Maharashtra State Board of Technical Education, Mumbai

Teaching and Examination Scheme for Post S.S.C. Diploma Courses

Program Name : Diploma in Automobile Engineering

Program Code : AE **With Effect From Academic Year: 2017 – 18**

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

Semester : Third **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
								Theory							Practical					
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total	
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Strength of Materials	SOM	22306	3	2	2	7	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
2	Materials and Manufacturing Processes	MMP	22307	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Automobile Engines	AEN	22308	3	-	4	7	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
4	Automobile Transmission System	ATS	22309	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
5	Basic Electrical and Electronics Engineering	BEE	22310	4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Automobile Engineering Drawing	AED	22023	1	-	4	5	--	--	--	--	--	--	--	50@	20	50~	20	100	40	100
			Total	**17**	**2**	**16**	**35**	--	**350**	--	**150**	--	**500**	--	**200**	--	**200**	--	**400**	--	**900**

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

Theory and practical periods of 60 minutes each. Total Marks : **900**

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

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

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

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

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

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Mechanical Engineering Program Group**

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

Semester : **Third**

Course Title : **Strength of Materials**

Course Code : **22306**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

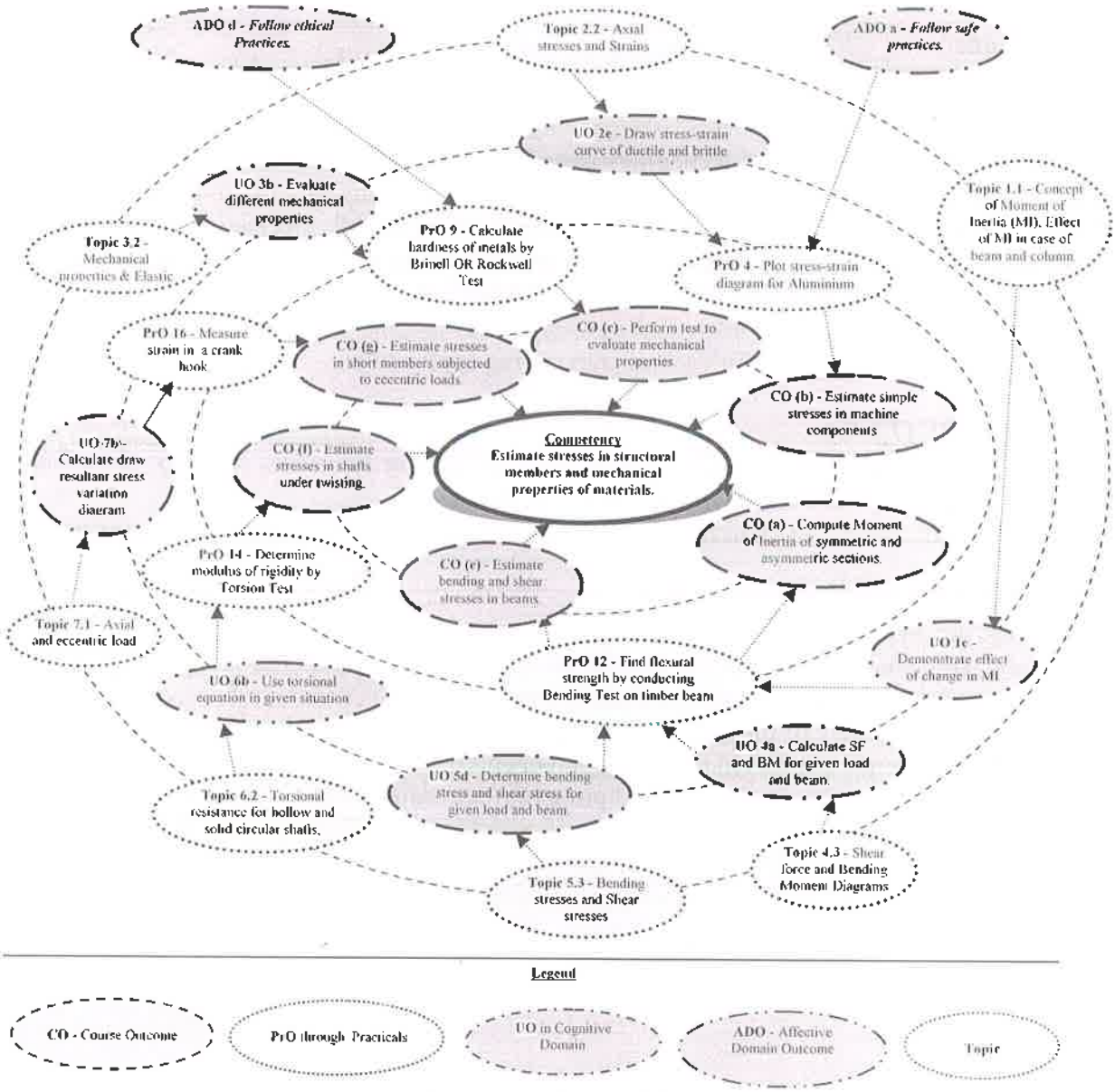

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

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

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.	Awareness about significance of particular test	15
b.	Understanding working principle of machine	15
c.	Preparation of experimental set up	20
d.	Setting and operation	20
e.	Observations and recording	10
f.	Interpretation of result and conclusion	10
g.	Answer to sample questions	5
h.	Submission of report in time	5
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

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

12. SUGGESTED MICRO-PROJECTS

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Third**

Course Title : **Materials and Manufacturing Processes**

Course Code : **22307**

1. RATIONALE

Due to globalization Automobile sector experiencing a vital change over, where the emphasis is on reducing weight of vehicles, fuel economy, ergonomically design and cost. It is essential to understand various materials, their composition, properties and applications. Manufacturing process is a core technological subject in Automobile engineering course. A diploma holder of Automobile engineering should be proficient in the selection and use of manufacturing processes for the variety of materials available now days. The knowledge of this subject is essential as prerequisite knowledge for subjects like Automobile component design and Automobile manufacturing processes.

2. COMPETENCY

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

- **Select relevant material and manufacturing process to produce automobile components.**

3. COURSE OUTCOMES (COs)

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

a. Select the appropriate material for manufacturing of automobile components.
b. Select appropriate heat treatment process for automobile components.
c. Prepare a pattern and mould for casting automobile components.
d. Select machining parameters, cutting tools and cutting fluids for machining automobile components.
e. Perform various operations on lathe, drilling and milling machines to required for manufacturing of automobile 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.

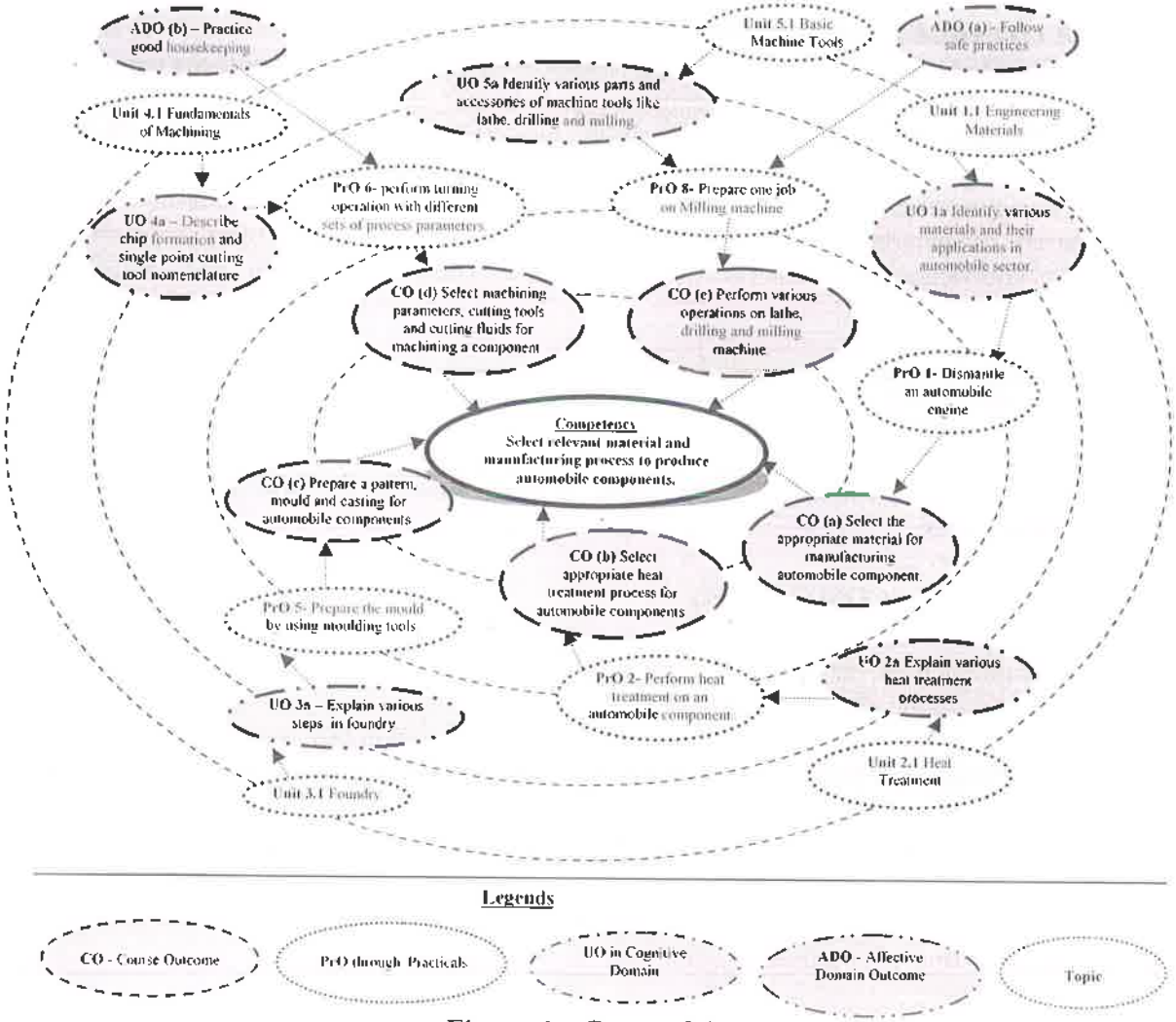

Figure 1 - Course Map

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 a)	Dismantle an automobile engine/steering assembly/suspension assembly/clutch assembly/gearbox and	I	02*
b)	Identify the properties, grades/designation of the materials		02
c)	Identify ferrous and non-ferrous metals for a given automobile		02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	component.		
2	Perform heat treatment on an automobile component. (Part-I)	II	02*
3	Perform heat treatment on a automobile component. (Part-II)		02
4	Develop one pattern for a given job considering all aspects of pattern making for group of 4 to 6 student. Job shall involve split pattern with core and core print.	III	
a)	Calculate of all dimensions based on final product.		02
b)	Planning the rough block to required dimensions.		02
c)	Prepare the pattern.		02*
d)	Polish the pattern.		02
5	Prepare a sand mould for the above pattern.	III	
a)	Prepare the green sand and selecting suitable foundry tools.		02*
b)	Prepare cope and drag portions of green sand mould.		02*
6	Prepare similar MS jobs on lathe machine and perform turning operation with different sets of speed, feed and depth of cut.	IV	
7	Prepare one job on lathe machine for following operations: Facing, step turning, taper turning, chamfering, threading, knurling.	V	
a)	Select suitable work holding tool, cutting tool, raw material, Loading the job, centering.		02*
b)	Facing, step turning.		02
c)	Taper turning.		02
d)	Chamfering and threading		02
e)	Knurling		02
8	One job in a group of 4 to 6 students on milling machine involving face/end milling, keyway/slot milling.	V	
a)	Selecting the work holding device, cutter, machining parameters.		02
b)	Face milling		02
c)	End milling		02
d)	Key way		02
e)	Slot milling		02
	Total		**32**

Note

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

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

S. No.	Performance Indicators	Weightage in %
1.	Dimensional accuracy	40
2.	Surface finish achieved	20
3.	Use of protective equipment	10
4.	Following safety rules	20

S. No.	Performance Indicators	Weightage in %
5.	Submitting workshop diary in time	10
	Total	**100**

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

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

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

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

6. 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	Wood working lathe	01
2	Center Lathe Machine (Length between centers : 2000 mm)	03
3	Radial drilling machine (Drill diameter : upto 40 mm)	03
4	Pattern making, moulding and casting shop with necessary equipments.	02
5	Plastic Hand Moulding Machine	02
6	Feed system	02
7	Metallurgical Microscope ideal for examining Large and Single Side polished Metal samples	
8	Reheating furnace	
9	Power hacksaw	03,04
10	Milling machine	04

7. 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 Engineering Materials	1a. Identify the properties, grades/designation of the given material with	1.1 **Introduction:** Need of advanced materials in automobile sector. Classification of engineering materials.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification. 1b. Identify ferrous metal for the given automobile component with justification. 1c. Identify non-ferrous metal for the given automobile component with justification. 1d. Describe applications of the given materials in the given types of automobiles.	1.2 **Ferrous metals and their alloys:** Cast iron: types, composition and applications. Plain carbon steel: types, composition and applications. 1.3 Alloy Steels: Alloy steels like stainless steel, Tool steels, their composition and Application. Effects of alloying elements like- Nickel, chromium, silicon, molybdenum and tungsten on the properties of steel. 1.4 **Non-ferrous metals and their alloys:** Aluminium and its alloys: duralumin, 'Y' alloy, their composition, properties and applications. Copper and its alloys: brass, bronze, gun metal, Babbitt metal their composition, properties and applications. Magnesium alloys: Properties and applications of AZ31 Titanium alloys: Properties and applications of Ti-6Al-4V 1.5 **Other materials:** Polymeric materials-properties and applications; Thermoplastics- Nylons and Polypropylene; Thermosetting Plastics-Epoxy resins and Polyesters Rubber – Natural and synthetic Ceramic materials: Properties and application in automotive industry; Composites: Properties and applications of Glass fiber (GRP/GFRP), Carbon fiber (CRP/CFRP)
Unit– II Heat Treatment	2a. Interpret the given Iron-Iron carbide (Fe-Fe3C) equilibrium diagram. 2b. Explain with sketches the given type of heat treatment process and its application. 2c. Differentiate the features of the two given heat treatment process 2d. Select the relevant heat treatment process for the given automobile component with justification.	2.1 **Introduction:** Need of Heat treatment. Concept of phase and phase transformations. Cooling curve for pure iron, Iron-Iron carbide (Fe-Fe3C) equilibrium diagram. 2.2 **Common heat treatment processes and their applications in Automobile sector:** Annealing, Normalizing, Hardening, Tempering, Surface hardening processes: Case carburizing, Nitriding, Cyaniding, Induction and Flame hardening.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– III Foundry	3a. Describe with sketches the given manufacturing process applicable to Automobile engineering. 3b. Describe with sketches the steps in foundry process of the given component. 3c. Describe with sketches the process of pattern making based on the given aspects. 3d. Describe with sketches the process of preparing the given type of mould by using the given moulding tools. 3e. Identify defects in the given casting with their probable remedies.	3.1 **Introduction:**Introduction to various manufacturing processes, Importance of foundry processes, Steps in foundry process, Types of Foundries, Advantages and disadvantages of foundry process. 3.2 Pattern Making: Pattern materials and their selection, Types of pattern and their selection, Pattern Allowances. Pattern colour coding. 3.3 Moulding: Moulding tools and flasks. Moulding sand: Composition, Types and properties, Classification of moulding processes. Use of Core, core print and core boxes. 3.4 Casting: Gating system in casting-Function and Block diagram, Process and applications: Pressure Die casting, Shell moulding and True Centrifugal casting, Defects in casting: causes and remedies.
Unit-IV Fundamentals of Machining	4a. Select the machining parameters for the given job with justification. 4b. Identify the type of chip formed based on the given type of material and machining parameters with justification. 4c. Select the relevant cutting tool material and cutting fluid for the given situation with justification. 4d. Describe with sketches the features of the different types of cutting. 4e. Describe the given cutting tool with sketches.	4.1 **Chip formation**: Mechanism of chip formation, Types of chips Orthogonal and Oblique cutting Machining parameters like Cutting Speed, Feed and Depth of cut, Tool life. 4.2 **Cutting tools and fluids:** Types of cutting tools: single and multi-point, Cutting tool materials: Selection, Properties and types Single point cutting Tool nomenclature and tool signature, Cutting fluids: Properties, types
Unit –V Basic Machine Tools	5a. Identify various parts and accessories of the given tpe of machine tool sketch. 5b. Explain with sketches the procedures of given operations on the given type of machine. 5c. Prepare the specification of the given type of	5.1 **Introduction:**Definition of machine tool, Types of machine tools. 5.2 **Lathe:** Classification of lathes. Major parts of Centre lathe machine with block diagram, Lathe specifications. Accessories used on lathe, Operations performed on lathe – Turning, Taper turning by swiveling compound rest, Facing, Knurling and Threading.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	machine tool. 5d. Describe the safety precautions to be taken during operation of the given type of machine.	5.3 **Drilling:** Classification of drilling machines. Major parts of bench drilling machine with block diagram, Operations performed on drilling machines – drilling, boring, reaming and taping. 5.4 **Milling:** Classification of milling machines, major parts of column and knee type universal milling machine, standard milling cutters, Milling operations like Face milling, Gang milling, Key-way milling and End milling.

***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	Engineering Materials	10	04	06	06	16
II	Heat Treatment	06	02	02	04	08
III	Foundry	13	04	08	08	20
IV	Fundamentals of Machining	06	02	02	04	08
V	Basic Machine Tools	13	04	06	08	18
Total		**48**	**16**	**24**	**30**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare specification of machine tools.
b. Prepare list of various cutting tools available in the market.
c. List of various Material codes as per IS designation.
d. Prepare a sequence of operation for any one automobile component.
e. List the automobile components which require heat treatment.

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. Visit to foundry shop where automobile components are manufactured and demonstrate various foundry activities.
g. Visit to machine shop where automobile components are manufactured and demonstrate various machine tools, cutting tools and cutting fluids.
h. Visit to heat treatment shop where automobile components are processed and demonstrate various heat treatments.

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. Select any one component of automobile for each group.
b. List the material used for the manufacturing of the selected component.
c. Write the names of manufacturing processes used.
d. Prepare the process sheet (Process sheet shall include operation number, work description, name of machine tool, cutting tool used, measuring instruments and machining time etc.)

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Engineering Materials and Metallurgy	Rajput R. K.	S. Chand Limited, New Delhi. 2013, ISBN 13: 9788121927093
2	Material Science and Metallurgy	Kodgire V. D.	Everest Publishing House , Pune. 1020, ISBN: 9788186314005, 8186314008

S. No.	Title of Book	Author	Publication
3	A Course in Workshop Technology, Vol. I and Vol. II	Raghuvanshi B. S.	Dhanpat Rai and Company Pvt. Ltd. 2011, ISBN-13: 1234567144375
4	Elements of Workshop Technology Vol. I and Vol. II	Hajra Choudhury S.K.; Hajra Choudhury A.K	Media Promotors, Kolkatta, 2009, ISBN: 978-8185099156

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://en.wikipedia.org/wiki/Foundry
b. http://www.iifncts.org/wp-content/site/index.php
c. http://www.imtma.in/
d. http://cmti-india.net/
e. http://www.mechengg.net

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Third**

Course Title : **Automobile Engines**

Course Code : **22308**

1. RATIONALE

This is a core technology course. All automotive vehicles are powered by engines. Hence the fundamental knowledge of automobile engine is most essential for an auto technologist. This course will help in understanding the procedure of inspection, diagnosis and testing of various types of engines and other systems. This course also forms the basis for the Advanced Automobile Engine and vehicle maintenance.

2. COMPETENCY

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

- **Check the functioning of the 2-wheeler and passenger car engine 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 the IC engine specifications.
b. Identify various petrol and diesel engine components.
c. Troubleshoot petrol and diesel fuel supply system.
d. Check ignition systems.
e. Use service manual for routine maintenance of cooling and lubrication systems.
f. Estimate I.C. engine performance.

4. TEACHING AND EXAMINATION SCHEME

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

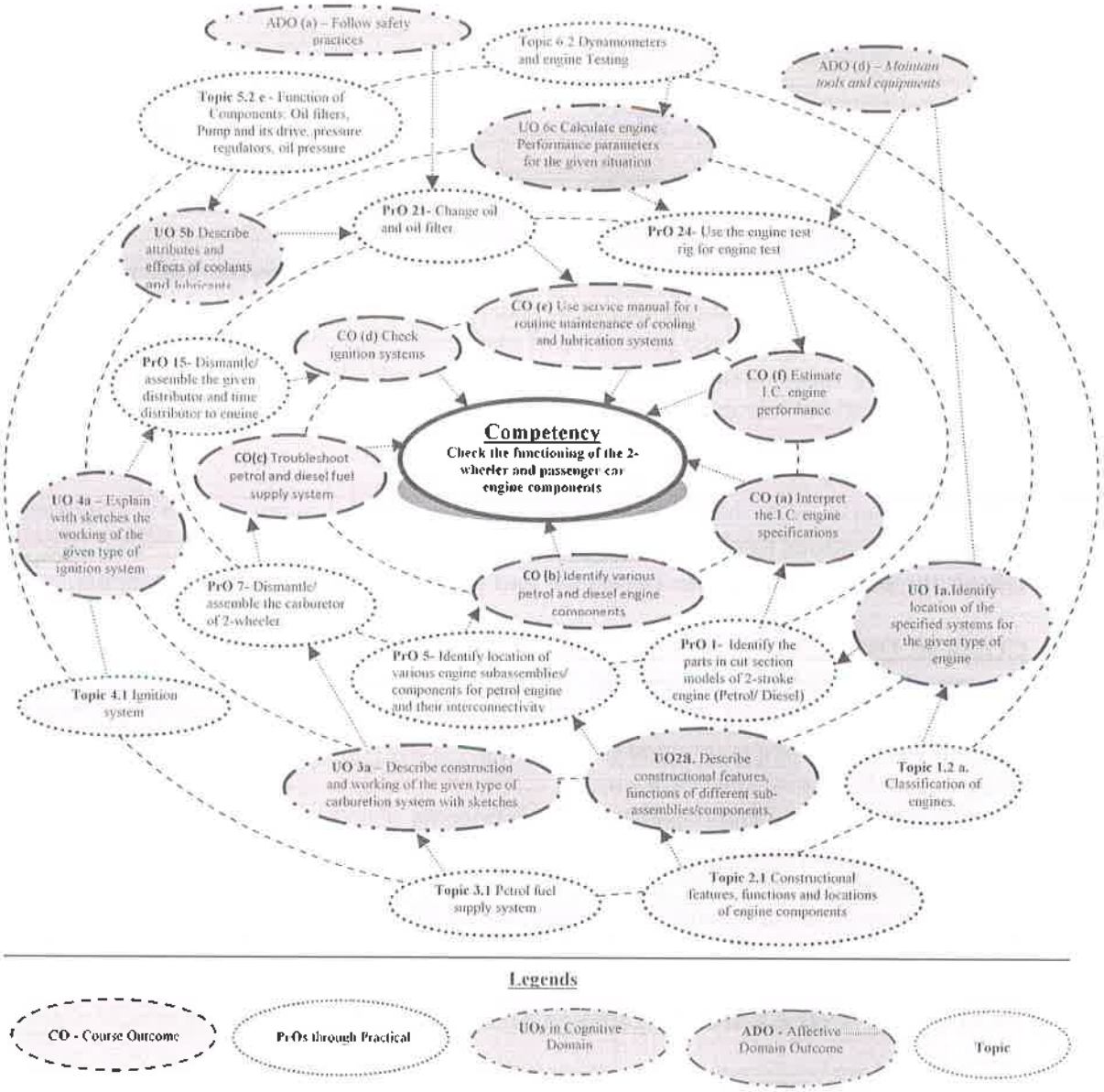

Figure 1 - Course Map

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.	Identify the parts in cut section models of 2-stroke engine (petrol/ diesel).	I	02*
2.	Identify the parts in cut section models of 4-stroke engine (petrol/ diesel).	I	02
3.	Use special tools in dismantling 2-stroke engine.	I	02
4.	Use special tools in assembling 4-stroke engine.	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
5.	Identify location of various engine subassemblies/ components for petrol engine and their interconnectivity. Part - I	II	02
6.	Identify location of various engine subassemblies/ components for diesel engine and their interconnectivity. Part - II	II	02*
7.	Dismantle/ assemble the carburetor of 2-wheeler. Part - I	III	02*
8.	Dismantle/ assemble the carburetor of 2-wheeler. Part - II	III	02
9.	Trace induction and fuel supply system of a diesel engine	III	02*
10.	Dismantle/assemble fuel injector of a diesel engine	III	02*
11.	Dismantle/ assemble Single element Fuel injection pump of a diesel engine.	III	02*
12.	Trace ignition system of a 2-wheeler engine.	IV	02*
13.	Trace ignition system of a 4-wheeler engine.	IV	02
14.	Carry out maintenance of Spark Plug, ignition coil and HT cords.	IV	02
15.	Dismantle/ assemble the given distributor and time distributor to engine. Part - I	IV	02
16.	Dismantle/ assemble the given distributor and time distributor to engine. Part - II	IV	02
17.	Check 4-wheeler engine cooling system.	V	02
18.	Test Thermostat Valve and Electric Cooling Fan Thermo-switch.	V	02
19.	Replace/replenish coolant of an engine after checking.	V	02
20.	Check lubrication system of a passenger car engine.	V	02
21.	Change oil and oil filter.	V	02*
22.	Service oil pump of passenger car engine.	V	02
23.	Perform the servicing of Oil Pressure Relief Valve	V	02
24.	Use the engine test rig for engine test. Part I	VI	02*
25.	Use the engine test rig for engine test. Part II	VI	02
26.	Use the engine test rig for engine test. Part II	VI	02
27.	Conduct Morse Test on multi-cylinder petrol engine. Part I	VI	02*
28.	Conduct Morse Test on multi-cylinder petrol engine. Part II	VI	02
29.	Dismantle/ Assemble a multi-cylinder diesel engine. Part - I	VI	02*
30.	Dismantle/ Assemble a multi-cylinder diesel engine. Part - II	VI	02
31.	Dismantle/ Assemble a multi-cylinder petrol engine. Part - I	VI	02*
32.	Dismantle/ Assemble a multi-cylinder petrol engine. Part - II	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 %
1.	Follow safety rules and adopt standard practices for handling	20

S. No.	Performance Indicators	Weightage in %
	tools	
2.	Refer workshop manual and include relevant data in the journal.	20
3.	Sketching layouts, components and conclusion	30
4.	Answer to simple questions	20
5.	Timely completion of the task and term-work.	10
	Total	**100**

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

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

a. 'Valuing Level' in 1st year
b. 'Organizing Level' in 2nd year
c. 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	General purpose tools (Spanners, ring spanner and socket)- 6mm to 32 mm	All
2	Special purpose tools (Piston ring expander, Piston ring compressor, Valve lifter, Torque wrench)- Torque wrench range- 10 Nm to 200Nm.	
3	Two stroke engine cut-section model- single cylinder (motorized/ manual)	
4	Four stroke engine cut-section model- single cylinder (motorized/ manual)	
5	Two stroke engine (Single cylinder) Petrol / Diesel	
6	Four stroke engine (Single / Multi-cylinder)	
7	Fuel Supply system (Petrol)- including carburettor, fuel pump and fuel filter of two wheeler/ four wheeler	
8	Fuel Supply system (Diesel) - Fuel Injection pump, primary filter, secondary filter, Injectors.- Single cylinder/ multi-cylinder engine FIP unit .	
9	Magneto coil ignition system- including Magneto, Ignition coil, Spark plug and battery.	
10	Distributor	
11	Four stroke multi-cylinder diesel/ petrol engine with water cooling system	
12	Four stroke diesel / petrol engine with lubrication system.	

S. No.	Equipment Name with Broad Specifications	PrO. No.
13	Single cylinder/ multi-cylinder Engine test rig with dynamometer.	
14	Four stroke CI and SI engines	
15	Engine dismantling and assembly tools	
16	Consumables (cotton waste, fuel and lubricants), Water supply provision, Electrical supply provision, Exhaust gas outlet, Wooden blocks, safety equipment, fire extinguisher	

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 I.C. Engine.	1a. Identify location of the specified systems for the given type of engine. 1b. Explain with sketches the working principle of the given type of engine. 1c. Identify the engines from the given specifications with justification. 1d. Interpret the specifications of the given type of engine.	1.1 Definition of I C engine, Engine nomenclature. 1.2 **Classification** a. Classification of engine on the basis of: Cycle of operation, Fuel, Method of Charging, Ignition, Cooling, Cylinder arrangement, Camshaft, layout, b. Vertical and horizontal engines and its Merits and Demerits 1.3 **Types of Engines** a. Four-Stroke Spark Ignition and Four-Stroke Compression Ignition Engine. b. Two-Stroke and Four-Stroke engine scavenging 1.4 **Engine Specifications and applications** a. Engine Specifications - Two Wheelers, Light Motor Vehicle, Medium Motor Vehicle and Heavy Motor Vehicle. b. Applications of IC Engines.
Unit – II Constructional Features of Engine Components.	2a. Describe constructional features, functions and materials of the given systems/sub-assemblies/ components of the given I.C. engines with sketches. 2b. Differentiate the working/materials between the given types of engine component. 2c. Compare the salient features of the given types of valves and cams arrangement.	2.1 **Constructional features, functions, locations and materials of engine components.** a. Cylinder block, Cylinder liners – Dry and Wet, Cylinder head, Inlet and Exhaust manifold, Tappet cover, Timing cover, Crank case. Oil Sump. b. Crank Mechanism: Piston and piston rings, Piston pin, Connecting rod, Crank Shaft, Cam shaft, Flywheel, Bearings, Oil seals, Gaskets. c. Valve and Valve Operating Mechanisms: Overhead Valve and Overhead Cam arrangements; Valve Cooling. 2.2 **Camshaft Drives and Valve Timing** Camshaft drives: Timing Gears, Chain and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2d. Identify relative position of crankshaft and camshaft in the given situation with justification.	Belt drive. b. Relation between speed of camshaft and crank Shaft. Valve timing Diagram.
Unit– III Fuel and Air feed System	3a. Describe construction and working of the given type of carburetion system with sketches. 3b. Explain with sketches the construction and working of the given type of fuel injection systems. 3c. Describe with sketches the working of the given type of governor in the given type of engine. 3d. Select relevant lubrication system for the given situation with justification. 3e. Choose the relevant fuel supply system components for the given situation with justification.	3.1 **Petrol fuel supply system.** a. Pump feed :Layout, Function of Components and location; Construction and working of components: Fuel Tank. Fuel Filter, S. U. Electrical Fuel Pump b. Air cleaners – dry type and oil wetted types. c. Working Principle of Simple Carburettor, Air Fuel ratio requirements, Circuits in Two-wheeler carburettor. **3.2 Diesel fuel supply system** a. Diesel Engine: Need and requirements of Fuel Injection Systems; Layout of Fuel Injection systems Individual pump, Unit injector system, Distributor system and Common rail system. b. Fuel Injector and types of nozzles. c. Fuel metering in Fuel Injection Pump (Inline pump and Distributor pump) 3.3 Working of Mechanical Governor in Fuel Injection Pump.
Unit– IV Ignition and Exhaust System	4a. Explain with sketches the working of the given type of ignition system. 4b. Explain with sketches the firing order for the given type of engine. 4c. Explain with sketches the construction and working of the given type of exhaust system 4d. Select the relevant type of silencer/Mufflers for the given engine with justification.	4.1 **Ignition System** a. Requirements of ignition system. b. Magneto and Battery Ignition systems c. Firing order used in 3,4 and 6 cylinder engines 4.2 **Exhaust system** a. Function of Exhaust manifold. b. Types of silencer / Mufflers (Construction and Working).
Unit– V Cooling and Lubricatio n system	5a. Describe layout, construction and working of the given cooling System with sketches. 5b. Describe attributes and effects of the given type	5.1 **Engine cooling system**: a. Need of cooling system and limitations of cooling system. b. Types: Air, Water/ Liquid cooling system (Layout and Function of Components) c. Properties of coolants and coolant additives

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	of coolant and lubricant. 5c. Describe with sketches properties of the given type of engine oil and their effects. 5d. Select the relevant coolant, lubricant and engine oil for the given situation with justification.	5.2 **Cooling system components:** a. Construction and working of: Thermostat valve, Water expansion tank, Temperature Indicators, Pressure cap, Water pump, Fan and fan belt, Electrically driven Fan circuit. b. Radiator: Construction and type of radiator cores. c. Types and Characteristics of a Coolant , and their effect on performance of engine cooling; Lubrication system: Need, Properties and additives of lubricating oil, Parts to be lubricated d. Classification of Lubricating Oils on the basis of Viscosity (SAE) and Load (API) Severity rating; Types of lubrication system: Splash, Pressure – wet sump and dry sump e. Function of Components: Oil filters, Pump and its drive, pressure regulators, oil pressure gauge.
Unit– VI I.C. Engine Performance.	6a. Interpret the given engine performance parameters and their implications. 6b. Explain with sketches the working principle of the given type of dynamometer. 6c. Calculate engine Performance parameters for the given situation. 6d. Prepare heat balance sheet for the given situation.	6.1 **Performance parameters.** a. Definitions: Indicated Power, Brake Power and Frictional Power. b. Efficiencies - Air standard, Mechanical, Brake Thermal, Indicated Thermal, Volumetric and Relative. 6.2 **Dynamometers and engine testing:** a. Working Principle and types of Dynamometers: Hydraulic and Eddy current. b. Engine Testing: Morse Test, Willian's line Method for finding Frictional Power. c. Heat balance sheet and Method of calculating Volumetric Efficiency and Fuel Consumption.

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 I.C. engines	08	04	02	04	10
II	Constructional features of engine components.	08	04	04	04	12

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
III	Fuel and air feed system	10	04	04	06	14
IV	Ignition and exhaust system	04	02	02	04	8
V	Cooling and lubrication system	10	02	04	06	12
VI	I.C. Engine performance	08	02	06	06	14
Total		**48**	**18**	**22**	**30**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare journal of practicals.
b. Undertake micro-projects.
c. List down the specifications of a bike engine.
d. Compare engine specifications of two bikes of different manufacturers.
e. Record the specifications of diesel engine of a electric generator.
f. Visit an auto parts shop and list down the salient features of three lubricating oils and three coolants.
g. Compare engines of petrol and diesel version of same car of a manufacturer on the basis of Power, Tourqe, RPM, noise, pollution, maintenance etc.

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. Choose a modern engine. Search information on any one system from website. Prepare a report for the same.
b. Make a few engine components/ their models using suitable material like thermocol/ wood/ plastic.
c. Prepare a CAD production drawing of the same. Suitable technique like 3D printing may be used.
d. Investigate valve timing diagram of a four stroke engine. Verify result with manufacturer's specification.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Automobile Engg. Vol.-2	Singh, Kirpal	Standard Publishers, New Delhi, 2015: ISBN: 9788180142062
2	Automobile Engineering	Jain K. K. and Asthana	Tata McGraw Hill Publishers, 2010, New Delhi ISBN : 007044529X
3	Automobile EngineeringVol.1	Chhikara, Anil	Satya Prakashan, New Delhi, 2009, ISBN: 9788176843515
4	Automobile Engineering	Gupta, R.B.	Satya Prakashan, New Delhi, 2011, ISBN: 9788176843799
5	Automobile Engineering	Ramlingam, K.K.	Scitech Publications, New Delhi, 2008, ISBN-9788183715744
6	Internal Combustion Engine Fundamentals	Heywood, John B.	McGraw-Hill International Edition New Delhi, 2010, ISBN: 9781259002076
7	Internal Combustion Engine	Newton and Steeds	Butterworth Publishers, NY, 2000 ISBN: 9780750644495

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in
b. https://www.youtube.com/watch?v=bLXDPs7UrXs for I.C. engine working principle
c. www.Learnengineering.org
d. https://www.youtube.com/watch?v=Rlw7Z4ksFgg for time an engine without timing marks
e. https://www.youtube.com/watch?v=OrfjuiQTIk4&t=60 for engine lubrication system

f. https://www.youtube.com/watch?v=vErfnY5bPrY and https://www.youtube.com/watch?v=9BYm0HnLGRU for carburettor working animation
g. https://www.youtube.com/watch?v=EhwK2KWDH1Y for fuel filter animation
h. https://www.youtube.com/watch?v=JSymXTP8HTg for Distributor type FIP animation
i. https://www.youtube.com/watch?v=IjXnbFVJKRY for Jerk type FIP animation

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Third**

Course Title : **Automobile Transmission System**

Course Code : **22309**

1. RATIONALE

This course provides knowledge about the various components of vehicle layout and the power transmission train used. This course will also help the students during inspection, installation, operation and maintenance of transmission system of automobile. This course is therefore a core course for automobile engineers and they should develop desired knowledge and skills over it.

2. COMPETENCY

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

- **Check the functioning of the automobile power transmission system 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 proper tools and equipment to check automobile transmission system components.
b. Select relevant vehicle layout and chassis for specific purpose.
c. Check automobile transmission system components.
d. Dismantle/assemble automobile transmission system components.
e. Diagnose simple problems pertaining to wheels and tyres of automobiles.

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.

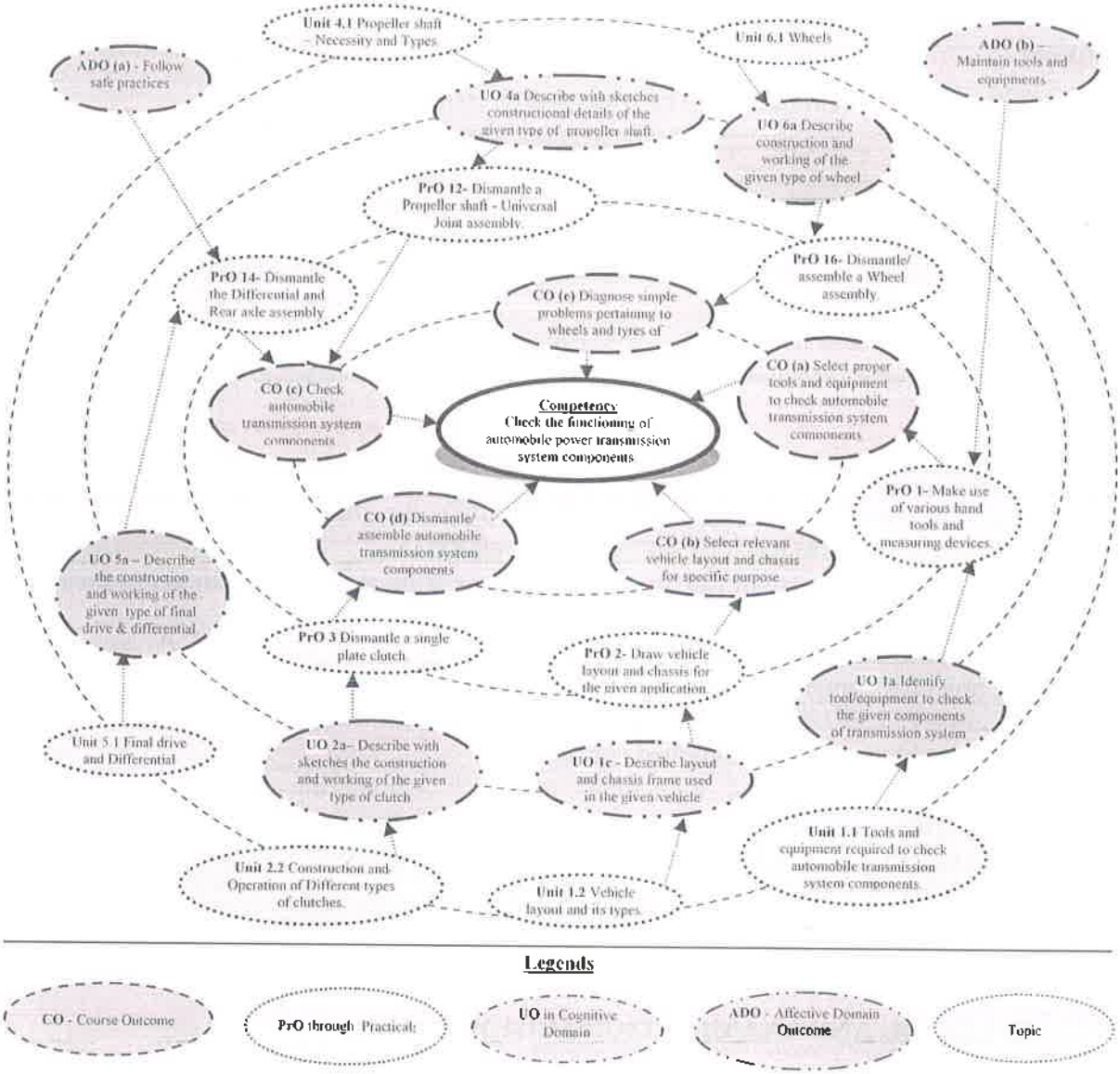

Figure 1 - Course Map

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	Make use of various hand tools and measuring devices.	I	02*
2	Trace vehicle layout and chassis of the given vehicle.	I	02*
3	Dismantle a single plate dry type clutch assembly.	II	02*
4	Assemble a single plate dry type clutch assembly.	II	02
5	Dismantle a Multi-plate clutch assembly used in two wheelers.	II	02*
6	Assemble a Multi-plate clutch assembly used in two wheelers.	II	02
7	Dismantle a Synchromesh gear box.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Assemble a Synchromesh gear box	III	02
9	Dismantle a Vario-drive used in mopeds.	III	02*
10	Assemble a Vario-drive used in mopeds.	III	02
11	Identify the components of the sequential automatic transmission.	III	02*
12	Dismantle a Propeller shaft - Universal Joint assembly.	IV	02*
13	Assemble a Propeller shaft - Universal Joint assembly.	IV	02
14	Dismantle the Differential and Rear axle assembly.	V	02*
15	Assemble the Differential and Rear axle assembly.	V	02
16	Dismantle/ Assemble a Wheel assembly.	VI	02*
	Total		**32**

Note

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

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

S. No.	Performance Indicators	Weightage in %
a.	Follow safety rules and adopt standard practices for handling tools and equipments.	20
b.	Refer workshop manual and include relevant data in the journal.	10
c.	Sketching, Drawing layouts and conclusion.	40
d.	Answer to sample questions/Demonstration ability	20
e.	Timely submission of journal.	10
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Vehicles – a) Two Wheeler – Minimum 100 cc motorcycle of make Bajaj/Hero/ Honda/Yamah/ TVS or alike. b) Three wheeler – RERWD Auto Rickshaw of Make Bajaj/ Piaggio or alike in good working condtion. c) Four wheeler vehicle – Car (FEFWD)/LMV (FERWD) of make Maruti/ TATA/Mahindra or alike in good running condtion.	All
2	Cut – section working model of Single Plate dry clutch: Coil spring/Diaphragm type single plate clutch assembly used in car/LMV/HMV suitably mounted on M.S. stand and in good operating condition.	3
3	Cut – section working model of Multi-Plate Wet type clutch: Multi-Plate Wet type clutch used in motorcycle suitably mounted on M.S. stand and in good operating condition.	3
4	Cut – section working model of simple Pulley based vario-drive used in mopeds.	3
5	Cut – section working model of four wheeler transmission system: Synchromesh gear box used in LMV/HMV suitably mounted on M.S. stand and in good operating condition.	5
6	Cut – section working model of Sequential automatic transmission system.	7
7	Cut – section working model of Final drive and differential used in Car/LMV/HMV and suitably mounted on M.S. stand and in good operating condition.	9
8	Four wheeler chassis – Cut section working model of chassis of Front Engine Rear wheel drive/Four wheel drive vehicle with Engine, transmission, steering, brakes, suspension and electrical systems.	All
9	Four wheeler chassis – Cut section working model of chassis of Front Engine Front wheel drive car of any make with MPFI engine, transmission, steering, brakes, suspension and electrical systems.	

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 Overview of Automotive Transmission System	1a. Identify tool/equipment to check the given component of automotive transmission system. 1b. Interpret the given vehicle layout for functional relationship of the given components of	1.1 Tools and equipment required to check automotive transmission system components. 1.2 Vehicle layout and its types: (a) Introduction of related terms- an automobile, Chassis, Body, Types of vehicles and Vehicle layout. (b) Classification of vehicle layout with respect to- i) Location of engine, ii) No of live axles, iii)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	transmission system. 1c. Describe layout and chassis frame used in the given vehicle. 1d. Select the relevant frame for the given capacity of vehicle with justification. 1e. Identify the materials of the given types of frames.	Arrangement of Engine, Passenger and Luggage section, iv) Application (c) Layout of the front engine rear wheel drive vehicle- Location and functions of major components of transmission system. 1.3 Chassis Frames: Necessity of frame. (a) Loads acting on frame. (b) Types of frames- conventional (ladder and x-member type), semi integral and integral types. Sub frames. (c) Frame sections-channel, box and tubular sections. (d) Materials for frames.
Unit– II Automotive Clutches	2a. Describe with sketches the construction and working of the given type of clutch. 2b. Describe with sketches the operation of the given clutch actuating mechanism. 2c. Compare with sketches the types of clutches on the basis of construction, torque transmission, size.	2.1 Clutch: Necessity of clutch, Requirements of automotive clutches, Classification - Friction and Non friction type clutches 2.2 Construction and Operation of Different type of clutches a. Construction and Operation of a Single plate (coil and Diaphragm) dry clutch, Multi-plate – Dry and wet clutch, Centrifugal clutch. b. Construction details of Clutch plate. Clutch lining materials. c. Clutch operating mechanisms-mechanical, hydraulic, vacuum. d. Fluid Coupling – Principle, Construction and Working
Unit– III Automotive Gear boxes	3a. Describe with sketches the construction and working of the given type of gear box. 3b. Determine the gear ratio for the given type of gear arrangement. 3c. Describe the power flow diagrams for the given type of gear box when forward and reverse gears are in engaged positions. 3d. Describe with sketches the method of lubrication for the given type of gearbox.	3.1 Necessity of Gear Box 3.2 Types of automotive Gear Boxes -Construction and operation of - Sliding Mesh, Constant Mesh, Synchromesh gear box, Power flow diagrams for forward and reverse gears in engaged position. 3.3 Torque Converter- Construction and working and application. 3.4 Concept of Semiautomatic and automatic transmission. 3.5 Variator Drive, Continuously variable transmission 3.6 Gear selector mechanism with gear lever mounted on top of gear box. 3.7 Transfer case – Purpose, construction and working. 3.8 Lubrication of gear box.
Unit-IV Propeller shaft and	4a. Describe with sketches the constructional details of the given type of	4.1 Propeller shaft - Necessity and Types. Constructional details of Hollow and solid propeller shaft.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Universal joints	propeller shaft. 4b. Compare with sketches the given type of axle drives based on construction, working, loads acting on it and applications. 4c. Describe with sketches the construction, working and applications of the given type of universal joint.	4.2 Types of rear axle drives – construction, working and applications of Torque tube drive and Hotchkiss drive. 4.3 Universal Joint – Functions, Types, Construction and Operation of simple Hooke's joint, Constant velocity joints – Inboard Tripod Joint and outboard Rezappa joint. 4.4 Functions and construction of slip joint.
Unit –V Final drive, Differential and Rear axle	5a. Explain with sketches the construction and working of the given of type of final drive and differential. 5b. Compare with sketches the given types of rear axles used in the given four wheeler based on construction, working and application. 5c. Describe with sketches the method of lubrication for the given type of rear axle assembly.	5.1 Final drive and Differential a. Necessity and types of final drive. b. Necessity and types of differential. c. Construction and working of final drive and differential. 5.2 Rear Axle a. Necessity of Rear Axle. b. Loads acting on the rear axle c. Types of rear axles- semi floating, Three quarter floating and full floating type. d. Rear axle casing- split and banjo type. e. Double reduction axle. f. Method of lubrication for rear axle assembly.
Unit-VI Wheels and Tyres	6a. Describe construction and working of the given type of wheel with sketches. 6b. Compare with sketches the the given types of tyres based on specifications, construction and performance. 6c. Select the suitable tyre and its inflation for the given application. 6d. Interpret the specifications for the given type of tyre.	**6.1** Wheels: Functions, Types of wheels - construction and applications of Wired spoke wheel, Disc wheel and Alloy wheels. 6.2 Tyres a. Functions of tyre, Types of Tyres - Construction and working of tubed tyre and Tubeless tyres. Radial ply, Cross ply, Belted bias types of tyres, Tyre Specifications. b. Concept of Aspect ratio. c. Types of tread patterns. d. Tyre inflation –Types and effects of incorrect tyre inflation. e. Tyre rotation – Necessity.

***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	Overview of Automotive Transmission System	08	04	04	04	12
II	Automotive Clutches	10	02	08	06	16
III	Automotive Gearboxes	10	02	08	06	16
IV	Propeller shaft and Universal joints	06	02	04	02	08
V	Final drive, Differential and Rear axle	08	02	04	04	10
VI	Wheels and tyres	06	02	04	02	08
Total		**48**	**14**	**32**	**24**	**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. Compare clutches used in a two wheeler, four wheeler and moped.
d. Write down the parts of transmission system of your bike with detailed specification and manufacturer's name.
e. List examples/situations where universal joints are used.
f. Write down the specification of tube less tyres for three leading tyre manufacturers.
g. Compare broad base and narrow base tyres.
h. Visit a nearby vehicle repair shop and observe the construction and working of two and four wheeler gear boxes.

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. Observe the number of vehicles running on road and classify them according to different bases.
b. Collect the data of any three vehicles of same category and compare them.
c. Collect the data of Indian Motor vehicle manufacturers and their products and write a report on it.
d. Collect the data of different types of clutches commonly used in vehicles and compare it.
e. Collect the different types of universal joints from scrap/garage and write report with their comparison.
f. Identify the advance systems used in modern vehicle and prepare report on it.
g. Prepare cut-section models of any one used transmission system component/assembly.
h. Collect the data of different types of tyres from market and compare it.
i. Collect the different types of tyre tread sections and demonstrate their applications.
j. Prepare display boards or charts for clutch, gear box, propeller shaft and universal joints, differential and types of rear axle, wheels and tyres etc.

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1	Automobile Engineering	Gupta, R. B.	Satya Pralkashan, New Delhi, 2010 ISBN-13: 9788176843799
2	Automobile Engineering	Gupta K. M.	Umesh Publication, New Delhi, 2011. ISBN-13: 5551234002614
3	Automobile Engineering	Jain, K.K.; Asthana, R.B.	TATA McGraw Hill Publications, New Delhi, 2015, ISBN-007044529X, 97800705291.
4	Automobile Engineering	Narang, G.B.S	Khanna Publishers, New Delhi, 2012. ISBN-13: 1234567144518
5	Automobile	Singh, Kirpal	Standard Publishers distributors, New

S. No.	Title of Book	Author	Publication
	Engineering Vol. II		Delhi, 2009, ISBN-13: 978-8180142062
6	Automotive Mechanics	Srinivasan, S.	Tata McGraw-Hill Education – 2nd Edition, 2003, ISBN 13: 9780070494916
7	Motor Automotive Technology	Schwaller, Anthony E.	Delmar Publishers Inc. New Delhi, 2009, ISBN-13: 978-0827351004
8	Automotive Mechanics	Crouse, William H; Anglin Donald L	McGraw Hill Education (India) Pvt. Ltd. 2006 ISBN 13: 9780070148604
9	Automobile Mechanics	Giri, N. K.	Khanna Publishers, New Delhi, 8th Edition, 2008, ISBN: 9788174092168
10	Basic Automobile Engineering	Nakra, C. P.	Dhanpat Rai Publication Co. (P) Ltd., New Delhi, 2009, ISBN-13: 9788187433224

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=H7Iay0Ke_t4-For Clutch
b. https://www.youtube.com/watch?v=OQ9eI7mEmxw-For Clutch
c. https://www.youtube.com/watch?v=F8W5hp1Y2XE-For Synchromesh Gear box
d. https://www.youtube.com/results?search_query=Differential+
e. https://www.youtube.com/results?search_query=Rear+axle

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

Program Code : **AE/ME**

Semester : **Third**

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

Course Code : **22310**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

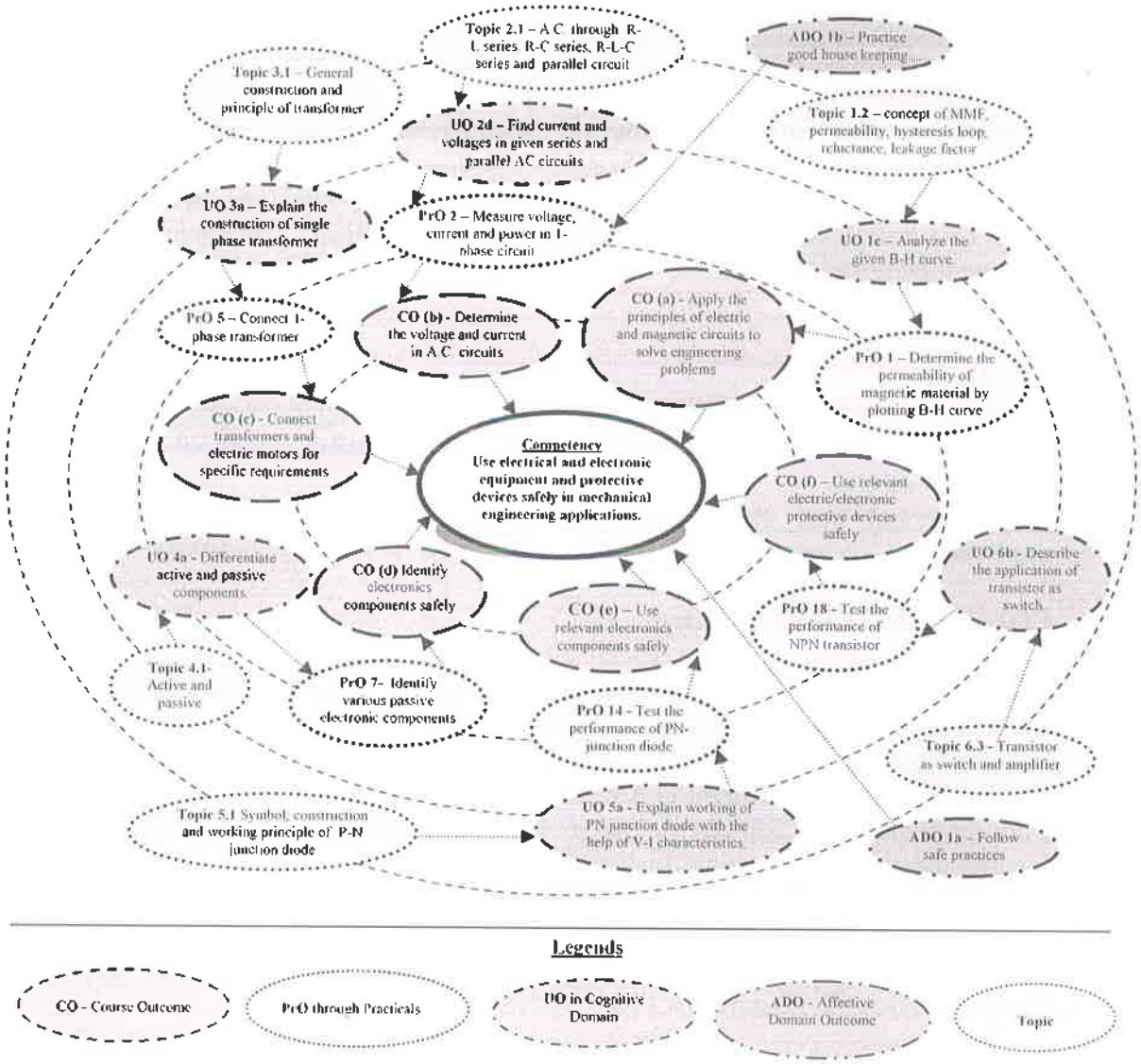

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

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

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

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

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

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Third**

Course Title : **Automobile Engineering Drawing**

Course Code : **22023**

1. RATIONALE

Automobile engineering technologists, irrespective of their field of operation in an automobile industry, is expected to possess a thorough understanding of drawing, which includes clear visualization of objects and automobile components with the proficiency in reading and interpreting variety of production drawings. Besides, they are also expected to possess drafting skills depending upon job function, to perform day to day activity i.e. communicating and discussing innovative ideas and concepts with supervisors and passing on instructions to subordinates unambiguously. This course is enhancing the knowledge and skills acquired in the earlier two courses viz. Engineering Graphics & Engineering Drawing.

2. COMPETENCY

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

- Prepare drawings of automobile components using conventional drawing instruments and standards.

3. COURSE OUTCOMES (COs)

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

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

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	
1	-	4	5	--	--	--	--	--	--	--	50@	20	50~	20	100	40	

(#):No theory Exam; (~[2]): For the courses having ONLY practical examination, the PA has two parts – marks for ~[2] (i) practical part - 30 marks (60%) (ii) micro-project part – 20 marks (40%).

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.

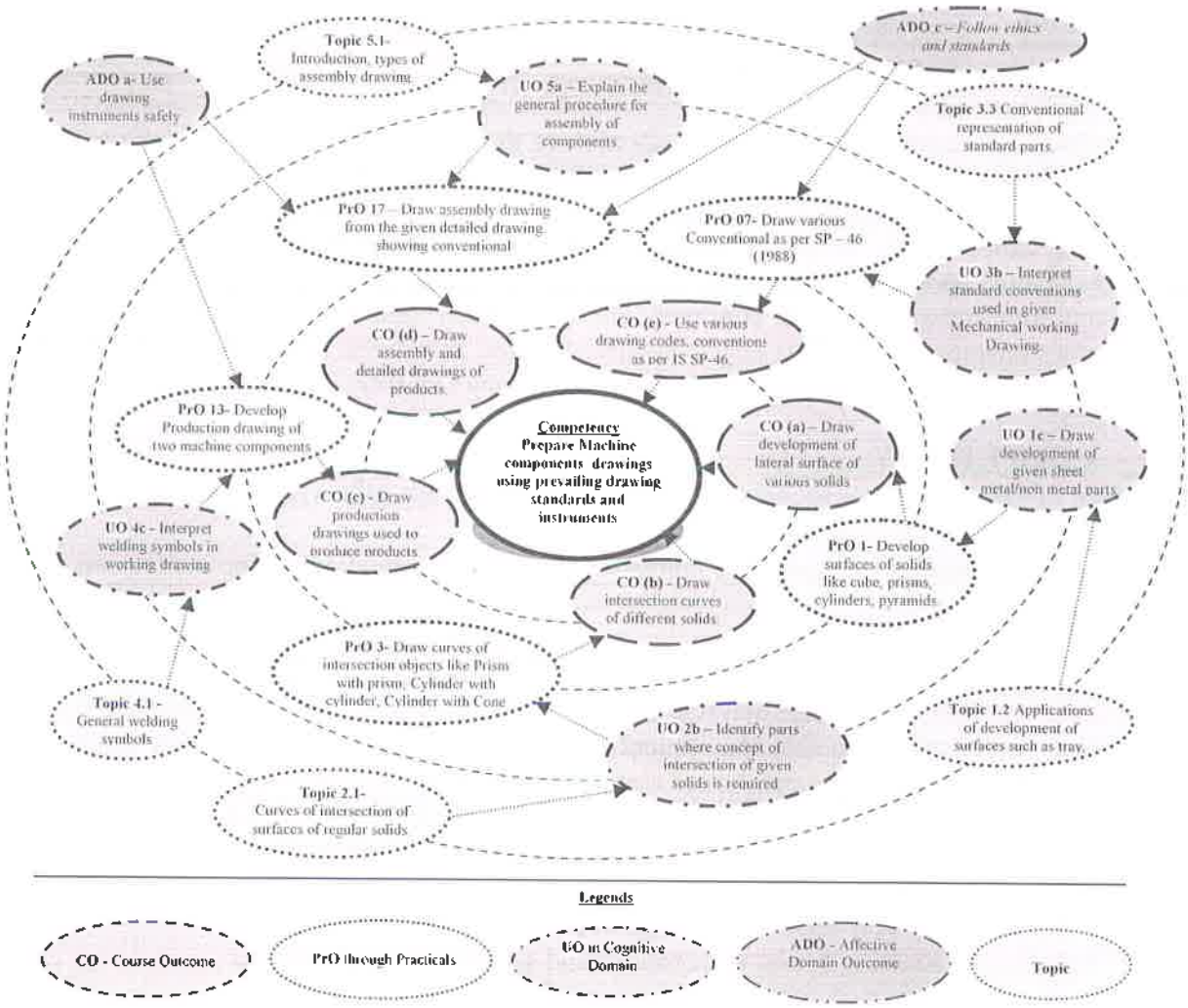

Figure 1 - Course Map

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
Sheet No.:1			
1	Develop surfaces of solids like cube, prisms, cylinders, pyramids. (Part I)	I	02*
2	Develop surfaces of solids like pyramids, cones. (Part II)		
Sheet No.:2			
3	Draw curves of intersection of any two objects like Prism with prism (Tri-angular and square), Cylinder with cylinder, Square	II	02*

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
19	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part III)	V	02
20	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part IV)	V	02
21	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part V)	V	02
22	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part VI)	V	02
23	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part VII)	V	02
24	Draw assembly drawing from the given detailed drawing showing conventional representations, Dimensional and Geometrical tolerances and surface finish symbols. (Part VIII)	V	02
Sheet No.:7			
25	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part I)	VI	02*
26	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part II)	VI	02
27	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part III)	VI	02
28	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part IV)	VI	02
29	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part V)	VI	02
30	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part VI)	VI	02
31	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part VII)	VI	02
32	Draw detailed drawings from given assembly drawing of Rocker arm showing conventional representation, Dimensional and Geometrical tolerances and surface finish symbols. (Part VIII)	VI	02
	Total		**64**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be

performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. Unit.No.
1.	Drawing Table with Drawing Board of Full Imperial/ A1 size	All
2.	Paper Models of objects for development of Lateral surfaces of solid	01, 02
3.	Models of solids showing intersection curves	03 to 06
4.	Models of machine components for conventional representation	07 to 09
5.	Actual assemblies mentioned in unit V	13 to 32
6.	Set of various production drawings being used by industries	All
7.	Specimen library of various machine components	All
8.	Set of drawings sheets mentioned in section 6.0 could be developed by experienced teachers and made available on the MSBTE portal to be used as reference/standards	All

S. No.	Equipment Name with Broad Specifications	PrO. Unit.No.
9.	Drawing equipment's and instruments for class room teaching-large size: a. T-square or drafter (Drafting Machine) b. Set squares (45^0 and 30^0- 60^0) c. Protractor Drawing instrument box (containing set of compasses and dividers)	All
10.	Interactive board with LCD overhead projector	All

8. UNDERPINNING THEORY COMPONENTS

The following topics 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 Development of Surfaces	1a. Identify parts where concept of development of the given surfaces is required. 1b. Describe the procedure to draw development of lateral surfaces of the given solid. 1c. Describe the procedure to draw development of given sheet metal/non metal parts.	1.1 Developments of Lateral surfaces of cube, prisms, cylinder, pyramids, cone. (Parallel and Radial Line methods) 1.2 Applications of development of surfaces such as tray, funnel.
Unit-II Intersection of Solids	2a. Identify parts where concept of intersection of the given solids is required. 2b. Describe different methods of Intersection of surfaces of solids 2c. Describe the procedure to draw curves of intersection of the given solid combinations.	2.1 Method of Intersection of surfaces of two solids: Line Method, Cutting Plane Method. 2.2 Curves of intersection of surfaces of the regular solids in the following cases: Prism with prism(Tri-angular and square), Cylinder with cylinder, Square Prism with Cylinder when (i) the axes are at 90° and intersecting. (ii) The axes are at 90° and Offset. 2.3 Cylinder with Cone: when axis of cylinder is parallel to both the reference planes and cone resting on base on HP with axis intersecting and offset from axis of cylinder.
Unit– III Conventional Representation	3a. Use IS SP-46 (1988) codes. 3b. Interpret standard conventions used in the given mechanical working drawing. 3c. Select the standard	3.1 Conventional breaks in pipe, rod and shaft. 3.2 Conventional representation of common features like slotted head, radial rib, knurling, serrated shaft, splined shaft, ratchet and pinion, repeated parts, square on shafts, holes on circular pitch, internal

	conventions in practice for the given situation.	and external thread. 3.3 Conventional representation of standard parts like ball and roller bearing, keys, gears, springs. 3.4 Pipe joints and valves. 3.5 Counter sunk and Counter bored holes. 3.6 Tapers (As per standard conventions using IS SP – 46 (1988)
Unit– IV Conventional Representation and Production Drawings	4a. Calculate tolerances of the given machine components. 4b. Identify fit required between mating parts of the given machine components based on the given tolerance values. 4c. Interpret welding symbols in the given working drawing. 4d. Interpret surface roughness characteristics from the values the given on component drawing. 4e. Describe the procedure to draw above conventional representations for the given situation.	4.1 Limits, Fits and Tolerances: a) Definitions, introductions to ISO system of Tolerance. b) Dimensional tolerances:-Terminology, selection and representation of dimensional tolerance- number and grade method. Definitions concerning Tolerance and Limits system, unilateral and bilateral tolerance, Hole and shaft base systems, Types of fits- Clearance, transition and Interference, Selection of fit for engineering applications. Calculation of limit sizes and identification of type of fit from the given sizes like Ø50 H7/s6, Ø30 H7/d9 etc. 4.2 Geometrical Tolerances: Types of geometrical tolerances, terminology for deviation, Tolerances of form and position and its geometric representation. Tolerance frame, datum feature, magnitude of tolerance and symbol, representation and interpretation of geometrical tolerance on drawing. 4.3 General welding symbols, length and size of weld, surface contour and finish of weld, all round and site weld, symbolic representation in Engineering practices and its interpretation. 4.4 Machining symbol and surface texture: Indication of machining symbol showing direction of lay, sampling length, roughness grades, machining allowances, manufacturing methods. Representation of surface roughness on drawing.
Unit– V Details to Assembly	5a. Explain the general procedure for assembly of components. 5b. State details of components and the sequence of components	5.1 Introduction, types of assembly drawing, accepted norms to be observed for assembly drawings, sequence for preparing assembly drawing. Bill of Material. Assembly drawings of: a) Couplings - Universal couplings

	of the given assembly. 5c. Describe the procedure to draw assembly drawing from the given detailed drawing.	b) Bearing –Pedestal Bearing c) Tool Post – Lathe Square tool post. d) Screw Jack e) Drilling Jig
Unit– VI Assembly to Details	6a. Identify various components in the given assembly and the sequence of dismantling it. 6b. Describe the procedure for dismantling the assembly into components. 6c. Describe the procedure to draw detailed drawing from the given assembly drawing.	6.1 Basic principles of process of dismantling the assembly into components. 6.2 Details of following assemblies a) Non - Return Valve b) Piston & connecting rod assembly, c) Single plate clutch assembly d) Rotary Gear pump. e) Fuel injector.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

-Not applicable-

10. SUGGESTED STUDENT ACTIVITIES

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

a. Student should maintain a separate A3 size sketch book which will be the part of term work and submit it along with drawing sheets. Following assignment should be drawn in the sketch book
   i. Minimum 5 problems each on Unit No I and II.
   ii. Convention Representation of material, gear, spring, bearings, internal threads, external threads, welding joints, machining symbol, direction of lays.
b. Students should collect Production drawings from nearby workshops/industries and try to visualize the part from the given views.
c. Prepare paper models of development of lateral surfaces of solids
d. Visit any sheet metal workshop and prepare a report related to type of components, dimensions, material, area of application, raw material required, name of operations performed.
e. Prepare clay/ paper models of solids showing curves of intersection.
f. Each student should explain at least one problem for construction and method of drawing in sheet to all batch colleagues.
g. Each student will assess at least one sheet of other students (May be a group of 5-6 students identified by teacher can be taken) and will note down the mistakes committed by them. Student will also guide the students for correcting the mistakes, if any.
h. Student to make assembly and dismantling physically of at least one automobile assembly.

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 during practice.
i. Arrange visit to nearby industries and workshops for understanding various production drawings.
j. Show video, animation films, solid modeling software to explain intersection of solid, Assembly and details
k. Prepare wall charts for Dimensional and Geometrical Tolerances.

12. SUGGESTED MICRO-PROJECTS

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

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Machine Drawing	Bhatt N.D., Panchal V.M.	Charotar Publishing house pvt ltd., Anand, Gujarat, 2013, ISBN 9789380358635
2	Engineering Drawing practice for schools and colleges IS:SP- 46	Bureau of Indian standard	BIS, New Delhi, Third reprint, Octomber 1998 ISBN 8170610912
3	Production Drawing	Narayanan L.K., Kannaich P., VenkatReddy K.	New Age International Publication, New Delhi, 2009, ISBN: 9788122435016
4	Engineering Drawing	Bhatt N.D.	Charotar Publishing house pvt ltd. Anand, Gujarat, ISBN:9789380358178
5	A text book of Machine Drawing	Gill P.S.	S.K.Kataria and Sons, New Delhi,2007, ISBN: 9789350144169
6	Machine Drawing	Sidheshwar	McGraw Hill, New Delhi, 2009, ISBN : 9780074603376
7	Machine Drawing	Ajeet Singh	McGraw Hill Education, New Delhi, ISBN No.: 007065992-3
8	Engineering Drawing	Basant Agrawal, C.M. Agrawal	McGraw Hill Education, New Delhi 2009, ISBN No. 978-00-7066-863-8

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. sketch up 7 software for solid modelling
b. http://www.weldingtechnology.org
c. http://www.newagepublishers.com
d. Engineering graphics and Drawing v 1.0 from cognifront
e. http://www.youtube.com/watch?v=o1YPja2wCYQ
f. http://www.youtube.com/watch?v=9AGD4tihjCg&feature=plcp
g. http://www.youtube.com/watch?v=n65NU32inOU
h. http://www.youtube.com/watch?v=tyRVsSsNiUQ
i. http://www.youtube.com/watch?v=_M5eYB6056M
j. http://www.youtube.com/watch?v=UyROI-bAMu4
k. http://www.youtube.com/watch?v=eix8xbqb93s
l. http://www.youtube.com/watch?v=kWOl6ttDTBc
m. http://www.youtube.com/watch?v=gJbrO2jtoa8&feature=related
n. http://www.youtube.com/watch?v=PXgkBadGHEE
o. Engineering Graphics & Drawing v 1.0 from Cognifront

Maharashtra State Board of Technical Education, Mumbai

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

Program Name : Diploma in Mechnical Engineering

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

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

Semester : Third — **Scheme - I**

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

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

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

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

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

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

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

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

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Mechanical Engineering Program Group**

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

Semester : **Third**

Course Title : **Strength of Materials**

Course Code : **22306**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

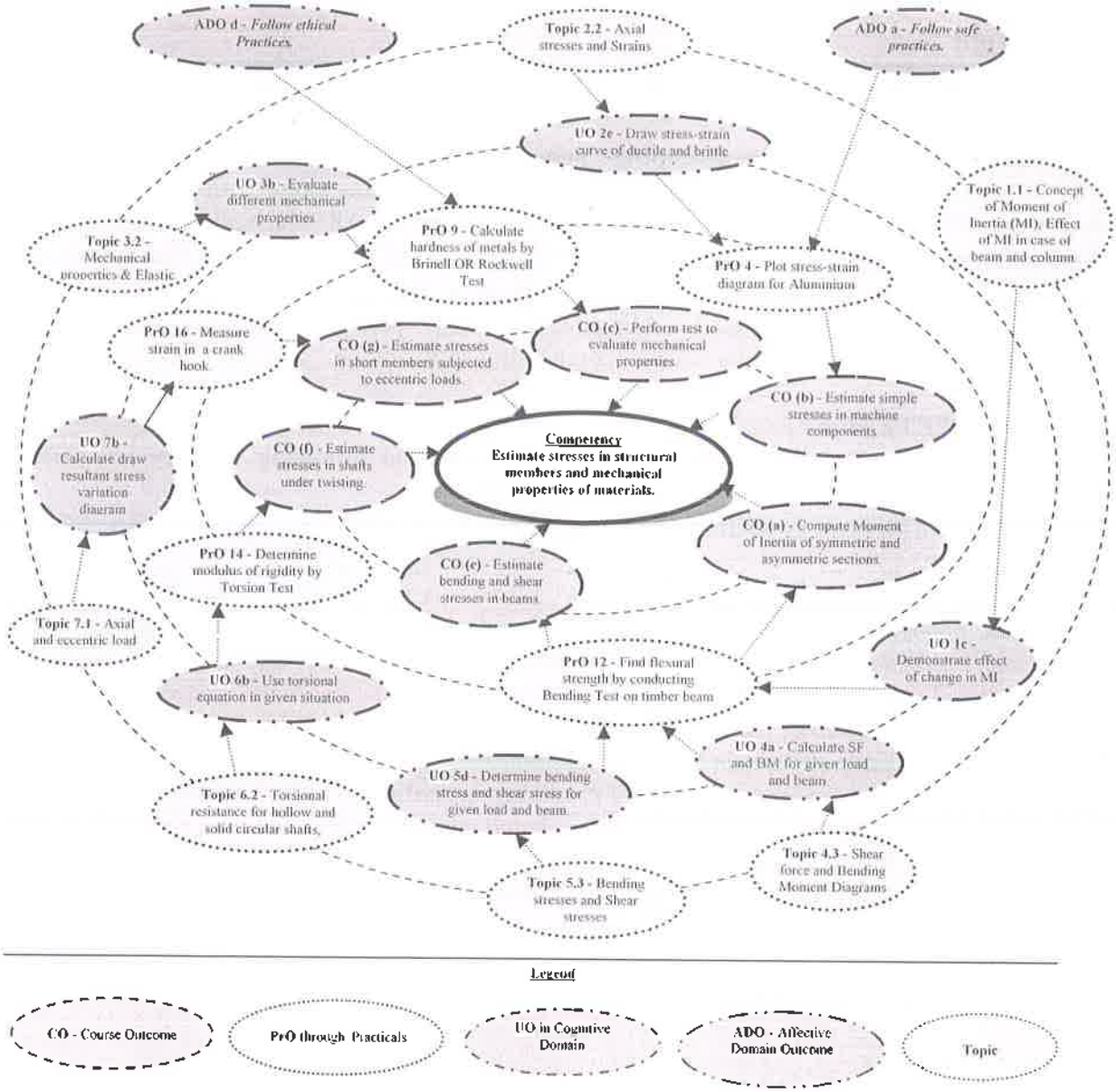

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

*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.	Awareness about significance of particular test	15
b.	Understanding working principle of machine	15
c.	Preparation of experimental set up	20
d.	Setting and operation	20
e.	Observations and recording	10
f.	Interpretation of result and conclusion	10
g.	Answer to sample questions	5
h.	Submission of report in time	5
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

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

12. SUGGESTED MICRO-PROJECTS

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

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

Program Code : **AE / ME**

Semester : **Third**

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

Course Code : **22310**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

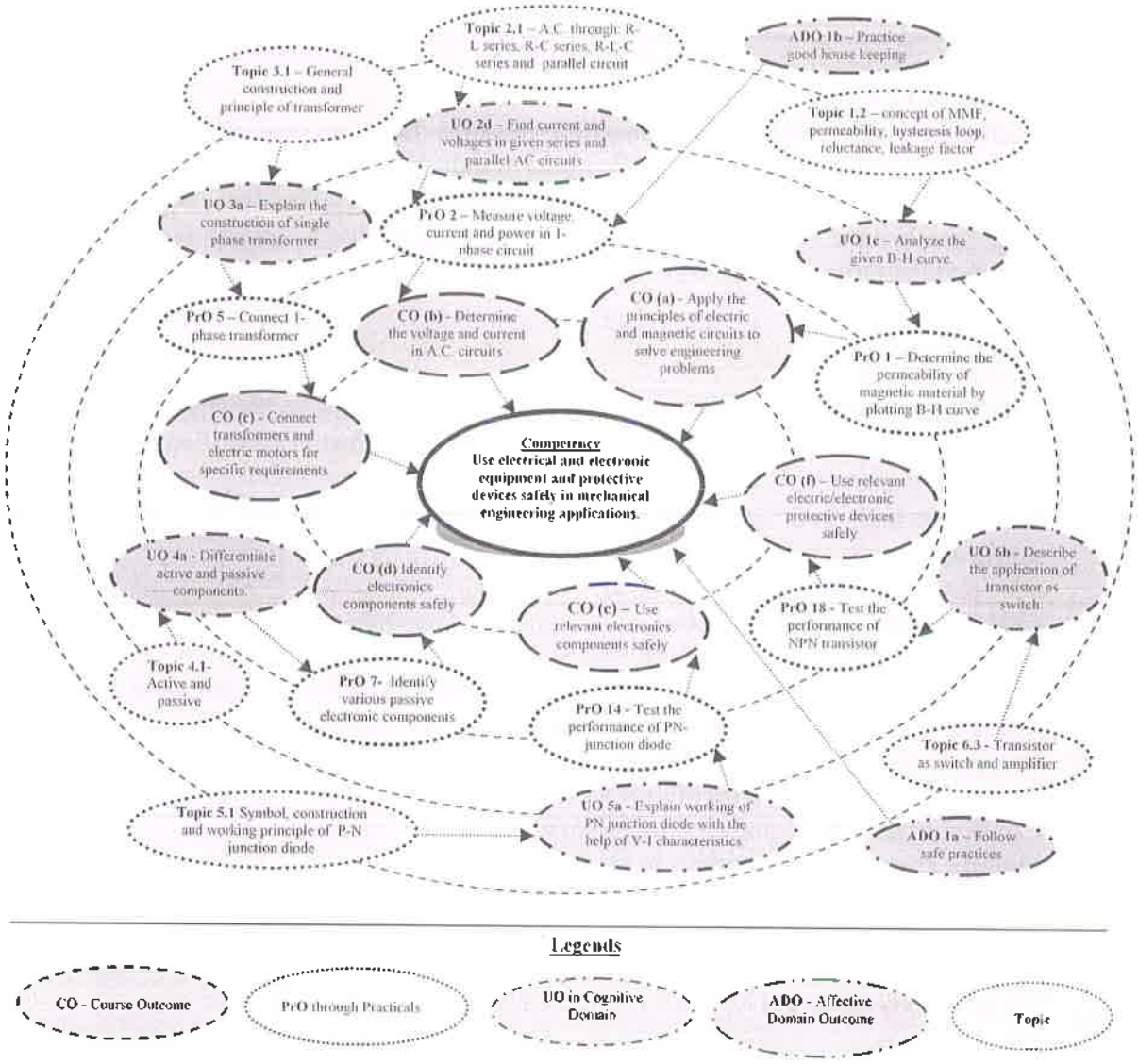

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

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

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

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

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

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

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

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

Semester : **Third**

Course Title : **Thermal Engineering**

Course Code : **22337**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

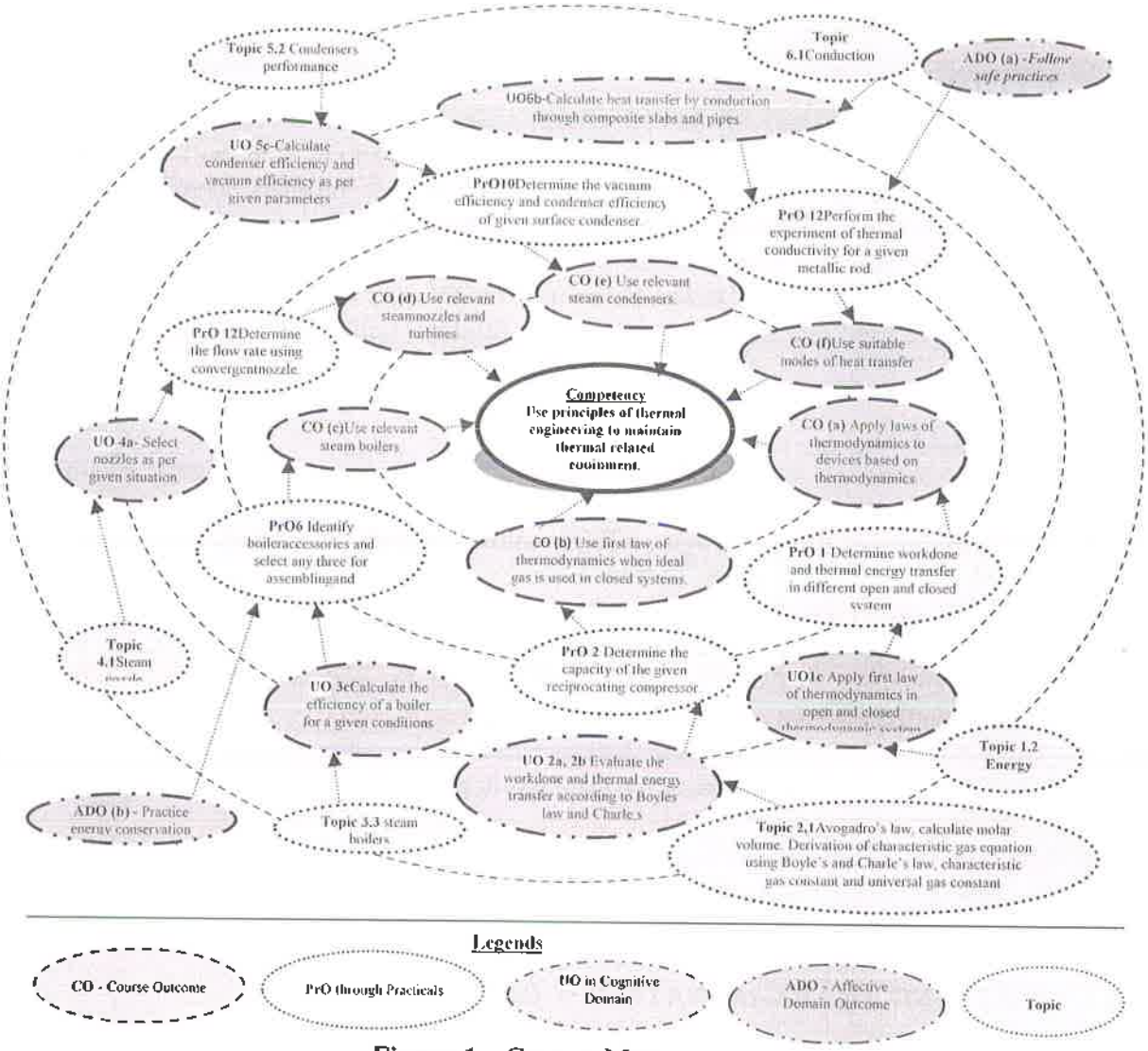

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Mechanical Working Drawing**

Course Code : **22341**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.
Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment.*

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

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

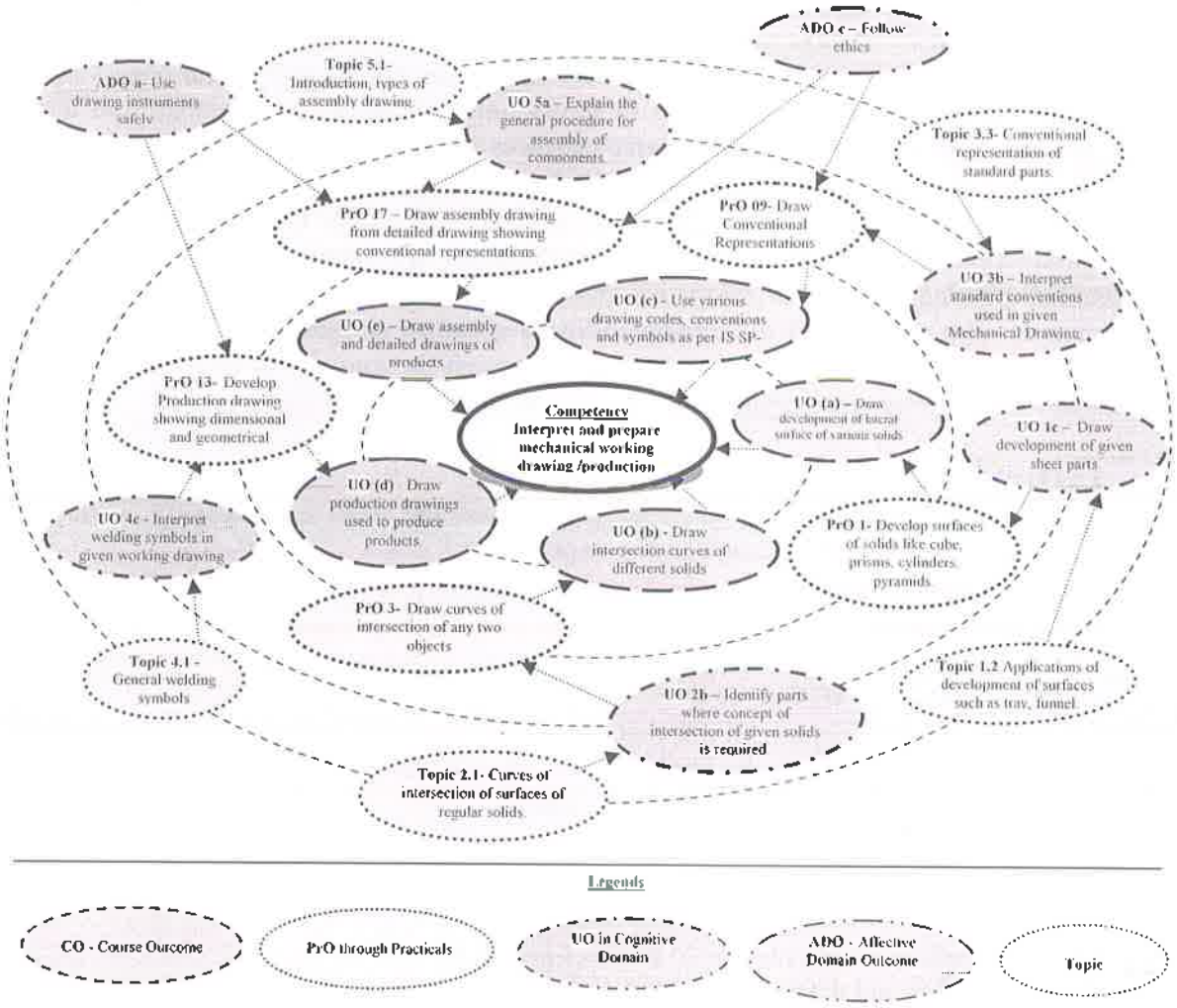

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/EXERCISES

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

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

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

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

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

Note:

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SOFTWARE/LEARNING WEBSITES

a. sketch up 7 software for solid modelling
b. http://www.weldingtechnology.org
c. http://www.newagepublishers.com
d. Engineering graphics and Drawing v 1.0 from cognifront
e. http://www.youtube.com/watch?v=o1YPja2wCYQ
f. http://www.youtube.com/watch?v=9AGD4tihiCg&feature=plcp
g. http://www.youtube.com/watch?v=n65[illegible]2mOE
h. http://www.youtube.com/watch?v=tyRVsSsNiUQ

i. http://www.youtube.com/watch?v=_M5eYB6056M
j. http://www.youtube.com/watch?v=UyROI-bAMu4
k. http://www.youtube.com/watch?v=eix8xbqb93s
l. http://www.youtube.com/watch?v=kWOI6ttDTBc
m. http://www.youtube.com/watch?v=gJbrO2jtoa8&feature=related
n. http://www.youtube.com/watch?v=PXgkBadGHEE
o. Engineering Graphics & Drawing v 1.0 from Cognifront
p. http http://npkauto.com/assignments


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Engineering Metrology**

Course Code : **22342**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4 TEACHING AND EXAMINATION SCHEME

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

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

during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.
***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

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

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

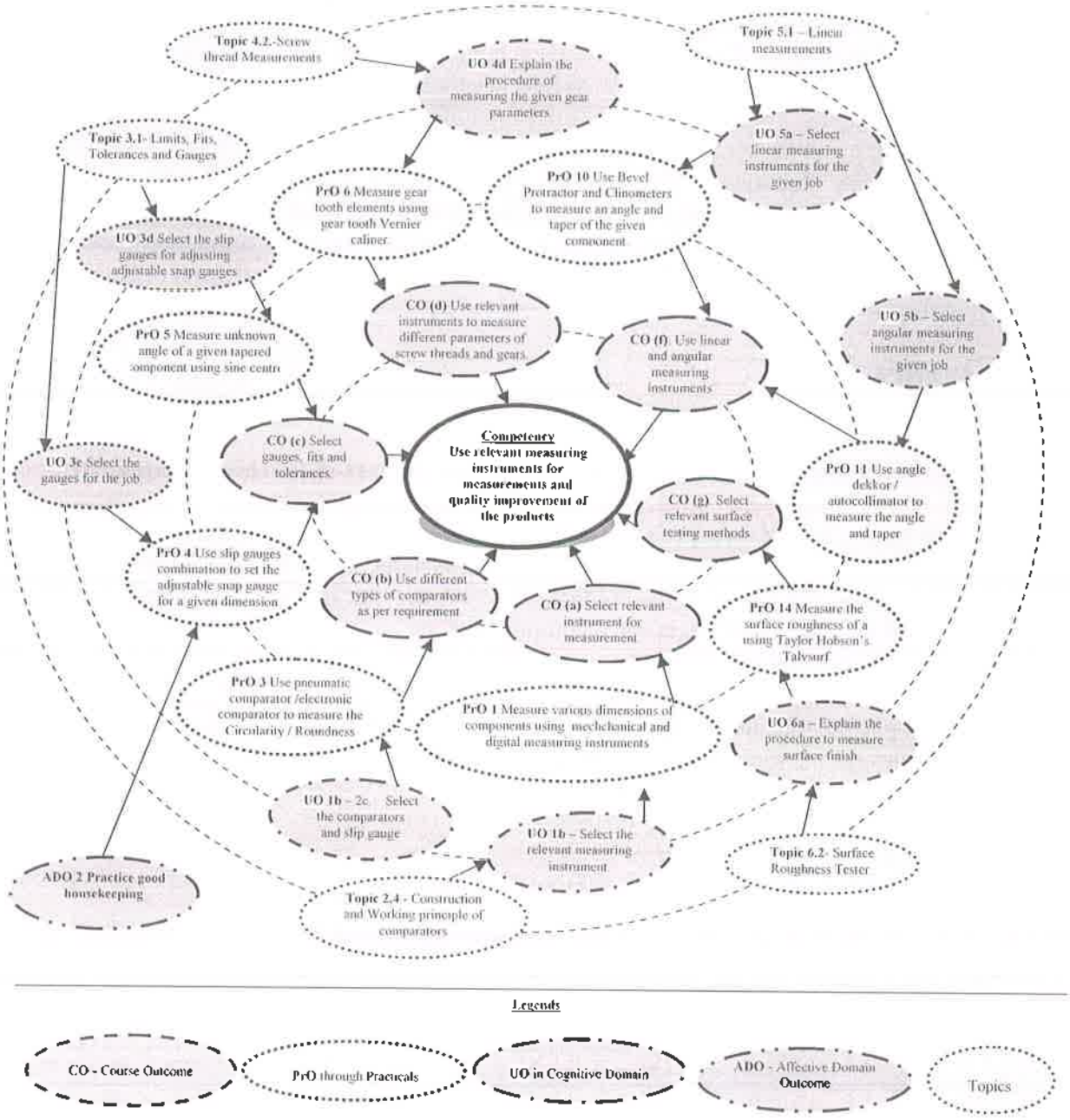

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

Note

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

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED TITLES OF MICRO-PROJECTS

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112106138
b. https://cosmolearning.org/video-lectures/pyrometry-cont
c. Tangram Software for CMM
d. Dong-Do software for Electronic comparator
e. https://www.youtube.com/watch?v=VpmZjIsV4C4
f. www.youtube.com/watch?v=qNIlZYAk9pI
g. https://www.youtube.com/watch?v=xcvNl1HHY9o
h. https://www.youtube.com/watch?v=DxdFiIDrFBc
i. https://www.youtube.com/watch?v=-_ZeUgVjajc
j. https://www.youtube.com/watch?v=iTjBPHtADA4
k. https://www.youtube.com/watch?v=I4h644S_64w
l. https://www.youtube.com/watch?v=XQT6RSNN9sA
m. https://www.youtube.com/watch?v=FgNAIKTTNtE
n. https://www.youtube.com/watch?v=sLZeR7RMGFA
o. https://www.youtube.com/watch?v=QGBRwXwxnuU
p. https://www.youtube.com/watch?v=jTbRMMgbnNU
q. https://www.youtube.com/watch?v=KeZ5CfPOlBc
r. https://www.youtube.com/watch?v=3hOVfbGSQ0c
s. https://www.youtube.com/watch?v=80sNyYPTXPA
t. https://www.youtube.com/watch?v=EWqThb9Z1jk
u. https://www.youtube.com/watch?v=j-u3IEgcTiQ
v. https://www.youtube.com/watch?v=CLEP5LQ-y0I

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Mechanical Engineering Materials**

Course Code : **22343**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

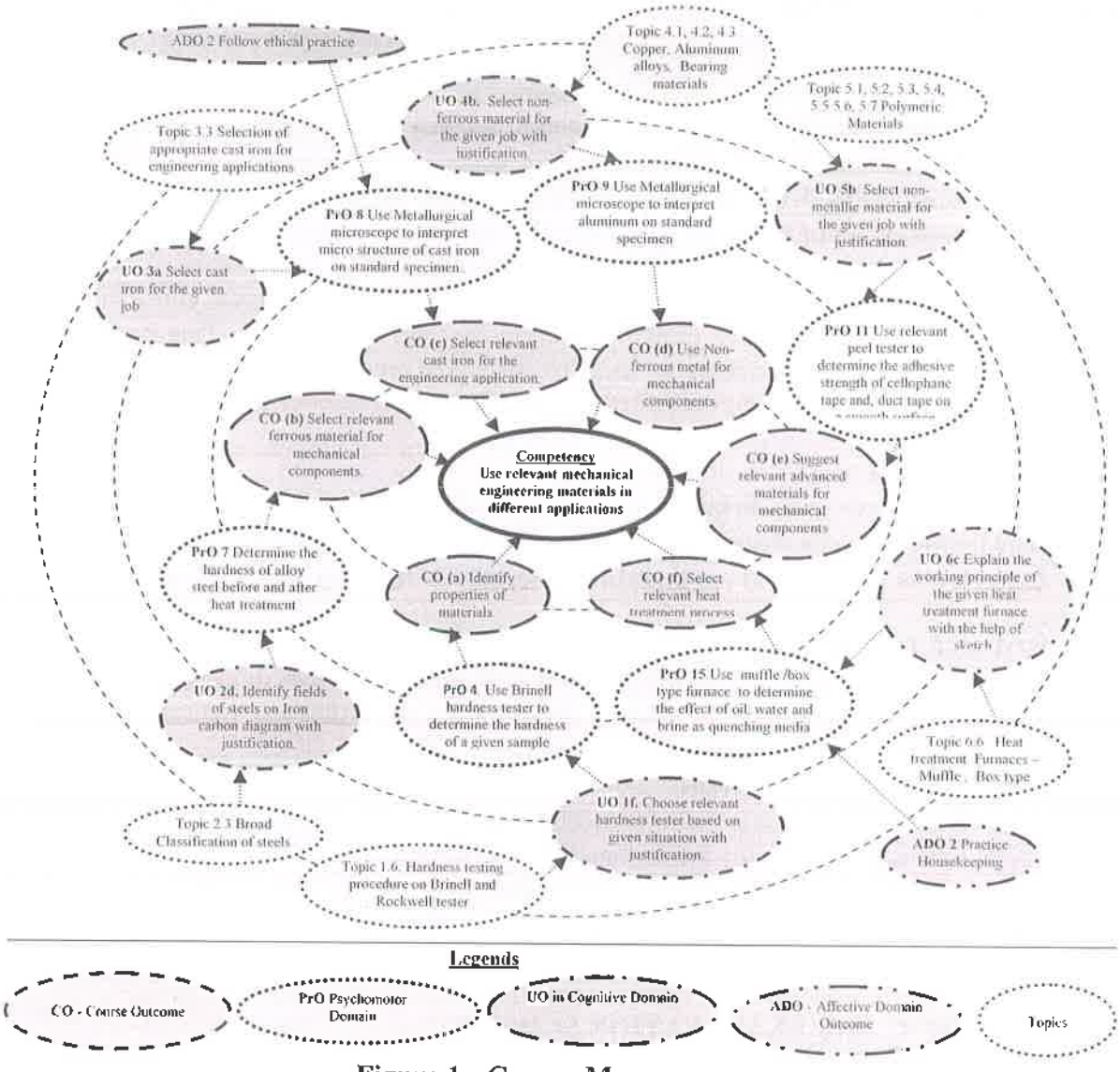

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

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

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

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

S. No.	Performance Indicators	Weightage in %
	Total	100

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED TITLES OF MICRO-PROJECTS

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

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

Maharashtra State Board of Technical Education, Mumbai

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

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

Program Code : PG / PT — **With Effect From Academic Year: 2017 - 18**

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

Semester : Third — **Scheme : I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
								Theory						Practical						
				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	Strength of Materials	SOM	22206	3	2	2	7	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
2	Thermal Engineering	TEN	22337	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Machining Processes	MPR	22338	3	-	2	5	4	70	28	30*	00	100	40	25@	10	25	10	50	20	150
4	Theory of Machines	TOM	22344	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
5	Induatrial Fluid Power	IFP	22345	4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
6	Production Drawing	PDR	22028	2	-	4	6	--	--	--	---	--	--	--	50#	20	50~	20	100	40	100
			Total	**18**	**2**	**14**	**34**	--	**350**	--	**150**	--	**500**	--	**175**	--	**175**	--	**350**	--	**850**

Student Contact Hours Per Week: **34 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **850**

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

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

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

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

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

Program Name : **Mechanical Engineering Program Group**

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

Semester : **Third**

Course Title : **Strength of Materials**

Course Code : **22306**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

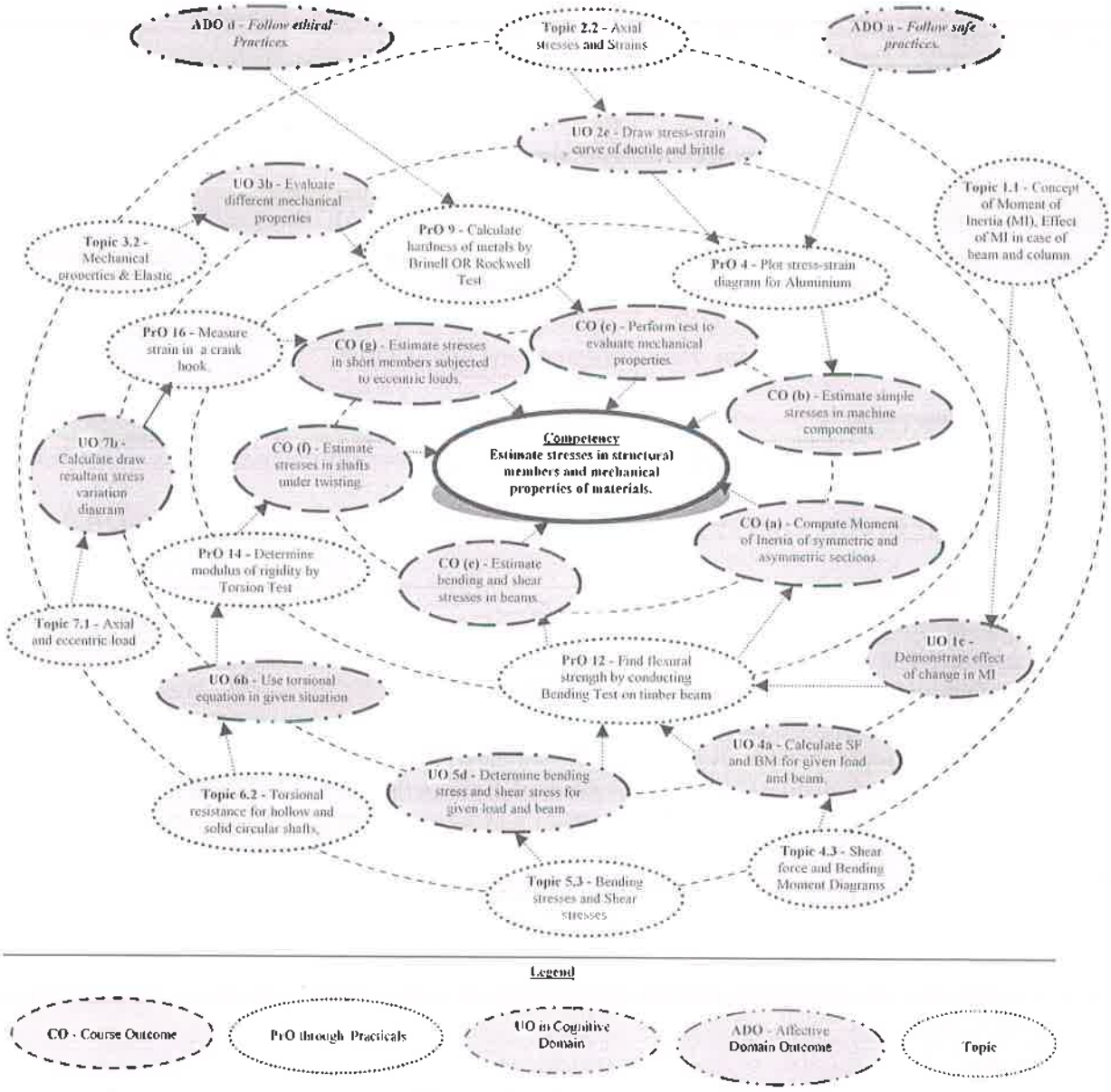

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part I & II) as per IS 1608 (I)	II	02*

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

Note

*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.	Awareness about significance of particular test	15
b.	Understanding working principle of machine	15
c.	Preparation of experimental set up	20
d.	Setting and operation	20
e.	Observations and recording	10
f.	Interpretation of result and conclusion	10
g.	Answer to sample questions	5
h.	Submission of report in time	5
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

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

12. SUGGESTED MICRO-PROJECTS

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

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

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

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

Semester : **Third**

Course Title : **Thermal Engineering**

Course Code : **22337**

1. RATIONALE

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

2. COMPETENCY

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

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

3. COURSE OUTCOMES (COs)

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

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

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

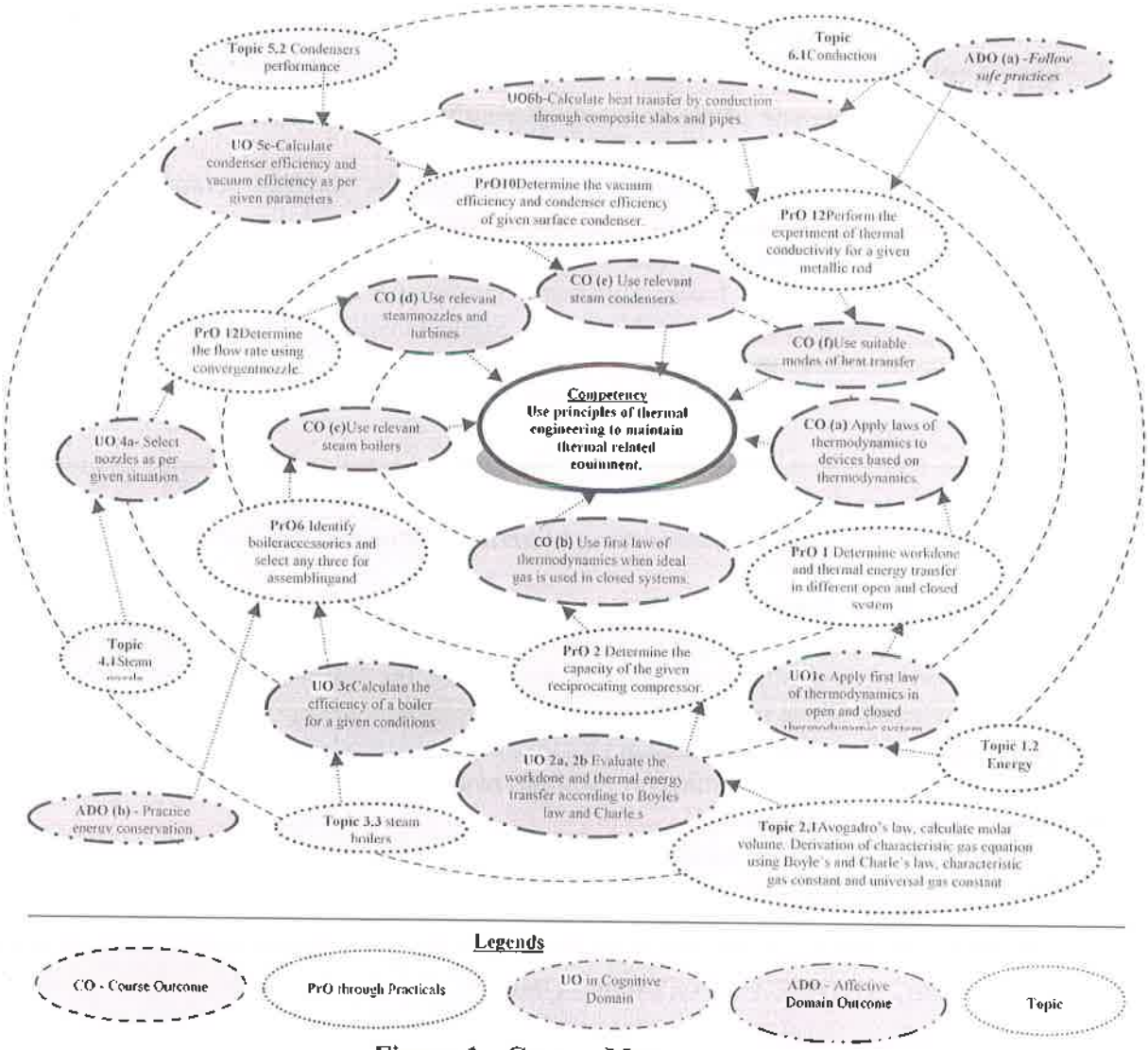

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

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

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

Note

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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

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

8. UNDERPINNING THEORY COMPONENTS

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

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

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

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

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

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

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

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

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

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

13. SUGGESTED LEARNING RESOURCES

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

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

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

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

Program Code : **PG / PT**

Semester : **Third**

Course Title : **Machining Processes**

Course Code : **22338**

1. RATIONALE

Production Engineers /Technicians often come across various type of machining processes. This is one of the core Production technology subject intends to help the students in understanding various aspects of conventional machining processes like turning, drilling, milling, broaching, gear cutting etc.

2. COMPETENCY

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

- **Produce various types of components using machining processes.**

3. COURSE OUTCOMES (COs)

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

a. Produce cylindrical jobs using lathe machine.
b. Perform drilling operations using relevant parameters.
c. Produce jobs using milling machines.
d. Produce jobs using grinding machine
e. Produce gear using milling machines.
f. Perform boring operation using relevant parameters.

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 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.

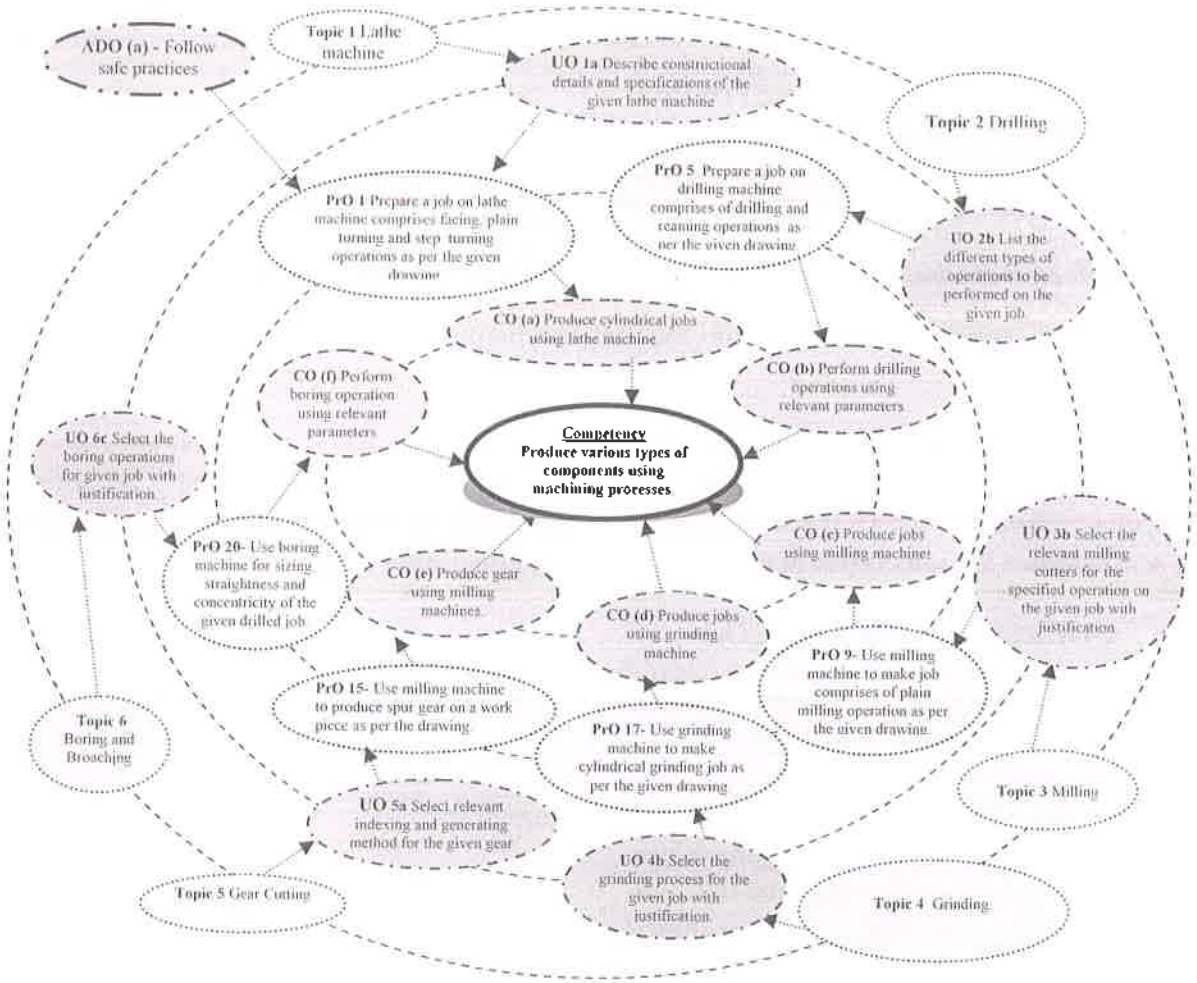

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare a job on lathe machine comprises facing, plain turning and step turning operations as per the given drawing.	I	02*
2.	Prepare a job on lathe machine comprises taper turning and grooving operations as per the given drawing.	I	02*
3.	Prepare a job on lathe machine comprises knurling and chamfering operations as per the given drawing.	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
4.	Prepare a job on lathe machine comprises threading as per the given drawing.	I	02*
5.	Prepare a job on drilling machine comprises of drilling and reaming operations as per the given drawing.	II	02*
6.	Prepare a job on drilling machine comprises of tapping operation as per the given drawing.	II	02
7.	Prepare a job on drilling machine comprises of counter-boring operation as per the given drawing.	II	02*
8.	Prepare a job on drilling machine comprises of countersinking as per the given drawing.	II	02
9.	Use milling machine to make job comprises of plain milling operation as per the given drawing	III	02*
10.	Use milling machine to make job comprises of side milling operation as per given drawing.	III	02
11.	Use milling machine to make job comprises face milling as per the given drawing.	III	02
12.	Use milling machine to make job comprises slitting operation as per the given drawing.	III	02
13.	Use milling machine to make job comprises end milling operation as per the given drawing.	III	02*
14.	Use milling machine to make job comprises gang milling operation as per the given drawing.	III	02
15.	Use milling machine to produce spur gear on a work piece as per the given drawing.	III and V	02 *
16.	Use surface grinding machine to make grinding job as per the given drawing.	IV	02*
17.	Use grinding machine to make cylindrical grinding job as per the given drawing.	IV	02
18.	Use bench grinding machine to prepare single point cutting tool geometry as per the given drawing.	I and IV	02
19.	Use tool and cutter grinder to prepare single point cutting tool geometry as per the given drawing.	I and IV	02
20.	Use boring machine for sizing. straightness and concentricity of the given drilled job.	VI	02
21.	Use broaching machine for internal or external broaching of the given job.	VI	02
	Total		**42**

Note

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Lathe Machine (distance between centers 1000 mm)	1 to 4
2.	Radial Drilling Machine: (Drill diameter up to 40 mm)	5 to 8
3.	Column and Knee type milling machine along with dividing head (Length x width of working table 800 mm x 300 mm)	9 to 15
4.	Bench Grinder	16,18
5.	Cylindrical / Surface Grinder	16 to 19
6.	Boring Machine	20
7.	Broaching Machine	21

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 Lathe	1a. Describe constructional details and specifications of the given lathe machine. 1b. List the different operations to be performed on a given job. 1c. Select the relevant machining parameters for given job with justification. 1d. Compute the machining time for the given job.	1.1 Introduction: Importance of material removal, mechanism of metal cutting. 1.2 Lathe Machine: Introduction, classification, basic parts of center lathe and their functions, Lathe specifications. 1.3 Lathe operations: facing, plain turning, taper turning (using compound slide), thread cutting, thread rolling, chamfering, grooving, knurling. 1.4 Cutting tool nomenclature and tool signature, cutting parameters and machining time calculations.
Unit– II Drilling	2a. Describe with sketches the construction and specifications of a given drilling machine. 2b. List the different types of operations to be performed on the given job. 2c. Name the nomenclature of given type of drill(s). 2d. Compute the drilling time for the given job.	2.1 Drilling Machine: Introduction, classification, machine specifications, basic parts of radial drilling machine and their functions, 2.2 Drilling machine operations: drilling, reaming, boring, counter sinking, counter boring, spot facing. 2.3 Twist drill nomenclature, cutting parameters and machining time calculations.
Unit– III Milling	3a. Describe with sketches the construction and specifications of the given milling machine. 3b. Select the relevant milling cutters for the specified operation on the given job with justification. 3c. Compute the milling time for the given job. 3d. Name the nomenclature of given milling cutter.	3.1 Milling Machine: Introduction, classification, machine specifications, basic parts of column and knee type milling machine and their functions. 3.2 Milling operations: plain milling, side milling, straddle milling, gang milling, face milling, slot milling, end milling, slitting. Up milling and down milling. 3.3 Standard milling cutter and its nomenclature, cutting parameters and machining time calculations.
Unit –IV Grinding	4a. Describe with sketches the construction and specifications of the given grinding machine. 4b. Select the grinding process for the given job with justification. 4c. Choose the relevant grinding wheel for the given job with justification.	4.1 Grinding: Introduction, classification, and working of surface and centerless grinding machine. 4.2 Types of grinding wheel, grinding wheel specifications, grinding wheel dressing and truing. 4.3 Selection criteria for grinding wheel, balancing of grinding wheels, safety

	4d. Prepare the specifications of the specified grinding wheel.	precautions.
Unit-V Gear Cutting	5a. Select relevant indexing and generating method for the given gear. 5b. Choose gear finishing method for a given job. 5c. Explain with sketch given gear finishing method. 5d. Explain with sketch given gear generating method.	5.1 Gear Cutting: Introduction, gear manufacturing methods, universal dividing head and indexing (simple and compound) methods. 5.2 Gear generating methods: Working principles of gear shaping and hobbing. 5.3 Gear finishing methods: Grinding, shaving, advantages, disadvantages and applications.
Unit-VI Boring and Broaching	6a. Select the relevant boring machine for the given job with justification 6b. Select the relevant broaching machine for the given job with justification. 6c. Select the boring operations for given job with justification. 6d. List the different elements of a given broach.	6.1 Boring: Introduction, classification, machine specifications, working of table type horizontal boring machine, tools and operations. 6.2 Broaching: Introduction, classification, specifications of broaching machines, basic parts of horizontal broaching machine and their functions. 6.3 Broach nomenclature, advantages, limitations and applications of broaching machine.

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	Lathe	10	04	06	04	14
II	Drilling	06	02	04	04	10
III	Milling	08	04	04	04	12
IV	Grinding	10	04	04	04	12
V	Gear Cutting	08	04	04	04	12
VI	Boring and Broaching	06	02	04	04	10
Total		**48**	**20**	**26**	**24**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed in workshop.
b. Visit to manufacturing to industries.
c. Write specifications of different machine tools observed during industrial visit.
d. Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

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-projects 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.

Suggestive lists of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Take any 05 component/machine part and identify machining processes required to manufacture it and plan the sequence of operations.
b. Take any component manufactured using 2-3 machining processes and calculate total machining time required for the same.
c. Prepare display board to demonstrate the type of gears.
d. Prepare a report with detailed specifications of machines available in the institute workshop.

13. SUGGESTED LEARNING RESOURCES

S. No	Title of Book	Author	Publication
1	Workshop Technology Vol-II	Hajra Choudhury, S. K.	Media Promoters and Publishers; New Delhi ISBN: 9788185099156
2	Manufacturing Technology Vol-II	Rao P. N.	McGraw Hill, New Delhi ISBN: 9781259081231
3	Hand book on Production Technology	HMT	McGraw Hill, New Delhi ISBN: 9780070964433
4	Production Technology Vol- II	Khanna O. P	Dhanpat Rai Publications, New Delhi, 2012, ISBN: 978-9383182039
5	Production Engineering	Sharma P. C.	S. Chand and Co, New Delhi, 1999, ISBN: 978-8121901116

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://www.nptelvideos.in/2012/12/manufacturing-processes-ii.html
b. http://www.nptelvideos.in/2012/12/manufacturing-processes-i.html
c. Simulations of machining processes from YouTube and educational websites.

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

Program Code : **PG / PT**

Semester : **Third**

Course Title : **Theory of Machines**

Course Code : **22344**

1. RATIONALE

Knowledge of various mechanisms and machines is a pre-requisite for enabling a mechanical engineer to work in an industry. This course provides the knowledge of kinematics and dynamics of different machine elements and popular mechanisms such as four link mechanisms, cam-follower, belt-pulley, chain sprocket, gears, flywheel, brake and clutch to enable a diploma holder to carry out maintenance of these and it also serves as a prerequisite for course 'Elements of Machine Design' to be studied in later semester.

2. COMPETENCY

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

- **Use principles of kinematics and dynamics in maintenance of various equipment.**

3. COURSE OUTCOMES (COs)

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

a. Identify various links in popular mechanisms.
b. Select suitable mechanism for various applications.
c. Interpret the motion of cams and followers.
d. Recommend relevant belts, chains and drives for different applications.
e. Choose relevant brakes and clutches for various applications
f. Select suitable flywheel and governor for various applications.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

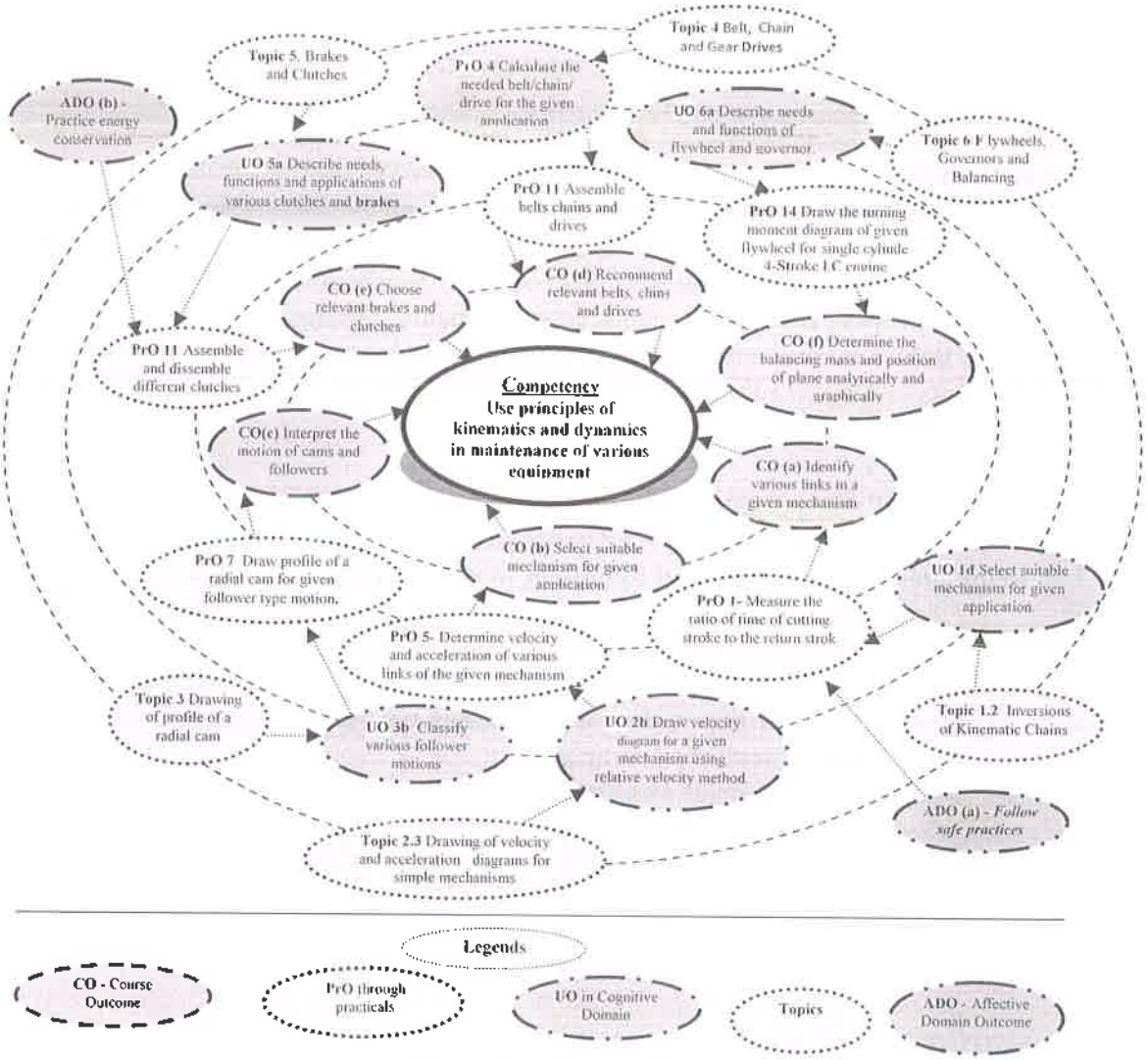

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure the ratio of time of cutting stroke to the return stroke in shaping machine by varying the stroke length. Following activities need to be performed: (Part I) a. Measuring dimensions of different links of given shaper machine b. Sketching c. Labeling of sketch	I	02*
2	Measure the ratio of time of cutting stroke to the return stroke in	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	shaping machine by varying the stroke length. Following activities need to be performed: (Part II) a. Measuring dimensions of different links of given shaper machine b. Sketching c. Labeling of sketch		
3	Estimate important kinematic data related to following mechanisms to sketch them. a) Bicycle free wheel sprocket mechanism b) Geneva mechanism	I	02
4	Estimate important kinematic data related to following mechanisms to sketch them. a) Ackerman's steering gear mechanism b) Foot operated air pump mechanism	I	02
5	Determine velocity and acceleration of various links of the given mechanism (any two) by relative velocity method for analysis of motion of links (Minimum 2 problems on A2 size drawing sheet).	II	02*
6	Determine velocity and acceleration in an I. C. engine's slider crank mechanism by Kleins's construction (Minimum 2 problems on A2 size drawing sheet).	II	02
7	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part I	III	02*
8	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part II	III	02
9	Estimate slip, length of belt, angle of contact in an open and cross belt drive.	IV	02*
10	Calculate breaking torque required in different breaks at different speeds and load situations.	IV	02
11	Assemble and dismantle different brakes and clutches. (Part I)	V	02*
12	Assemble and dismantle different brakes and clutches. (Part II)	V	02
13	Assemble and dismantle belts and chains.	V	02*
14	Draw the turning moment diagram of given flywheel for single cylinder 4-Stroke I.C engine. (Part I)	VI	02*
15	Draw the turning moment diagram of given flywheel for single cylinder 4-Stroke I.C engine. (Part II)	VI	02
16	Measure radius and height of all types of governors for different rotational speeds, mass of balls and spring stiffness (in spring loaded governors)	VI	02
17	Perform balancing of rotating unbalanced system	VI	02
	Total		**34**

Note:

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

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

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

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Working models of bicycle free wheel sprocket mechanism, geneva mechanism, Ackerman's steering gear mechanism and foot operated air pump mechanism, slider crang mechanism, elliptical trammel, skotch yoke mechanism, oldham's coupling, hooks joint, inversions of four bar mechanisms.	03, 04, 05, 06 and for demo in theory class for unit-I and II
2.	Working models of locomotive coupler, Beam engine, Pantograph, Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper, Scotch Yoke mechanism, Elliptical trammel and Oldham's Coupling.	03, 04, 05, 06 and for demo in theory class for unit-I and II
3.	Working models of various cam follower arrangements for demonstration.	07, 08

S. No.	Equipment Name with Broad Specifications	PrO. No.
4.	Working models with different belts in different arrangements.	09
5.	Working and cut section models of various types of brake assemblies.	10
6.	Various types of clutch assemblies.	11
7.	Single cylinder 4-Stroke I.C engine with flywheel	13, 14
8.	Working models of various types of governors.	15
9.	Working models of a. various belt drives, b. chain and sprocket, c. various gear drives.	For demo in theory class for unit-IV
10.	Working models of various types of brakes	02, and for demo in theory class for unit-V
11.	Working Models of Gear trains - all types.(Simple, compound, reverted, epicyclical).	For demo in theory class for unit-IV
12.	Balancing machines -Revolving masses, Reciprocating masses	16

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals and type of Mechanisms	1a. Identify various links in the given figure of the mechanism with justification. 1b. Describe with sketches the constructional details of the given type of mechanism 1c. Select suitable mechanism for the given application with justification. 1d. Select suitable material of the mechanism for the given application with justification.	1.1 **Kinematics of Machines:** Introduction to Statics; Kinematics, Kinetics, Dynamics; Kinematic links, joints, pairs, chain and its types; Constrained motion and its types, Inversion, Mechanism, Machine and Structure. 1.2 **Inversions of Kinematic Chains and their materials:** Four bar chain – Locomotive coupler, Beam engine and Pantograph. Single slider Crank chain – Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper; Double Slider chain - Scotch Yoke mechanism, Elliptical trammel, Oldham's Coupling.
Unit– II Velocity and Acceleratio	2a. Use analytical method (without derivation) to calculate the velocity and acceleration of given link	2.1 Concept of relative velocity and relative acceleration of a point on a link, angular acceleration, inter-relation between linear and angular velocity and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
n in Mechanisms	in the given single slider crank mechanism 2b. Estimate velocity and acceleration of any link at any instant in the given mechanism. 2c. Describe with dimensioned sketch of the given mechanism. 2d. Describe with velocity diagram for a given mechanism using relative velocity method. 2e. Describe with acceleration diagram for the given mechanism. 2f. Explain with velocity and acceleration diagram for the given mechanism using Klein's construction.	acceleration. 2.2 Analytical method and Klein's construction to determine velocity and acceleration of different links in single slider crank mechanism. 2.3 Drawing of velocity and acceleration diagrams for simple mechanisms. Determination of velocity and acceleration of point on link by relative velocity method (Excluding Coriollis component of acceleration)
Unit– III Cams and Followers	3a. Identify the type of motion of follower in the given situation with justification. 3b. Describe with dimensioned sketch of the given cam and follower arrangement. 3c. Describe with cam profile for the given motion of knife-edge and roller follower with and without offset application using Graphical method.	3.1 Introduction to Cams and Followers. Cam and follower terminology. Classification of Cams and Followers. Applications of Cams and Followers. 3.2 Types of follower motions and their displacement diagrams -Uniform velocity, Simple harmonic motion, uniform acceleration and retardation. 3.3 Drawing of profile of a radial cam based on given motion of reciprocating knife-edge and roller follower with and without offset.
Unit-IV Belt, Chain and Gear Drives	4a. Calculate velocity ratio, belt tensions, slip and angle of contact in the given belt drive. 4b. Estimate power transmitted and condition for maximum power transmitted in the given belt drive for given data. 4c. Select suitable belt for the given application with justification. 4d. Calculate Train value and velocity ratio for the give	4.1 Belt Drives – Introduction to Flat belt, V-belt and its applications, materials used for flat and V-belts. Introduction of timing belt and pulley. Angle of lap, length of belt, Slip and creep. Determination of velocity ratio of tight side and slack side tension, centrifugal tension and initial tension, condition for maximum power transmission. Merits, demerits and selection of belts for given applications. 4.2 Chain Drives – Introduction to chain drives, Types of chains and sprockets, Methods of lubrication. Merits,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	simple, compound, reverted and epicyclic gear trains using spur and helical gears. 4e. Select suitable gear for the given application with justification. 4f. Select suitable drives for the given application with justification.	demerits and selection of chains for given applications. 4.3 Gear Drives – Introduction to gear drives, Classification of gears, Law of gearing, gear terminology, Types of gear trains, Train value and velocity ratio for simple, compound, reverted and epicyclic gear trains using spur and helical gears. Merits, demerits and selection of gear drives for given applications.
Unit-V Brakes and Clutches	5a. Calculate braking force, braking torque and power lost in friction in the given shoe and band brake for the given data. 5b. Explain with sketches the various parts of the given brakes with their functions and constructional details. 5c. Describe with sketches the needs, functions and applications of the given clutches. 5d. Explain with sketches the various parts of the given clutch with their functions and constructional details.	5.1 Introduction to Brakes – Types, Functions and Applications. 5.2 Construction and principle of working of i) Shoe brake, ii) Band brake iii) Internal expanding shoe brake iv) Disc Brake. 5.3 Braking force, braking torque and power for shoe and band brake. 5.4 Clutches-Uniform pressure and Uniform Wear theories. Introduction to Clutch - Types, Functions and Applications, Construction and principle of working of a. Single-plate clutch, b. Multi-plate clutch, c. Centrifugal Clutch d. Cone clutch e. Diaphragm clutch.
Unit –VI Flywheels, Governors and Balancing	6a. Explain with sketches the method of balancing a rotating mass as per the given conditions. 6b. Estimate the balancing mass and position of plane analytically and graphically in the given situation for the given data. 6c. Explain with sketches the turning moment diagram for the given single cylinder 4-Stroke I.C Engine for the given data.	6.1 Flywheel-Introduction to flywheel – need, function and application of flywheel with the help of turning moment diagram for single cylinder 4-Stroke I.C Engine. 6.2 Coefficient of fluctuation of energy, coefficient of fluctuation of speed and its significance. 6.3 Governors- Introduction, types, functions and applications, Terminology of Governors. Comparison of Flywheel and Governor. 6.4 Balancing- Need and types of balancing, Balancing of single rotating mass, Analytical and Graphical methods for balancing of several masses revolving in one plane.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals and type of Mechanisms	10	04	06	04	14
II	Velocity and Acceleration in Mechanisms	06	02	04	04	10
III	Cams and Followers	08	04	04	04	12
IV	Belt, Chain and Gear Drives	10	04	04	06	14
V	Brakes and Clutches	06	02	02	04	08
VI	Flywheels, Governors and Balancing	08	02	04	06	12
Total		**48**	**18**	**24**	**28**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare journal of practicals.
b. Undertake micro-projects.
c. Compile information from internet related to various mechanisms/elements like piston, crank, connecting rod, cam, clutch, brake, flywheel, governor, or animation of mechanism etc. along with functions and areas of application of each.
d. List the mechanisms which you are using in your day to day life. Sketch any three from these.
e. List the different mechanisms used in a typical car.
f. Identify and measure the dimensions of Flywheel used in automobile engines, generators, punching and riveting machines.
g. Identify the type of clutches used in different automobiles and also the type of brakes in automobile and bicycle.
h. Visit the market and collect the data of items which are used in any mechanisms. Data includes specifications, cost, applications, etc. Also name the mechanism/s in which such item/s is/are used.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various mechanisms.
f. Guide student(s) in undertaking micro-projects
g. Encourage students to refer different websites for deeper understanding of the course.
h. Monitor the performance of students in Lab.
i. Show models, education charts and videos, real life examples of various mechanisms.
j. Demonstration of real industrial parts and mechanisms used in different devices.
k. Demonstration of different real industrial parts, cams, power transmission elements through movies/animations.
l. Industrial visit, animations/movies, models of different types of governors.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Prepare working model of any one mechanism using low cost materials.
b. Prepare animations of various mechanisms using free software's available on internet.
c. Market survey of belts for collecting specifications,.
d. Field survey to collect information about applications of timing belts.
e. Field survey to collect information about applications of flywheels and governors.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Theory of Machines	Rattan S. S.	McGraw-Hill Education, 1986 ISBN: 9780070591202
2	Theory of Machines	Khurmi R. S., Gupta J. K.	S. Chand Publications, New Delhi, 2015 ISBN: 9788121925242
3	Theory of Machines	Bevan Thomas	Pearson Education India, New Delhi, 1986, ISBN: 9788131729656

S. No.	Title of Book	Author	Publication
4	Theory of Machines and Mechanisms	Ballaney P.L.	Khanna Publisher, New Delhi, 2003, ISBN 9788174091222
5	A Text Book of Theory of Machines	Bansal R.K., Brar J. S.	Laxmi Publication, New Delhi, 2004, ISBN 9788170084181

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.iitm.ac.in/video.php?subjectId=112104121
b. http://www.technologystudent.com/gears1/gears7.htm
c. http://kmoddl.library.cornell.edu/model.php?m=20
d. http://www3.ul.ie/~kirwanp/whatisacamandfollowersyste.htm
e. http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-
f. Delhi/Kinematics%20of%20Machine/index.htm
g. http://elearning.vtu.ac.in/12/enotes/Des_Mac-Ele2/Unit6-RK.pdf
h. en.wikipedia.org/.../Canadian_Committee_for_the_Theory_of_Machines...
i. global.oup.com/.../theory-of-machines-and-mechanisms-978019537123...
j. www.tecquipment.com/Theory_of_Machines.aspx
k. www.researchgate.net/.../0094-114X_Mechanism_and_Machine_Theory
l. www.journals.elsevier.com/mechanism-and-machine-theory/
m. journalseek.net/cgi-bin/journalseek/journalsearch.cgi?field=issn...
n. site.iugaza.edu.ps/wp-content/.../IUGAZA%20TOM2012_CH1-2.pdf
o. www.iftomm.org/
p. www.wiziq.com/online-tests/44047-mechanical-theory-of-machine
q. www.cs.ubc.ca/~murphyk/Teaching/CS340-Fall07/infoTheory.pdf

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

Program Code : **PG / PT**

Semester : **Third**

Course Title : **Industrial Fluid Power**

Course Code : **22345**

1. RATIONALE

Knowledge of fluid properties, fluid flow is essential in all fields of engineering. Hydraulic systems and pneumatic systems are widely used in industrial automation systems. This subject requires knowledge of basic engineering sciences, fluid mechanics, mathematics etc. Diploma engineers come across such systems in all the segments of industries. This subject will give the students, the basic skills and knowledge of hydraulics and pneumatics which will be directly needed in the industrial environment.

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 different types of Hydraulic and Pneumatic systems.**

3. COURSE OUTCOMES (COs)

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

a. Interpret various fluid characteristics and flow problems.
b. Calculate various losses in flow through pipes.
c. Select relevant components for hydraulic and pneumatic systems.
d. Maintain hydraulic circuits / components.
e. Maintain pneumatic circuits / 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
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

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

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

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

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

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

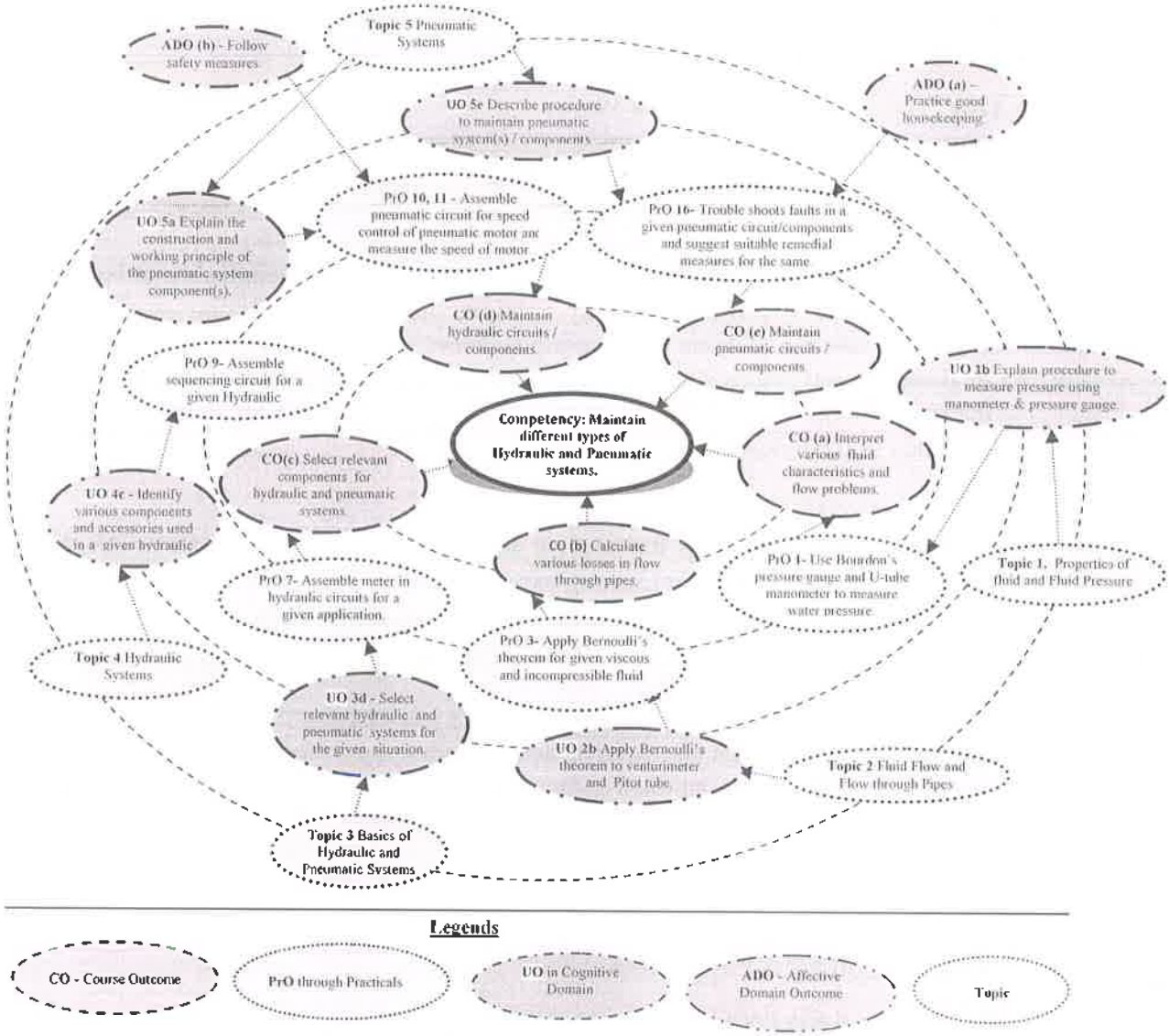

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use Bourdon's pressure gauge and U-tube manometer to measure water pressure.	I	02
2	Use measuring tank and stop watch to measure discharge of water.	I	02
3	Apply Bernoulli's theorem for given viscous and incompressible fluid.	II	02*
4	Determine coefficient of discharge of Venturimeter.	II	02*
5	Use hydraulic test rig to calculate minor frictional losses in pipe fittings for bends, a contraction and an enlargement.	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
6	Use hydraulic test rig to calculate minor frictional losses in pipe fittings for gate valve.	II	02*
7	Assemble meter in hydraulic circuits for a given application.	IV	02
8	Assemble meter out hydraulic circuits for a given application.	IV	02
9	Assemble sequencing circuit for a given Hydraulic application.	IV	02
10	Assemble pneumatic circuit for speed control of double acting cylinders for a given application.	V	02*
11	Measure the speed of double acting cylinder for assembled circuit in PrO 10.	V	02
12	Assemble pneumatic circuit for speed control of pneumatic motor.	V	02*
13	Measure the speed of pneumatic motor for assembled circuit in PrO. 12.	V	02
14	Assemble sequencing circuit for a given Pneumatic application.	V	02*
15	Troubleshoot faults in a given hydraulic circuit/components and suggest suitable remedial measures for the same.	IV	02
16	Troubleshoot faults in a given pneumatic circuit/components and suggest suitable remedial measures for the same.	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 %
1.	Preparation of experimental setup	20
2.	Setting and operation	20
3.	Observation and recording	10
4.	Interpretation of result and conclusion	20
5.	Follow safety measures and good housekeeping.	10
6.	Answer to sample questions	10
7.	Submission of report in time	10
Total		**100**

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

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

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	**Bourdon's pressure gauge:** Dial size: 1-1/2", 2", 2-1/2" or 4", Accuracy : +/- 2-1-2 % ANSI Grade A (4" SS only), Case : 304 SS, Bezal : 304 SS Crimped, Socket: Brass or 316 SS, Bourden Tube: Brass or 316 SS, U-Tube Manometer and Manometric liquid – Mercury, Water tank and Stop Watch.	1, 2
2	**Bernoulli's theorem apparatus:** Centrifugal Pump of max. head 21 m, Water flow 1.35 liter/sec max., Motor rating: 0.37 kW, Sump tank capacity : 250 liter, High flow volumetric tank : 40 liter, Low flow volumetric tank : 6 liter, Height of working surface : 1 m above floor level.	3
3	**Discharge measurement test Rig:** Sump tank with flow: 1000 x 700 x 300 mm, Measuring tank: 400 x 600 x 250 mm, Mercury Manometers (Differential). Each line provided with flow control valve. Pressure tubes of different pipe lines are connected to common manometers through cocks. Venturimeter & Flow control valve at the end of each line.	4
4	**Test rig for frictional losses:** Centrifugal Pump of max. head 21 m, Water flow 1.35 liter/sec max., Motor rating: 0.37 kW, Sump tank capacity : 250 liter, High flow volumetric tank : 40 liter, Low flow volumetric tank : 6 liter, Height of working surface : 1 m above floor level.	5, 6
5	Plastic coated charts/models of Hydraulic and Pneumatic components, Symbols and Circuits.	7 to14
6	**A hydraulic trainer Kit – 01 Set of Standard make** Power pack unit equipped with pump, Relief valve, 3/2, 4/2, 4/3 DC valve, Pressure gauge, Flow control valve with built in Non-return valve, Single acting and double acting cylinder, hydraulic motor, Filter, Manifold assembly, Pressure Regulator, Couplings, connectors, Pipes and/or hoses etc;	7, 8, 9, 15
7	**A pneumatic trainer Kit – 01 Set of Standard make** Reciprocating air compressor, FRL unit, 3/2, 5/2 DC valve, Pressure gauge assembly, Dual pressure valve, Quick exhaust valve, Flow control valve, Single acting and double acting cylinder, Air Motor, Manifold assembly, Pressure regulator, Couplings, connectors, Pipes and/ or hoses etc;	10, 11, 12, 13, 14, 16
8	**Tool Kit:** - Basic technician tool kit with open ring spanners from 4-5 to 30-32. Allen key set 0-6 mm, Ball pin hammer, pipe wrench etc;	All

S. No.	Equipment Name with Broad Specifications	PrO. No.
9	Simulation Software for Hydraulic and Pneumatic circuits.	7 to14

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 Properties of fluid and Fluid Pressure	1a. Differentiate between specified types of pressure. 1b. Explain with sketches the procedure to measure pressure using the specified type of manometer and different types of pressure gauges. 1c. Calculate centre of pressure and total pressure of the given type of regular immersed body. 1d. Calculate pressure head for a given condition.	1.1 **Properties of Fluid:** Density, Specific gravity, Specific volume, Specific Weight, Dynamic viscosity, Kinematic viscosity, Surface tension, Capillarity, Vapour pressure, Compressibility, Types of fluids: Ideal, Real, Newtonion, Non-Newtonion, Plastic. 1.2 **Fluid Pressure and Pressure Measurement:** Concept of atmospheric pressure, Gauge pressure and vacuum pressure, Pressure head measurement by U-tube manometer and Bourdon's pressure gauge. Pascal's Law, concept of static pressure, pressure head, centre of pressure and total pressure for rectangular & circular plane surfaces immersed in liquid in horizontal, vertical and inclined position.
Unit– II Fluid Flow and Flow Through Pipes	2a. Use continuity equation for a given conditions. 2b. Apply Bernoulli's theorem to the given device to determine the given parameter. 2c. Apply laws of fluid friction for the given data. 2d. Determine the specified losses in flow through pipes, fittings and valves with the given data.	2.1 **Fluid Flow:** Types of fluid flows, Rate of flow (Discharge), law of continuity, Reynolds's number, Energies possessed by flowing liquids like pressure, kinetic and potential energy, total energy equation, Bernoulli's theorem with proof and its application to Venturimeter and Pitot tube. 2.2 **Flow Through Pipes:** Laws of fluid friction (Laminar and turbulent flow), Darcy's equation and Chezy's equation for frictional losses, Minor losses in fittings and valves.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– III Basics of Hydraulic and Pneumatic Systems	3a. Explain the physical characteristics and functions of given hydraulic oils. 3b. Select the relevant fluid for given hydraulic and Pneumatic Systems with justification. 3c. Select relevant filter for the given hydraulic and pneumatic systems with justification. 3d. Select relevant hydraulic and pneumatic systems for the given situation with justification.	3.1 Essential physical characteristics and functions of hydraulic Oils, Classification - Mineral based, Fire resistant and Biodegradable Oils, ISO Viscosity Grades of Oils. 3.2 Filters: Contaminations, Need, Types & location of filter. 3.3 General layout, Applications, Merits and limitations of hydraulic and Pneumatic Systems, Hydraulic and Pneumatic Symbols as per ISO.
Unit-IV Hydraulic Systems	4a. Explain with sketches the types, material, functions, and/or working principal of the given hydraulic system component(s). 4b. Select the relevant actuators for the given situation with justification. 4c. Identify the components and accessories used in the given hydraulic circuit diagram. 4d. Describe the procedure to maintain the specified hydraulic component/system. 4e. Construct with explanation the hydraulic circuit for the given situation.	4.1 Centrifugal Pump: Classification of Pumps, Construction, principle of working, priming methods, Water hammer and cavitation phenomenon, Trouble Shooting. 4.2 Positive displacement Pumps: - Construction, working principle and applications of Vane pump, gear pump, rotor pump, screw pump & piston Pump. 4.3 Pressure control Valves: Construction, principle of working of pressure relief valve - direct, pilot operated, Sequence valves. 4.4 Direction control valves: - spool valve - 2/2, 4/2, 4/3 methods of actuation. Types of different center positions. Pilot operated check valve. 4.5 Flow control valves: pressure compensated, non-pressure compensated flow control valve, 4.6 Actuators: Classification of actuators, Construction & working principle of Rotary Actuators - Hydraulic motors, Linear Actuators - Cylinders - single acting, double acting. 4.7 Accessories: Types, Material and functions of Pipes, Hoses, Fittings, Seals and gaskets, Accumulators. 4.8 Circuits: Speed control of actuator, Meter-in, Meter-out, sequencing circuit using sequence valve & Motion synchronization circuit.
Unit –V Pneumatic	5a. Explain with sketches the types, material, functions and/or	5.1 Types and Selection of air compressors for pneumatic systems.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Systems	working principal of the given pneumatic system component(s). 5b. Identify the components and accessories used in the given pneumatic circuit diagram. 5c. Select the relevant air compressors for given situation with justification. 5d. Select actuators for given situation with justification. 5e. Describe the procedure to maintain the specified pneumatic component/system. 5f. Construct with explanation the pneumatic circuit for the given situation.	5.2 Air Receiver, FRL unit. 5.3 Valves: Construction and working principle of Pressure regulating valves, Direction control valves, Flow control valves, Time Delay valve, Quick exhaust valve, twin Pressure valve. 5.4 Actuators: Construction and working principal of Rotary Actuators - Pneumatic motors, Linear Actuators – Cylinders - single acting double acting. 5.5 Accessories: Types, Material and functions of Pipes, Hoses and fittings. 5.6 Circuits: Speed control of actuator, 'Meter-in', 'Meter-out', Roller operated Sequencing and dual control circuit.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Properties of fluid and Fluid Pressure	12	04	04	04	12
II	Fluid Flow and Flow Through Pipes	12	04	06	04	14
III	Basics of Hydraulic and Pneumatic Systems	10	06	04	02	12
IV	Hydraulic Systems	16	04	08	06	18
V	Pneumatic Systems	14	04	06	04	14
Total		**64**	**22**	**28**	**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. Prepare journal of practicals.

b. Undertake micro-projects
c. Collect information about different types of pumps, pressure measuring devices, filters, power packs, accumulators, compressors, pipes & hoses etc, from local market and from internet. Comparison (types, specification, material, size range, market price, applications etc;) of various models manufactured by different manufacturers. The market survey is to be completed in a group of (max.) three to four students and the report of the same is to be included as part of term work.
d. Collect oil samples used for hydraulic systems and prepare a report based on properties, name of manufacturers, detailed technical specifications, trade names, costs, packing sizes.
e. Study of any one mobile hydraulic system such as in earth moving equipments or any one stationary hydraulic system such as in any machine tool and its detailed report.
f. Study of any one pneumatic circuit such as circuits used in special purpose machines, low cost automation systems, material handling systems and its detailed report.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

a. Students should build up the circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the hydraulic/pneumatic trainer and run the circuit.
b. Design based Problems / Open Ended Problem: Student can be given an application of a power transmission system for which they can evaluate the functional requirements and design appropriate circuit. They must identify the components, and relevant parameters. The application must involve use of hydraulics/pneumatics and/or combinations of different power transmission systems.
c. Perform repairing and / or replacement of defective components in the oil hydraulic / pneumatic system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Hydraulics and Fluid Mechanics including Hydraulic Machines	Modi P. N, Seth S. M.	Standard Book House, New Delhi. ISBN-13: 978-8189401269
2	A Textbook of Fluid Mechanics and Hydraulic Machines	R. K. Bansal	Lakshmi publication. ISBN-13: 978-8131808153
3	Fluid Power with application's	Esposito Anthony	Pearson Education, Inc 2000. ISBN : 1292023872
4	Oil Hydraulic system - Principles and maintenance	Majumdar S. R.	McGraw Hill Publications, New Delhi, ISBN: 0-07-463748-7
5	Pneumatics Systems - Principles and maintenance	Majumdar S. R.	McGraw Hill Publications, New Delhi, ISBN: 0-07-460231-4
6	Hydraulic and Pneumatic Power For Production Industrial Hydraulics	Stewart D.	Industrial Press INC. 200, Madison Avenue, New-York 10016, ISBN: 0-8311-1114-3
7	Industrial Hydraulic	Pippenger John, Tyler Hicks	McGraw Hill Publications, New Delhi, ISBN: 0-88275-776
8	Industrial Hydraulics Manual	Vickers Perry	Vickers Systems International (Company Manual)
9	Basic Pneumatic manual	Festo	Festo (Company Manual)

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a http://nptel.ac.in/courses
b Various system components' manufacturers' catalogues.
c Open source software

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

Program Code : **PG / PT**

Semester : **Third**

Course Title : **Production Drawing**

Course Code : **22028**

1. RATIONALE

A Production Engineer, irrespective of his field of operation in an industry, is expected to possess a thorough understanding of drawing. This includes clear visualization of objects and the proficiency in reading and interpreting a wide variety of production drawings. Besides, they are also expected to possess certain degree of drafting skills depending upon job function. They have to perform day to day activities like communicating and discussing ideas with supervisors and passing on instructions to subordinates unambiguously. This course envisages reinforcing and enhancing the knowledge and skill acquired in the earlier two courses viz. Engineering Graphics and Engineering drawing.

2. COMPETENCY

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

- **Prepare production drawings/assembly drawings manually using prevailing drawing instruments.**

3. COURSE OUTCOMES (COs)

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

a. Draw development of lateral surface of various solids.
b. Draw intersection curves of different solids.
c. Use conventions and symbols as per SP-46 (1988).
d. Apply limits, fits and specify tolerances.
e. Prepare production drawing of the machine assembly.

4. TEACHING AND EXAMINATION SCHEME

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

*(~[2]): For the **practical only courses,** the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e.30 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e.20 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

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

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

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

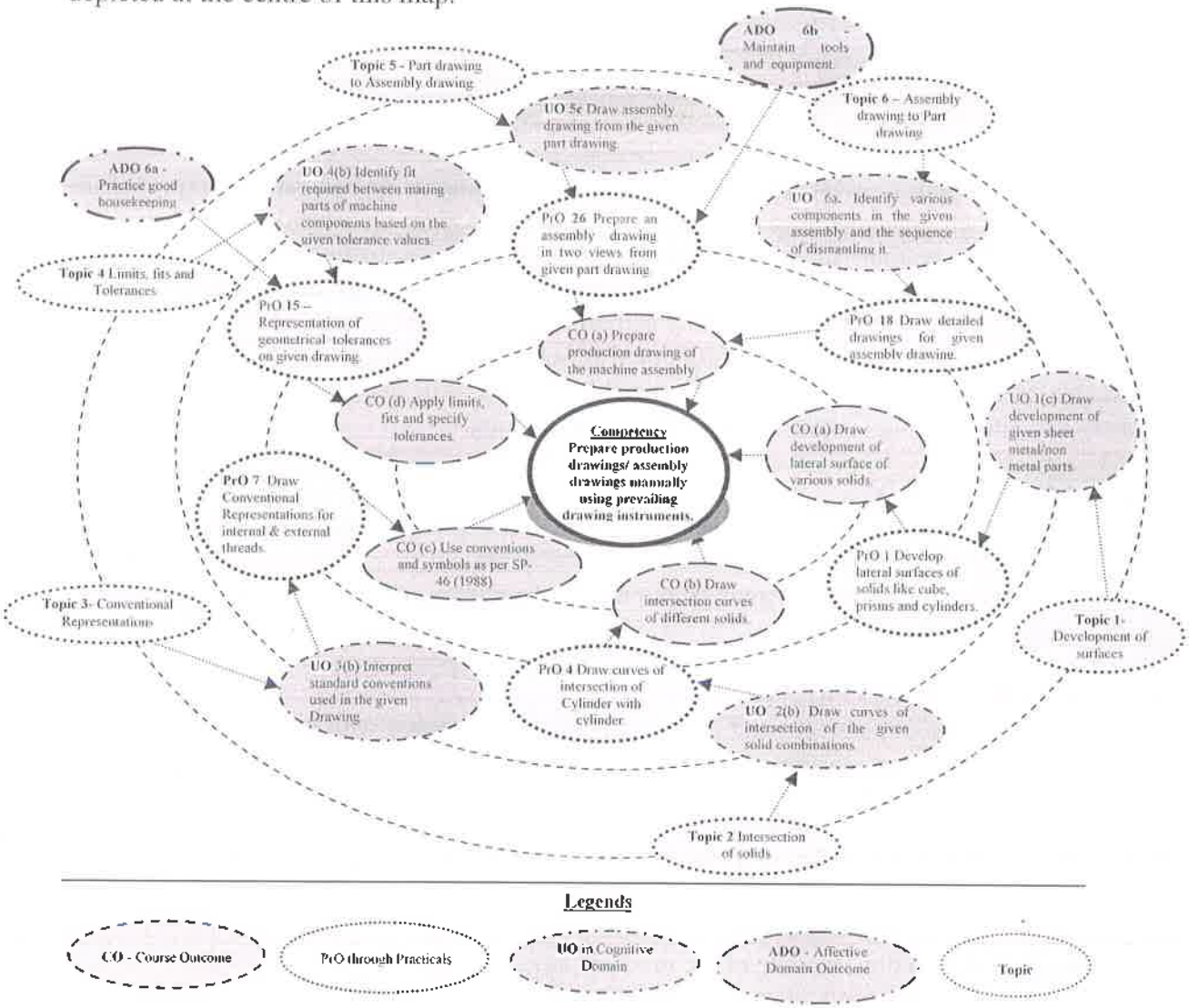

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/EXERCISES

The practical's 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
Sheet No.:1 (Two Problems)			
1	Develop lateral surfaces of solids like cube, prisms and cylinders. (Problem 1)	I	02*
2	Develop lateral surfaces of solids like pyramids, cones. (Problem 2)	I	02*
Sheet No.:2 (Any two Problems)			

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
3	Draw curves of intersection of square Prism with square prism.	II	02
4	Draw curves of intersection of Cylinder with cylinder.	II	02
5	Draw curves of intersection of Square Prism with Cylinder.	II	02*
Sheet No.:3			
6	Draw Conventional Representations as per SP – 46 (1988) for various sections, knurling, serrated shaft, splined shaft, holes on circular pitch, internal and external thread, taper, Counter sunk and Counter bored hole and pipe fittings. (Part I)	III	02*
7	Draw Conventional Representations as per SP – 46 (1988) for various sections, knurling, serrated shaft, splined shaft, holes on circular pitch, internal and external thread, taper, Counter sunk and Counter bored hole and pipe fittings. (Part II)	III	02*
8	Draw Conventional Representations as per SP – 46 (1988) for various sections, knurling, serrated shaft, splined shaft, holes on circular pitch, internal and external thread, taper, Counter sunk and Counter bored hole and pipe fittings. (Part III)	III	02*
Sheet No.:4			
9	Draw Conventional Representations as per SP – 46 (1988) for ball and roller bearing, spur gear, Springs with square and flat ends & sprocket wheel & General welding symbols. (Part I)	III	02*
10	Draw Conventional Representations as per SP – 46 (1988) for ball and roller bearing, spur gear, Springs with square and flat ends & sprocket wheel & General welding symbols. (Part II)	III	02*
11	Draw Conventional Representations as per SP – 46 (1988) for ball and roller bearing, spur gear, Springs with square and flat ends & sprocket wheel & General welding symbols. (Part III)	III	02*
Sheet No.:5			
12	ISO system of Tolerance, unilateral and bilateral tolerance, Hole and shaft base systems, Types of fits - Clearance, transition and Interference. (Part I)	IV	02*
13	ISO system of Tolerance, unilateral and bilateral tolerance, Hole and shaft base systems, Types of fits - Clearance, transition and Interference. (Part II)	IV	02*
14	ISO system of Tolerance, unilateral and bilateral tolerance, Hole and shaft base systems, Types of fits - Clearance, transition and Interference. (Part III)	IV	02*
Sheet No.:6			
15	Types of geometrical tolerances, Representation of machining symbol showing direction of lay, sampling length, roughness grades, machining allowances & manufacturing methods. (Part I)	IV	02*
16	Types of geometrical tolerances, Representation of machining symbol showing direction of lay, sampling length, roughness grades, machining allowances & manufacturing methods. (Part II)	IV	02*
17	Types of geometrical tolerances, Representation of machining symbol showing direction of lay, sampling length, roughness grades, machining allowances & manufacturing methods. (Part III)	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
For PrOs 18 to 25: Prepare an assembly drawing in two views from given part drawing mentioned in Unit V (5.2) showing overall dimensions, sectional details, Dimensional and Geometrical tolerances, surface finish symbols and bill of material.			
Sheet No.:7			
18	Part drawing to Assembly drawing – Problem 1.(Part I)	V	02*
19	Part drawing to Assembly drawing – Problem 1.(Part II)	V	02*
20	Part drawing to Assembly drawing – Problem 1.(Part III)	V	02*
21	Part drawing to Assembly drawing – Problem 1.(Part IV)	V	02*
22	Part drawing to Assembly drawing – Problem 2, on sketchbook (Part I)	V	02
23	Assembly drawing to part drawing – Problem 2, on sketchbook (Part II)	V	02
24	Part drawing to Assembly drawing – Problem 2, on sketchbook (Part III)	V	02
25	Part drawing to Assembly drawing – Problem 2, on sketchbook (Part IV)	V	02
For PrOs 26 to 33: Draw part drawings from given assembly drawing mentioned in Unit V (5.2) showing conventional representation, sectional details, Dimensional and Geometrical tolerances, surface finish symbols, material and quantity.			
Sheet No.:8			
26	Assembly drawing to part drawing - Problem 1. (Part I)	VI	02*
27	Assembly drawing to part drawing - Problem 1. (Part II)	VI	02*
28	Assembly drawing to part drawing - Problem 1. (Part III)	VI	02*
29	Assembly drawing to part drawing - Problem 1. (Part IV)	VI	02*
30	Assembly drawing to part drawing - Problem 2, on sketchbook (Part I)	VI	02
31	Assembly drawing to part drawing - Problem 2, on sketchbook (Part II)	VI	02
32	Assembly drawing to part drawing - Problem 2, on sketchbook (Part III)	VI	02
33	Assembly drawing to part drawing - Problem 2, on sketchbook (Part IV)	VI	02
For PrOs 34 to 36: Draw a fabrication drawing (assembly and part drawing) showing weld symbol, weld length, weld size, weld finish, weld tolerances, and other relevant instruction about welding.			
34	Problem 1, on sketchbook (Part I)	III	02
35	Problem 1, on sketchbook (Part II)	III	02
36	Problem 1, on sketchbook (Part III)	III	02
	Total		**72**

Note

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

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

S. No.	Performance Indicators	Weightage in %
1.	Interpretation of given problem	20
2.	Draw sheet using different drafting instrument	30
3.	Use of drawing instruments	10
4.	Line work, Dimensioning, Annotation & presentation of the sheet	15
5.	Answers to sheet related questions	10
6.	Submit the assigned sheet on time	5
7.	Follow cleanliness and housekeeping in Drawing Hall	5
8.	Attendance and punctuality	5
TOTAL		**100**

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

a. Practice good housekeeping.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.
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/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Drawing Table with Drawing Board of Full Imperial / A1 size	All
2.	Paper/wooden Models of objects for development of Lateral surfaces of solid.	01, 02
3.	Models / Charts of solids showing intersection curves	03 to 05
4.	Models / Charts of machine components for conventional representation	06 to 11
5.	Actual assemblies mentioned in unit V	18 to 33
6.	Set of various production drawings being used by industries	All
7.	Specimen library of various machine components	All
8.	Set of drawings sheets mentioned in section 6.0 could be developed by experienced teachers and made available on the MSBTE portal to be used as reference/standards.	All

S. No.	Equipment Name with Broad Specifications	PrO. No.
9.	Drawing equipment's and instruments for class room teaching-large size: a. T-square or drafter (Drafting Machine) b. Set squares (45^0 and 30^0- 60^0) c. Protractor d. Drawing instrument box (containing set of compasses and dividers) e. Drawing sheets, drawing pencils, Eraser, Drawing pins / clips etc;	All
10.	Interactive board with LCD overhead projector.	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 Development of surfaces	1a. Draw development of lateral surfaces of the given solid. 1b. Identify parts where concept of development of the given surfaces is required. 1c. Draw development of given sheet metal/non-metal parts.	1.1 Developments of lateral surfaces of cube, prisms, cylinder, pyramid and cone. 1.2 Applications of development of surfaces such as tray, funnel.
Unit-II Intersection of solids	2a. Identify parts where concept of intersection of the given solids is required. 2b. Draw curves of intersection of the given solid combinations.	2.1 Curves of intersection of the regular solids in the following cases. 2.2 Square prism with square prism, cylinder with cylinder, square prism with cylinder when, (i) The axes are at 90° and bisecting. (ii) The axes are at 90° and Offset.
Unit– III Conventional representation	3a. Use IS SP-46 (1988) codes. 3b. Interpret standard conventions used in the given Drawing. 3c. Use standard conventions in practice. 3d. Interpret welding symbols in the given working drawing.	3.1 Standard conventions using IS SP – 46 (1988) for the following. 3.2 Sections - Half, removed, revolved, offset, partial and aligned sections. 3.3 Conventional representation of slotted head, knurling, serrated shaft, splined shaft, holes on circular pitch, internal and external thread and pipe fittings. 3.4 Conventional representation of ball and roller bearing, spur gear, springs with square and flat ends and sprocket wheel. 3.5 Taper, counter sunk and counter bored hole. 3.6 General welding symbols, length and size of weld, surface contour

		and finish of weld, all round and site weld, symbolic representation in engineering practices and its interpretation.
Unit– IV Limits, fits and tolerances	4a. Calculate tolerances on the given machine components. 4b. Identify fit required between mating parts of machine components based on the given tolerance values. 4c. Interpret surface roughness characteristics from the values the given-on component drawing. 4d. Draw above conventional representations for the given situation.	4.1 Introductions to ISO system of Tolerance, terminology of dimensional tolerances, unilateral and bilateral tolerance, hole and shaft base systems, types of fits - clearance, transition and interference, Selection of fit for engineering applications, Calculation of limit sizes and identification of type of fit. 4.2 Geometrical Tolerances: Types of geometrical tolerances, representation of geometrical tolerance on drawing. 4.3 Machining symbol and surface texture: Representation of machining symbol showing direction of lay, sampling length, roughness grades, machining allowances and manufacturing methods.
Unit– V Part drawing to Assembly drawing	5a. Explain the general procedure for assembly of components. 5b. State details of components and the sequence of components of the given assembly. 5c. Draw assembly drawing from the given detailed drawing.	5.1 Introduction, types of assembly drawing, accepted norms to be observed for assembly drawings, sequence for preparing assembly drawing, Bill of Material. 5.2 Oldham's and Universal coupling, Foot Step and Pedestal Bearing, Lathe tool Post, Bench vice & Pipe Vice, Screw Jack, Non-return valve, Lathe tail stock, Drill Jig etc;
Unit– VI Assembly drawing to part drawing	6a. Identify various components in the given assembly and the sequence of dismantling it. 6b. Describe the procedure for dismantling the assembly into components. 6c. Draw detailed drawing from the given assembly drawing.	6.1 Basic principles of process of dismantling the assembly into components. 6.2 Details of all assemblies mentioned in unit V (5.2).

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	Unit Title	Teaching	Distribution of Theory Marks

No.		Hours	R Level	U Level	A Level	Total Marks
I	Development of surfaces	05	-	-	-	-
II	Intersection of solids	05	-	-	-	-
III	Conventional representation	04	-	-	-	-
IV	Limits, fits and tolerances	06	-	-	-	-
V	Part drawing to Assembly drawing	06	-	-	-	-
VI	Assembly drawing to part drawing	06	-	-	-	-
Total		**32**	-	-	-	-

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Student should maintain a separate A3 size sketch book which will be the part of term work and submit it along with drawing sheets. Following assignment should be drawn in the sketch book
   i. Minimum 4 problems each on Unit No I and II.
   ii. Conventional representation of Unit No III
   iii. Representation of Unit No IV
   iv. Minimum 1 of each assembly & part drawing.
   Note- Problems on sheet and in the sketch, book should be different.
b. Students should collect Production drawings from nearby workshops/industries and try to visualize the part from the given views.
c. Prepare paper models of development of lateral surfaces of solids.
d. Visit any sheet metal workshop and prepare a report related to type of components, dimensions, material, area of application, raw material required, name of operations performed.
e. Prepare clay/ paper models of solids showing curves of intersection.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in 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. Instruct students to visit workshop and different laboratories in your institute, observe different assemblies and its components mentioned in UNIT V & VI and make a list of assemblies and components, drawings and write its applications.
g. Show video/animation films to explain process and functioning of various assemblies.
h. Show charts, physical components and models available in the institute.

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-projects 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. Dismantle any machine assembly having 6 to 10 parts. Prepare report having name of the assembly and components, drawing of assembly and components, material used, application etc.
b. Assemble components of a given machine assembly and make a complete assembly and prepare a report comprising of name of the assembly and components, drawing of assembly and components, material used, application etc
c. Make components of an assembly using waste materials, wax, soap, thermocol etc. and create its assembly.
d. Prepare and display chart showing conventional representation of machine components with sketch pens.
e. Make PPT showing assembly and details of various machines including animation videos.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Machine Drawing	Bhatt N.D. and Panchal V.M.	Charotar Publishing house, Anand, 2013 Gujarat, India. ISBN:978-93-80358-69-7
2.	Production Drawing	Narayanan,L. K. Kannaich P. Venkat Reddy K.	New Age International Pvt.Ltd. New Delhi; 2016 ISBN: 9788122440546
3.	Machine Drawing	Junnarkar N. D.	Pearson Education India, New Delhi, 2011 ISBN no.9788131706787
4.	Machine Drawing	Bhattacharyya Basudeb	Oxford University Press, New Delhi ISBN no.:9780198070771 (Edition:2011)
5.	Machine Drawing	Dhawan R.K.	S. Chand and Co., New Delhi, 2016 ISBN no.9789385676499

S. No.	Title of Book	Author	Publication
6.	IS Code SP 46 - Engineering Drawing Practice for School and colleges	BIS	Bureau of Indian standards, New Delhi ISBN no.:9788170610199

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.slideshare.com
b. https://en.wikipedia.org/wiki/Production_drawing
c. http://nptel.ac.in/syllabus/syllabus.php?subjectId=112106075
d. mech.iitm.ac.in/Production Drawing.pdf
e. www.youtube.com/watch?v=mYsCd6xduJw
f. www.youtube.com/watch?v=m734SORpMKA
g. www.youtube.com/watch?v=Y-_LjEjyLhA
h. www.youtube.com/watch?v=rlekMsBVeTc
i. www.youtube.com/watch?v=SP9SQWJOzIsandlist=PLq9CY8uTsDpZsHlnc7XWRXyaGd1ncqpoo