## 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 Abbre viation | 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.

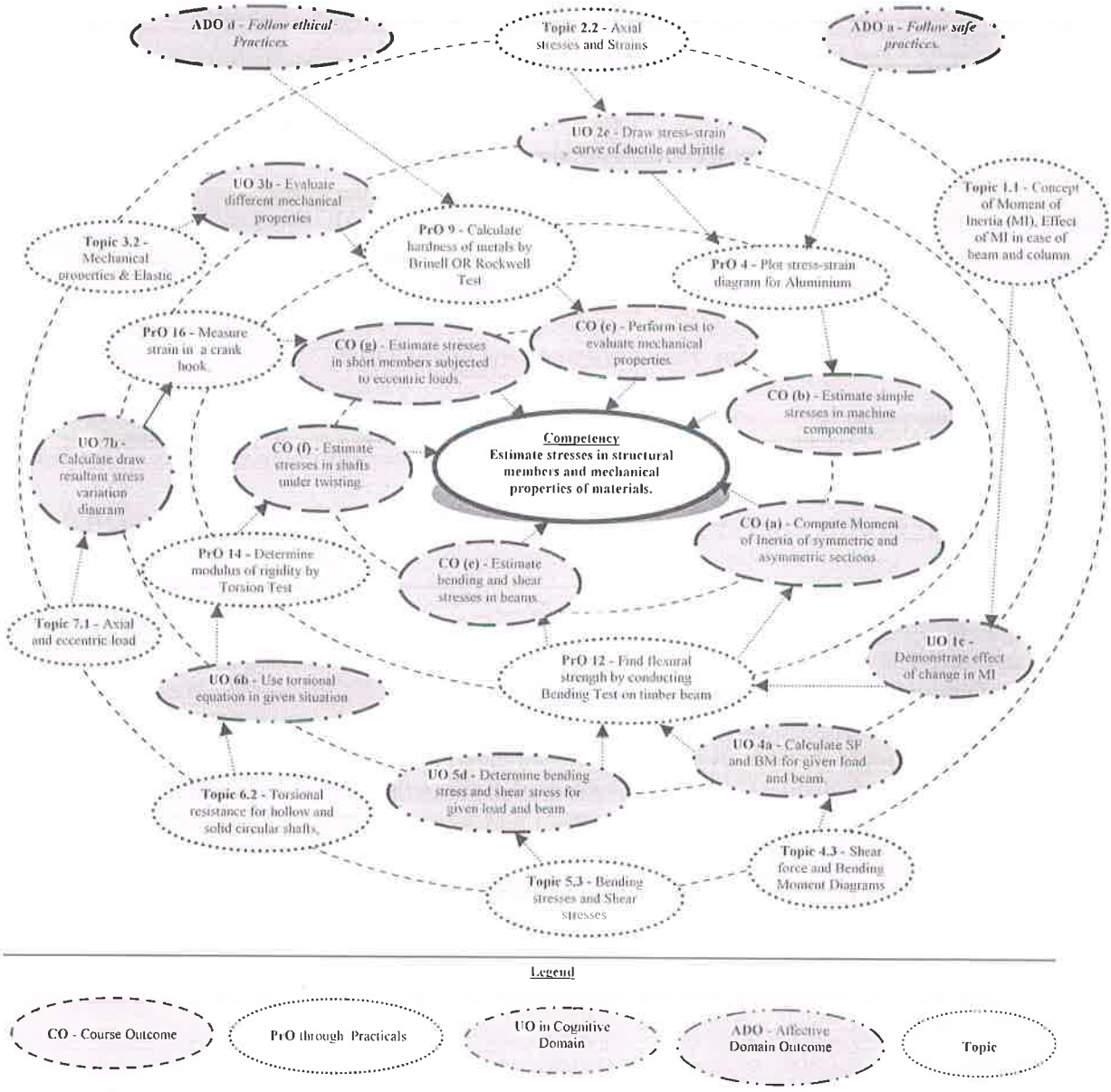


**Figure 1 - Course Map**

## 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) per IS 1608432 (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.<br>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<br>Accuracy + 1 % of the true torque<br>Suitable For: Torsion and Twist test on diverse metal rods and flats<br>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.<br>1b. Calculate MI of the given simple composite shape.<br>1c. Explain with sketches effect of change in MI in case of the given beam and column.<br>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.<br>1.2 MI about axes passing through centroid, Parallel and Perpendicular axes theorem, Polar MI, radius of gyration.<br>1.3 MI of standard basic shapes.<br>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.<br>2b. Use Hooke's law for the | 2.1 Equilibrium, Rigid body, Deformable body.<br>Axial Stress- meaning, Resistance, Types of stresses; Axial (linear) Strain – concept, |

| | | |
|---|---|---|
| | given stress condition.<br>2c. Calculate Modulus of Elasticity and Rigidity for the given situation.<br>2d. Determine nature and magnitude of thermal stress in the given situation.<br>2e. Draw stress-strain curve of the given ductile and brittle material(s) in tension.<br>2f. Calculate shear stresses for the given single/double shear condition. | types.<br>2.3 Hooke's Law, Young's Modulus, Axial deformation in a body and bodies in series.<br>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.<br>2.5 Shear stress and shear strain, Modulus of rigidity, punching shear, shear connectors, single and double shear.<br>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.<br>3b. Evaluate different mechanical properties of the given material.<br>3c. Identify types of load acting in the given situation with justification.<br>3d. Identify type of material from the given data with justification.<br>3e. Calculate strain and axial deformation in each direction under the given bi- and tri-axial stresses.<br>3f. Estimate Resilience, Modulus of resilience, Proof Resilience for the given case. | 3.1 Types of loads (actions) and related deformations, Flexure, torsion, shear.<br>3.2 Mechanical properties: Elasticity, Plasticity, Ductility, Brittleness, Malleability, Fatigue, Creep, Toughness, Hardness.<br>3.3 Strength, Factor of Safety, Stiffness and flexibility.<br>3.4 Linear and lateral strain, Poisson's ratio, changes in lateral dimension.<br>3.5 Uni- Bi –Tri-axial stress systems, strain in each direction, Bulk modulus, volumetric strain.<br>3.6 Relation between three moduli.<br>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.<br>4b. Draw SFD and BMD for the given loaded beam.<br>4c. Locate point of maximum BM and point of contra-flexure in the given case.<br>4d. Draw deflected shape of beam from the given BMD.<br>4e. Use flexural formula for the given bending situation.<br>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.<br>4.2 Meaning of SF and BM, Relation between them, Sign convention.<br>4.3 SFD and BMD, Location of point of maximum BM, Deflected shape from BMD, Location of Point of Contra-flexure.<br>4.4 Theory of simple bending, Assumptions in |

| | | |
|---|---|---|
| | fibers in bending for the given beam.<br>4g. Determine Section modulus and Moment of resistance for the given beam.<br>4h. Determine bending stress and shear stress for the given load and beam.<br>4i. Draw bending stress and shear stress variation diagram for the given beam. | theory of bending, Flexural formula, Neutral axis.<br>4.5 Moment of resistance, Section modulus.<br>4.6 Bending stress variation diagram across depth for cantilever and simply supported beam for symmetrical and unsymmetrical sections.<br>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<br>5b. Calculate torque and power transmitted by a shaft in the given situation.<br>5c. Determine shear stress and angle of twist in a shaft for the given power to be transmitted/torque.<br>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.<br>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.<br>6b. Calculate resultant stress and draw resultant stress variation diagram for the given situation.<br>6c. Mark core (kernel) of the given standard section.<br>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).<br>6.2 Axial stress and bending stress, resultant stress intensities, resultant stress variation (Eccentricity about one axis only).<br>6.3 Limiting eccentricity, Core of section.<br>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.

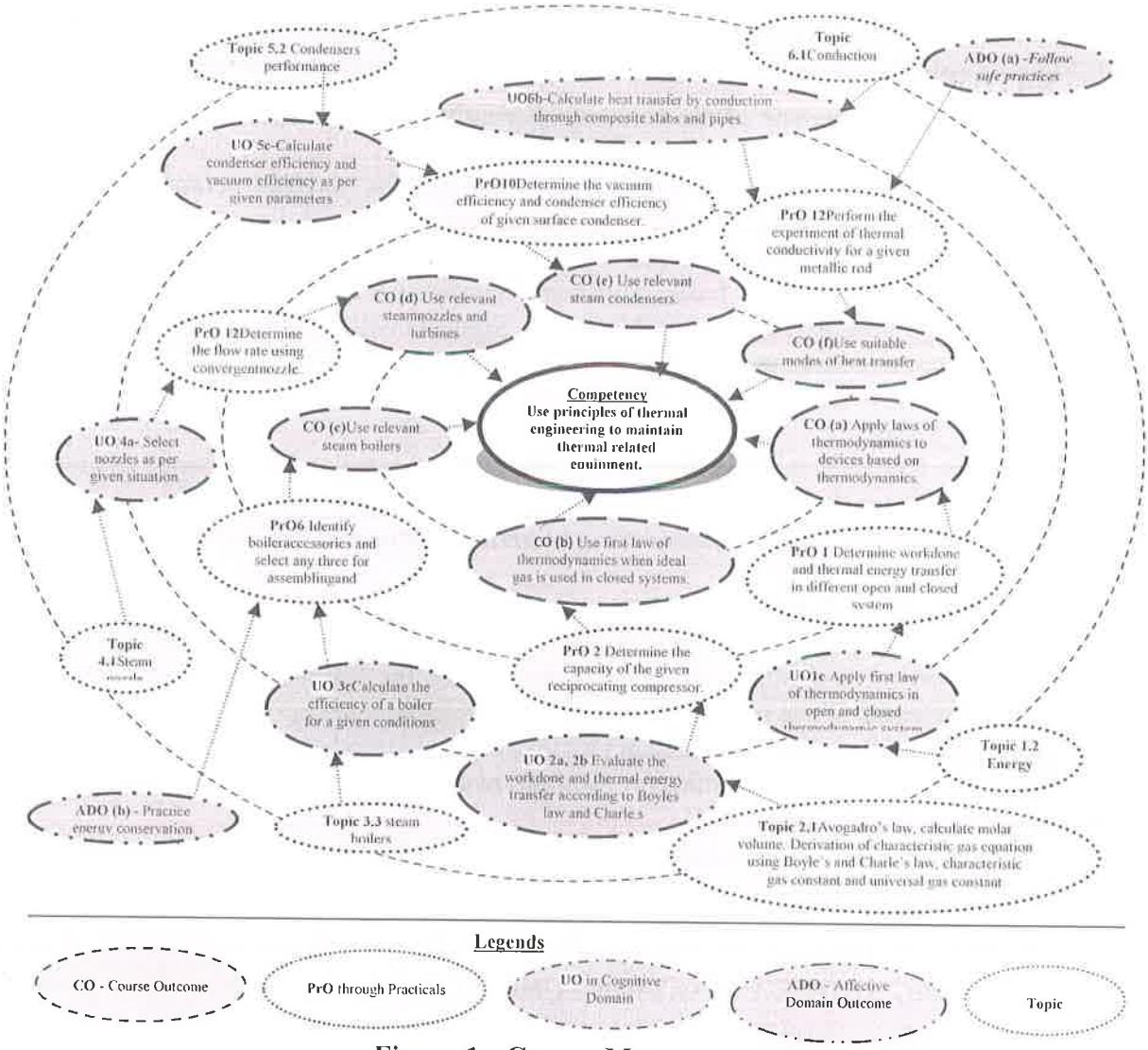


**Figure 1 - Course Map**

## 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.<br>1b. Explain the phenomena when thermodynamic principles is applied to the given condition of gas.<br>1c. Explain the phenomena when first law of thermodynamics in the given thermodynamic system.<br>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.<br>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.<br>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.<br>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.<br>2b. Evaluate the workdone and thermal energy transfer according to Charle's law for the given situation.<br>2c. Calculate the mass of a gas and its final condition parameters after undergoing Polytropic process for the given situation..<br>2d. Determinecharacteristic gas constant of commonly used gases for the given data.<br>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.<br>**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.<br>3b. Represent different vapor processes on suitable co-ordinates in the given situation.<br>3c. Calculate the efficiency of given type of boiler for the given conditions.<br>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.<br>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.<br>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).<br>3.4 Boiler mountings and accessories.<br>3.5 Boiler instrumentation.<br>3.6 Methods of energy conservation in boilers. |
| **Unit-IVSteam turbines** | 4a. Select the nozzles for the given situation.<br>4b. Determine thermal efficiency for the specified type of steam turbine for given conditions.<br>4c. Interpret thegiven types of steam cycles to estimate efficiencies in a steam power plant<br>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.<br>4.2 Steam turbine - Classification of turbines, Construction and working of impulse and reaction turbine.<br>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.<br>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.<br>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.<br>5d. Evaluate the thermal performance for the given data of the team condenser<br>5e. Interpret the thermal design of the given type of cooling tower.<br>5f. Select condensers for the given situation with justification<br>5g. Select cooling tower for the given situation with justification | air leakage and its effect, concept of condenser efficiency, vacuum efficiency (Simple numerical).<br>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.<br>6b. Use Stefan Boltzman law of radiation in the given situation.<br>6c. solve thermal engineering problems with the given data using principles of energy mechanisms.<br>6d. Explain construction and working of a given type of heat exchangers with sketches.<br>6e. Select heat exchangers for the given situation with justification. | 6.1 Modes of heat transfer - Conduction, convection and radiation.<br>6.2 Conduction - Fourier's law, thermal conductivity, conduction through cylinder, thermal resistance, composite walls,list of conducting and insulating materials.<br>6.3 Convection - Newton's law of cooling, natural and forced convection.<br>6.4 Radiation- Thermal Radiation, absorptivity, transmissivity, reflectivity, emissivity, black and gray bodies, Stefan-Boltzman law.<br>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.

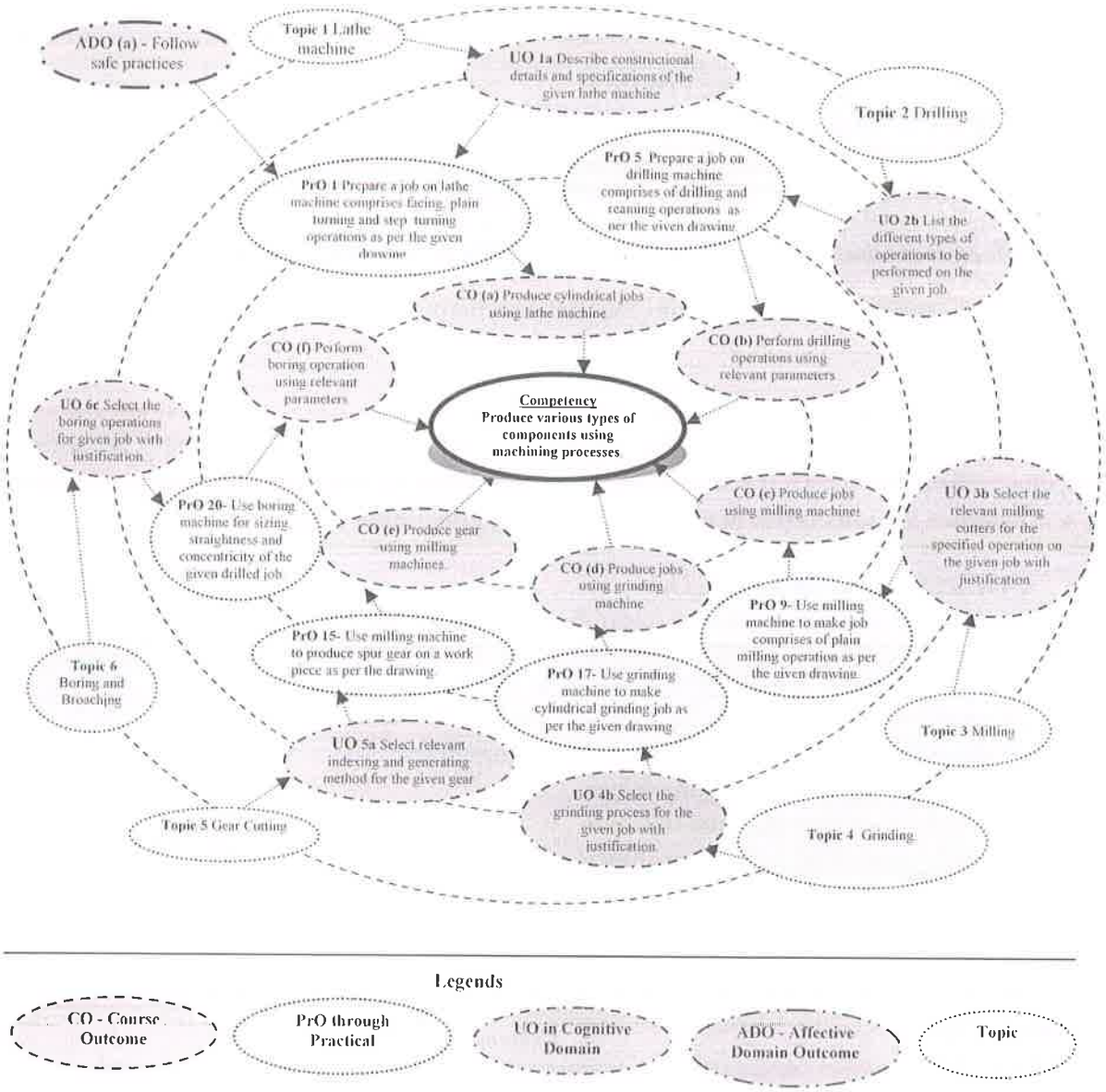


**Figure 1 - Course Map**

## 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.<br>1b. List the different operations to be performed on a given job.<br>1c. Select the relevant machining parameters for given job with justification.<br>1d. Compute the machining time for the given job. | 1.1 Introduction: Importance of material removal, mechanism of metal cutting.<br>1.2 Lathe Machine: Introduction, classification, basic parts of center lathe and their functions, Lathe specifications.<br>1.3 Lathe operations: facing, plain turning, taper turning (using compound slide), thread cutting, thread rolling, chamfering, grooving, knurling.<br>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.<br>2b. List the different types of operations to be performed on the given job.<br>2c. Name the nomenclature of given type of drill(s).<br>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,<br>2.2 Drilling machine operations: drilling, reaming, boring, counter sinking, counter boring, spot facing.<br>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.<br>3b. Select the relevant milling cutters for the specified operation on the given job with justification.<br>3c. Compute the milling time for the given job.<br>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.<br>3.2 Milling operations: plain milling, side milling, straddle milling, gang milling, face milling, slot milling, end milling, slitting. Up milling and down milling.<br>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.<br>4b. Select the grinding process for the given job with justification.<br>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.<br>4.2 Types of grinding wheel, grinding wheel specifications, grinding wheel dressing and truing.<br>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.<br>5b. Choose gear finishing method for a given job.<br>5c. Explain with sketch given gear finishing method.<br>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.<br>5.2 Gear generating methods: Working principles of gear shaping and hobbing.<br>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<br>6b. Select the relevant broaching machine for the given job with justification.<br>6c. Select the boring operations for given job with justification.<br>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.<br>6.2 Broaching: Introduction, classification, specifications of broaching machines, basic parts of horizontal broaching machine and their functions.<br>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.

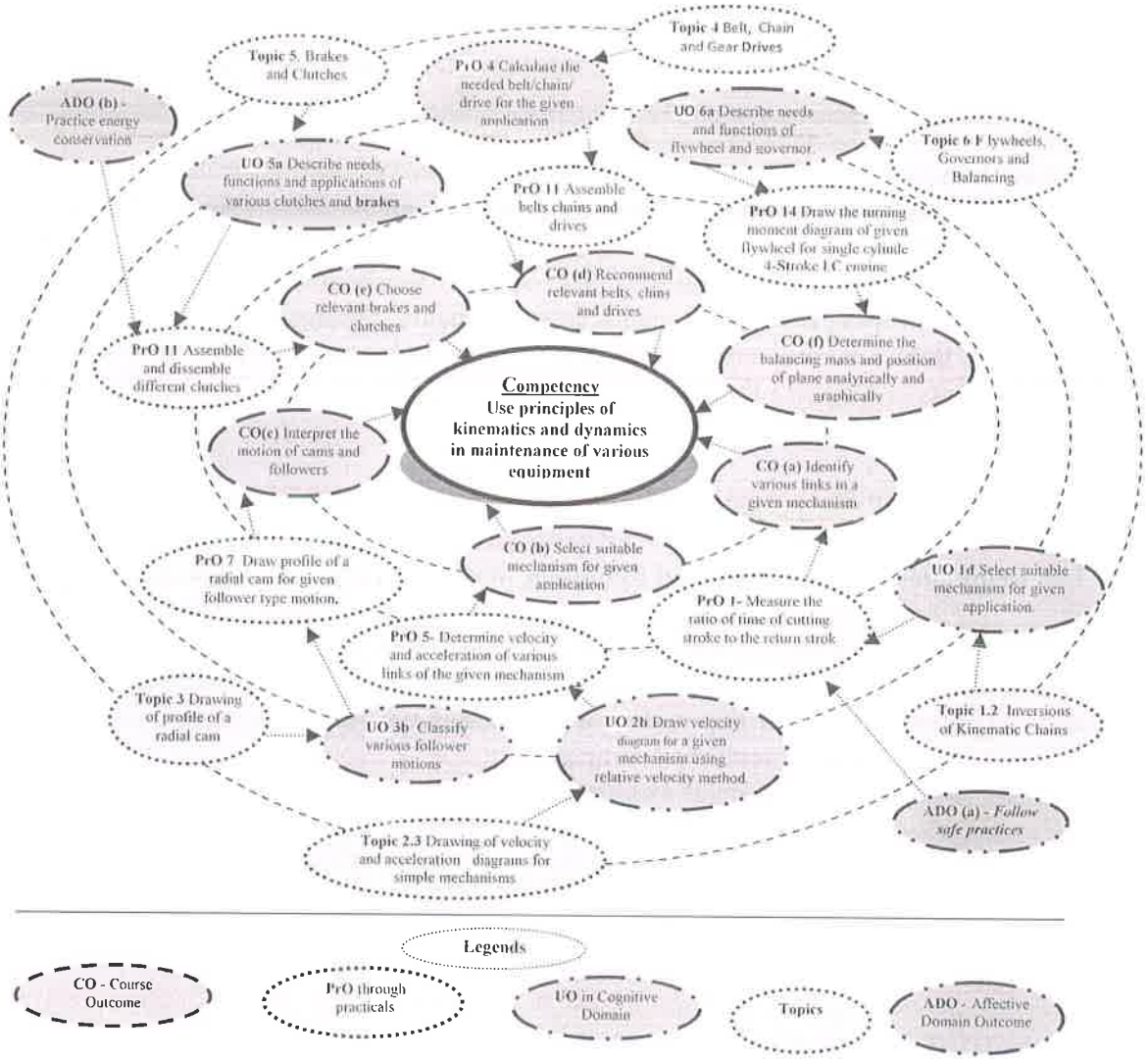


**Figure 1 - Course Map**

## 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)<br>a. Measuring dimensions of different links of given shaper machine<br>b. Sketching<br>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)<br>a. Measuring dimensions of different links of given shaper machine<br>b. Sketching<br>c. Labeling of sketch | | |
| 3 | Estimate important kinematic data related to following mechanisms to sketch them.<br>a) Bicycle free wheel sprocket mechanism<br>b) Geneva mechanism | I | 02 |
| 4 | Estimate important kinematic data related to following mechanisms to sketch them.<br>a) Ackerman's steering gear mechanism<br>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<br>a. various belt drives,<br>b. chain and sprocket,<br>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.<br>1b. Describe with sketches the constructional details of the given type of mechanism<br>1c. Select suitable mechanism for the given application with justification.<br>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.<br>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<br>2b. Estimate velocity and acceleration of any link at any instant in the given mechanism.<br>2c. Describe with dimensioned sketch of the given mechanism.<br>2d. Describe with velocity diagram for a given mechanism using relative velocity method.<br>2e. Describe with acceleration diagram for the given mechanism.<br>2f. Explain with velocity and acceleration diagram for the given mechanism using Klein's construction. | acceleration.<br>2.2 Analytical method and Klein's construction to determine velocity and acceleration of different links in single slider crank mechanism.<br>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.<br>3b. Describe with dimensioned sketch of the given cam and follower arrangement.<br>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.<br>3.2 Types of follower motions and their displacement diagrams -Uniform velocity, Simple harmonic motion, uniform acceleration and retardation.<br>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.<br>4b. Estimate power transmitted and condition for maximum power transmitted in the given belt drive for given data.<br>4c. Select suitable belt for the given application with justification.<br>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.<br>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.<br>4e. Select suitable gear for the given application with justification.<br>4f. Select suitable drives for the given application with justification. | demerits and selection of chains for given applications.<br>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.<br>5b. Explain with sketches the various parts of the given brakes with their functions and constructional details.<br>5c. Describe with sketches the needs, functions and applications of the given clutches.<br>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.<br>5.2 Construction and principle of working of i) Shoe brake, ii) Band brake iii) Internal expanding shoe brake iv) Disc Brake.<br>5.3 Braking force, braking torque and power for shoe and band brake.<br>5.4 Clutches-Uniform pressure and Uniform Wear theories. Introduction to Clutch - Types, Functions and Applications, Construction and principle of working of<br>a. Single-plate clutch,<br>b. Multi-plate clutch,<br>c. Centrifugal Clutch<br>d. Cone clutch<br>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.<br>6b. Estimate the balancing mass and position of plane analytically and graphically in the given situation for the given data.<br>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.<br>6.2 Coefficient of fluctuation of energy, coefficient of fluctuation of speed and its significance.<br>6.3 Governors- Introduction, types, functions and applications, Terminology of Governors. Comparison of Flywheel and Governor.<br>6.4 Balancing- Need and types of balancing, Balancing of single rotating mass, Analytical and Graphical methods for balancing of several masses revolving in same plane. |

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

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

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

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

## 10. SUGGESTED STUDENT ACTIVITIES

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

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

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

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

## 12. SUGGESTED MICRO-PROJECTS

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

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

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

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

## 13. SUGGESTED LEARNING RESOURCES

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

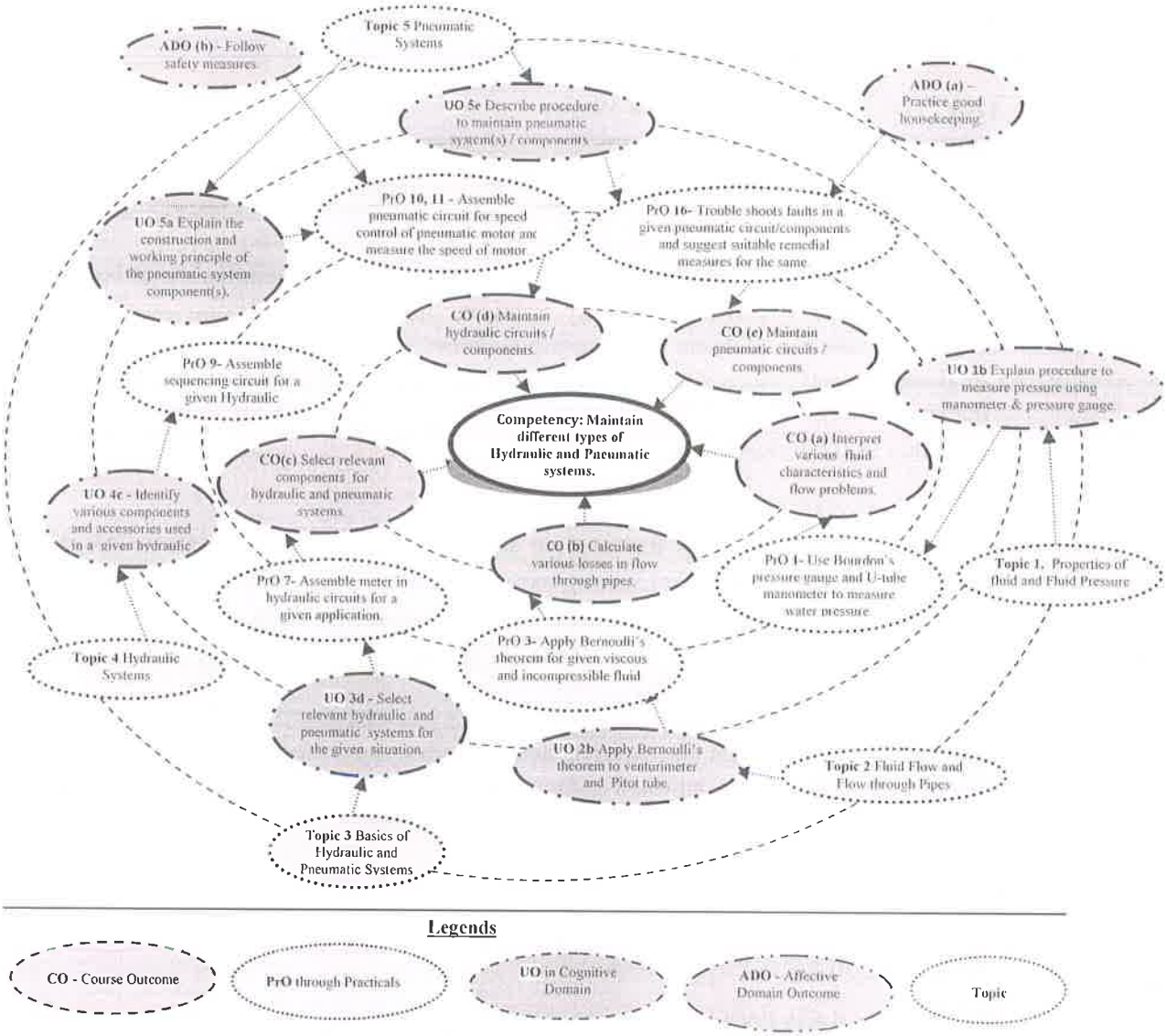


**Figure 1 - Course Map**

## 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.<br>1b. Explain with sketches the procedure to measure pressure using the specified type of manometer and different types of pressure gauges.<br>1c. Calculate centre of pressure and total pressure of the given type of regular immersed body.<br>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.<br>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.<br>2b. Apply Bernoulli's theorem to the given device to determine the given parameter.<br>2c. Apply laws of fluid friction for the given data.<br>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.<br>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.<br>3b. Select the relevant fluid for given hydraulic and Pneumatic Systems with justification.<br>3c. Select relevant filter for the given hydraulic and pneumatic systems with justification.<br>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.<br>3.2 Filters: Contaminations, Need, Types & location of filter.<br>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).<br>4b. Select the relevant actuators for the given situation with justification.<br>4c. Identify the components and accessories used in the given hydraulic circuit diagram.<br>4d. Describe the procedure to maintain the specified hydraulic component/system.<br>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.<br>4.2 Positive displacement Pumps: - Construction, working principle and applications of Vane pump, gear pump, rotor pump, screw pump & piston Pump.<br>4.3 Pressure control Valves: Construction, principle of working of pressure relief valve - direct, pilot operated, Sequence valves.<br>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.<br>4.5 Flow control valves: pressure compensated, non-pressure compensated flow control valve,<br>4.6 Actuators: Classification of actuators, Construction & working principle of Rotary Actuators - Hydraulic motors, Linear Actuators - Cylinders - single acting, double acting.<br>4.7 Accessories: Types, Material and functions of Pipes, Hoses, Fittings, Seals and gaskets, Accumulators.<br>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).<br>5b. Identify the components and accessories used in the given pneumatic circuit diagram.<br>5c. Select the relevant air compressors for given situation with justification.<br>5d. Select actuators for given situation with justification.<br>5e. Describe the procedure to maintain the specified pneumatic component/system.<br>5f. Construct with explanation the pneumatic circuit for the given situation. | 5.2 Air Receiver, FRL unit.<br>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.<br>5.4 Actuators: Construction and working principal of Rotary Actuators - Pneumatic motors,<br>Linear Actuators – Cylinders - single acting double acting.<br>5.5 Accessories: Types, Material and functions of Pipes, Hoses and fittings.<br>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 given 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.

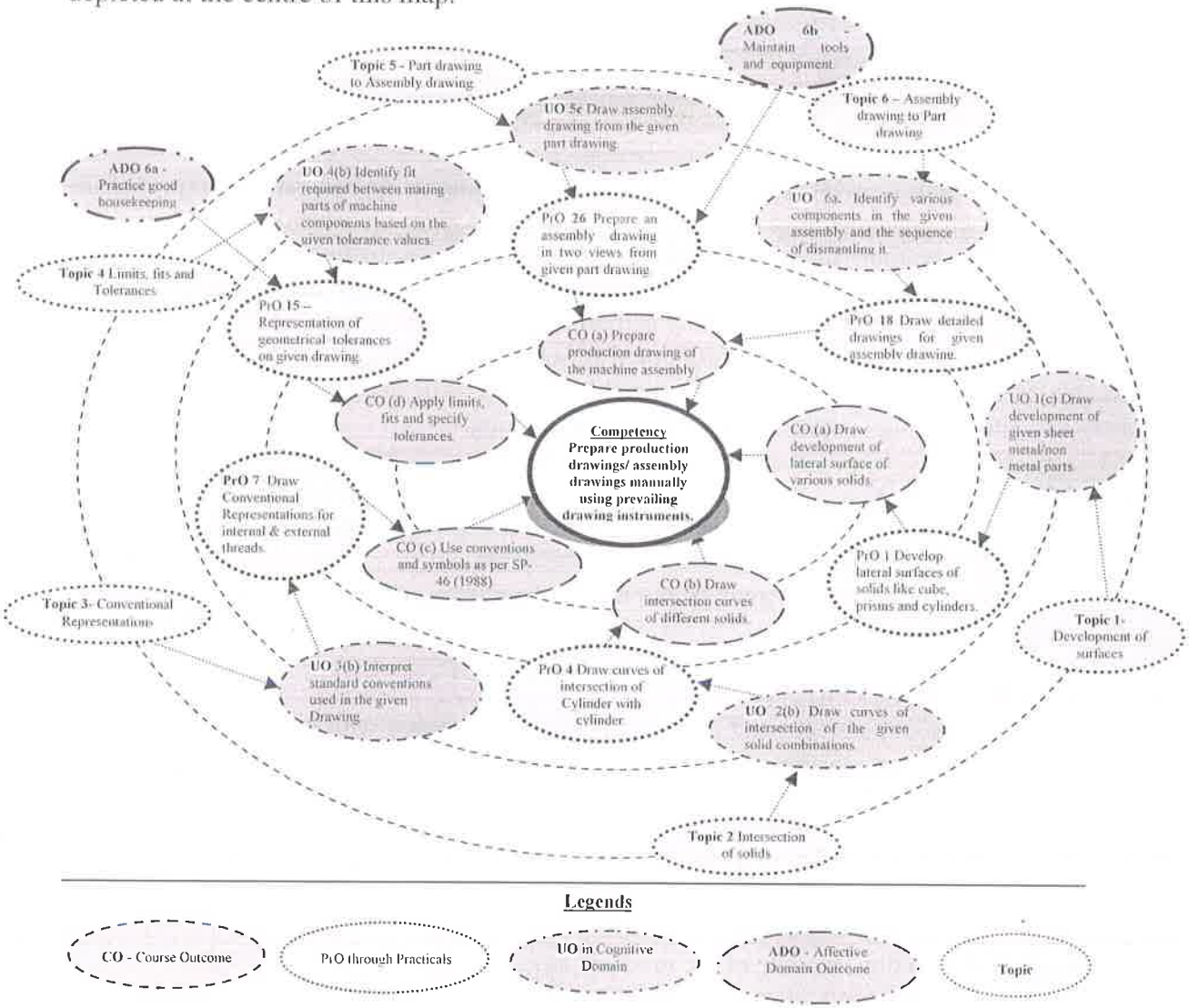


**Figure 1 - Course Map**

## 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:<br>a. T-square or drafter (Drafting Machine)<br>b. Set squares ($45^0$ and $30^0$- $60^0$)<br>c. Protractor<br>d. Drawing instrument box (containing set of compasses and dividers)<br>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.<br>1b. Identify parts where concept of development of the given surfaces is required.<br>1c. Draw development of given sheet metal/non-metal parts. | 1.1 Developments of lateral surfaces of cube, prisms, cylinder, pyramid and cone.<br>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.<br>2b. Draw curves of intersection of the given solid combinations. | 2.1 Curves of intersection of the regular solids in the following cases.<br>2.2 Square prism with square prism, cylinder with cylinder, square prism with cylinder when,<br>(i) The axes are at 90° and bisecting.<br>(ii) The axes are at 90° and Offset. |
| **Unit– III Conventional representation** | 3a. Use IS SP-46 (1988) codes.<br>3b. Interpret standard conventions used in the given Drawing.<br>3c. Use standard conventions in practice.<br>3d. Interpret welding symbols in the given working drawing. | 3.1 Standard conventions using IS SP – 46 (1988) for the following.<br>3.2 Sections - Half, removed, revolved, offset, partial and aligned sections.<br>3.3 Conventional representation of slotted head, knurling, serrated shaft, splined shaft, holes on circular pitch, internal and external thread and pipe fittings.<br>3.4 Conventional representation of ball and roller bearing, spur gear, springs with square and flat ends and sprocket wheel.<br>3.5 Taper, counter sunk and counter bored hole.<br>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.<br>4b. Identify fit required between mating parts of machine components based on the given tolerance values.<br>4c. Interpret surface roughness characteristics from the values the given-on component drawing.<br>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.<br>4.2 Geometrical Tolerances: Types of geometrical tolerances, representation of geometrical tolerance on drawing.<br>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.<br>5b. State details of components and the sequence of components of the given assembly.<br>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.<br>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.<br>6b. Describe the procedure for dismantling the assembly into components.<br>6c. Draw detailed drawing from the given assembly drawing. | 6.1 Basic principles of process of dismantling the assembly into components.<br>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