**

Course Title : **Management**

Course Code : **22509**

1. RATIONALE

An engineer has to work in industry with human capital and machines. Therefore, managerial skills are essential for enhancing their employability and career growth. This course is therefore designed to provide the basic concepts in management principles, safety aspects and Industrial Acts.

2. COMPETENCY

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

- **Use relevant managerial skills for ensuring efficient and effective management.**

3. COURSE OUTCOMES (COs)

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

a. Use basic management principles to execute daily activities.
b. Use principles of planning and organising for accomplishment of tasks.
c. Use principles of directing and controlling for implementing the plans.
d. Apply principles of safety management in all activities.
e. Understand various provisions of industrial acts.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(*#) Online Theory Examination.

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

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

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

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

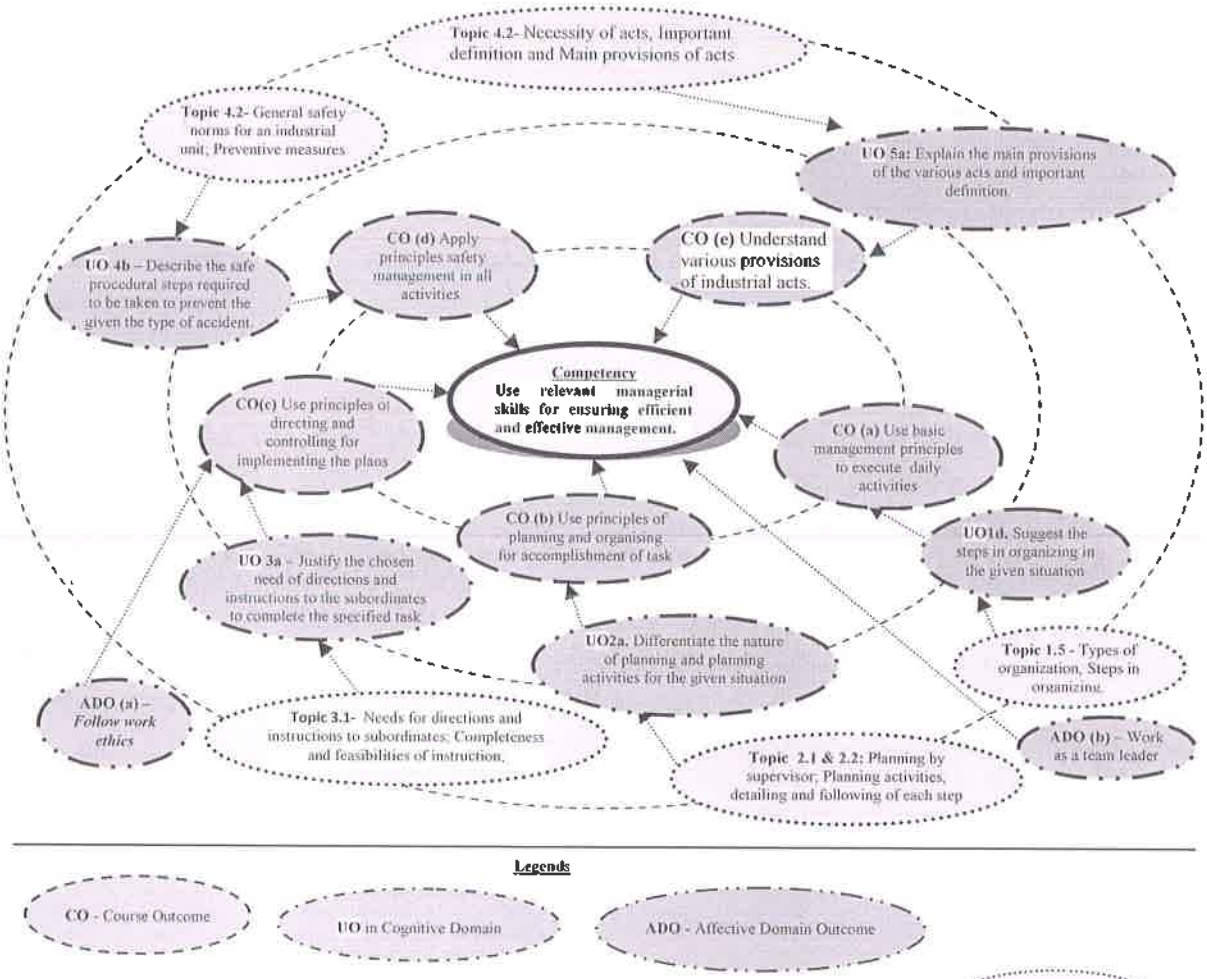


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

- Not applicable -

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

- Not applicable -

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to management concepts and managerial skills	1a. Differentiate the concept and principles of management for the given situation. 1b. Explain functions of management for given situation. 1c. Compare the features of the given types of planning 1d. Suggest the steps in organizing in the given situation. 1e. Suggest suitable type of organization for the given example. 1f. Identify the functional areas of management for the given situation 1g. Suggest suitable managerial skills for given situation with justification	1.1 Definitions of management, role and importance of management. 1.2 Management characteristics and principles, levels of management and their functions; management, administration and organization, relation between management and administration. 1.3 Functions of management: planning, organizing, leading/directing, staffing and controlling. 1.4 Types of planning and steps in planning 1.5 Types of organization, Steps in organizing 1.6 Functional areas of management. 1.7 Managerial skills.
Unit – II Planning and organizing and at supervisory level	2a. Differentiate the nature of planning and planning activities for the given situation. 2b. Suggest the step wise procedure to complete the given activity in the shop floor. 2c. Prepare materials and manpower budget for the given production activity. 2d. Describe with block diagrams the organization of the physical resources required for the given situation. 2e. Describe the human needs to satisfy the job needs for the specified situation. 2f. List the tasks to be done by the concerned individuals for completing the given activity.	**Planning at supervisory level** 2.1 Planning by supervisor. 2.2 Planning activities, detailing and following of each step. 2.3 Prescribing standard forms for various activities. 2.4 Budgeting for materials and manpower. **Organizing at supervisory level** 2.5 Organizing the physical resources. 2.6 Matching human need with job needs. 2.7 Allotment of tasks to individuals and establishing relationship among persons working in a group
Unit– III Directing and Controlling at supervisory level	3a. Justify the chosen need of directions and instructions to the subordinates to complete the specified task. 3b. Select the feasible set of instructions to complete the given simple task, with justification 3c. Predict the possible mistakes for completing the given simple activity. 3d. Describe the managerial control	**Directing at supervisory level** 3.1 Needs for directions and instructions to subordinates; Completeness and feasibilities of instructions 3.2 Personal counselling advanced predictions of possible mistakes. 3.3 Elaborating decisions, laying disciplinary standards in overall working **Controlling at supervisory level**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	actions and remedial measures required to be taken for completing the given task successfully.	3.4 Managerial control; Understanding team and link between various departments in respect of process and quality standards; Steps in control process 3.5 Controlling methods; Control over the performance in respect of quality, quantity of production, time and cost. Measuring performance, comparing with standards, correcting unfavorable deviations.
Unit – IV Safety Management	4a. State the general safety norms required to be taken in the given case. 4b. Suggest preventive measures of plant activities in the given situation. 4c. Describe the safe procedural steps required to be taken to prevent the given the type of accident. 4d. Prepare a work permit in to conduct the given maintenance activity. 4e. Explain the causes of the specified type of accident in the given situation. 4f. Prepare the specifications of the firefighting equipment required for the given type of fire.	4.1 Need for safety management measures 4.2 General safety norms for an industrial unit; Preventive measures. 4.3 Definition of accident, types of industrial accident; Causes of accidents; 4.4 Fire hazards; Fire drill. 4.5 Safety procedure 4.6 Work permits.
Unit – V Legislative Acts	5a. Explain the purpose of the act 5b. Explain the main provisions of the various acts and important definition.	5.1 Necessity of acts, Important definition and Main provisions of acts. 5.2 Industrial Acts: a. Indian Factory Act b. Industrial Dispute Act c. Workman Compensation Act d. Minimum Wages Act

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to management	12	06	06	04	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	concepts and managerial skills					
II	Planning and organizing and at supervisory level	08	04	06	04	14
III	Directing and controlling at supervisory level	08	04	06	04	14
IV	Safety Management	08	04	06	04	14
V	Legislative Acts	12	02	06	04	12
Total		**48**	**20**	**30**	**20**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Write assignments based on the theory taught in classrooms. Assignments consist of ten questions having long answers including charts, symbols, drawing, observations etc.
b. Prepare/Download information about various industrial acts.
c. Visit to any Manufacturing industry and prepare a report consisting of:
    i. Organization structure of the organization/ Dept.
    ii. Safety measures taken in organization.
    iii. Mechanism to handle the disputes.
    iv. Any specific observation you have noticed.
d. Give seminar on relevant topic.
e. Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Study of management principles applied to a small scale industry.
b. Study of management principles applied to a medium scale industry.
c. Study of management principles applied to a large scale industry.
d. Prepare case studies of Safety measures followed in different types of organization.
e. Study of measures to be taken for ensuring cyber security.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Management and entrepreneurship	Veerabhadrappa, Havinal	New age international publishers, New Delhi, 2014: ISBN: 978-81-224-2602-1
2	Principles of management	Chaudhry omvir Singh prakash	New Age international publishers, 2012, New Delhi ISBN: 978-81-224-3039-4
3	Industrial Engineering and management	Dr. O. P. Khanna	Dhanpath ray and sons, New Delhi
4	Industrial Engineering and management	Banga and Sharma	Khanna Publication, New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.versesolutions.com/
b. https://www.books.google.co.in/books?isbn=817758412X
c. https://www. www.educba.com › Courses › Business › Management

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Power Engineering and Refrigeration**

Course Code : **22562**

1. RATIONALE

Power producing and absorbing devices are essentials for mechanical engineering. It is necessary for mechanical engineering technologists to analyze working and plot the performance of devices like internal combustion engines, air compressors, gas turbines so that he will be able to operate them effectively in an industrial situation. This knowledge is also useful in selecting suitable prime mover for given application and to maintain and test the same. This course also gives basic exposure of refrigeration and air-conditioning equipment which play a vital role in maintaining controlled atmosphere in different domestic and industrial applications. A separate elective course on Refrigeration and Air-conditioning is also available in sixth semester for in-depth knowledge of the course.

2. COMPETENCY

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

- **Maintain power engineering and refrigeration devices.**

3. COURSE OUTCOMES (COs)

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

a. Identify different components of I C engines and its auxiliaries.
b. Test the performance of I C Engine.
c. Maintain reciprocating air compressors.
d. Identify different components of gas turbines and jet engines.
e. Test the performance of refrigeration and air-conditioning systems.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

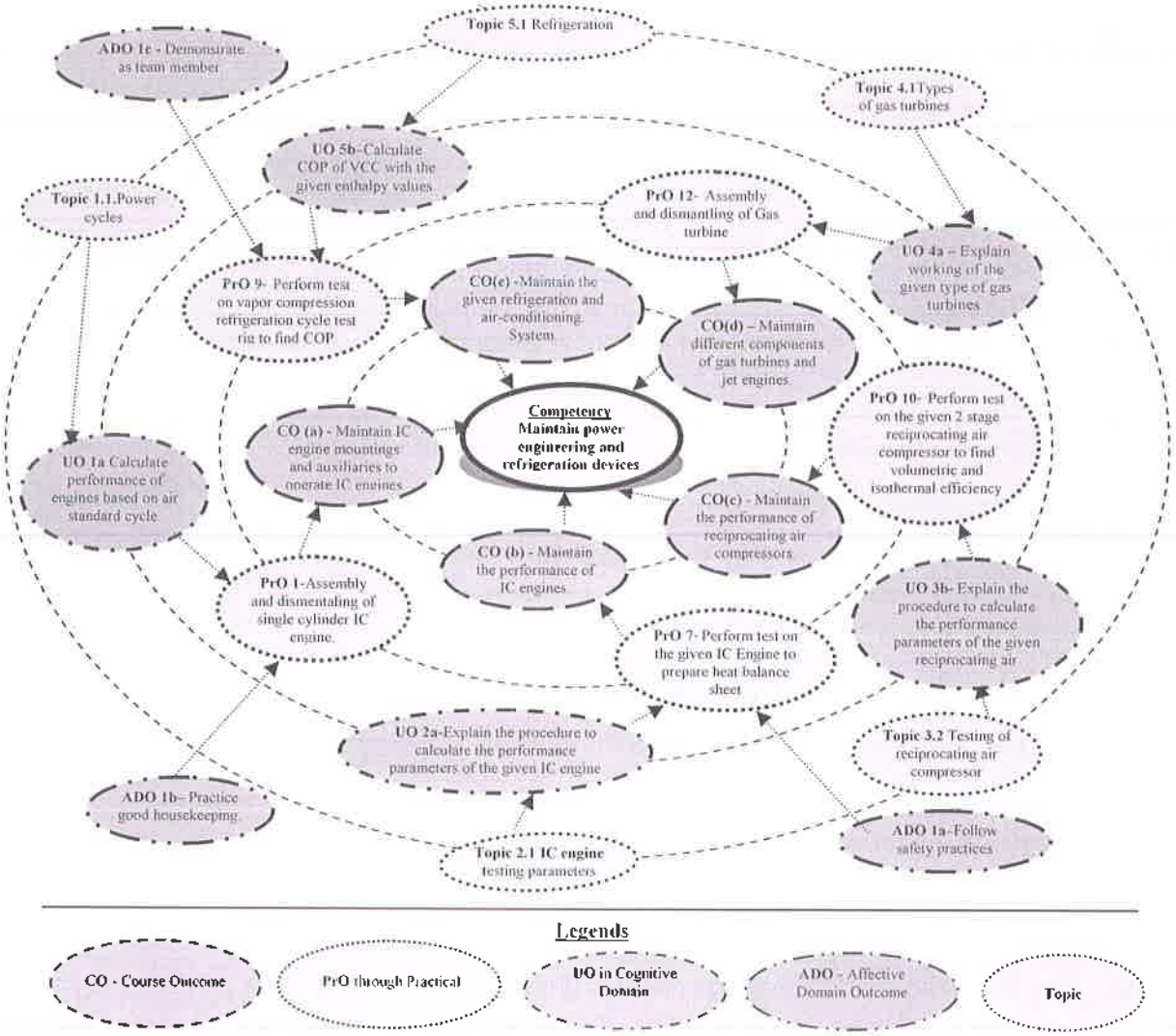


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Assemble/Dismantle single cylinder IC Engine. (Part-I)	I	02*
2	Assemble/Dismantle single cylinder IC Engine. (Part-II)	I	02*
3	Assemble/Dismantle multi cylinder IC Engine. (Part-I)	I	02
4	Assemble/Dismantle multi cylinder IC Engine. (Part-II)	I	02
5	Assemble/Dismantle inline/rotary fuel injection pump in a diesel engine.	I	02
6	Perform test on the given IC Engine to prepare heat balance sheet and plot performance characteristics. (Part-I)	II	02*
7	Perform test on the given IC Engine to prepare heat balance sheet and plot performance characteristics. (Part-II)	II	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Perform Morse Test on the given IC Engine to perform Morse Test.	II	02
9	Use exhaust gas analyzer to measurement and analyze pollutants in the given IC engine.	II	02
10	Perform diagnosis test on given IC engine using Engine Control Unit	II	02*
11	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-I)	III	02*
12	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-II)	III	02*
13	Assemble/Dismantle of Gas turbine model.	IV	02
14	Perform test on vapor compression refrigeration cycle test rig to find COP (Part-I)	V	02*
15	Trace the refrigerant flow of domestic refrigerator and measure temperatures at critical points for different settings of thermostat.	V	02
16	Assemble/Dismantle various components of domestic refrigerator.	V	02
17	Assemble/Dismantle various components of Water Cooler and Window/Split air conditioning units.	V	02
	Total		**34**

Note

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

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

S. No.	Performance Indicators	Weightage in %
a.	Preparing setup for experimentation	20
b.	Performing the practical and reading different instruments	20
c.	Measuring performance parameters	30
d.	Answer to sample questions	20
e.	Submit report in time	10
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Single cylinder IC engine suitable for assembly / dismantling with necessary tool set. (Engine complying latest Euro Norms)	1,2
2	Multi cylinder IC engine suitable for assembly / dismantling with necessary tool set. (Engine complying latest Euro Norms)	3,4
3	Inline / Rotary fuel pump of a latest version with necessary tool set.	5
4	Test rig on single cylinder IC engine. 3/5/7 HP petrol / diesel engine with required accessories.	6,7
5	Test rig on multi cylinder IC engine. 3/5/7 HP petrol engine with required accessories.	8
6	Exhaust gas analyzer 3/5 gas analyzer.	9
7	Engine Control Unit	10
8	Test rig on two stage reciprocating air compressor. Pressure and temperature gauges at suitable locations with manometer. Minimum ½ HP compressor motor.	11,12
9	Gas turbine and Jet engine models (working model or scrap turbine).	13
10	Charts and videos on construction and working of different components of gas turbines and jet engines.	23
11	Test rig on vapor compression cycle to find different COPs. ¼ to ½ HP compressor, pressure gauges and temperature gauges at suitable locations.	14, 15
12	Domestic refrigerator. Minimum 165 ltrs. Water cooler, Ice plant and Cold storage, Deep freezer (Actual working or scrap units)	16
13	Refrigeration tools required for repair and maintenance process of refrigeration and air-conditioning units	17
14	Window and split air-conditioner units, central air-conditioning unit. (Actual working or scrap units)	18,19
15	AxCYCLE Software: Thermodynamic Simulation Software for heat balance calculations of heat production and energy conversion cycles	All

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Internal Combustion Engines	1a. Calculate performance of given engine(s) based on corresponding air standard cycle. (Only Carnot and Otto Cycles) 1b. Explain with sketches valve timing diagrams for the given engine with sketches. 1c. Explain with sketch the	1.1 **Power cycles:** Engine terminology, working of 4 stroke engines, Carnot cycle, Otto cycle, diesel cycle, dual cycle, actual indicator diagrams for 4 stroke engines. 1.2 **Basic of IC Engines:** Working and comparison of four stroke and two stroke cycle engines and SI and CI

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
	construction and working of the given IC engine auxiliary (Turbo-Charger, Inline fuel injection pump, piezoelectric injectors, EGR, MPFI systems). 1d. Explain maintenance procedure of the given fuel injection pump, MPFI system and EGR and CRDI unit. 1e. Apply BS6 Norms to the given engine(s). 1f. State the procedure to undertake routine maintenance of the given IC engine	engines. 1.3 **IC Engines auxiliaries:** Valve timing diagrams, VVT-I engines – concept and arrangement, supercharging – objectives and advantages, Turbocharging, Variable Geometry Turbochargers, MPFI layout, various Sensors, rotary and inline fuel injection pump, piezoelectric injectors, EGR layout, viscous coupling for fan. 1.4 Common rail direct injection diesel engines (CRDI) controlled by electronic control unit. 1.5 Diagnostic tools used for fault finding of two wheelers. 1.6 List of Methods to reduce pollution in diesel engines as prescribed in BS6
Unit– II Testing of IC Engines and Emission Control	2a. Explain the procedure to calculate the performance parameters of the given IC engine. 2b. Explain the procedure to calculate indicated power of the given engine using Morse test. 2c. Explain procedure to measure emissions of exhaust gases in the given engine. 2d. Explain procedure to perform diagnosis using Engine Control Unit in the given engine. 2e. Explain methods to control exhaust emissions in the given engine.	2.1 **IC engine testing parameters**: IP, BSFC, components of heat balance sheet, thermal and mechanical efficiency, Morse test. 2.2 Combustion in IC engines, Octane Number (RON, MON) & Knock Resistance. 2.3 **Exhaust emissions and control:** Polluting emissions in IC engines, effects on environment, measurement of exhaust emissions, effect of air-fuel ratio on exhaust emissions (with graph), Euro IV and Euro VI norms for M and N1 vehicles, catalytic converter, SCR. 2.4 **Engine Control Unit (ECU):** working and diagnosis procedure.
Unit– III Air Compressors	3a. Explain with sketches working of the given compressor. 3b. Explain the procedure to calculate the performance parameters of the given compressor. 3c. Recommend the type of compressor for the given applications with justification. 3d. State the procedure to undertake routine maintenance of the given type of air compressor.	3.1 **Reciprocating compressors** – applications, working of single stage and two stage compressors with PV diagrams. Intercooling. 3.2 **Testing of reciprocating air compressors:** Pressure ratio, compressor capacity, FAD, volumetric efficiency, isothermal efficiency, numerical. Methods of energy saving. 3.3 **Rotary compressors:** Screw, centrifugal, Lobe type, vane type compressors and Axial flow compressors. Comparison of rotary with reciprocating.

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
Unit-IV Gas Turbines and Jet Propulsion	4a. Explain with sketches working of the given type of gas turbines. 4b. Identify different components of the given engine with justification. 4c. Explain with sketches the working of given rocket propulsion systems. 4d. State the procedure to undertake routine maintenance of the given gas turbine. 4e. State the procedure to undertake routine maintenance of the given propulsion engine.	4.1 **Types of Gas Turbines:** Constant pressure, open cycle and closed cycle gas turbines, Brayton cycle, applications, Aero derivative and heavy frame engines 4.2 **Jet propulsion:** Turbojet, Turboprop, engines. 4.3 **Rocket propulsion:** liquid and solid propellant systems.
Unit –V Refrigeration and Air-conditioning	5a. Sketch Carnot cycle and Vapor compression cycle (VCC) with the given type of PV, TS, PH diagrams. 5b. Calculate COP of Vapor compression cycle (VCC) for the given enthalpy values. 5c. Choose the refrigerant based on properties for given application with justification. 5d. Explain with sketches construction and working of the given components of vapor compression systems. 5e. Select suitable VCC component of the given refrigeration systems using ASHRAE Handbook with justification. 5f. Determine the given property(s) of the given air using psychrometric chart. 5g. Explain with sketches construction and working of the given refrigeration and air conditioner. 5h. State the procedure to undertake routine maintenance of the given type of air compressor.	5.1 **Refrigeration:** Unit of refrigeration, EER, SEER, Carnot cycle, Vapor compression cycle, sub cooling and superheating, components of vapor compression systems, refrigerant properties, concepts of GWP, ODP, TEWI, LCCP. 5.2 **Applications:** Specification, Working and construction of Domestic refrigerator, water cooler, ice plant and cold storage. 5.3 **Air-conditioning**: Definition, classification-comfort air conditioning, industrial air conditioning, applications . 5.4 **Psychrometry:** properties of air, psychrometric processes, psychrometric chart. 5.5 **Applications:** Specification, Working and construction of Window, split air-conditioner, central air-conditioning,

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	IC engines	12	04	08	04	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
II	Testing of IC engines and emission control	12	04	04	08	16
III	Air compressors	08	02	04	08	14
IV	Gas turbines and Jet propulsion	04	02	02	04	08
V	Refrigeration and Air-conditioning	12	04	04	08	16
Total		**48**	**16**	**22**	**32**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a) Prepare a power point presentation on emission norms.
b) Make charts for performance characteristics of IC Engine.
c) Make a chart showing heat balance sheet format to display in laboratory.
d) Collect specifications of gas turbine based engines used for power generation and for jet engines.
e) Collect specifications of domestic refrigerators and window air-conditioners from manufacturer's websites.
f) Collect information on different tests actually used for IC engines.
g) Measure DBT and WBT using thermometer and calculate rest of the properties of air using psychrometric chart.
h) Prepare trouble shooting chart for domestic refrigerator / window air-conditioner
i) Prepare electrical trouble shooting chart for refrigeration system.
j) Prepare trouble shooting chart for IC engine.
k) Prepare seminar report on dual fuel and hybrid engines.
l) Visit an industry where air compressors are monitored online using SACDA or similar system. Write a report on the same.
m) Collect IC Engine fuel characteristics including information on RON and MON.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with power engineering system utility and equipment.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various working of compressor, gas turbine and refrigerant flow in refrigerator and air conditioner.
i) Show different parts of various refrigeration and air conditioning units.
j) Show constructional details of various Gas turbines, Jet Engines, Reciprocation and Rotary Compressors.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a) Display various components of MPFI system on wooden board with labels.
b) Prepare a report on OBD measurements.
c) Take sample of cooling load calculations sheet; list the components of cooling load along with percentage contribution of different loads in a refrigeration or air conditioning.
d) Display various parts of a hermetically sealed / open compressor on wooden board with labels.
e) Collect and display different gaskets required for a single cylinder /multi cylinder IC engine.
f) Prepare report on different types of lubricating oils, oil filters, coolants, for petrol engines wrt physical and chemical properties, cost, safety, disposal etc.
g) Make a working model of air compressor.
h) Prepare a step-by-step procedure for dismantling and assembly of multi cylinder IC engine. Tabulate different tools used in dismantling of IC engines against components for which these tools are used.
i) Collect information about electrical motor drives used in vehicles such as Tesla and Google's car.
j) Comparative study of hybrid vehicles and conventional vehicles.
k) Collect charts using internet regarding Combustion: combustion in SI engines, pre-ignition, detonation – concept, factors affecting detonation, Homogeneous Charged Compression Ignition Engine.
l) Collect working and constructional details of different types of Reciprocating and Rotary compressors.
m) Collect specifications, working and constructional details of different types of refrigeration and air conditioning units (Domestic refrigerator, water cooler, ice plant and cold storage, Window, split air-conditioner, central air-conditioning)

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Internal Combustion Engines	Mathur M. I.; Sharma R. P.	Dhanpatrai Publications (P) Ltd, New Delhi 2012, ISBN: 1234567144047
2	Thermal Engineering	Rajput R. K.	Laxmi Publications, New Delhi 2010, ISBN: 8131808041, 9788131808047
3	A Textbook of Internal Combustion Engines	Rajput R.K.	Laxmi Publications; Third edition, New Delhi, (2016) ISBN-13: 978-8131800669
4	IC Engines Combustion and Emissions	Pundir B. P.	Narosa Publishing House), New Delhi (2010) ISBN-13: 978-8184870879
5	Refrigeration and Air Conditioning	Khurmi R. S.; Gupta J. K.	S. Chand Publications, New Delhi (2016), ISBN: 978-81-219-2781-9
6	Thermal Engineering	Singh Sadhu, Pati Sukumar	Pearson Education; First edition, New Delhi, (2018) ISBN-13: 978-9352866687

14. SOFTWARE/LEARNING WEBSITES

a) https://jalopnik.com/how-variable-valve-timing-works-500056093
b) https://www.araiindia.com/pdf/Indian_Emission_Regulation_Booklet.pdf
c) http://www.fchart.com/ees/demo.php
d) http://industrial-ebooks.com/CBT_software/Aircompressor-Training91.php
e) https://www.gspteam.com/products.html


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Advanced Manufacturing Processes**

Course Code : **22563**

1. RATIONALE

Mechanical technologists (diploma holders) have to work with men, machines and materials. With the advancements, newer difficult to machine materials and complex shapes with high surface finish is the demand of the manufacturing sector. To machine these materials and also the complex geometries with very high surface finish the student must have the knowledge of non – conventional machining processes like EDM, ECM, LBM, PAM, WJM, EBM, WEDM and also the conventional machining like milling processes, gear manufacturing, grinding, surface finishing, Broaching, boring processes etc. This course is aimed to make them achiever the various outcomes required for the given jobs.

2. COMPETENCY

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

- **Maintain the functioning of advanced manufacturing processes and equipment.**

3. COURSE OUTCOMES (COs)

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

a. Maintain the non conventional machining process to produce complex and hard to machine components.
b. Produce components using milling machine.
c. Choose relevant machining process to produce gears.
d. Maintain CNC machine to produce components effectively.
e. Prepare CNC part programs for simple components.
f. Maintain the functioning of automated equipment.

4. TEACHING AND EXAMINATION SCHEME

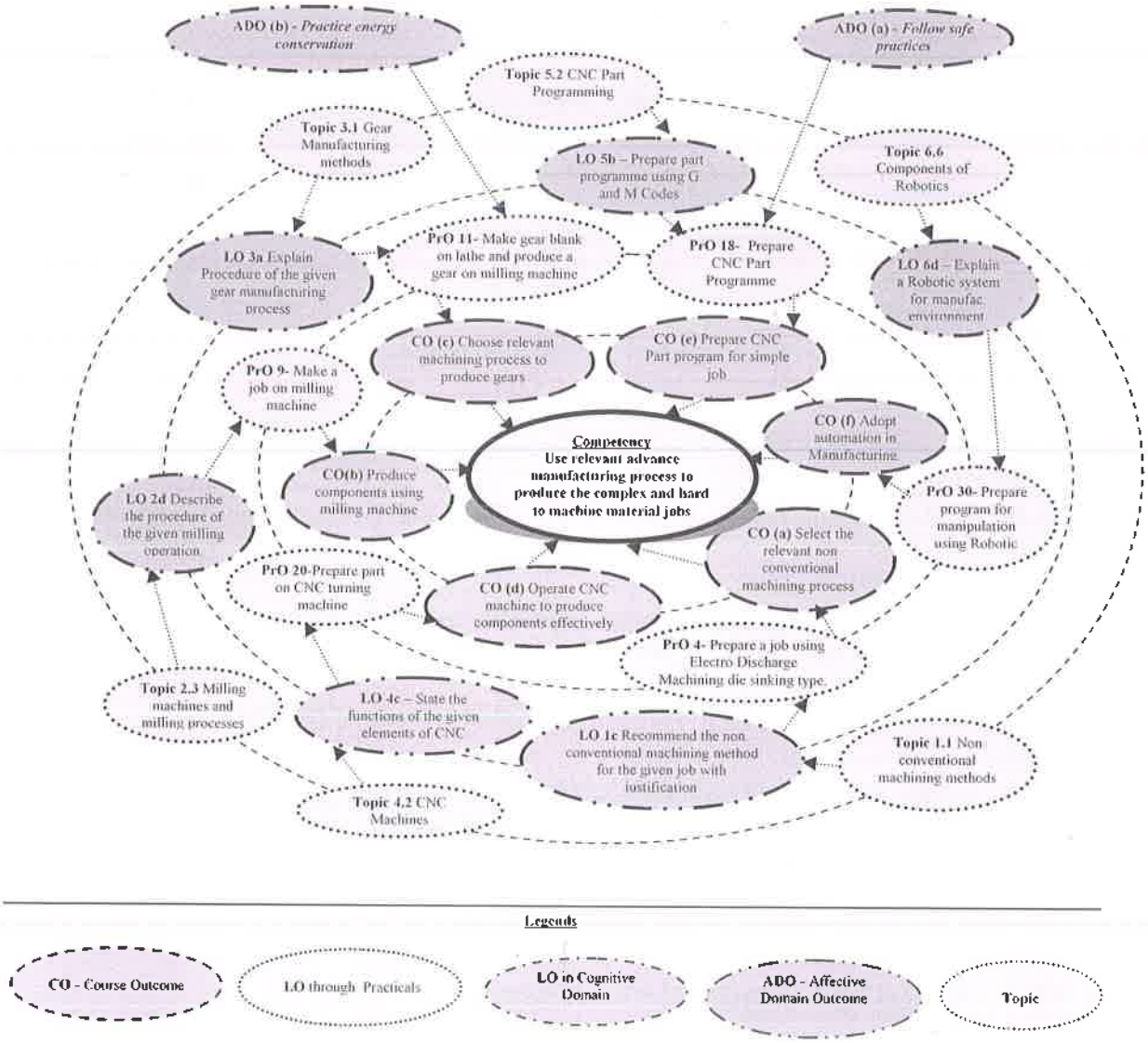
Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40

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

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

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

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



6. SUGGESTED PRACTICALS/ EXERCISES

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

For practical number 1 to 13 write a detailed report on the machine specification, tool and work piece specifications, criterion of selection of process and performance parameters, process carried out, set up, working principle with sketches and name of other industrial components produced using same process.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare a job using Abrasive Jet Machining/Observe the same in an industry(Part I)	1	02
2	Prepare a job using Abrasive Jet Machining/Observe the same in	1	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	an industry. (Part II)		
3	Prepare a job using Electro Discharge Machining die sinking type/Observe the same in an industry. (Part I)	I	02
4	Prepare a job using Electro Discharge Machining die sinking type /Observe the same in an industry. (Part II)	I	02
5	Prepare a job using Electro Discharge Machining wire cut type /Observe the same in an industry. (Part I)	I	02*
6	Prepare a job using Electro Discharge Machining wire cut type /Observe the same in an industry. (Part II)	I	02*
7	Prepare a job using Electro Chemical Machining/Observe the same in an industry. (Part I)	I	02*
8	Prepare a job using Electro Chemical Machining/Observe the same in an industry. (Part II)	I	02*
9	Make a job on milling machine which includes plain milling, slotting by using end mill cutter or slitting saw, or side and face milling cutter. (Part I)	II	02*
10	Make a job on milling machine which includes plain milling, slotting by using end mill cutter or slitting saw, or side and face milling cutter. (Part II)	II	02*
11	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part I)	II	02*
12	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part II)	II	02
13	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part III)	II	02
14	Prepare a job or assembly of jobs like Gear and shaft assembly, Shaft and keyway which involves operations like end mill, turning, grinding operations. (Part I)	III	02*
15	Prepare a job or assembly of jobs like Gear and shaft assembly, Shaft and keyway which involves operations like end mill, turning, grinding operations. (Part II)	III	02*
16	Operate CNC machines and try to change different parameters and controls to see their effect during machining. (Part I)	IV	02*
17	Operate CNC machines and try to change different parameters and controls to see their effect during machining. (Part II)	IV	02*
18	Prepare CNC part programme using G and M codes with ISO format for Simple contour milling of part. (Part-I)	V	02 *
19	Prepare part on virtual CNC machine simulator using part programme developed in PrO 18 and generate cycle time process sheet using CAM Software. (Part-II)	V	02*
20	Prepare part on CNC turning machine using part program developed in PrO 18. (Part-III)	V	02*
21	Prepare CNC part program using G and M codes with ISO format for Simple contour milling of part. (Part-I)	V	02*
22	Prepare part on virtual CNC machine simulator using part program developed in PrO 21 and generate cycle time process sheet using CAM Software. (Part-II)	V	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
23	Prepare part on CNC turning machine using part program developed in Sr. no. 21. (Part-III)	V	02*
24	Prepare CNC part program using G and M codes with ISO format for Turning parts using canned cycle - with threading or drilling or other. (Part-I)	V	02
25	Prepare part on virtual CNC machine simulator using part program developed in PrO 24 and generate cycle time process sheet using CAM Software. (Part-II)	V	02
26	Prepare part on CNC turning machine using part program developed in PrO 24. (Part-III)	V	02
27	Import solid model into CAM environment of any CAM software and perform manufacturing simulation. (Part-I)	V	02
28	Prepare part on CNC turning machine using automatic part program developed in PrO 27. (Part-II)	V	02
29	Observe and use Flexible Machine Station in an industry	VI	02
30	Prepare a simple program for manipulation of standard components using Robotic arm	VI	02*
31	Observe the Robotics system in an industry	VI	02
	Total		**64**

Note

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

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

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

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

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

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

- 'Valuing Level' in 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.	Abrasive Jet machining	1,2
2.	Electro Discharge Machine	3 to 6
3.	Electro Chemical Machine: Tool area 10mmx30mm or 15mmx20mm; Cross Head Stroke 40 mm; Supply Single phase 230 V. A.C.; Electrical Output Rating 0 - 100 Amps and voltage from 0 - 25 V DC; Tool Feed Rate In the range of 0.2 to 1 mm / min.; Machining Time 0 to 1999 seconds, variable through touch screen.; Display For voltage, output current; feed rate electrolyte temp; Protection For Current overload, short circuit; USB Port For data storage; pulsating facility On time 100 microseconds to 1 second variable, off time 100 microseconds to 1 second variable, plus amplitude 1v-10v variable; LCD display For forward and reverse, feed rate settings, feed rate; Tool Area 300 square mm;	7,8
4.	Lathe machine, turning tool, boring tool, Standard dial bore gauge. Minimum 500 mm between centre, with required set of work holding devices, cutting tools, accessories and tool holders	11 to 13,
5.	Milling machine, face milling cutter, side and face milling cutter, end mill cutter. Minimum 500 mm longitudinal traverse, with required indexing head, set of work holding devices, cutting tools, accessories and tool holders.	15
6.	Drilling Machine (Bench type, or Column type, or if possible Radial): Minimum 25 mm capacity, with required set of work holding devices, cutting tools, accessories and tool holders.	11,12,13 ,15
7.	CNC Turning 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC. (Suggested)	16 to 28
8.	CNC Milling 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC.(Suggested)	16 to 28
9.	CNC Simulation software and control pads (CAMLAB CNC Software, MasterCAM/NXCAM/, DONC CNC machine simulator, PRO, SWANSOFT, CAPSMILL and CAPSTURN IN cam software, DONCMILL AND DONCTURN software)	16 to 28
10.	PRO¬FICNC programming manuals and watch PROFICNC on https://youtu.be/3ghwlpmhwpm to integrated CNC machine with multiple industry standard CNC controllers like FANUC, SIEMENS, FAGOR AND	16 to 28

S. No	Equipment Name with Broad Specifications	PrO. No.
	MITSUBISHI.	
11.	Any Latest educational version of CAD/CAM integration software .	16 to 28
12.	Robotic Arm	31

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Non-Conventional Machining Processes	1a. Describe with sketches the working principle of the given non - conventional machining method and draw set up of the same. 1b. Describe advantages, limitations and applications of the given non - conventional machining method. 1c. Recommend the non conventional machining method for the given job with justification. 1d. Recommend the process parameters for the given job and non-conventional machining process with justification.	1.1 **Fundamentals of Non – conventional methods –** Needs and types of non – conventional methods. Importance of methods. 1.2 **Working principle, set up, process parameters of –** EDM, , WEDM ECM, PAM, AJM, USM, EBM and LBM. 1.3 **Advantages, limitations and applications of** - EDM, , WEDM ECM, PAM, AJM, USM, EBM and LBM.
Unit– II Milling Machines and Milling Processes	2a. Explain with sketches the working of the given milling machine. 2b. Draw sketches of the given milling machine parts and cutters. 2c. Describe the procedure of the given milling operation. 2d. Explain the procedure of the indexing for the given gear manufacturing	2.1 **Milling: -** Working Principle of milling machine, types of milling machines 2.2 **Milling cutters** – Different types of cutters used in milling, face milling cutter, end milling cutter, Staggered tooth milling cutter, side and face milling cutter, form milling cutters, metal slitting saw etc. 2.3 **Milling Processes** – Plain milling, face milling, side milling, end milling, Straddle milling, gang milling, slotting, slitting, Up milling and down milling 2.4 **Cutting Parameters –** Cutting speed, feed. 2.5 **Dividing head** – types, function of dividing head, method of indexing, index plates.
Unit– III Gear Manufactu	3a. Explain with sketches procedure of the given gear manufacturing	3.1 **Gear manufacturing methods –** Function and types of gears, gear manufacturing methods,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
ring	process. 3b. Draw sketches of the given gear hob, hobbing process or gear shaping process. 3c. Explain with sketches the given gear finishing process. 3d. Recommend the process parameters for the given gear manufacturing and finishing process with justifications.	3.2 **Gear hobbing** – Working principle, types of gear hobbing, advantages, limitations and applications of gear hobbing 3.3 **Gear shaping** – Gear shaping by pinion cutter, gear shaping by rack cutter, advantages, limitations and applications of both the methods and Comparison of gear hobbing and gear shaping 3.4 **Gear finishing methods** – Need of gear finishing, gear finishing methods, a) Gear shaving b) Gear grinding c) Gear burnishing d) Gear lapping e) Gear honing
Unit-IV Fundamentals of Computer Aided Manufacturing (CAM)	4a. State the functions of the given element(s) of the CNC Machine 4b. Select tool(s) and tool holder(s) used on a CNC machine for the given job with justification 4c. Explain the given work and tool holding and changing device(s) used on a CNC turning centre 4d. Explain the given work and tool holding and changing device(s) used on a CNC Machining centre	4.1 CAM concept, NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences. 4.2 CNC machines: Types, classification, working and constructional features Advantages, limitations and selection criteria. 4.3 Elements of CNC machines - Types, sketch, working and importance of: Slide ways; Re-circulating ball screw; Feedback devices (transducers, encoders); Automatic tool changer (ATC); Automatic pallet changer (APC); 4.4 CNC tooling : Tool presetting-concept and importance; Qualified tools- definition need and advantages; Tool holders- types and applications. 4.5 CNC turning centres: Types; Features; Axes nomenclature; Specification; Work holding devices -types, working and applications. 4.6 CNC machining centres: Types; Features; Axes nomenclature; Specification; Work holding devices-types, working and applications.
Unit V– CNC Part Programming	5a. Interpret the given CNC part programming code(s). 5b. Prepare part programme using G and M codes for the given job. 5c. Apply advanced CNC part programming features like canned cycle, do loop, subroutine etc. in the given	5.1 Definition and importance of various positions like machine zero, home position, work piece zero and programme zero. 5.2 CNC part programming: programming format and structure of part programme. 5.3 ISO G and M codes for turning and milling-meaning and applications of important codes.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	situation. 5d. Explain procedure for setting the given compensation(s) on the given CNC machine.	5.4 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation). 5.5 Simple part programming for milling using ISO format. 5.6 Importance, types, applications and format for: Canned cycles; Macro; Do loops; Subroutine; 5.7 CNC turning and milling part programming using canned cycles, Do loops and Subroutine. 5.8 Need and importance of various compensations: Tool length compensation; Pitch error compensation; Tool radius compensation; Tool offset. 5.9 Simple part programming using various compensations. 5.10 Virtual CNC machine simulators. Generation of generating shop documentation using a CAM software, cycle time sheets, tools list with tool layout, spindle utilization graphs, program for different control systems and different configuration of machines
Unit-VI Automation and Robotics	6a. Compare Fixed and flexible Automation on given parameters with justification. 6b. Justify the use of Group Technology for the given situation. 6c. Justify the use of FMS in a given situation. 6d. Explain a Robotic system used for a given manufacturing environment. 6e. Select different components of Robotics with justification.	6.1 Automation-Define, need of automation, high and low cost automation, examples of automations. 6.2 Types of Automation - Fixed (Hard) automation, programmable automations and Flexible automations (Soft).Comparison of types of automations. 6.3 Group Technology- concept, basis for developing part families, part classification and coding with example, concept of cellular manufacturing. Advantages and limitations. 6.4 Flexible Machining System- Introduction, concept, definition and need, sub systems of FMS, comparing with other manufacturing approaches. 6.5 Introduction to Robotics- definition of robot and robotics, advantages disadvantages and applications. 6.6 Components of Robotics manipulator, end effectors, actuators, sensors, controller, processor and software.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Non conventional Machining Methods	10	02	04	06	12
II	Milling Machines and Milling Processes	10	02	04	06	12
III	Gear Manufacturing	10	02	02	06	10
IV	Fundamentals of Computer Aided Manufacturing	10	02	04	06	12
V	CNC Part Programming	14	04	04	08	16
VI	Automation and Robotics	10	02	02	04	08
Total		**64**	**14**	**20**	**36**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare journal based on practical performed in measurement laboratory. Journal consist of drawing, observations, required measuring tools, equipments, date of performance with teacher signature.
b) Tabulate various cutting tools materials with main elements, properties and applications.
c) List process parameters for various machines (Each student will be given different machine).
d) Calculate RPM for lathe, milling cutter and drill spindle; based on given data. (Each student should be given different data for diameters and cutting speeds)
e) Prepare a report on at least one industrial component with its complete technical details covering the points like design criterion, features included with Dimensional/Geometric constraints, manufacturing resource requirements, challenges in controlling its quality and cost, etc.
f) Collect the technical details about all production facilities available at nearby industry/industries.
g) Visit or participate in the technical events, exhibition, conference, seminar etc.
h) Collect/download at least four different machine tool catalogues including at least one special purpose, non-conventional or advanced machine.
i) Collect/download at least one catalogue each of cutting tool, work holding device and tool holder.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate actual components and products with various concepts of advance machining processes.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various concepts of advance machining processes.
i) Demonstrate the process properly before students start doing the same.
j) Encourage students to refer different websites to have deeper understanding of the subject.
k) Observe continuously and monitor the performance of students in Lab.
l) Arrange the industrial visits in such a way that students are able to observe advance machining processes.
m) Encourage students to watch various videos on you tube or any particular website related to advance machining processes used to produce a component.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Prepare a list of industrial components which are produced through non conventional machining processes and describe the manufacturing procedure of the same in brief
b. Prepare a list of domestic and industrial components on which Lapping, honing, buffing, Electroplating, Galvanizing, metal spraying and powder coating are performed. For each process collect information about the material, machines and other resources required. Also prepare list of industries in your state doing these processes.

c. Manufacture any product like a small assembly of components which has been designed in the course Design of Machine Elements. Student will prepare the report on following.
   i. Prepare production drawings of the assembly and details.
   ii. Manufacture the parts.
   iii. Note down work holding devices, cutting tools and cutting parameters used for each part and each operations. Summarize this in tabular form.
   iv. On completion, present and share the experience of this mini project with photos/videos of mini project execution and with work distribution executed. Use power point presentation.

d. Produce job with various machining methods:
   i. Part should include plain/taper turning, knurling, threading, cylindrical/surface grinding, etc.
   ii. Sketch the production drawing of the part.
   iii. Outline the processes.
   iv. Calculate/select, set, observe and record the cutting parameters for each process.
   v. List the cutting tools and measuring instrument like vernier caliper, micrometer or gauge if any you have used. Also state specifications of each.
   vi. List the work holding devices you have used. Also state specifications of each.
   vii. Produce the part

e. Produce a complex job:
   i. Part should include shaping, milling, drilling, tapping, boring, slotting, surface grinding, cylindrical grinding, super finishing like lapping, polishing etc.
   ii. Select and sketch the production drawing of the part.
   iii. Outline the processes. Prepare process plan for the same.
   iv. Prepare workshop layout and route sheet.
   v. Produce the part, Calculate/select, set, observe and record the cutting parameters for each process.
   vi. List the cutting tools you have used. Also state specifications of each.
   vii. List the work holding devices you have used. Also state specifications of each.

f. Prepare a technical report on specifications, operating procedure, selection of operational parameters, details about tool/work holders used, machine setting, product details being manufactured for each method/machine like gear forming/generating, honing/lapping/buffing machine, Non-conventional machine, Jig boring machine, Broaching machine etc.

g. Visit a work shop which contains latest industrial Turret lathe, Capstan lathe, Single spindle automats, Automatic machines. Write a detail report on working of such machine or machines, parts produced, and other relevant information. Identify the jobs produced on such machines and draw the sketches of jobs.

h. Prepare a report on how to select parameters for machining Aluminum, Mild steel, Stainless steel and Inconel materials on CNC machine.

i. Comparative study of any two CNC turning centers or any two Vertical Machining centers and report the differences.

j. Comparative study of two different CNC systems for turning centers: Fanuc and Fagor using suitable virtual CNC machine simulator software.

k. Study and report 10 commonly used work piece materials and best grades of cutting tools that used to cut them efficiently.

l. Study machining process and reduce machining cycle time of parts from local CNC job shops.

m. Study of two different CNC systems for VMC: Siemens and MITSUBISHI M 70 with the help of CNC machine simulator software and furnish the report
n. Explore PRO¬FICNC programming manuals and watch PROFICNC on https://youtu.be/3ghwlpmhwpm to integrated CNC machine with multiple industry standard CNC controllers like FANUC, SIEMENS, FAGOR AND MITSUBISHI.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Manufacturing Science and Technology	Rao, K Vara Prasada	New Edge Publication, New Delhi, 2009, ISBN: 978-81-224-2759-2
2	Unconventional manufacturing processes	Singh M.K.	New Edge Publication, New Delhi, 2009, ISBN: 978-81-224-2244-3
3	A text book of Production Engineering	Sharma P.C.	S.Chand Publication, New Delhi 8th Edition 2012, ISBN 978812190116
4	Machine Tools Technology	Kandasami G. S.	Khanna Publishers, New Delhi, 2/e, 1989
5	Manufacturing ProcessesVol II	Bawa H.S.	McGraw Hill, New Delhi, ISBN - 0070583722
6	Fundamentals of Metal Machining and Machine Tools	Knight W. A., Boothroyd Geoffrey	McGraw-Hill Education, New Delhi, 2006, ISBN 1-57444-659-2
7	Production Technology	HMT, Banglore	McGraw-Hill Education, New Delhi, 2001, ISBN 13:978-0-07-96443-3
8	Advanced Machining Processes	Jain V. K.	Allied Publishers, Mumbai, 2009 ISBN 81-7764-294-4
9	CNC Machines.	Pabla B.S., Adithan M.	New Age International, New Delhi, 2014, ISBN: 9788122406696
10	Computer Numerical Control-Turning and Machining centres	Quesada Robert	Prentice Hall India, New Delhi, 2014 ISBN: 978-0130488671
11	CAD/CAM	Sareen Kuldeep	S. Chand, New Delhi, 2012 ISBN: 9788121928748
12	Introduction to NC/CNC Machines	Vishal S.	S.K. Kataria and Sons, New Delhi, 2010, ISBN: 978-8188458110
13	Computer Aided Manufacturing	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill, New Delhi, 2017 ISBN: 978-0074631034
14	CAD/CAM: computer aided design and manufacturing	Groover Mikell P, Zimmered W Emory	Prentice Hall, New Delhi, 2011 ISBN: 9780131101302

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

i. http://nptel.ac.in/video.php?subjectId=112105126
ii. http://nptel.ac.in/courses.php?disciplineId=112
iii. http://nptel.ac.in/courses/112104028/
iv. http://nptel.ac.in/courses/112105126/27
v. http://www.youtube.com/watch?v=bmooEZyivxo
vi. http://www.youtube.com/watch?v=mWy9awGv6so
vii. http://www.youtube.com/watch?v=mKES5Fyz9l0

viii. http://www.youtube.com/watch?v=BgGXQUeYNKw
ix. http://www.youtube.com/watch?v=eaeEn1Gs4aQ
x. http://www.youtube.com/watch?v=49GpJ7yhecg
xi. http://www.youtube.com/watch?v=XfYXelZ4IaY
xii. http://www.youtube.com/watch?v=SNWF_4jQ2pU
xiii. w.youtube.com/watch?v=pI1QGpmKqow
xiv. http://www.youtube.com/watch?v=N7NofmHWWPQ
xv. http://en.wikipedia.org/wiki/Microelectromechanical_systems
xvi. http://www.engineersgarage.com/articles/mems-technology
xvii. http://www.nptel.ac.in
xviii. http://www.youtube.com/watch?v=M3eX2PKM1RI
xix. http://www.youtube.com/watch?v=EHQ4QIDqENIandlist=PLBkq kLQO2nAt5MNLo eUhvkFS9M0p8y_1
xx. https://cadem.com/lms/
xxi. https://cadem.com/cncetc/
xxii. http://www.mtabindia.com
xxiii. http://www.swansoftcncsimulator.com
xxiv. https://goo.gl/4xvdhw https://goo.gl/fi4eqf
xxv. https://cadem.com/cncetc/
xxvi. https://youtu.be/3ghwlpmhwpm


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
MUMBAI

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

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

Semester : **Fifth**

Course Title : **Elements of Machine Design**

Course Code : **22564**

1. RATIONALE

Design department of industry is one of the major job areas for Diploma Technicians. Fundamental knowledge of Applied Mechanics, Strength of Materials, Engineering Materials, Theory of Machines and Computer Aided Design and Drafting is essential. To enable a student to work there he should know how to design the simple machine elements. He should also be aware of usual design procedures, selection procedures, codes, norms, standards and guidelines for selection of appropriate material. This subject aims at developing analytical and selection abilities in the student to give solutions to simple engineering design problems using standard procedures.

2. COMPETENCY

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

- **Design simple machine components.**

3. COURSE OUTCOMES (COs)

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

a. Select suitable materials for designing machine elements.
b. Design joints and levers for various applications.
c. Design the power transmission elements like shafts, keys and couplings.
d. Recommend the power screws and suitable fasteners for different applications.
e. Choose springs for various applications.
f. Select standard components with their specifications from manufacturer's catalogue.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical				
				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	4	70	28	30*	00	100	40	25@	10	25	10	50	20

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

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

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

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

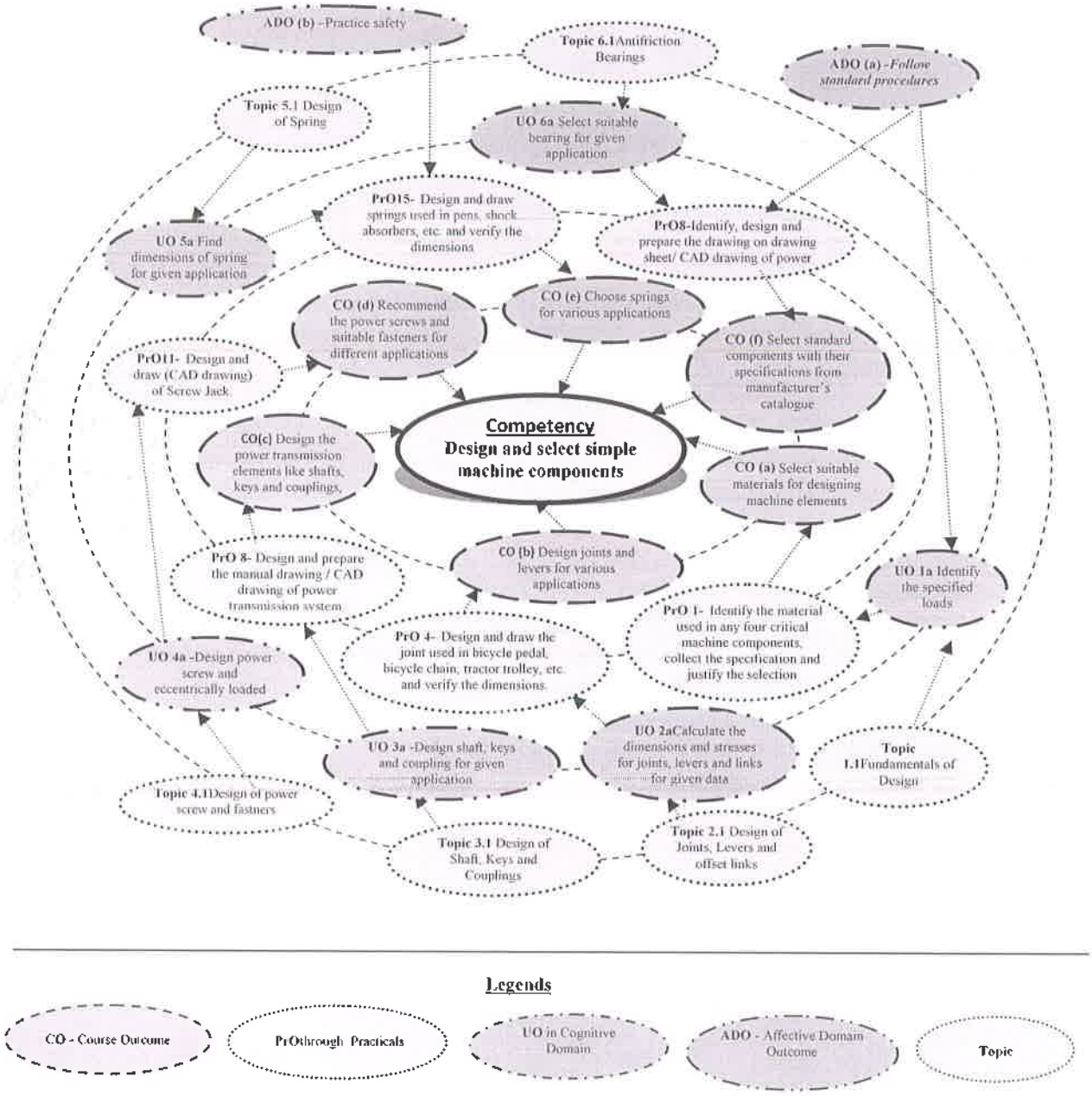


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the material used in any four critical machine components,	I	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	collect the specification of the materials and justify the selection. (group of 4 students)		
2	Draw various modes of failure for the machine components used in various laboratories/ workshops, under different loading conditions.	I	02*
3	Use IS codes for design of any two machine elements. (ISO metric threads, Cast iron Flexible coupling, Keys, Screws, Bolts, Nuts, similar components). (Group of 4 students)	I	02*
4	Design and draw the joint used in bicycle pedal, bicycle chain, tractor trolley, rail wagons/coaches, and similar components and verify the dimensions. (Group of 4 students) (Part-I)	II	02*
5	Design and draw the joint used in bicycle pedal, bicycle chain, tractor trolley, rail wagons/coaches and similar components and verify the dimensions. (Group of 4 students) (Part-II)	II	02*
6	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions. (Part-I)	II	02
7	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions. (Part-II)	II	02
8	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shafts, keys, couplings, bearings, pulley and belt drive used in various machine like lathe machine, flour mills,sewing machine and transmission system in different machines and justify the dimensions. (Part-I)	III	02*
9	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shaft, keys, coupling, bearing, pulley and belt drive used in various machine like lathe machine, flour mills, sewing machine and transmission system in different machines and justify the dimensions. (Part-II)	III	02*
10	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shaft, keys, coupling, bearing, pulley and belt drive used in various machine like lathe machine, flour mills, sewing machine and transmission system in different machines and justify the dimensions. (Part-III)	III	02*
11	Design and draw (CAD drawing) of Screw Jack used for heavy vehicles, cars and other similar applications and verify the dimensions. (Part-I)	IV	02
12	Design and draw (CAD drawing) of Screw Jack used for heavy vehicles, cars and other similar applications and verify the dimensions. (Part-II)	IV	02
13	Design and draw fasteners used in civil structures (Railway platform shades, bridges, Eccentric loaded brackets), bridges, household electrical panels, column brackets and similar	IV	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	components and verify the dimensions. (Four design cases) (Part-I)		
14	Design and draw fasteners used in civil structures (Railway platform shades, bridges, Eccentric loaded brackets), bridges, household electrical panels, column brackets and similar components and verify the dimensions.(Four design cases) (Part-II)	IV	02*
15	Design and draw springs used in pens, shock absorbers, rocker arm spring, safety valve, bicycle/ two-wheeler side stand, railway buffers and similar components. (Four design cases) (Part-I)	V	02*
16	Design and draw springs used in pens, shock absorbers, rocker arm spring, safety valve, bicycle/ two-wheeler side stand, railway buffers and similar components and verify the dimensions. (four design cases) (Part-II)	V	02*
17	Design and draw Spur Gear used Agriculture machinery, Sugar Can Juice Machine and similar components and verify the dimensions. (One design case)	V	02*
	Total		**32**

Note

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

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

S. No.	Performance Indicators	Weightage in %
a.	Identification of loads and other boundary conditions	20
b.	Selection of material	20
c.	Apply suitable design procedure	20
d.	Identify exact mode of failure	10
e.	Neatness in drawing	20
f.	Answer to sample questions	10
Total		**100**

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

a. Follow safe practices in using drawing instruments and CAD workstations.
b. Follow neatness while preparing the drawings.
c. Practice good housekeeping.
d. Work as a leader/a team member.
e. Follow standard procedures and codes.
f. Use design data book and Manufacturer's catalogue.
g. Follow ethical Practices.

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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

S. No.	Equipment Name	Specifications	PrO.S. No.
1	i) Cotter joint ii) Knuckle joint iii) Turn-Buckle	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	03
2	i) Foot, Hand, Bell-crank lever ii) Offset link	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	04
3	i) Pulley, Shaft, Keys and couplings. (all types) ii) Belt, Chain, Gear drive, Metallic rope.	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	05
4	Models of lead screw of lathe, feed screw of machine tools, clamping screws, toggle jack screw, screw jack.	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	06
5	Ball bearing-single, double row, angular contact and thrust, rolling contact bearings- cylindrical, taper roller, thrust, pedestal, journal, pivot bearing, Spur gear, Helical gears	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	05
6	Different Springs, Nut-Bolt, Standard sections	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	All
7	Wall charts for- Types of levers Types of joints Tolerance, surface finish, limits and fits. Helical springs Bolted joints Welded joints Bearing designation Various types of bearings	All charts should be plastic or acrylic coated –size 3ft x 3ft	All

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of	1a. Write general design procedure for the given component under static	1.1 Machine design philosophy and phases in design, design considerations.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Design	loading. 1b. Identify the specified loads and stresses for the given component with justification. 1c. Identify the materials for the given machine components with justification. 1d. Select the relevant standards and codes for design of the given component. 1e. Explain various modern design considerations in the given situation.	1.2 Types of loads, concept of stresses, bearing pressure, bending and torsion stresses, principal stresses, strain, stress-strain diagram. (Simple Numerical) 1.3 Factor of Safety, conditions for selection of F.S 1.4 Stress concentration meaning, causes and remedies. 1.5 Designation of materials as per IS and introduction to International standards, advantages of standardization, use of design data book, use of standards in design and preferred numbers series. 1.6 Concept of creep, Fatigue, S-N curve, Endurance limit. 1.5 Maximum principal stress theory and Maximum shear stress theory. 1.6 Modern Design considerations Ergonomics and aesthetic considerations in design. Ecology, social consideration and Concept of Product Design.
Unit– II Design of joints, Levers and offset links	2a. Write design procedure for the given joint(s), lever(s) and link(s). 2b. Sketch the given joint(s), lever(s), link(s) and their resisting sections. 2c. Calculate the dimensions and stresses for the given joints, levers and links for given data. 2d. Calculate the dimensions and stresses for the given C-clamp for given data.	2.1 Design of Cotter Joint, Knuckle Joint, 2.2 Turnbuckle. 2.3 Design of Levers:- Hand/Foot Lever and 2.4 Bell Crank Lever, 2.5 Lever for lever safety valve, 2.6 Design of Off-set links, C-clamp, Overhang Crank
Unit– III Design of Shaft, Keys and Couplings	3a. Write design procedure for the given shaft, keys and couplings. 3b. Sketch the given shaft, key(s) and coupling(s). 3c. Design the given shaft, key and coupling for given application. 3d. Select the given shaft, keys and coupling for given application from manufacturer's catalogue/ design handbook with justification.	3.1 Types of shafts, Shaft materials, Standard sizes, Design of solid and hollow shafts based on strength and rigidity criteria. 3.2 Design of hollow and solid shaft for combined bending and twisting moments and considering the effect of shock and fatigue. ASME code of design for line shafts supported between bearings with one or two pulleys in between or one overhung pulley. 3.3 Types of keys, effect of keyways on the strength of shaft, design of rectangular and square sunk keys. 3.4 Types of couplings, Design of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		muff coupling, flanged couplings (protected and unprotected) and Bushed pin type flexible coupling.
Unit-IV Design of Power screws and Fasteners	4a. Write strength equations for the given screw and nut combination. 4b. Sketch the given type of Jack. 4c. Design the given power screw and eccentrically loaded bolted joint for given data. 4d. Calculate the length of weld for the given application. 4e. Recommend the type of fasteners for the given situation based on catalogue with justification.	4.1 Basic concepts of power screw Thread Profiles used for power Screws, relative merits and demerits of each, Self locking and overhauling properties, Torque required to overcome thread friction, efficiency of power screws, types of stresses induced. 4.2 Design of Screw Jack, Toggle Jack (only screw and nut). 4.3 Stresses in Screwed fasteners, bolts of Uniform Strength, Design of Bolted Joints subjected to eccentric loading. 4.4 Design of parallel and transverse fillet welds, axially loaded symmetrical Section.
Unit –V Design of Springs	5a. Identify the type of spring used in the given application. 5b. Choose suitable material for spring with justification and write specification. 5c. Sketch the given type of spring. 5d. Write design procedure of the given type of helical compression/tension spring. 5e. Find dimensions of spring for the given application.	5.1 Classification and Applications of Springs, Spring - terminology, materials specifications. Stresses in helical tension and compression springs, Wahl's correction factor, Deflection of springs, Energy stored in springs. 5.2 Design of Helical tension and compression springs subjected to concentric applied loads like I.C. engine valves, weighing balance, railway buffers. 5.3 Leaf springs - construction and applications.
Unit-VI Selection of Antifriction Bearings and Gears	6a. Identify the given type of bearing. 6b. Explain the procedure of designing and selection of the given type of bearing. 6c. Select suitable bearing for given application from manufacturer's catalogue with justification. 6d. Select suitable Spur Gear for given application from manufacturer's catalogue with justification.	6.1 Classification of Bearings – Sliding contact and rolling contact. 6.2 Terminology of Ball bearings – life load relationship, basic static load rating and basic dynamic load rating. 6.3 Selection of ball bearings using manufacturer's catalogue 6.4 Design of spur gear using Lewis and Buckinghams equation. (Simple Numerical), selection of gears from standard sizes.

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Design	10	06	04	04	14
II	Design of Joints, Levers and Offset links	08	02	02	04	08
III	Design of Shafts, Keys and Couplings	10	02	04	10	16
IV	Design of Power screws and Fastners	12	02	06	08	16
V	Design of Springs	06	02	04	04	10
VI	Selection of Antifriction Bearings and Gears	02	02	02	02	06
Total		**48**	**16**	**22**	**32**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare journal of practicals.
b. Undertake micro-projects.
c. Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
d. Collect different types of springs and write applications of the same.
e. Collect different types of used bearings and make display model and their application.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various failure modes.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.
k. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Take any day to day life component, find load, stresses and also prepare chart/model for the same.
b. Make models of various joints and levers highlight resisting sections of different elements.
c. Make models of various shafts, keys and pulleys highlight resisting sections.
d. Make models of various couplings highlight resisting sections of different elements.
e. Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
f. Prepare model of eccentrically loaded bolted and welded joint and highlight the maximum loaded section.
g. Prepare list of different types of bearings used in a bike and write their specifications and basis for selection.
h. Prepare list of different types of Gears used in Agriculture machinery, Sugar can juice machine, gear boxes of two and three wheelers and similar machines, write their specifications and basis for selection.
i. Prepare list of different types of levers and springs used in a bike, bicycle, Auto Rickshaw, Moped and write their specifications and basis for selection.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Design of Machine Elements	Bhandari V. B.	McGraw-hilleducation India pvt. limited, New Delhi, 2017, ISBN-13:978-9339221126
2	Machine Design	Khurmi R. S. and Gupta J. K.	S. ChandNew Delhi, 2005, ISBN 10:8121925371 ISBN13:9788121928372

S. No.	Title of Book	Author	Publication
3	Machine Design	Jindal U. C.	Pearson Education India New Delhi, 2010, ISBN13: 9788131716595
4	Machine Design	Pandya and Shah	CharotarPublishing house pvt. Ltd. Anand, Gujarat, 2015, ISBN-13:9789385039102
5	Mechanical EngineeringDesign	Shigley	McGraw-hilleducation India pvt. limited, New Delhi, 2017, ISBN-13:978-9339221638
6	Design Data Book	PSG	PSG College ofTechnology Coimbatore, 2012, ISBN-10: 8192735508
7	IS Codes: IS 4218: 1967 ISO Metric Threads IS 2693: 1964 Cast Iron Flexible Couplings IS 2292: 1963 Taper keys and Keyways IS 2293: 1963 Gib Head Keys and Keyways IS 2389: 1963 Bolts, Screws, Nuts and Lock Nuts IS 4694: 1968 Square threads IS 808: 1967 Structural Steel SKF/NBC Catalogue for Bearings	ISO	Indian Standard Bureau New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112105124/
b. https://www.youtube.com/watch?v=CLeLFUrvO2g
c. www.machinedesignonline.com
d. www.engineeringtoolbox.com
e. https://www.youtube.com/watch?v=N5SckoiTDxA
f. https://www.youtube.com/watch?v=GfbcxJmjn9s
g. http://www.ignou.ac.in/upload/Unit-5-60
h. https://sizes.com/numbers/preferred_numbers.htm
i. www.robot-and-machines-design.com/en/articles/mech
j. http://www.youtube.com/flangedcoupling
k. http://www.youtube.com/screwjack

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Tool Engineering (Elective)**

Course Code : **22565**

1. RATIONALE

Tools are basic component required for any machining process. The quality and efficiency of any machining operation basically depends upon quality of tools which in turn depends upon the proper shape, size and material of the tools. Productivity and quality of machining operations may further be enhanced by proper and quick mounting of tools and jobs on machines using suitable Jigs and Fixtures. Therefore, this course attempts to develop abilities in students to select a tool of proper size and shape for required machining operation. The design of basic cutting tools, jigs and fixtures are also dealt with in this course.

2. COMPETENCY

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

- **Use different types of tools, dies, jigs and fixtures to machine simple components.**

3. COURSE OUTCOMES (COs)

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

a. Interpret geometries of various cutting tools.
b. Use relevant cutting tool insert and tool holders for different machining operations.
c. Use relevant locating and clamping devices for components.
d. Use relevant Jig and Fixture for components and machining operations.
e. Use relevant Press tools and Press tools operations.
f. Use relevant Die for bending and forging simple components.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

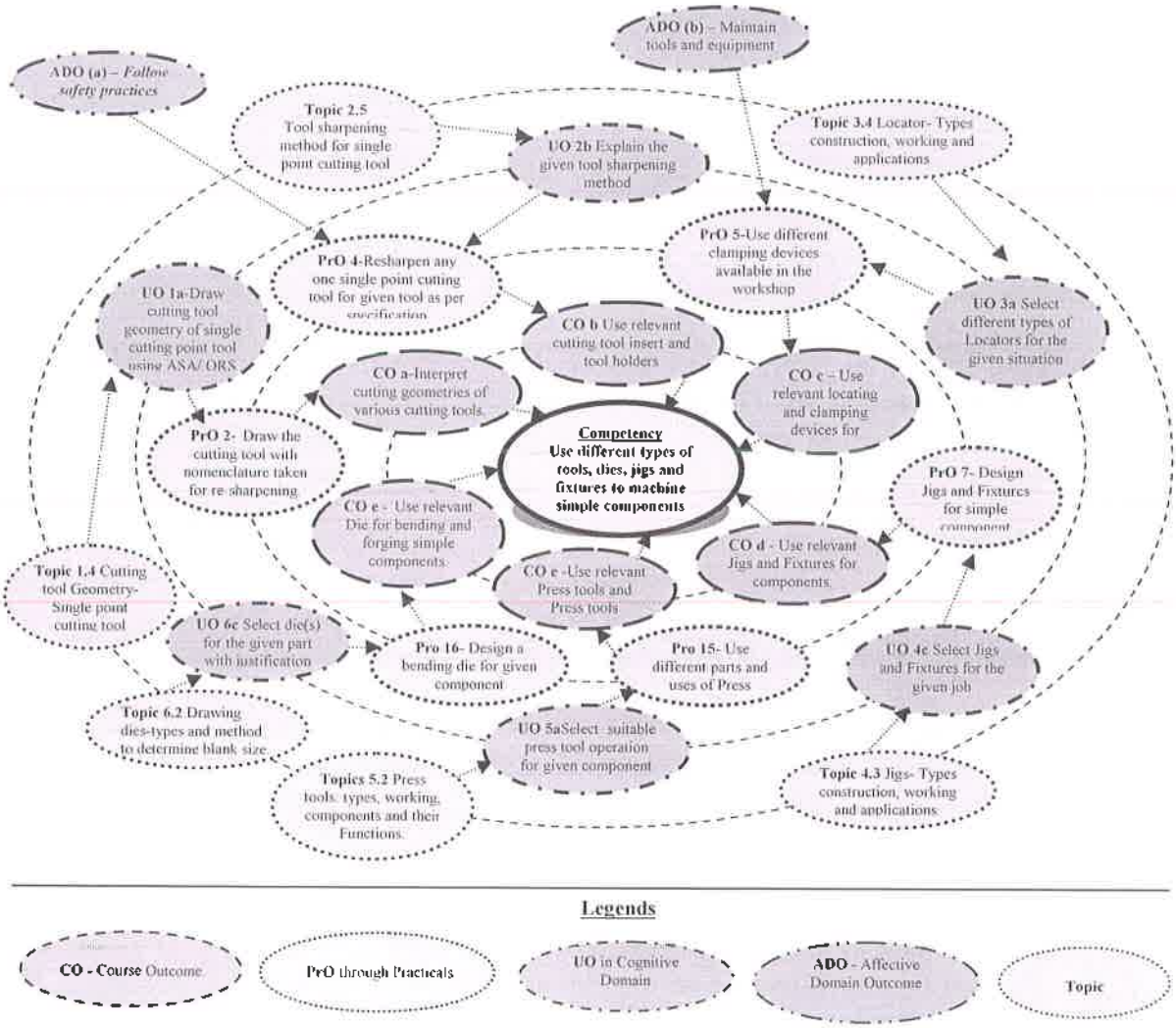


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the use of different types of tools, and their designation systems.	I	02*
2	Draw the cutting tool with nomenclature taken for re-sharpening.	I	02
3	Use different tool holders and their use with specific applications.	II	02*
4	Re-sharpen any one Single Point Cutting Tool as per given specification.	II	02
5	Use different clamping devices and their use available in the workshop.	III	02
6	Use different locators and their use available in the workshop	III	02
7	Design a Jig and Fixture for machining of a given simple component. (Part-I)	IV	02*
8	Design a Jig and Fixture for machining of a given simple component. (Part-II)	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Draw assembly and detail drawing of the designed Jig.	IV	02*
10	Draw assembly and detail drawing of the designed Fixture.	IV	02*
11	Design a progressive cutting die for a simple component.	V	02
12	Draw assembly and detail drawing of the designed progressive cutting die. (Part-I)	V	02
13	Draw assembly and detail drawing of the designed progressive cutting die. (Part-II)	V	02
14	Prepare Strip layout of simple component.	V	02*
15	Use different parts and uses of Press.	V	02*
16	Design a bending die for given component.	VI	02*
17	Draw bending die indicating all parts and dimensions.	VI	02
18	Estimate blank size for Deep Drawing a simple component.	VI	02
	Total		**36**

Note

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Single point cutting tool- 2 Qty	1,4,5
2	Drill – M12/M16/M20 size	1
3	Grinding Machine- Grinder Size 100 mm min.	1,4,5
4	Tool holders- Milling Cutter mandrill, Drill tool holder, Tool post of Lathe machine (Qty one each)	2
5	Clamping devices for drilling machine, Milling machine, Chucks (Qty one each)	5
6	Different Press tools	13

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Basics of Tool Engineering	1a. Classify the given cutting Processes. 1b. Estimate cutting forces in the given simple numerical problem situation. 1c. Draw cutting tool geometry of single cutting point tool using given ASA or ORS system. 1d. State the shear angle required for the given job with justification	1.1 Principles in tool engineering. 1.2 Mechanics of Metal cutting: requirements of tools. 1.3 Cutting forces – Merchant circle, types of chips, chip thickness ratio, shear angle. Shear angle- concept, need and method to give shear angle on punch and die. 1.4 Types of metal cutting process - orthogonal, cutting 1.5 Cutting tool Geometry- Single point cutting tool
Unit– II Cutting Tool Material and Holding Devices	2a. List the different properties and composition of the given tool material(s). 2b. Interpret ISO designation of the given tool insert. 2c. Select tool holders and inserts for the given component and machining operation with justification. 2d. Explain the given tool sharpening method(s).	2.1 Cutting tool materials - types, composition, properties and applications. 2.2 Carbide inserts -types, ISO -designation and Applications. Other inserts like CBN and PCBN. 2.3 Tool holders for turning, milling machines and CNC machines. 2.4 ISO designations of Tool holders. 2.5 Tool sharpening method for single point cutting tool.
Unit-III Locating and Clamping devices	3a. Explain principle of location with reference to the given work piece. 3b. Calculate the Degrees of freedom in the given situation. 3c. Select different types of Locators for the given	3.1 Concept, definition locating and clamping. 3.2 Use of locating and clamping principles on shop floor. 3.3 Degree of freedom concept and importance. 3.4 Locator- Types construction, working and applications. 3.5 Clamping devices - Types construction,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	situation with justification. 3d. Select different types of Clamping devices for the given situation with justification.	working and applications 3.6 Fool proofing and ejecting techniques.
Unit –IV Jigs and Fixtures	4a. Differentiate between given type of jig and fixture. 4b. Select the relevant Jigs for the given component with justification. 4c. Select the relevant fixtures for the given component with justification 4d. Explain the design procedure for the given Jig and fixture.	4.1 Concept, definition of jigs and fixtures. difference between jigs and fixtures. 4.2 Jigs- Types construction, working and applications. 4.3 Fixtures - Types construction, working and Applications. 4.4 Design considerations and procedure for Jigs and Fixtures.
Unit-V Press Tool design	5a. Select suitable press tool operation for the given simple press tool component with justification. 5b. Calculate press tonnage and centre of pressure for the given press tool component. 5c. Prepare scrap strip layout for the given press tool component. 5d. Design progressive cutting die for the given simple press tool component.	5.1 Press working processes-types, sketches and Applications. 5.2 Press tools: types, working, components and their Functions. 5.3 Concept, meaning, definitions and calculations of press tonnage and shut height of press tool. Shear action in die cutting operation. 5.4 Centre of pressure: Concept, meaning, definition, Methods of finding and importance. 5.5 Die clearance: Concept, meaning, definition, Reasons, effects and methods of application. 5.6 Cutting force: Methods to calculate and methods of reducing. 5.7 Scrap strip layout: - Concept, importance, method to prepare, and determining percentage stock utilization. 5.8 Types, working, and applications of stock stop, pilots, strippers and knockouts. 5.9 Cutting dies-types and applications. 5.10 Design of progressive cutting die: a) Sketch the component. b) Prepare scrap strip layout. c) Calculate tonnage. d) Determine centre of pressure. e) Determine dimensions of punches, die block and die shoe. f) Prepare sketch of stripper plate. g) General assembly sketch of punches arrangement, die block, die shoe and stripper plate.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-VI Bending, Drawing and Forging Dies	6a. Calculate bend radius, bend allowance and spring back for the given simple part. 6b. Draw labeled sketch of the given die(s). 6c. Select die(s) for the given part with justification.	6.1 Bending dies - a) Types and Parts and functions of bending die. b) Definition, calculations and factors affecting bend radii, bend allowance and spring back. c) Method to compute bending pressure.: Types, sketch, working and applications of bending dies. 6.2 Drawing dies-types and method to determine blank size for drawing operation, Types, sketch, working and applications of drawing dies (embossing, curling, bulging, coining, swaging and hole flanging). 6.3 Forging dies- terminology, types, sketch, working and application

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Tool Engineering	06	02	02	04	08
II	Cutting Tool Material and holding devices	06	02	02	04	08
III	Locating and Clamping devices	06	02	04	04	10
IV	Jigs and Fixtures	08	02	04	06	12
V	Press Tool design	12	04	06	10	20
VI	Bending, Drawing and Forging Dies	10	02	04	06	12
Total		**48**	**14**	**22**	**34**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Visit any industry and collect information related to tool engineering practices.
b. Prepare journal based on practical performed in Tool Engineering laboratory. Journal consists of drawing, observations, required materials, tools, equipments, date of performance with teacher signature.

c. Prepare/Download specifications of followings:
   i. Tools and equipment in Tool engineering laboratory.
   ii. Machineries in Tool Engineering laboratory
d. Undertake a market survey of local dealers for tools, equipments; machineries and raw material and prepare a report.
e. Visit to any press tool industry and prepare a report consisting of
   i. Types of press
   ii. Types of dies
   iii. Types of operations
   iv. Types of fool proofing arrangement
   v. Safety precautions observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Preparation of Wax/Rubber model of various dies/single point cutting tools.
b. Collect various Carbide inserts as per ISO specification.
c. Measure press capacity of any press available in industry or nearby industry.
d. Design simple Clamming devices/Jigs/Fixtures/locating for simple jobs.
e. Collect specifications of different Jigs and fixtures.
f. Sketch different jigs /fixtures/clamping devices available in institute workshop.
g. Identify and restrict degree of freedom of a given component for designing a clamping/locating device for a given machining operation.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Fundamentals of Electrical Networks	Gupta, B.R, and Singhal Vandana	S.Chand and Co., New Delhi, 2005 ISBN: 978-81-219-2318-7
2	Tool Design	Donaldson Cyrll	Mcgraw Hill Education, 2000 ISBN: 9780070153929, 0070153922
3	Tool Engineering, Jigs and Fixture	Atkins Albert	McGraw-Hill, 1922 ISBN/ASIN: 1151454966
4	Fundamentals of Tool Engineering Design	Basu S. K.	Oxford Ibh, 1979 ISBN 812040016X, 9788120400160
5	Tool Engineering and Design	Nagpal G. H.	Khanna Publication, 2003 ISBN : 817409203X
6	Machine tool and Tool Design	Sharma P. C.	S.Chand Publishing, 2012 SBN: 9788121923620,

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=Mn9jpqI8rao
b. https://www.youtube.com/watch?v=bUrp8JMRwx4andvl=en
c. https://www.youtube.com/watch?v=qaG_vxsfLUg
d. https://www.youtube.com/watch?v=EgTzD_8dUFc
e. https://www.youtube.com/watch?v=CrWxJ58la1E
f. https://www.youtube.com/watch?v=Pb20Rkx25yA
g. https://www.youtube.com/watch?v=Hp7UC5ite5M
h. https://www.youtube.com/watch?v=lcrK2Po8fJI
i. https://www.youtube.com/watch?v=_E1GCE2dDcY
j. https://www.youtube.com/watch?v=7yzvno4AvKw
k. https://www.youtube.com/watch?v=yoUxqeAN0So
l. https://www.youtube.com/watch?v=_r7djWX8X34
m. https://www.youtube.com/watch?v=Us7kjBmRL-Q
n. https://www.youtube.com/watch?v=S9qzJat3Mzk
o. https://www.youtube.com/watch?v=I71YrXafg0o
p. https://www.youtube.com/watch?v=wulJZzORm3wandpbjreload=10
q. https://www.youtube.com/watch?v=i5ZGSMXw5nU
r. https://www.youtube.com/watch?v=WJ_VlWd0EsA
s. https://www.youtube.com/watch?v=93-VH01ACB4
t. https://www.youtube.com/watch?v=MtNTFvP0uAI
u. https://www.youtube.com/watch?v=eqKa2gv9Kx0
v. https://www.youtube.com/watch?v=m8EoGASM0SI
w. https://www.youtube.com/watch?v=til4UOBTRg0

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Power Plant Engineering (Elective)**

Course Code : **22566**

1. RATIONALE

Electrical power is the main resource for any type of industry. Economic growth of the nation essentially results into growth in power sector. Various conventional power plants such as Hydro, Steam, Gas, Diesel, Nuclear power plants are employed for power generation. Most of the power plants use mechanical engineering equipment and components. Hence, this course attempts to provide the basic knowledge of the components, operation and maintenance of power plants to the students and would also acquaint them with the latest technological advances taking place in this sector.

2. COMPETENCY

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

- **Maintain power generation systems related to mechanical engineering.**

3. COURSE OUTCOMES (COs)

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

a. Identify various components of Hydro, Steam, Gas, Diesel power plants.
b. Select high pressure Boiler for power generation capacity of plants.
c. Identify components of Steam, Diesel and Gas turbine power plants.
d. Measure waste heat recovery in a typical thermal power plants.
e. Identify components of Nuclear power plants.
f. Estimate economic parameters of power plants.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

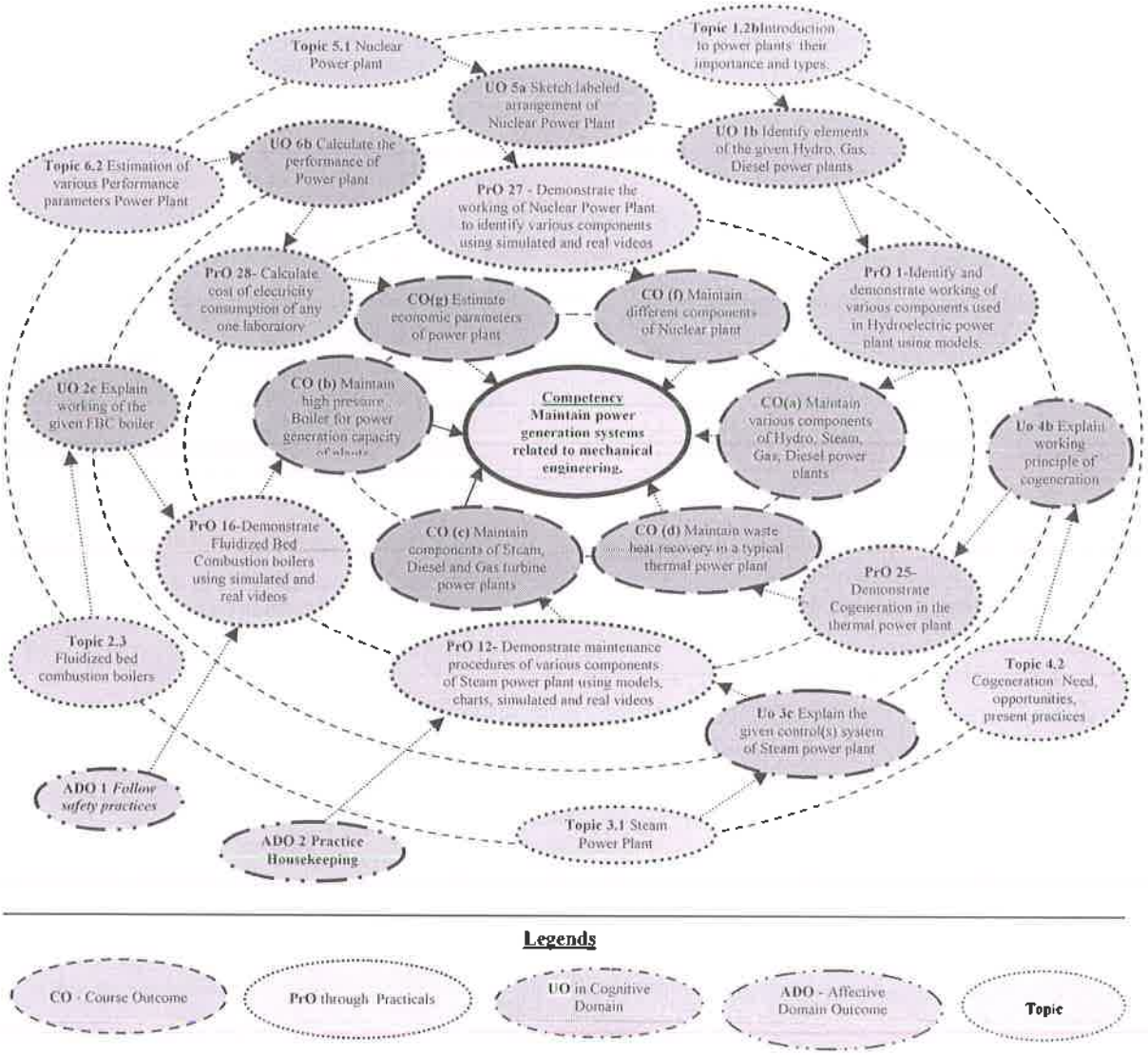


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Identify various components used in Hydroelectric power plant using models, charts, simulated and real videos.	I	02*
2	Maintain various components of Hydroelectric power plant using models, charts, simulated and real videos.	I	02
3	Identify various components used in Gas turbine power plant using models, charts, simulated and real videos.	I	02
4	Identify various components used in Gas turbine power plant using models, charts, simulated and real videos.	I	02
5	Maintain Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant	I	02*
6	Identify and demonstrate working of various components used in	I	02

	Diesel engine power plant using models, charts, simulated and real videos.		
7	Identify various components used in Diesel engine power plant using models, charts, simulated and real videos.	I	02
8	Maintain component like Diesel engine, Air filters, Super chargers, Engine starting system, Fuel system, Lubrication system, Cooling system, Governing system etc.of Diesel engine power plant	I	02*
9	Identify various components used in Diesel generating set using models, charts, simulated and real videos.	I	02
10	Maintain a typical small size Diesel generating set used in houses or shops	I	02*
11	Identify various components used in Steam power plant using models, charts, simulated and real videos.	III	02*
12	Maintain condenser, economizer etc. components of Steam power plant.	III	02*
13	Maintain working of any two types of High pressure Boilers using models, charts, simulated and real videos on High pressure Boilers.	II	02*
14	Maintain Fluidized Bed Combustion boilers using models, charts, simulated and real videos.	II	02*
15	Maintain the working of electro static precipitators using model, charts, simulated and real videos.	II	02
16	Maintain temperature and feed water control system using model, charts, simulated and real videos.	II	02*
17	Prepare model diagram of steam power plant by selecting various components for a given load. (Part-I)	III	02
18	Prepare model diagram of steam power plant by selecting various components for a given load. (Part-II)	III	02
19	Develop maintenance procedure for preventive and predictive maintenance of a typical Hydro Power Plant and its components.	I	02
20	Develop maintenance procedure for preventive and predictive maintenance of a typical Diesel power plant and its components.	I	02*
21	Develop maintenance procedure for preventive and predictive maintenance of typical FBC boilers and its components.	II	02*
22	Develop maintenance procedure for preventive and predictive maintenance of a typical High-pressure boiler and its components	II	02
23	Develop maintenance procedure for preventive and predictive maintenance of a typical Steam Power Plant and its components.	III	02*
24	Develop maintenance procedure for preventive and predictive maintenance of a typical Gas Power Plant and its components.	III	02
25	Demonstrate the concept of Cogeneration in the given thermal power plant using model, charts, simulated and real videos.	IV	02*
26	Maintain Trigeneration in the given thermal power plant using model, charts, simulated and real videos.	IV	02
27	Maintain the working of Nuclear Power Plant to identify various components using models, charts, simulated and real videos.	V	02*
28	Calculate cost of electricity consumption of any one Laboratory. (Part-I)	VI	02*
29	Calculate cost of electricity consumption of any one Laboratory. (Part-II)	VI	02*
	Total		32

Note

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

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

S.No.	Performance Indicators	Weightage in %
a.	Arrangement of available equipment / test rig or model	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Working Model of Hydro power plant- Small Turbine (capacity-0.25KW),lighting system as a load (min.10 bulbs of various capacity)	01
2	Model of gas power plant including all major components	02
3	Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant	04
4	5 KVA Diesel Generating set.	04
5	Working model of Steam Power plant- oil fired Boiler (min Capacity-0.5KW), Reaction steam Turbine, Surface Condenser, generator, power distribution system to power bank.	04,08,12

S. No.	Equipment Name with Broad Specifications	PrO. No.
6	Condenser, economizer etc. components of Steam power plant.	14
7	Working model of Loffler Boiler	05,12
8	Working model of Benson Boiler	05,12
9	Working model of Electro static Precipitator	07,12
10	Model of FBC Boiler	06,12
11	Working model of Feed water control system	04,08,12
12	Temperature sensor and temperature sensing system	04,08,12
13	Model of Nuclear Power plant	09
14	AxCYCLE Software:Thermodynamic Simulation Software for heat balance calculations of heat production and energy conversion cycles.	All

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Hydro, Gas, Diesel Power Plants	1a. Explain energy conversion in the given power plant. 1b. Identify elements of the given Hydro, Gas, Diesel power plant(s). 1c. Explain preventive procedure of the given power plants. 1d. Explain predictive maintenance procedure of the given power plants.	1.1 World and national scenario of demand and supply of energy. 1.2 Introduction to power plants: their importance and types. 1.3 Hydroelectric power plant: Classification, General arrangement, operating principle, advantages and limitations, Maintenance. 1.4 Diesel power plant: Introduction, components, advantages and limitations, Diesel generating set, Maintenance.
Unit– II High Pressure Boilers	2a. Explain with sketches of the working of the given type of boiler 2b. Compare the salient features of the given types of high pressure boilers. 2c. Explain Preventive maintenance of the given High pressure boilers. 2d. Explain Predictive maintenance of the given High pressure boilers.	2.1 High Pressure Boilers – Classification. 2.2 Construction and principle of working of Lamont boiler, Benson boiler, Loeffler boiler, Velox boiler, Schmidt Hartman boiler, Ramsin boiler 2.3 Fluidized bed combustion boilers (FBC): principle, need, types, various arrangement, control system and advantages over other boiler systems. 2.4 Comparison of various types of boilers 2.5 Indian Boiler Regulation Act 2.6 Maintenance procedure of major components of high pressure and FBC boilers
Unit-III Steam and Gas Power Plants	3a. Explain with sketches the given Fuel handling system. 3b. Identify various elements of the given Steam power plant and its control system. 3c. Explain with sketches the given control(s) system of	**Steam Power Plants** 3.1 Steam power plant: Introduction, components, advantages and limitations 3.2 Fuel handling systems in power plants: types, components 3.3 Electro-Static Precipitators 3.4 Control systems of power plant –

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Steam power plant. 3d. Identify the given Component(s) of Gas Power Plant. 3e. Explain preventive maintenance of the given major component of given turbine power plants. 3f. Explain predictive maintenance of the given major component of given turbine power plants	Elements, Types, desirable characteristics. 3.5 Steam temperature control and feed water control systems. 3.6 Maintenance procedure of major components of Steam power plant. **Gas Turbine Power Plants** 3.7 Open and close cycle with constant pressure gas turbine power plant 3.8 Components of gas turbine power plant 3.9 Methods to improve the thermal efficiency of a simple open cycle constant pressure gas turbine power plan 3.10 Advantages of gas turbine power plant over others. 3.11 Maintenance procedure of major components of Gas turbine power plants.
Unit –IV Waste Heat Recovery, Cogeneration and Trigeneration	4a. Explain the need of waste heat recovery of the given thermal power plants. 4b. Explain with sketches working principle of cogeneration and trigeneration in the given thermal power plant.	4.1 Waste heat recovery in thermal power plants: Need, opportunities, present practices 4.2 Cogeneration: Need, opportunities, present practices 4.3 Trigeneration: Need, opportunities, present practices
Unit-V Nuclear Power Plants	5a. Sketch labeled arrangement of the given nuclear power plant. 5b. Explain with sketches working of the given reactors. 5c. Compare the calorific values of the given types of fuels. 5d. Interpret the regulations for nuclear power plants.	5.1 Nuclear power plant: Classification, General arrangement, operating principles 5.2 Nuclear Fuels and Reactors 5.3 Advantages and limitations 5.4 Introduction to regulating agencies and regulations: Atomic Energy Regulatory Board (AERB), International Atomic Energy Agency (IAEA)
Unit-VI Economic Analysis of Power Plants.	6a. Estimate Cost of Electricity in the given situation using simple numerical problems. 6b. Calculate performance parameters for the given power plant using simple numerical problems.	6.1 Estimation of production cost of electrical energy in various types of power plants. 6.2 Estimation of various Performance parameters. 6.3 Factors affecting choice of a power plant.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Power plants	08	02	04	06	12
II	High Pressure Boilers	08	02	04	06	12
III	Steam and Gas Power Plants	10	02	04	08	14
IV	Waste Heat Recovery, Cogeneration and Trigeneration	06	02	02	04	08
V	Nuclear Power Plants	08	02	04	06	12
VI	Economic Analysis of Power Plants	08	02	04	06	12
Total		48	**12**	**22**	**36**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a) Prepare journal based on practical performed in Power Plant Engineering laboratory. Journal consists of drawing, observations, required equipment, date of performance with teacher signature.
b) Prepare/Download the specifications of followings:
   i. Power plant equipment.
   ii. Steam power plant equipment and elements.
   iii. Gas turbine power plant equipment and elements.
   iv. Hydro power plant equipment and elements.
   v. Diesel power plant equipment and elements.
c) Visit to any Power plant and prepare a report consisting of
   i. Various advanced systems
   ii. Various standards
   iii. Maintenance of components of power plant observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with power plant system and equipments.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various components, operation and maintenance of power plants.
i) Before starting practical, teacher should demonstrate the working of power plant.
j) Instructions to students regarding care and maintenance of measuring equipments.
k) Show video/animation films to explain functioning of various power plants
l) Teacher should ask the students to go through instruction and Technical manuals

12. SUGGESTED MICRO-PROJECTS

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

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

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

a) Collection of information of control systems of power plant.
b) Collection of information about nearby cogeneration plant.
c) Comparative study of various parameters of performance evaluation of a power plant.
d) Measure operating parameters of Boiler using appropriate instruments.
e) Maintenance of a diesel generator set (DG set).
f) Collect information regarding preventive, predictive and breakdown maintenance of various power plants.
g) Develop maintenance procedure for preventive and predictive maintenance of a typical Hydro Power Plant and its components.
h) Develop maintenance procedure for preventive and predictive maintenance of a typical Diesel power plant and its components.
i) Develop maintenance procedure for preventive and predictive maintenance of typical FBC boilers and its components.
j) Develop maintenance procedure for preventive and predictive maintenance of a typical High-pressure boiler and its components
k) Develop maintenance procedure for preventive and predictive maintenance of a typical Steam Power Plant and its components.
l) Develop maintenance procedure for preventive and predictive maintenance of a typical Gas Power Plant and its components.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Power Plant Engineering	Nag, P. K.	Tata McGraw Hill India, 2007 ISBN: 9789339204044
2	Power Plant Technology	El-Wakil M. M.	McGraw Hill Education, (India),

S. No.	Title of Book	Author	Publication
			2010 ISBN: 9780070702448
3	Power Plant Engineering	Raja, A. K.	Prentice Hall, 2006 ISBN : 9788122418316
4	A Text Book of Power Plant Engineering	Sharma, P. C. and Nagpal	McGraw Hill Education, (India) ISBN : 9789350143841
5	Steam and Gas Turbine and Power plant Engineering	Yadav, R	Central Publication house ISBN : 9788185444352

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=-hooifWJ1jY
b. https://www.youtube.com/watch?v=Uhjhufhg3Xk
c. https://www.youtube.com/watch?v=_UwexvaCMWA
d. https://www.youtube.com/watch?v=_AdA5d_8Hm
e. https://www.youtube.com/watch?v=ChvI2v85fsU
f. https://www.youtube.com/watch?v=IdPTuwKEfmA
g. https://www.youtube.com/watch?v=XjbczcFNrNU
h. https://www.youtube.com/watch?v=0rsPFdkwR0
i. https://www.youtube.com/watch?v=gDVukHOxURc
j. https://www.youtube.com/watch?v=02p5AKP6W0Q
k. https://www.youtube.com/watch?v=FXBqvLWxbr0
l. https://www.youtube.com/watch?v=dCPfHifMbOk
m. https://www.youtube.com/watch?v=b6-n0pFu5d4
n. https://www.youtube.com/watch?v=iUXHzYLgrB0
o. https://www.youtube.com/watch?v=ZssGiY6rfYE
p. https://www.youtube.com/watch?v=F01AFJe2j2A
q. https://www.youtube.com/watch?v=c6wDRQMD-YE
r. https://www.youtube.com/watch?v=ks-G4FYVtg
s. https://www.youtube.com/watch?v=H6EClYcfXKw
t. https://www.youtube.com/watch?v=KmYbupS4u-k
u. https://www.youtube.com/watch?v=rEJKiUYjW1E
v. https://arupatan.in/info/959/coal_mill_operation_power_plant/
w. https://www.youtube.com/watch?v=KmYbupS4u-k


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

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

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

Semester : **Fourth**

Course Title : **Capstone Project – Planning**

Course Code : **22050**

1. RATIONALE

According to the requirement of National Board of Accreditation (NBA), 'learning to learn' is an important Graduate Attribute (GA No.11). It is required to develop this skill in the students so that they continue to acquire on their own new knowledge and skills from different 'on the job experiences' during their career in industry. An educational 'project' just does that and may be defined as ***'a purposeful student activity, planned, designed and performed by a student or group of students to solve/ complete the identified problem/task, which require students to integrate the various skills acquired over a period to accomplish higher level cognitive and affective domain outcomes and sometimes the psychomotor domain outcomes as well'***. Projects mainly serve this purpose of developing learning-to-learn skills with an aim to develop the following attributes in the students:

a) Initiative, confidence and ability to tackle new problems
b) Spirit of enquiry
c) Creativity and innovativeness
d) Planning and decision making skills
e) Ability to work in a team and to lead a team
f) Ability of self directed learning which is required for lifelong learning
g) Persistence (habit of not giving up quickly and trying different solutions in case of momentary failures, till success is achieved)
h) Resourcefulness
i) Habit of keeping proper records of events and to present a formal comprehensive report of their work.

2. COMPETENCY

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

- **Plan innovative/creative solutions independently and/or collaboratively to integrate various competencies acquired during the semesters to solve/complete the identified problems/task/shortcomings faced by industry/user related to the concerned occupation.**

3. COURSE OUTCOMES (COs)

The following could be some of the major course outcomes depending upon the nature of the projects undertaken. However, in case of some projects few of the following course outcomes may not be applicable.

a) Write the problem/task specification in existing systems related to the occupation.
b) Select, collect and use required information/knowledge to solve the problem/complete the task.
c) Logically choose relevant possible solution(s).
d) Consider the ethical issues related to the project (if there are any).
e) Assess the impact of the project on society (if there is any).
f) Prepare 'project proposals' with action plan and time duration scientifically before beginning of project.

g) Communicate effectively and confidently as a member and leader of team.

4. TEACHING AND EXAMINATION SCHEME

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

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

5. Capstones Project

One of the dictionary meaning is the 'crown' or the stone placed on top of the building structure like 'kalash on top of Temples and Mosques' or 'Cross on top of churches'. Capstone projects are culminating experiences in which students synthesize the competencies acquired over whole programme. In some cases they also integrate cross-disciplinary knowledge. Thus Capstone projects prepare students for entry into a career and can be described as a 'rite of passage' or 'minimal threshold' through which participants change their status from student to graduate. A capstone project therefore should serve as a synthesis — reflection and integration — to bridge the real-world preparatory experience to real life. Thus capstone project should have emphasis on integration, experiential learning, and real-world problem solving and hence these projects are very important for students. To develop the highly essential industry oriented skills and competencies in the students, the capstone projects are offered in the last two semesters to serve for following purposes:

a) Integrate the competencies acquired by the students in the previous and current semesters.
b) Provide opportunities for interdisciplinary work in tackling problems likely to be faced by them in industry which are exciting and challenging.

6. Capstone Project Planning

Students are supposed to find out a suitable project and prepare a detailed plan in fifth semester so that it can be executed smoothly in sixth semester. The main characteristic of any project whether small or big is that it requires simultaneous application of various types of skills in the different domains of learning. Moreover, project normally do not have a predefined single solution, in other words for the same problem different students may come up with different but acceptable solutions. Further, in the process of arriving at a particular solution, the student must be required to make a number of decisions after scrutiny of the information s/he has accumulated from experiments, analysis, survey and other sources.

The projects will have a detailed project proposal, which must be executed or implemented within the time allocated, simultaneously maintaining a logbook periodically monitored by the teacher. A detailed project report is to be prepared as project progresses, which has to be submitted after the project is over. For self assessment and reflection students have to also prepare a portfolio of learning.

During the guidance and supervision of the project work, teachers' should ensure that students acquire following ***learning outcomes*** (depending upon the nature of the project work some of these learning outcomes may not be applicable):

a) Show the attitude of enquiry.
b) Identify the problems in the area related to their programme.
c) Identify the information suggesting the cause of the problem and possible solutions.
d) Assess the feasibility of different solutions and the financial implications.

e) Collect relevant data from different sources (books/internet/market/suppliers/experts etc. through surveys/interviews).
f) Prepare required drawings and detailed plan for execution of the work.
g) Work persistently and participate effectively in group work to achieve the targets.
h) Work independently for the individual responsibility undertaken.
i) Ask for help from others including guide, when required.
j) Prepare portfolio to reflect *(chintan-manan)* on experiences during project work.
k) Prepare seminar presentations to present findings/features of the project.
l) Confidently answer the questions asked about the project.
m) Acknowledge the help rendered by others in success of the project.

If students are able to acquire these *learning outcomes*, then they would be able to acquire the COs as discussed in section 3.

7. Scopes of Projects

Scope of the project work should be decided based on following criteria:

a) Relation to diploma programme curriculum: When students intend to select topics for the project work they need to choose a project which relates well to their curriculum (It may be beyond curriculum, but it should relate to it) and requires implementation of theories already learnt and skills already possessed by them from the previous semesters.

b) Abilities possessed by the group of students: Projects should be chosen so that it can be completed mainly using students' problem solving capabilities and depth of learning. It is natural that highly motivated students or high achievers may come out with projects which are more complex and challenging. Teachers should guide students to choose challenging projects according to the students' ability.

c) Resources Available: Students and Guides should keep in mind the availability of resources while deciding the topic and the scope of the project. Some of the important resources which need consideration are:

i. Time available
ii. Raw Material/Components required
iii. Manufacturing/Fabrication equipment and tools required
iv. Testing/Measuring equipment and instruments required
v. Access to Journals (Library/Digital)
vi. Expertise for theoretical guidance (available in polytechnic, nearby institutes or nearby industries)
vii. Expertise and technology required for fabrication (if required)
viii. Software required.

An important aspect to be considered is to decide who will choose a project. The best practice is that teacher should guide students about the above factors to be considered for choosing the project and based on these factors students should do the ground work and identify the possible projects and teachers should work as only facilitator and Guide in final selection of the project title and its scope.

d) Suggested Type of Capstone Projects

In general, the projects that the students can take up could be of the following types;

i. Feasibility studies.
ii. Design projects
iii. Market surveys about raw material, components or finished products.
iv. Prototype (design, make, test and evaluate).
v. Advanced experimental work requiring the development of existing equipment to be used and developed.
vi. Field works: This could include surveys, using equipment, charting data and information from visual observation.

vii. Comparative Studies: Theoretical study of two systems/mechanisms/ processes in detail and comparing them on the basis of cost/energy conservation/impact on environment/technology used etc.
viii. Application of Emerging technology: Theoretical study of some emerging technology and feasibility of its application in some real life situation in detail.
ix. Fabrication of some equipment/machine etc.
x. Construction of some structure.
xi. Development of software or use of software for solving some broad-based problem.

8. GUIDELINES FOR UNDERTAKING A PROJECT

The selection of the *Capstone Project title* must have emphasis to the Elective courses/ Elective Group taken for the study and exam for 5th and 6th semester. The students will then work on the identified problem/task through a rigorous process of understanding and analyzing the problem, conducting a literature search, deriving, discussing (monitored by the guide every fortnight) and designing the ***Semester V 'Project Proposal'*** with the following ***sub-titles***:

a) Rationale (one page)
b) Introduction
c) Literature Survey
d) Problem Definition
e) Proposed Methodology of solving Identified problem
f) In-case some prototype has to be fabricated then its tentative design and procedure for making it should be part of the proposal.
g) Resources and consumables required.
h) Action Plan (sequential list of activities with probable dates of completion)

As soon as the 'Project Proposal' is approved by the teacher, the student will begin to maintain a dated ***'Project Logbook'*** for the whole semester. This is a sort of a 'weekly diary' indicating all the activities conducted by the student every week in the semester to complete the project. This *'project logbook'* should be got signed by the teacher at regular intervals for progressive assessment to match the project proposal. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the 'Project Report' at the end of the semester by him/her.

9. PORTFOLIO FOR SELF-DIRECTED LEARNING

To ensure that students acquire these outcomes, students should also be guided to prepare a **'Portfolio'**, so that they may reflect on their weaknesses/mistakes and learn from them. ***Students should also be encouraged to discuss with their guide and record not only technical problems but also problems related to group work, planning, execution, leadership in the team etc., so that students can also identify their weaknesses in affective domain and take remedial actions to overcome the same.*** If they wish, the students can also show their portfolio to their teachers (whom they trust) for obtaining teachers' comments on their reflection for pointing out their mistakes so that they can improve their performance.

'Portfolio' is the record of the reflection (thinking or *chintan-manan*) on experiences to which students undergo during the different stages of the project. In a portfolio, students record their critical experiences and reflect (think or do *chintan-manan*) on them in writing. This process of reflecting on the experiences make them learn from their mistakes and build on their strengths. To help students in reflection, a Portfolio format with reflective prompts (simple thought provoking questions) for different stages of the project is given as annexure B.

12.1 Purposes of Portfolio Preparation

Reflection by self is important since group work is so complex that it is difficult for teachers to appreciate the real problems amongst the students. In a portfolio, prompts (simple thought provoking questions) are given to trigger reflection on different aspects of project work. Prompts help the students to ask questions from themselves regarding different aspects of the project work and interpersonal relationships. Process of answering these questions forces students to think about behavioral problems and possible remedies/solution to deal with those problems. Portfolio preparation therefore helps in reflection on building the strengths and elimination of the weaknesses of the students pertaining to following qualities which the industry also need.

a) Plan properly for execution of given work.
b) Take appropriate decisions.
c) Arrange resources.
d) Work as member and leader of team.
e) Communicate properly.
f) Resolve the conflicts.
g) Manage the time well.
h) Have concern for ethical, societal and environmental issues.
i) Learn-to-learn from experiences.

It may be seen that these qualities are not directly related with the theoretical subject knowledge and can be developed only through real life experiences. Project work is one such type of experience where opportunity is available to develop all these qualities.

However, even during project work, emphasis of most of the students and teachers remains on development of the technical knowledge and skills while development of above qualities is neglected. Students can develop these qualities if they reflect (do thinking or *Chintan-Manan*) on their experiences from the point of view of these qualities and find out their own weaknesses and strengths. Because if somebody wants to improve his/her abilities then first step for that person is to have self awareness about his/her weaknesses and strengths.

Though portfolio preparation requires considerable time, it is essential, if we want to learn from the experiences and develop these qualities. Writing down reflections helps in better reflection as it is well known that when a person starts writing something he/she becomes more cautious about his/her view and evaluate those views before writing. Thus process of writing improves the quality of reflection or thinking. Moreover, if reflections on different stages of work are written down, over a period of time a large amount of reflection can be generated, and if this reflection is looked back, it may help in identifying some pattern of behaviour in individual which may be improved or rectified latter on as per requirement.

12.2 Guidelines for Portfolio Preparation and assessment

The main purpose of portfolio preparation is learning based on self-assessment and ***portfolio is not to be used for assessment in traditional sense.***

a) Each student has to prepare his/her portfolio separately. However, he/she can discuss with the group members about certain issues on which he/she wants to write in the portfolio.
b) For fifth semester and sixth semester, there will be only one portfolio but it will have two separate parts, first part for project planning (having two sections A and B) second part for project execution. (having two sections C and D)
c) Whatever is written inside the ***portfolio is never to be used for assessment***, because if teachers start giving marks based on whatever is written in the portfolio, then students would hesitate in true self-assessment and would not openly describe their own mistakes or shortcomings.

d) Some marks are allocated for portfolio, these marks are to be given based on how sincerely portfolio has been prepared and not based on what strengths and weaknesses of the students are mentioned in the portfolio.
e) Portfolio has to be returned back to the students after assessing it (assessment is only to see that whether portfolio is completed properly or not) by teachers. Because student is the real owner of the portfolio.
f) Students mainly learn during portfolio preparation, but they can further learn if they read it after a gap. And hence they are supposed to keep the portfolios with them even after completion of the diploma because it is record of their own experiences (it is like diary some people write about their personal experiences), because they can read it again after some time and can revise their learning (about their own qualities)

Even after completion of Diploma programme, students can continue to prepare portfolio related to different experiences in their professional and personal life and by refereeing back to old portfolios after a gap of some years, they can learn that how their personality has evolved over the years. They can also see a pattern of behaviour in their own personality which may be source of their weaknesses or strengths and they can take remedial measures based on this study of their portfolios.

Note

Since some sections of the portfolio are related with interpersonal relationships and student may find it difficult to write these experiences in English. Language should not be the barrier in reflection and hence students should be allowed to prepare the portfolio in their preferred language such as *Marathi* or *Hindi if they find it difficult to write in English.*

The amount and type of mistakes identified by students would not affect the marks received by the students. The total 7 Marks allocated for portfolio (4 marks for PA and 3 for ESE) are only for proper completion of the portfolio.

10. PROJECT REPORT

At the end of fifth Semester, the student will prepare a Semester V 'Project Report' with the following sub-titles:

- Certificate (in the Format given in this document as annexure A)
- Acknowledgements
- Abstract (in one paragraph not more than 150 words)
- Content Page
- Chapter-1 Introduction and background of the Industry or User based Problem
- Chapter-2 Literature Survey for Problem Identification and Specification,
- Chapter-3 Proposed Detailed Methodology of solving the identified problem with action plan
- References and Bibliography

Note: The report should contain relevant diagrams and figures, charts.

11. ASSESSMENT OF CAPSTONE PROJECT – PLANNING

Like other courses, assessment of Project work also has two components, first is progressive assessment, while another is end of the term assessment. The mentor faculty will undertake the progressive assessment to develop the COs in the students. They can give oral informal feedback about their performance and their interpersonal behaviour while guiding them on their project work every week. The following characteristics/ qualities informally or formally should be considered during different phases of the project work which will be assessed thrice as discussed in sub-section.

(A) Initial Phase

i. **Definition of the Problem**
   a) Accuracy or specificity

b) Appropriateness with reference to desired course outcomes.

ii. **Methodology of Conduction the Project**
   a) Appropriateness
   b) Flexibility
   c) Clarity

iii. **General Behaviour**
   a) Initiative
   b) Resourcefulness
   c) Reasoning ability
   d) Imagination/creativity
   e) Self-reliance

(B) Intermediate Phase

i. **Performance of Student**
   a) Ability to follow correct procedure
   b) Manipulative skills
   c) Ability to collect relevant information
   d) Ability to observe, record & interpret
   e) Ingenuity in the use of material and equipment
   f) Target achievement

ii. **General Behaviour**
   a) Persistence
   b) Interest
   c) Commitment
   d) Confidence
   e) Problem solving ability
   f) Decision making ability
   g) Initiative to act
   h) Team spirit.
   i) Sharing of material etc.
   j) Participation in discussion
   k) Completion of individual responsibilities

(C) Final Phase

i. **Quality of Product**
   a) Dimensions
   b) Shape
   c) Tolerance limits
   d) Cost effectiveness
   e) Marketability
   f) Modernity

ii. **Quality of Report**
   a) Clarity in presentation and organization
   b) Styles and language
   c) Quality of diagrams, drawings and graphs
   d) Accuracy of conclusion drawn
   e) Citing of cross references
   f) Suggestion for further research/project work

iii. **Quality of presentation**
   a) Understanding of concepts, design, methodology, results, implications etc
   b) Communication skills
   c) Ability to draw conclusions and generalization

12. PROGRESSIVE ASSESSMENT (PA) GUIDELINES

15 Marks are allocated for the formal progressive assessment. However, following points need consideration during the three times of formal progressive assessment of the students at the end of 4th, 12th and 14th week.

a) ***Fortnightly monitoring*** by the mentoring teachers is necessary and marks given progressively (even the gradual chapter preparation) so that that students will not copy earlier reports or get things done or reports from the market. The ***students should not be awarded marks*** if they have not done on their own.

b) For progressive assessment at the end of 14th week, students should be asked to give the power point presentation before group of teachers and junior students (so that junior students may also get awareness about the capstone project work they have to carry out in future).

c) Although marks for *portfolio preparation* is to be given at the end of 14th week, students should be asked to bring their partly prepared portfolio (relevant sections prepared) also during their assessment at the end of 4th week and 12th week.

d) Marks for portfolio preparation should be based only on proper preparation of portfolio by writing answers to most of the prompts (self-questions to students) in the portfolio. These marks should not be based on the mistakes indicated by students in their working (while answering the prompts) and corrective actions taken by them.

e) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks if they have done enough efforts.)

f) ***Originality of the report*** (written in own words) would be given more importance rather than use of glossy paper or multi-colour printing.

12.1 Progressive Assessment (PA) Criteria

Allocation Criteria of the ***25 marks*** are for the Progressive Assessment (PA).

S. No.	Criteria	Marks
	First Progressive Assessment at the end of 4th week	
1	**Problem Identification/Project Title** (Innovation /Utility of the Project for industry/ User/Academia) marks to be also given based on (i) Accuracy or specificity of the scope and (ii) Appropriateness of the work with reference to desired course outcomes.	02
2	**Industrial Survey and Literature Review**: marks to be given based on extent/volume and quality of the survey of Industry / Society / Institutes/Literature/Internet for Problem Identification and possible solutions	02
3	**General Behaviour**: initiative, resourcefulness, reasoning ability, imagination/creativity, self-reliance to be assessed **Note:** Oral feedback on general behaviour may also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back/suggestions**	**00**
	Second Progressive Assessment at the end of 12th week	
4	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester	**03**

S. No.	Criteria	Marks
5	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	02
6	**Log book** (for work done in fifth semester, detailed and regular entry would be basis of marks)	02
7	**General Behaviour** (persistence, interest, confidence, problem solving ability, decision making ability, initiative to act, team spirit, sharing of material etc., participation in discussions, completion of individual responsibilities, leadership) **Note:** Oral feedback on general behaviour should also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back./suggestions**	00
	Third Progressive Assessment at the end of 14th week	
8	**Portfolio for Self learning and reflection** (marks based on amount of reflection and completion of the portfolio for work done in fifth semester)	**04**
9	**Final Report writing including documentation**. (marks based on: clarity in presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work) Report has to be prepared for work done in fifth semester and planning for sixth semester work.	**06**
10	**Presentation** (presentation skills including communication skills to be assessed by observing quality of presentations and asking questions during presentation and viva/voce) Report has to be prepared for work done in fifth semester and plan for sixth semester.	**02**
11	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**02**
	Total	**25**

13. END-SEMESTER-EXAMINATION (ESE) ASSESSENT GUIDELINES

The ***remaining 25 marks*** are for the end semester examination (ESE). And marks would be given according to following criteria. Moreover, the suggested evaluation scheme can be changed slightly by the external faculty according to nature of problem / project following University guidelines..

a) For each project, the one or two students from the concerned group of students should be asked to present the power point presentation before the external and internal (for about 10 minutes) and then external should ask the questions from each member of the group separately to ascertain the contribution made by each student.

b) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks commensurate with their efforts.)

c) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).

d) Originality of the report (written in own words, even if there are grammatical and spelling mistakes) would be given more importance rather than quality of printing and use of glossy paper (and preparing report by copy pasting from other reports).

Note: It is very common that people are not able to complete the project in time despite best of their efforts. (Please recall that how many times people are able to complete in time, personal projects such as building own house or professional projects such as developing the lab in the institute). So if students have put in enough genuine efforts but could not complete the project in time then we should consider it sympathetically and they should be given marks based on their efforts and they should get more marks as compared to students who have got their projects completed by taking major help from others/market.

13.1 End-Semester-Examination (ESE) Assessment Criteria.

Allocation Criteria of the ***25 marks*** are for the end-semester-examination (ESE)

S. No.	Description	Marks
1	**Problem Identification/Project Title** (innovation /utility of the project for industry/ user/academia) marks to be also given based on (i) accuracy or specificity of the scope and (ii) appropriateness of the work with reference to desired course outcomes.	**02**
2	**Industrial Survey and Literature Review** (marks to be given based on extent/volume and quality of the survey of industry / society / institutes/literature/internet for problem identification and possible solutions)	**02**
3	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester.	**02**
4	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	**02**
5	**Log book** (for work during fifth semester, marks to be given based on detailed and regular entry	**03**
6	**Portfolio for Self learning and reflection** (for work during fifth semester) Marks based on amount of reflection and completion of portfolio.	**03**
7	**Project Report including Documentation** (for work during fifth semester and planning for sixth semester) (marks based on: clarity in	**04**

S. No.	Description	Marks
	presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work)	
8	**Presentation** (presentation skills including communication skills to be assessed by observing the quality of presentations and asking questions during presentation and viva/voce) Presentation should be based on work done in fifth semester and planning for sixth semester.	**03**
9	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**04**
	Total	**25**

14. SPECIAL TEACHING STRETAGIES (If any)

a) Teacher's should not spoon feed the students and let them try on their own at different stages of the project work and even first let them strive hard and only when efforts of students have failed, then teacher should guide them. Guidance should be in initially in the form of clues or hints rather than complete explanation, detailed explanation should be given only when students are not able to work based on clues/hints. The role of teacher should be limited to guide and facilitator

b) Teachers should guide students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) Teachers should ensure that students prepare the project plan in as much detail as possible, since this way only they would learn the importance of planning and how to do the detail planning. Teachers should allow students to proceed ahead only when they have detailed plan with them.

d) Teachers should motivate students to maintain log book and prepare portfolio. They should explain benefits of these activities to students and also train them in these activities, because most of them may be doing this first time.

e) Teachers should also encourage students to openly discuss their weaknesses and shortcomings in portfolio and teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them and their marks would not be affected by revealing their mistakes. Marks related to portfolio are awarded based only on the sincerity with which it is prepared and not based on strengths and weaknesses of students.

f) Teachers should continuously discuss with students about working of group and progress in the project and from this discussion should identify their personal qualities (both strengths and weaknesses) and suggest to them ways for improving those qualities.

g) Internal as well as external examiners should reward students for original work and efforts of students even if they are not fully successful or not able to complete the project in comparison to those students who have taken paid help from others to complete their project.

Annexure A

CERTIFICATE

This is to certify that Mr./Ms.....

From .....College having Enrolment No: .....

has completed ***Report on the Problem Definition/ Semester V Project Report/ Final Project Report*** having title .....

individually/ in a group consisting of..... persons under the guidance of the Faculty Guide.

.....
The mentor from the industry for the project
Name: .....
Telephone:.....

Annexure B

Portfolio for Self Directed Learning for Major Project Work

Name of Student:.....

Semester:.....**Programme/Branch:**.....

Roll Number:.....

Title of the Project:.....

Name and Designation of Project Guide:.....

Name of Polytechnic:.....

Part A: Selecting the Project and Team (Answers to the following questions to be included in 'Portfolio' as Reflection related to formation of group and finalization of project topic).

Note: This section has to be prepared just after the finalization of the Project topic and formation of the Project Team .

1. How many alternatives we thought before finalizing the project topic?
2. Did we consider all the technical fields related to branch of our diploma programme?
3. Why we found present project topic as most appropriate?
4. Whether all the group members agreed on the present project topic? If not? What were the reasons of their disagreements?
5. Whether the procedure followed in assessing alternatives and finalizing the project topic was correct? If not, discuss the reasons.
6. What were the limitations in other alternatives of project topic?
7. How we formed our team?
8. Whether we faced any problem in forming the team? If yes, then what was the problem and how was it resolved?

9. Am I the leader of our project team? If yes, then why was I chosen? If not, why I could not become the project team leader?
10. Do I feel that present team leader is the best choice available in the group? If yes, then why? If not, then why?
11. According to me who should be the leader of the team and why?
12. Can we achieve the targets set in the project work within the time and cost limits?
13. What are my significant good/ bad sharable experiences while working with my team which provoked me to think? What I learned from these experiences?
14. Any other reflection which I would like to write about formation of team and finalization of project title, if any?

Part B: Reflection related to project planning (Answers to the following questions to be included in 'Portfolio' as reflection on planning)

Note: This section has to be prepared just after the finalization of the 'Project Proposal'.

1. Which activities are having maximum risk and uncertainty in our project plan?
2. What are most important activities in our project plan?
3. Is work distribution is equal for all project group members? If not? What are the reasons? How we can improve work distribution?
4. Is it possible to complete the project in given time? If not what are the reasons for it? How can we ensure that project is completed within time.
5. What extra precaution and care should be taken in executing the activities of high risk and uncertainty? If possible, how such risks and uncertainties can be reduced?
6. Can we reduce the total cost associated with the project? If yes, then describe the ways?
7. For which activities of our project plan, arrangement of resources is not easy and convenient?
8. Did we make enough provisions of extra time/expenditure etc. to carry out such activities?
9. Did we make enough provisions for time delays in our project activity? In which activities there are more chances of delay?
10. In our project schedule, which are the days of more expenditure? What provisions we have made for availability and management of cash?
11. Any other reflection which I would like to write about project planning?

Teacher Evaluation Sheet (ESE)
for
Capstone Project Planning

Name of Student: .....

Name of Programme..... **Semester:** .....

Course Title and Code:.....

Title of the Capstone Project: .....

A. POs addressed by the Capstone Project (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

B. COs addressed by the Capstone Project (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

C. OTHER LEARNING OUTCOMES ACHIEVED THROUGH THIS PROJECT

a) **Unit Outcomes (Cognitive Domain)**

i. .....
ii. .....
iii. .....
iv. .....

b) **Practical Outcomes (in Psychomotor Domain)**

i. .....
ii. .....
iii. .....
.....
iv. .....
.....

c) **Affective Domain Outcomes**

i. .....
ii. .....
iii. .....
iv. .....

D. SUGGESTED RUBRIC FOR ASSESSMENT OF CAPSTONE PROJECT

(please tick below the appropriate rating i.e. poor, average etc., for each characteristic to be assessed and give marks in the respective cell according to performance of student)

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtain
First Progressive Assessment (at the end of 4th week)							

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
1	**Problem/Task Identification (Project Title)**	Relate to very few POs Scope of Problem not clear at all	i. Related to some POs ii. Scope of Problem/Task vague	i. Take care of at-least Three POs ii. Scope of Problem/task not very specific	i. Take care of more than three POs ii. Scope of problem/task very clear	02	
2	**Literature Survey /Industrial Survey**	Not more than ten sources (primary and secondary), very old reference	At-least 10 relevant sources, at least 5 latest	At –least 15 relevant sources, most latest	About 20 relevant sources, most latest	02	
Second Progressive Assessment (at the end of 12th week)							
3	**Project proposal**	Methods are not appropriate, All steps not mentioned, Design of prototype not started (if applicable).	Appropriate plan but not in much detail. Plan B for critical activities not mentioned. Time line is not developed. Design of Prototype is not complete. (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, but clarity is not there in methods, time line is given but not appropriate. Design of prototype is not detailed (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, clarity in methods with time line, Detailed design of prototype (if applicable)	02	
4	**Execution of Plan in fifth semester (please write by hand about students performance in appropriate column)**					02	
5	**Log Book**	Entries for most weeks are missing. There is no proper sequence and details are not correct.	Entries for some weeks are missing, details are not appropriate, not signed regularly by the guide.	Entries were made every week but are not in detail. Signed and approved by guide every week	Entries were made every week in detail, signed and approved by guide every week	03	
Third progressive Assessment at the end of 14th week							
6	Portfolio Preparation	Answer to only few of the 'questions from self' (prompts)	Answer to only about 50% of the 'questions from self'	Answer to most of the 'questions from self' (prompts) written. Some	Answer to nearly all the 'questions from self' (prompts) written in detail	03	

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
		written. Answers are not in much detail	(prompts) written. Answers are not in much detail	answers are not in much detail			
7	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions omitted, some details are wrong Nearly sufficient and correct details about methods, material, precautions and conclusion. but clarity is not there in presentation, not enough graphic description.	Detailed, correct and clear description of methods, materials, precautions and	Conclusions. Sufficient Graphic Description.	Very detailed, correct, clear description of methods, materials, precautions and conclusions. Enough tables, charts and sketches	**04**	
8	**Presentation**	Major information is not included, information is not well organized .	Includes major information but not well organized and not presented well	Includes major information and well organized but not presented well	Well organized, includes major information ,well presented	**03**	
9	**Defense**	Could not reply to considerable number of question.	Replied to considerable number of questions but not very properly	Replied properly to considerable number of question.	Replied to most of the questions properly	**04**	
					Total marks	**25**	

Any Other Comment:

.....

.....

Name and designation of the Faculty Member.....**Signature**.....

.....

Program Name : **Diploma in Mechanical Engineering / Plastic Engineering**

Program Code : **ME / PS**

Semester : **Fifth**

Course Title : **Solid Modelling and Additive Manufacturing**

Course Code : 22053

1. RATIONALE

Mechanical, Plastic, Automobile and allied Industries need to build model based applications which are being developed using "**solid modeling software**". This course deals with concepts of solid modeling to enhance solid modeling skills of diploma students. This course will enable the students to inculcate solid modeling and additive manufacturing concepts and methodology to solve engineering problems.

2. COMPETENCY

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

- **Develop 'Solid Models' of given machine components using any parametric CAD software.**

3. COURSE OUTCOMES (COs)

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

a. Prepare 2D Drawing using sketcher workbench of any parametric CAD software.
b. Generate 3D Solid models from 2D sketch using Part workbench of any parametric CAD software.
c. Prepare assembly of part models using Assembly workbench of any parametric CAD software.
d. Generate orthographic views of 3D solid models/assemblies using drafting workbench of any parametric CAD software.
e. Plot a drawing for given part model/assembly.
f. Print components using 3D Printer/Rapid prototyping machine.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

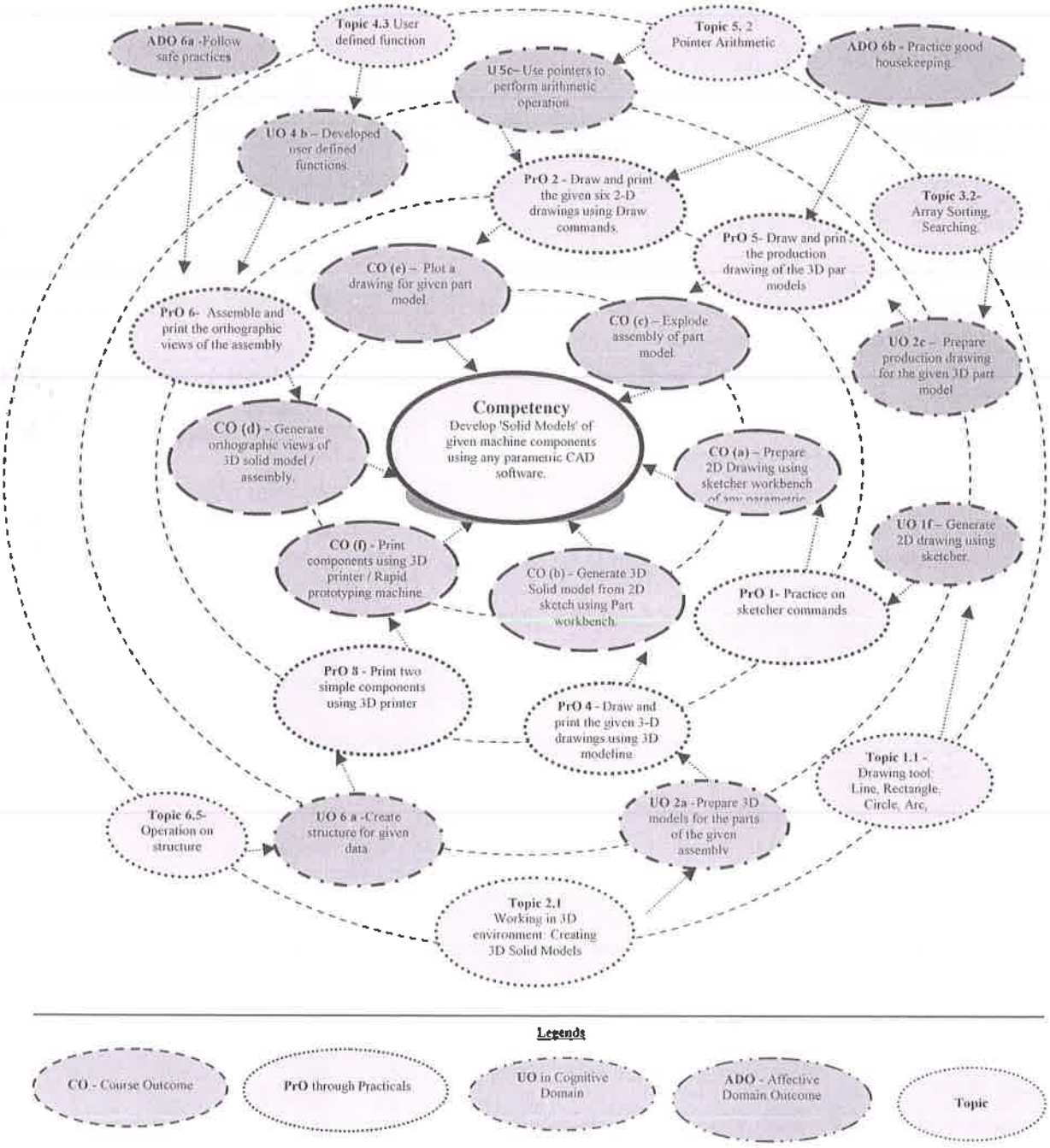


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare drawing template consisting of Name plate boundary lines and projection symbol.	I	02
2.	Draw and print two simple 2D geometries using sketcher commands	I, V	02*
3.	Draw and print two complex 2D geometries using sketcher commands	I, V	02
4.	Draw and print the given two simple 3-D drawings using 3D modeling commands	II, V	02*
5.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem-I)	II, V	02
6.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
7.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
8.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
9.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - I)	III, IV, V	02
10.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – I continued)	III, IV, V	02
11.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem - II)	II, V	02
12.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
13.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
14.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
15.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any	III, IV	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	assembly consisting of at least five parts. (Problem - II)	V	
16.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – II continued)	III, IV, V	02
17.	Print simple component using 3D printer / Rapid prototyping machine.	VI	02
18.	Print a complex component using 3D printer / Rapid prototyping machine. (Problem – I)	VI	02
	Total		**36**

Note

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

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

S. No.	Performance Indicators	Weightage in %
1	Use of proper commands	40
2	Completion of drawing with minimum size of model tree	20
3	Generation and printing of drawing views, tables, etc. and their arrangement on different sheet sizes.	20
4	Able to answer oral questions.	10
5	Completion of work in time.	10
	Total	**100**

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

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Handle solid modeling software carefully.
e. Plan for creation of solid model.
f. Demonstrate working as a leader / a team member.
g. Maintain software tools and equipment.
h. Follow ethical practices.

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

- 'Valuing Level' in 1st year

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	Expt. Sr. No.
1	Hardware: Personal computer, (i3/ i5 or higher), RAM minimum 4 GB, A3 / A4 size printer / plotter. Display-wide Screen preferably.	For all Experiments
2	Operating system: Windows XP/Windows 7/ Windows 8/Windows 10 or higher.	
3	Software: Any parametric solid modeling software.	
4	3D printer / Rapid prototyping Machine.	17, 18

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Working in 2D environment.	1a. Describe the given sketcher commands. 1b. Demonstrate the given modify commands. 1c. Apply dimensioning and Constraints	1.1 Drawing tool: Line, Rectangle, Circle, Arc, Ellipse, Spline, etc. 1.2 Editing tool: Trim, Extend, Erase, Mirror, etc. 1.3 Modify tool: Chamfer, Fillet, Copy, Move, etc. 1.4 Linear, angular dimensions. 1.5 Dimensioning constraint and Geometrical constraint. 1.6 Drawing template: prepare drawing template consisting of Name plate boundary lines and projection symbol.
Unit– II Development of Solid Models.	2a. Prepare 3D models for the parts of the given assembly using different commands with minimum tree. 2b. Describe intersection of the given Solid. 2c. Prepare production drawing for the given 3D part model / assembly.	2.1 Working in 3D environment: Creating 3D Solid Models of simple machine parts. 2.2 Part tool: Extrude, Hole, Revolve, Rib, Sweep, Swept blend, Pattern, etc. 2.3 Part Editing tool: Trim, Extend, Erase, Mirror, 2.4 Part Modify tool: Chamfer, Round, Copy, Move, Draft, etc. 2.5 Intersect 2 solid components by inserting new body option. Boolean operations: Union, subtract, intersection.
Unit– III Computer aided	3a. Use of assembly tools to prepare assembly using given 3D solid models.	3.1 Assembly Drawing: Preparation of assembly drawing by using assembly command.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Assembly	3b. Use of explode command for the given assembly.	3.2 Exploded view: Explode the assembly.
Unit-IV Drafting of 3D assembly	4a. Use drawing module to create orthographic views for the given assembly. 4b. Generate Bill of material for given assembly Drawing.	4.1 Orthographic projections: Generate orthographic projections of the assembly. 4.2 Bill of material: Prepare part list table.
Unit –V Plotting	5a. Use different settings for plotting. 5b. Use printer to plot drawing on A3 or A4 size sheet.	5.1 Printer selection, paper size, orientation. 5.2 Page set up.
Unit-VI Additive Manufacturing	6a. Describe the process of Additive manufacturing. 6b. Study construction and working of 3D printer / Rapid prototyping machine. 6c. Describe materials use for 3D printer / Rapid prototyping machine.	6.1 Additive manufacturing: 3D printing, Rapid prototyping. 6.2 File format: STL (Stereo Lithography). 6.3 3D printer software: part import, orientation, processing and printing.

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

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

Unit No.	Unit Title	Practical Hours	Distribution of practical Marks			
			R Level	U Level	A Level	Total Marks
I	Working in 2D environment	04	01	01	02	04
II	Development of Solid Models	14	02	01	05	08
III	Assembly Drawing	04	-	01	03	04
IV	Drafting of 3D assembly	04	-	02	02	04
V	Plotting	02	-	01	01	02
VI	Additive Manufacturing	04	-	01	02	03
Total		**32**	**03**	**07**	**15**	**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. Prepare journals based on practical performed in laboratory.
b. Give seminar on relevant topic.
c. Library/E-Book survey regarding 'Solid modeling' used in manufacturing industries.
d. Prepare power point presentation or animation for drafting/solid modeling/assembly/exploded view/3D printing.
e. List applications of 3D printing.
f. Visit to institute/industry having 3D printer/Rapid Prototyping machine.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual design and additive manufacturing.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain 3D printing and Rapid prototyping manufacturing methods.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. **2D drawing**: Each student will collect one or two drawings from the nearby industry/workshop and prepare a 2D drawing from it.
b. **3D model**: Each student will identify a small assembly from the institute workshop/laboratory. Measure the dimensions of each part and prepare sketches.

Using sketches prepared 3D model of parts and assembly. Plot the assembly and detail drawings. (eg. Bench vice, Machine vice, Tool post, Couplings, Joints, Bearings etc.)

c. **3D printing/RPT**: Each student will visit a nearby institute/industry. Collect information regarding troubleshooting of 3D printer/Rapid prototyping machine and prepare a report.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	CATIA V5R17 for Designers	Sham Tickoo	Softcover, Cadcim Technologies
2	Pro/Engineer Wildfire for Designers	Sham Tickoo	Softcover, Cadcim Technologies
3	Solid Works For Designers Release 2006	Sham Tickoo	Softcover, Cadcim Technologies
4	Autodesk Inventor for Designers: Release 10	Sham Tickoo	Softcover, Cadcim Technologies
5	NX 4 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
6	Solid Edge V19 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
7			

14. SOFTWARE/LEARNING WEBSITES

a. http://www.solidworks.in/sw/products/3d-cad/3d-solid-modeling.htm
b. http://web.iitd.ac.in/~hegde/cad/lecture/L30_solidmod_basics.pdf
c. https://en.wikipedia.org/wiki/Solid_modeling
d. http://npkauto.com/solid-modeling/
e. https://www.youtube.com/watch?v=vjX4PDJcFOI
f. https://www.youtube.com/watch?v=5BDHS4FN2-
g. https://www.youtube.com/watch?v=JjKs-lePlPY