B. E. (Common to all branches)

Choice Based Credit System (CBCS) and Outcome-Based Education (OBE)

SEMESTER - III

TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES			
Course Code	**21MAT 31**	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives: The goal of the course Transform Calculus, Fourier series and Numerical techniques 21MAT 31 is

- To have an insight into solving ordinary differential equations by using Laplace transform techniques
- Learn to use the Fourier series to represent periodical physical phenomena in engineering analysis.
- To enable the students to study Fourier Transforms and concepts of infinite Fourier Sine and Cosine transforms and to learn the method of solving difference equations by the z-transform method.
- To develop proficiency in solving ordinary and partial differential equations arising in engineering applications, using numerical methods

Teaching-Learning Process (General Instructions):

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical skills.
2. State the need for Mathematics with Engineering Studies and Provide real-life examples.
3. Support and guide the students for self–study.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress.
5. Encourage the students for group learning to improve their creative and analytical skills.
6. Show short related video lectures in the following ways:
   - As an introduction to new topics (pre-lecture activity).
   - As a revision of topics (post-lecture activity).
   - As additional examples (post-lecture activity).
   - As an additional material of challenging topics (pre-and post-lecture activity).
   - As a model solution for some exercises (post-lecture activity).

Module-1: Laplace Transform (8 Hours)

Definition and Laplace transforms of elementary functions (statements only). Problems on Laplace's Transform of $e^{at}f(t)$, $t^n f(t)$, $\frac{f(t)}{t}$. Laplace transforms of Periodic functions (statement only) and unit-step function – problems. Inverse Laplace transforms definition and problems, Convolution theorem to find the inverse Laplace transforms (without Proof) problems. Laplace transforms of derivatives, solution of differential equations. **(8 Hours)**

Self-study: Solution of simultaneous first-order differential equations.

(RBT Levels: L1, L2 and L3)

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-2: Fourier Series (8 Hours)

Introduction to infinite series, convergence and divergence. Periodic functions, Dirichlet's condition. Fourier series of periodic functions with period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis.

Self-study: Convergence of series by D'Alembert's Ratio test and, Cauchy's root test.

(RBT Levels: L1, L2 and L3)

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-3: Infinite Fourier Transforms and Z-Transforms (8 Hours)	
Infinite Fourier transforms definition, Fourier sine and cosine transforms. Inverse Fourier transforms, Inverse Fourier cosine and sine transforms. Problems. Difference equations, z-transform-definition, Standard z-transforms, Damping and shifting rules, Problems. Inverse z-transform and applications to solve difference equations **Self Study**: Initial value and final value theorems, problems. **(RBT Levels: L1, L2 and L3)**	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation
Module-4: Numerical Solution of Partial Differential Equations (8 Hours)	
Classifications of second-order partial differential equations, finite difference approximations to derivatives, Solution of Laplace's equation using standard five-point formula. Solution of heat equation by Schmidt explicit formula and Crank-Nicholson method, Solution of the Wave equation. Problems. **Self Study**: Solution of Poisson equations using standard five-point formula. **(RBT Levels: L1, L2 and L3)**	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation
Module-5: Numerical Solution of Second-Order ODEs and Calculus of Variations	
Second-order differential equations - Runge-Kutta method and Milne's predictor and corrector method. (No derivations of formulae). Calculus of Variations: Functionals, Euler's equation, Problems on extremals of functional. Geodesics on a plane, Variational problems **Self Study:** Hanging chain problem **(RBT Levels: L1, L2 and L3)**	
Course outcomes: After successfully completing the course, the students will be able : ➢ To solve ordinary differential equations using Laplace transform. ➢ Demonstrate the Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory. ➢ To use Fourier transforms to analyze problems involving continuous-time signals and to apply Z-Transform techniques to solve difference equations ➢ To solve mathematical models represented by initial or boundary value problems involving partial differential equations ➢ Determine the extremals of functionals using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

First test at the end of 5th week of the semester

Second test at the end of the 10th week of the semester

Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

The question paper will have ten questions. Each question is set for 20 marks.

There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. **B. S. Grewal**: "Higher Engineering Mathematics", Khanna publishers, 44th Ed.2018
2. **E. Kreyszig**: "Advanced Engineering Mathematics", John Wiley & Sons, 10th Ed. (Reprint), 2016.

Reference Books

1. **V. Ramana:** "Higher Engineering Mathematics" McGraw-Hill Education, 11th Ed.
2. **Srimanta Pal & Subodh C. Bhunia:** "Engineering Mathematics" Oxford University Press, 3rd Reprint, 2016.
3. **N.P Bali and Manish Goyal**: "A textbook of Engineering Mathematics" Laxmi Publications, Latest edition.
4. **C. Ray Wylie, Louis C. Barrett:** "Advanced Engineering Mathematics" McGraw – Hill Book Co.Newyork, Latest ed.
5. **Gupta C.B, Sing S.R and Mukesh Kumar:** "Engineering Mathematic for Semester I and II", Mc- Graw Hill Education(India) Pvt. Ltd 2015.
6. **H.K.Dass and Er. Rajnish Verma:** "Higher Engineering Mathematics" S.Chand Publication (2014).
7. **James Stewart: "**Calculus" Cengage publications, 7th edition, 4th Reprint 2019.

Web links and Video Lectures (e-Resources):

- http://.ac.in/courses.php?disciplineID=111
- http://www.class-central.com/subject/math(MOOCs)
- http://academicearth.org/
- http://www.bookstreet.in.
- VTU e-Shikshana Program
- VTU EDUSAT Program

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes
- Assignments
  Seminars

Semester - 03

METAL CASTING FORMING & JOINING PROCESS (IPCC)			
Course Code	**21ME32**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
* One additional hour may be considered wherever required			

Course objectives:

- To acquaint with the basic knowledge on fundamentals of metal forming processes
- To study various metal forming processes.
- To provide adequate knowledge of quality test methods conducted on welded and cast components.
- To provide knowledge of various casting process in manufacturing.
- To provide in-depth knowledge on metallurgical aspects during solidification of metal and alloys.
- To provide detailed information about the moulding processes.
- To impart knowledge of various joining process used in manufacturing.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

MODULE-1 **8 HOURS**

Introduction & basic materials used in foundry: *Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy. Introduction to casting process & steps involved – (Brief Introduction)-Not for SEE*

Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.

Sand moulding: Types of base sand, requirement of base sand. Binder, Additive's definition, need and types; preparation of sand moulds. Molding machines- Jolt type, squeeze type and Sand slinger.

Study of important moulding process: Green sand, core sand, dry sand, sweep mould, CO2mould, shell mould, investment mould, plaster mould, cement bonded mould.

Cores: Definition, need, types. Method of making cores,

Concept of gating (top, bottom, parting line, horn gate) and risers (open, blind) Functions and types.

Teaching-Learning Process	Understanding, Remembering Chalk & Talk Method / Power point presentation/ You tube videos

MODULE-2 **8HOURS**

Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace. **Casting using metal moulds**: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes. Casting defects, their causes and remedies.	
Teaching-Learning Process	. Understanding, Remembering Chalk & Talk Method / Power point presentation/ You tube videos
MODULE-3	**8 HOURS**
METAL FORMING PROCESSES ***Introduction of metal forming process:*** Mechanical behaviour of metals in elastic and plastic deformation, stress-strain relationships, Yield criteria, Application to tensile testing, train rate and temperature in metal working; Hot deformation, Cold working and annealing. ***Metal Working Processes:*** Fundamentals of metal working, Analysis of bulk forming processes like forging, rolling, extrusion, wire drawing by slab method, ***Other sheet metal processes:*** Sheet metal forming processes (Die and punch assembly, Blanking, piercing, bending etc., Compound and Progressive die), High Energy rate forming processes.	
Teaching-Learning Process	Understanding, Remembering Chalk & Talk Method / Power point presentation/ You tube videos
MODULE-4	**8 HOURS**
JOINING PROCESSES ***Operating principle, basic equipment, merits and applications of***: Fusion welding processes: Gas welding - Types – Flame characteristics; Manual metal arc welding – Gas Tungsten arc welding - Gas metal arc welding – Submerged arc welding.	
Teaching-Learning Process	Understanding, Remembering Chalk & Talk Method / Power point presentation/ You tube videos
MODULE 5	**8 HOURS**
Weldability and thermal aspects: Concept of weldability of materials; Thermal Effects in Welding (Distortion, shrinkage and residual stresses in welded structures); Welding defects and remedies. ***Allied processes***: Soldering, Brazing and adhesive bonding **Advance welding processes:** Resistance welding processes, friction stir welding (FSW).	
Teaching-Learning Process	Understanding, Remembering Chalk & Talk Method / Power point presentation/ You tube videos

PRACTICAL COMPONENT OF IPCC

Course objectives:

- Impart fundamental understanding of various casting, welding and forming processes
- To provide in-depth knowledge on metallurgical aspects during solidification of metal and alloys
- Discuss design methodology and process parameters involve in obtaining defect free component

Sl.NO	Experiments
1	Studying the effect of the clay and moisture content on sand mould properties
2	Preparation of sand specimens and conduction of the following tests: 1. Compression, Shear and Tensile tests on Universal Sand Testing Machine.

3	To determine permeability number of green sand, core sand and raw sand.
4	To determine AFS fineness no. and distribution coefficient of given sand sample.
5	Use of Arc welding tools and welding equipment Preparation of welded joints using Arc Welding equipment L-Joint, T-Joint, Butt joint, V-Joint, Lap joints on M.S. flats
6	To study the effect of heat affected zone on the microstructure of steel weldment using MMAW.
7	Preparing minimum three forged models involving upsetting, drawing and bending operations
8	Sheet metal punch/die design and layout optimization
Demo experiments for CIE	
9	To study the defects of Cast and Welded components using Non-destructive tests like: a) Ultrasonic flaw detection b) Magnetic crack detection c) Dye penetration testing
10	Mould preparation of varieties of patterns, including demonstration
11	To generate plastic curve of a given metal strip at room temperature and at recrystallization temperature during rolling. Observe the changes in metal characteristic after rolling.
12	Demonstration of material flow and solidification simulation using Auto-Cast software

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

1. Select appropriate primary manufacturing process and related parameters for obtaining initial shape and size of components.
2. Design and develop adequate tooling linked with casting, welding and forming operations.
3. Appreciate the effect of process parameters on quality of manufactured components
4. Demonstrate various skills in preparation of molding sand for conducting tensile, shear and compression tests using Universal sand testing machine.
5. Demonstrate skills in preparation of forging models involving upsetting, drawing and bending operations.
6. Demonstrate skills in preparation of Welding models.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

3. The question paper will have ten questions. Each question is set for 20 marks.
4. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
5. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Books

1. Ghosh, A. and Mallik, A. K., (2017), Manufacturing Science, East-West Press.
2. Parmar R. S., (2007), Welding Processes and Technology, Khanna Publishers.
3. Little R. L. – 'Welding and Welding Technology' – Tata McGraw Hill Publishing Company Limited, New Delhi – 1989
4. Grong O. – 'Metallurgical Modelling of Welding' – The Institute of Materials – 1997 – 2nd Edition
5. Kou S. – 'Welding Metallurgy' – John Wiley Publications, New York – 2003 – 2nd Edition.
6. Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' – Prentice Hall – 2013 – 7th Edition
7. Principles of foundry technology, 4th edition, P L Jain, Tata McGraw Hill, 2006.
8. Advanced Welding Processes technology and process control, John Norrish, Wood Head Publishing, 2006.

Web links and Video Lectures (e-Resources):

- (Link:http://www.springer.com/us/book/9781447151784http://nptel.ac.in/courses/112
- 105127/)
- http://www.astm.org/DIGITAL_LIBRARY/MNL/SOURCE_PAGES/MNL11.htm
- http://www.astm.org/DIGITAL_LIBRARY/JOURNALS/COMPTECH/PAGES/CTR10654J.htm
- MOOCs: http://nptel.ac.in/courses/112105126/.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Metal Casting: Design pattern/core for a given component drawing and develop a sand mould with optimum gating and riser system for ferrous and non-ferrous materials. Melting and casting, inspection for macroscopic casting defects.
- Welding: TIG and MIG welding processes – design weld joints – welding practice –weld quality inspection.
- Metal Forming: Press working operation – hydraulic and mechanical press -load calculation: blanking, bending and drawing operations – sheet metal layout design.

Semester - 03

MATERIAL SCIENCE AND ENGINEERING (IPCC)			
Course Code	**21ME33**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
* One additional hour may be considered wherever required			

Course objectives:

- Provide basic background to systematically approach for selection of materials for a wide range of products in engineering applications.
- Introduce the concept of crystal structure, atomic planes and directions.
- Introduce the concept of atomic packing, coordination, and symmetry elements.
- Introduce imperfections in solids.
- Introduce phase stabilities and phase diagrams.
- Teach mechanism of phase transformations.
- Introduce various heat treatment methods.

Teaching-Learning Process (General Instructions)

Teacher can use to accelerate the attainment of the various course outcomes.

Step 1: Prior Knowledge.

Step 2: Presenting material.

Step 3: Challenge.

Step 4: Feedback.

Step 5 Repetitions.

MODULE-1	**8 HOURS**

Structure of Materials

Introduction: Classification of materials, crystalline and non-crystalline solids, atomic bonding

Geometrical Crystallography: Symmetry elements: the operation of rotation, Proper and Improper rotation axes, Screw axes, Glide planes

Crystal Structure: Crystal Lattice, Unit Cell, Planes and directions in a lattice, Planar Atomic Density, packing of atoms and packing fraction, Classification and Coordination of voids, Bragg's Law

Imperfections in Solids: Types of imperfections, Point defects: vacancies, interstitials, line defects,

2-D and 3D-defects, Concept of free volume in amorphous solids.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE-2	**8 HOURS**

Physical Metallurgy

Alloy Systems: Classification of Solid solutions, Hume- Rothery Rules

Phase Diagrams: Gibbs Phase Rule, Solubility limit, phase equilibria and Phase Diagrams: Isomorphous systems, Invariant Binary Reactions, Lever Rule; important phase- diagrams , Iron-Carbon Diagram.

Diffusion: Diffusion-Fick's Laws, Role of imperfections in diffusion.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations,

	3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE-3	**8 HOURS**
Nucleation and growth: Introduction to homogeneous and heterogeneous nucleation, critical radius for nucleation. *Plastic Deformation:* Slip, Twinning; Recovery- Recrystallization-Grain Growth, Introduction to Strengthening mechanisms. Lever rule and phase diagram. *Heat treatment: Annealing, Normalizing, hardening, Tempering, Nitriding, Cyaniding, Induction Hardening and Flame Hardening,, Recent advances in heat treat technology.* TTT diagram, microstructural effects brought about by these processes and their influence on mechanical properties.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE-4	**8 HOURS**
Surface coating technologies: Introduction, coating materials, coating technologies, types of coating, advantages and disadvantages of surface coating. *Powder metallurgy: Introduction, Powder Production Techniques: Different Mechanical and Chemical methods, Characterization of powders (Particle Size & Shape Distribution), Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process, Sintering and Application of Powder Metallurgy.*	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE 5	**8 HOURS**
Materials Selection *The need for material selection in design, the evolution of Engineering materials.* *The Design Process and Materials Data: Types of design, design tools and materials data, processes of obtaining materials data, materials databases* *Engineering Materials and Their Properties: The classes of engineering materials and their structure, material properties: mechanical properties, functional properties.* *Material Selection Charts: Selection criteria for materials, material property Charts, deriving property limits and material indices, materials indices which include shape.*	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, **3.** Chalk and Talk.

PRACTICAL COMPONENT OF IPCC

Sl.NO	**Experiments**
1	Specimen preparation for macro and micro structural examinations and study the macrostructure and microstructure of a sample metal/ alloys-
2	To study the crystal structure of a given Cast Iron, Mild steel, Aluminium and Copper/Brass specimens and study the crystal imperfections in a given Cast Iron, Mild steel and Aluminium specimens.

3	Study the heat treatment processes (Hardening and tempering) of steel/Aluminium specimens.
4	To determine the hardness values of Mild Steel/ Aluminium by Rockwell hardness/Vickers Hardness.
5	To determine the hardness values of Copper/ Brass by Brinell's Hardness testing machine.
6	To study the creep behaviour of a given Cast Iron or Aluminium specimen.
7	To study of microstructure of welding Mild Steel components and Heat affected zone (HAZ) macro and micro examinations
8	To determine the tensile strength, modulus of elasticity, yield stress, % of elongation and % of reduction in area of Cast Iron, Mild Steel/Brass/ Aluminium and to observe the necking.
9	To conduct a wear test on Mild steel/ Cast Iron/Aluminium/ Copper to find the volumetric wear rate and coefficient of friction.
10	Study the chemical corrosion and its protection. ***Demonstration***
11	Study the properties of various types of plastics. ***Demonstration***
12	Computer Aided Selection of Materials: Application of GRANTA Edupack for material selection: Case studies based on material properties. ***Demonstration***

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Understand the atomic arrangement in crystalline materials and describe the periodic arrangement of atoms in terms of unit cell parameters.
2. Understand the importance of phase diagrams and the phase transformations.
3. Know various heat treatment methods for controlling the microstructure..
4. Correlate between material properties with component design and identify various kinds of defects.
5. Apply the method of materials selection, material data and knowledge sources for computer-aided selection of materials.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

6. The question paper will have ten questions. Each question is set for 20 marks.
7. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
8. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Text Books:

1. Ashby, M.F. (2010), *Materials Selection in Mechanical Design*, 4th Edition, Butterworth- Heinemann.
2. Azaroff, L.V., (2001) *Introduction to solids*, 1st Edition, McGraw Hill Book Company.
3. Avner, S.H., (2017), *Introduction to Physical Metallurgy*, 2nd Edition, McGraw Hill Education.
4. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.

Reference Books

1. Jones, D.R.H., and Ashby,M.F., (2011), *Engineering Materials 1:* An Introduction to Properties, Application and Design, 4th Edition, Butterworth-Heinemann.
2. Jones, D.R.H., and Ashby,M.F., (2012), *Engineering Materials 2:* An Introduction to Microstructure and Processing, 4th Edition, Butterworth-Heinemann.
3. Callister Jr, W.D., Rethwisch, D.G., (2018), *Materials Science and Engineering: An Introduction*, 10th Edition, Hoboken, NJ: Wiley.
4. Abbaschian, R., Abbaschian, L., Reed-Hill, R. E., (2009), *Physical Metallurgy Principles*, 4th Edition, Cengate Learning.
5. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.

Web links and Video Lectures (e-Resources):

1. Bhattacharya,B., *Materials Selection and Design,* NPTEL Course Material, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, http://nptel.ac.in/courses/112104122/

2. Prasad, R., Introduction to Materials Science and Engineering, NPTEL Course Material, Department of Materials Science and Engineering, Indian Institute of Technology Delhi, http://nptel.ac.in/courses/113102080/
3. Subramaniam, A., Structure of Materials, NPTEL Course Material, Department of Material Science and Engineering, Indian Institute of Technology Kanpur,https://nptel.ac.in/courses/113104014/
4. Schuh, C., 3.40J Physical Metallurgy. Fall 2009. Massachusetts Institute of Technology: MIT Open Course Ware, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
5. Ghosh, R.N., Principles of Physical Metallurgy, IIT Kharagpur, http://nptel.ac.in/syllabus/113105024/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

THERMODYNAMICS			
Course Code	21ME34	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hr

Course objectives:

- State the governing laws of Thermodynamics.
- Explain the concepts and principles of pure substances and entropy.
- Describe air standard, gas and vapour power cycles used in prime movers.

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction and Review of fundamental concepts*: Thermodynamic definition and scope, Microscopic and Macroscopic approaches, Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium,* (Only for Self study)

Zeroth law of thermodynamics. Temperature; scales, thermometry, Importance of temperature measuring instruments. Design of Thermometers.

Work and Heat: Thermodynamic definition of work; examples, sign convention, Displacement work, Heat; definition, units and sign convention, Expressions for displacement work and heat in various processes through p-v diagrams. Shaft work, Electrical work.

First Law of Thermodynamics: Statement of the first law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, Steady Flow Energy Equation (SFEE) and engineering applications.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Second Law of Thermodynamics and Entropy: Limitations of first law of thermodynamics. Devices converting heat to work; (a) In a thermodynamic cycle, (b) In a mechanical cycle. Thermal reservoir, direct heat engine; schematic representation and efficiency. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Carnot cycle, Clausius inequality, Statement-proof, Entropy-definition, a property, change of entropy, entropy as a quantitative test for irreversibility, entropy as a coordinate.

Available energy and Exergy: Available energy, Maximum work in a reversible process; useful work; Dead state; availability; Second law efficiency.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving.

Module-3	
Introduction and Review of Ideal and Real gases: *Ideal gas mixtures, Daltons law of partial pressures, Amagats law of additive volumes, Evaluation of properties of ideal gases. Real gases: introduction, Van-Der Waal's equation, Van-Der Waal's constants in terms of critical properties.* (Only for self study) **Compressibility factor, compressibility chart and applications.** **Thermodynamic relations:** Maxwell's equations, TdS equation**.** Ratio of Heat capacities and Energy equation, Joule-Kelvin effect, Clausius-Clapeyron equation. **Combustion thermodynamics:** Theoretical (Stoichiometric) air for combustion of fuels, excess air, actual combustion. Exhaust gas analysis. A/F ratio, energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion, adiabatic flame temperature, combustion efficiency.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving.
Module-4	
Pure Substances: P-T and P-V diagrams, triple point and critical points, sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat), Dryness fraction (quality) representation of various processes on T-S & H-S diagrams. **Vapour Power Cycles:** Carnot vapour power cycle, simple Rankine cycle, actual vapour power cycles, ideal and practical regenerative Rankine cycles, open and closed feed water heaters, Reheat Rankine cycle and characteristics of an Ideal working fluid in vapour power cycles.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving.
Module-5	
Gas power cycles Ericson Cycle, Stirling Cycle, Air standard cycles-Otto cycle, Diesel cycle and Dual cycle, computation of thermal efficiency and mean effective pressure, comparison of Otto, Diesel & Dual cycles. **Gas turbine Cycles:** Introduction and classification of gas turbine, gas turbine (Brayton) cycle; description and thermal analysis and methods to improve thermal efficiency of gas turbines, Jet Propulsion.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4. Arrange Industrial visit to a power plant.
Course Outcomes (Course Skill Set) At the end of the course the student will be able to: 1. Describe the fundamental concepts and principles of engineering thermodynamics. 2. Apply the governing laws of thermodynamics for different engineering applications. 3. Analyse the various thermodynamic processes, cycles and results. 4. Interpret and relate the impact of thermal engineering practices to real life problems.	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

1. First assignment at the end of 4th week of the semester
2. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

1. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

9. The question paper will have ten questions. Each question is set for 20 marks.
10. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Text Books Books

9. Basic and Applied Thermodynamics, P K Nag, 2nd Ed., Tata McGraw Hill Publications, 2017.
10. A textbook of Engineering Thermodynamics, R K Rajput, Fifth edition, Laxmi Publications, 2019.
3. Fundamentals of Thermodynamics by Claus Borgnakke and Richard E Sonntag, 8th edition, Wiley India Edition, 2020
4. Thermodynamics, An Engineering Approach, by Yunus A Cenegal, Michael A Boles, and Mehmet Kanoglu, 9th Edition, Tata McGraw Hill publications, 2019

Reference Books

1. Engineering Thermodynamics, J B Jones and G A Hawkins, John Wiley and sons, 1986.
2. An Introduction to Thermodynamics, Y V C Rao, Wiley Eastern, 2003
3. Applications of Thermodynamics, Dr V Kadambi and Dr T R Seetharam, Wiley Publications, 2018.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=9GMBpZZtjXM&list=PLD8E646BAB3366BC8
- https://www.youtube.com/watch?v=jkdMtmXo664&list=PL3zvA_WajfGAwLuULH-L0AG9fKDgplYne
- https://www.youtube.com/watch?v=1lk7XLOxtzs&list=PLkn3QISf55zy2Nlqr5F09oO2qcIwNNfrZ&index=3
- https://www.youtube.com/watch?v=Dy2UeVCSRYs&list=PL2_EyjPqHc10CTN7cHiM5xB2qD7BHUry7
-

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Organise Industrial visits to Thermal power plants and submission of report
- Case study report and power point presentation on steam power plant.
- List of thermal energy devices at homes, hostels and college premises and applicable laws

Semester 03			
MACHINE DRAWING AND GD & T			
Course Code	21MEL35	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2*:0	SEE Marks	50
Credits	01	Exam Hours	03
* One additional hour may be considered wherever required			

Course objectives:

- To acquire the knowledge of limits, tolerance and fits and indicate them on machine drawings.
- To make drawings using orthographic projections and sectional views
- To impart knowledge of thread forms, fasteners, keys, joints, couplings and clutches.
- To understand and interpret drawings of machine components leading to preparation of assembly drawings manually and using CAD packages.

Module 1 (only for CIE) **01 Sessions**

Review of basic concepts of Engineering Visualization

Geometrical Dimensioning and Tolerances (GD&T): Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in industry.

Module 2 (only for CIE) **02 Sessions**

Sections of Simple and hollow solids: True shape of sections.

Module 3 (only for CIE) **03 Sessions**

Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal & External) square and Acme. Sellers thread, American Standard thread, Helicoil thread inserts

Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly), simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, countersunk head screw, grub screw, Allen screw

Rivets

Keys: Parallel key, Taper key, Feather key, Gib-head key and Woodruff key.

Module 4 **03 Sessions**

Assembly of Joints, couplings and clutches (with GD&T) using 2D environment

Joints: Like Cotter joint (socket and spigot), knuckle joint (pin joint).

Couplings: Like flanged coupling, universal coupling

Clutches: Like Single Plate clutch, cone clutch

Module 5 **05 Sessions**

Assembly of Machine Components (with GD&T) using 3D environment

(Part drawings shall be given)

1. **Bearings**
2. **Valves**
3. **Safety Valves**
4. **I.C. Engine components**
5. **Lifting devices**
6. **Machine tool components**
7. **Pumps**

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

CO1: Interpret the Machining and surface finish symbols on the component drawings.

CO2: Apply limits and tolerances to assemblies and choose appropriate fits for given assemblies.

CO3: Illustrate various machine components through drawings

CO4: Create assembly drawings as per the conventions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks) and that for SEE minimum passing mark is 35% of the maximum marks (18 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

- CIE shall be evaluated for max marks 100. Marks obtained shall be accounted for CIE final marks, reducing it by 50%.
- CIE component should comprise of
  - Continuous evaluation of Drawing work of students as and when the Modules are covered.
  - At least one closed book **Test** covering all the modules on the basis of below detailed weightage.
  - ***Weightage for Test and Continuous evaluation shall be suitably decided by respective course coordinators***.

Module	**Max. Marks weightage**	**Evaluation Weightage in marks**	
		Computer display & printout	**Preparatory sketching**
Module 1	10	05	05
Module 2	15	10	05
Module 3	25	20	05
Module 4	25	20	05
Module 5	25	25	00
Total	**100**	**80**	**20**

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

- The duration of SEE is 03 hours**. Questions shall be set worth of 3 hours**
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.
- SEE shall be conducted and evaluated for maximum marks 100. Marks obtained shall be accounted for SEE final marks, reducing it to 50 marks.
- Question paper shall be set jointly by both examiners and made available for each batch as per schedule. **Questions are to be set preferably from Text Books.**
- Evaluation shall be carried jointly by both the examiners.
- Scheme of Evaluation: *To be defined by the examiners jointly and the same shall be submitted to the university along with question paper.*
- One full question shall be set from Modules 3 and 4 as per the below tabled weightage details. ***However, the student may be awarded full marks, if he/she completes solution on computer display without sketch***.

Module	Max. Marks Weightage	Evaluation Weightage in marks	
		Computer display & printout	Preparatory sketching
Module 4	40	30	10
Module 5	60	50	10
Total	**100**	**80**	**20**

Suggested Learning Resources:

Books:

- K L Narayana, P Kannaiah, K Venkata Reddy, "Machine Drawing", New Age International, 3rd Edition. ISBN-13: 978-81-224-2518-5, 2006
- N D Bhatt , "Machine Drawing", Charotar Publishing House Pvt. Ltd.,50th Edition, ISBN-13: 978-9385039232, 2014

Reference Books:

- Sadhu Singh, P. L. Sah, "Fundamentals of Machine Drawing", PHI Learning Pvt. Ltd, 2nd Edition, ISBN: 9788120346796, 2012
- Ajeet Singh, "MACHINE DRAWING", Tata McGraw-Hill Education, , ISBN: 9781259084607, 2012

Complex Analysis, Probability and Linear Programming			
Course Code	**21ME41**	CIE Marks	50
Teaching Hours/Week (L: T:P)	(2:2:0)	SEE Marks	50
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an insight into applications of complex variables and conformal mapping arising in potential theory, quantum mechanics, heat conduction and field theory.
- To develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, design engineering and microwave engineering.
- Analyze and solve linear programming models of real-life situations and learn about the applications to transportation and assignment problems.

Teaching-Learning Process (General Instructions):

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

7. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical skills.
8. State the need for Mathematics with Engineering Studies and Provide real-life examples.
9. Support and guide the students for self–study.
10. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress.
11. Encourage the students for group learning to improve their creative and analytical skills.

Show short related video lectures in the following ways

- As an introduction to new topics (pre-lecture activity).
- As a revision of topics (post-lecture activity).
- As additional examples (post-lecture activity).
- As an additional material of challenging topics (pre-and post-lecture activity).

As a model solution for some exercises (post-lecture activity).

Module-1

Calculus of complex functions: Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms and consequences. Applications to flow problems

Construction of analytic functions: Milne-Thomson method-Problems. (**8 hours)**

Self-Study: Review of a function of a complex variable, limits, continuity, and differentiability.

(RBT Levels: L1, L2 and L3)

Pedagogy: Chalk and talk method and Powerpoint Presentations

Module-2

Conformal transformations: Introduction. Discussion of transformations

$w = z^2$, $w = e^z$, $w = z + \frac{1}{z}, (z \neq 0)$. Bilinear transformations- Problems.

Complex integration: Line integral of a complex function-Cauchy's theorem and Cauchy's integral formula and problems. (**8 hours)**

Self-Study: Residues, Residue theorem – problems

(RBT Levels: L1, L2 and L3)

Pedagogy: Chalk and talk method and Powerpoint Presentations

Module-3

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Mean-Variance and Standard Deviations of a random variable. Binomial, Poisson, exponential and normal distributions- problems. **(8 hours)**

Self-Study: Two-dimensional random variables, marginals pdf's, Independent random variables

(RBT Levels: L1, L2 and L3)

Pedagogy: Chalk and talk method and Powerpoint Presentations

Module-4

Linear Programming Problems (L.P.P): General Linear programming Problem, Canonical and standard forms of L.P.P. Basic solution, Basic feasible solution, Optimal solution, Simplex Method-Problems. Artificial variables, Big-M method, Two-Phase method-Problems. **(8 hours)**

Self-Study: Formulation of an L.P.P and optimal solution by Graphical Method.

(RBT Levels: L1, L2 and L3)

Pedagogy: Chalk and talk method and Powerpoint Presentations

Module-5

Transportation and Assignment Problems: Formulation of transportation problems, Methods of finding initial basic feasible solutions by North-West corner method, Least cost method, Vogel approximation method. Optimal solutions-Problems. Formulation of assignment problems, Hungarian method-Problems. **(8 hours)**

Self-Study: Degeneracy in Transportation problem.

(RBT Levels: L1, L2 and L3)

Pedagogy: Chalk and talk method and Powerpoint Presentations

Course outcomes: At the end of the course the student will be able to:

- Use the concepts of an analytic function and complex potentials to solve the problems arising in fluid flow.
- Utilize conformal transformation and complex integral arising in aerofoil theory, fluid flow visualization and image processing.
- Apply discrete and continuous probability distributions in analyzing the probability models arising in the engineering field.
- Analyze and solve linear programming models of real-life situations and solve LPP by the simplex method
- Learn techniques to solve Transportation and Assignment problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

First test at the end of 5th week of the semester

Second test at the end of the 10th week of the semester

Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

The question paper will have ten questions. Each question is set for 20 marks.

There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

3. B. S. Grewal: "Higher Engineering Mathematics", Khanna publishers, 44th Ed.2018
4. E. Kreyszig: "Advanced Engineering Mathematics", John Wiley & Sons,10th Ed. (Reprint),2016.
5. S.D. Sharma: "Operations Research" Kedarnath Publishers Ed. 2012

Reference Books

8. V. Ramana: "*Higher Engineering Mathematics*" McGraw-Hill Education,11th Ed.
9. Mokhtar S.Bazaraa, John J.Jarvis & Hanif D.Sherali(2010*), Linear Programming and Network Flows(* 4th E*dition), John Wiley & sons.*
10. G.Hadley (2002) *Linear Programming, Narosa Publishing House*
11. F.S. Hillier. G.J. Lieberman: Introduction to Operations Research- Concepts and Cases, 9th Edition, Tata Mc-Graw Hill, 2010.
12. Srimanta Pal & Subodh C. Bhunia: "Engineering Mathematics" Oxford University Press,3rdReprint, 2016.
13. N.P Bali and Manish Goyal: "A textbook of Engineering Mathematics" Laxmi Publications, Latest edition.
14. C. Ray Wylie, Louis C. Barrett: "Advanced Engineering Mathematics" McGraw – Hill Book Co. New York, Latest ed.
15. H.K. Dass and Er. RajnishVerma:"Higher EngineeringMathematics"S.ChandPublication(2014).

Web links and Video Lectures (e-Resources):

- http://.ac.in/courses.php?disciplineID=111
- http://www.class-central.com/subject/math(MOOCs)
- https://www.coursera.org/learn/operations-research-modeling
- https://www.careers360.com/university/indian-institute-of-technology-madras/introduction-operations-research-certification-course
- http://people.whitman.edu/~hundledr/courses/M339.html
- VTU e-Shikshana Program
- VTU EDUSAT Program

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes
- Assignments
- Seminars

SEMESTER – IV

MACHINING SCIENCE AND JIGS & FIXTURES (IPCC)			
Course Code	21ME42	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 12 Lab slots	Total Marks	100
Credits	04	Exam Hours	
* ***Additional one hour may be considered as per requirement***			

Course objectives:

- To know the various subtractive machining processes in industries.
- To calculate the values of various forces involved in the machining operations.
- To understand and determine tool wear and tool life of different machining processes.
- To know various non-conventional machining and hybrid machining processes.
- To know the design of jigs and fixtures for various industrial/ machining members.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.
These are sample strategies; that teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different teaching methods to develop the outcomes through presentations/ video demonstrations/ simulations.
2. Chalk and talk method for problem-solving.
3. Arrange industrial visits to show the live working models other than laboratory topics.
4. Adopt collaborative learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.
6. Conduct laboratory demonstrations and practical experiments to enhance experiential skills.

MODULE-1 **8 HOURS**

Introduction to Machining Processes and Machine Tools: Subtractive manufacturing processes and classifications.
Construction, specification operations of machine tools:– Lathe, Shaping, Milling, Drilling, Grinding Machine.
Introduction to CNC machines: CNC Lathe, Milling, Drilling, Machine Center.

Teaching-Learning Process	1. Presentation, 2. Video/ Simulations demonstration, 3. Chalk and Talk are used for Problem Solving (In-general), 4. Laboratory Demonstrations and Practical Experiments on turning, milling operations

MODULE-2 **8 HOURS**

Mechanics of Metal Cutting:
Single point turning tool geometry (SPTT) influences the chip formation mechanisms of the Orthogonal and Oblique cutting process.
Cutting Force Analysis (Orthogonal Cutting): Analysis of machining forces and power requirement, 'Merchant's model of Orthogonal Cutting and Theory of Lee & Shaffer' Chip Velocity, Velocity relationships (simple numerical); the influence of cutting temperature on machinability.
Cutting Fluids: Characteristics of Cutting fluids, Selections, and applying methods of cutting fluids.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving (In-general).

MODULE-3	8 HOURS
Machinability and Tool Life Process of cutting tool failure wears and time relationship, tool wear index, feed marks, the effect of tool wear on the machined surface, surface finish, machinability, machinability index/rating, tool life & variables affecting tool life, tool materials. **Finishing Process:** Importance of surface finishing processes, Grinding, Abrasive Flow Machining, Honing. Sanding, Abrasive blasting, Polishing, Lapping. **Surface Finishing and Protection**: Powder Coating, Liquid Coating, Electroplating, Galvanizing, Anodizing.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video/ Simulations demonstration, 3. Chalk and Talk are used for Problem Solving (In-general).

MODULE-4	8 HOURS
Advanced Machining Process; Importance and classification of advanced machining process; Process principal, process parameters, and application of: - Abrasive Jet Machining (AJW), Water Jet Machining (WJM), Abrasive Water Jet Machining (AWJM); Ultrasonic Machining (USM); Electrical Discharge Machining (EDM); Wire Electrical Discharge Machining (WEDM); Electro Chemical Machining (ECM). Laser Beam Machining (LBM), Electron Beam Machining (EBM), and Plasma Arc Machining (PAM). **Hybrid Machining Process:** Importance of hybrid machining process; Process principal, process parameters, and application of: - Electrochemical Discharge Machining (ECDM), Ultrasonic Assisted Electric Discharge Machining (UAEDM), Electrochemical Discharge Grinding (EDG), Powder Assisted Electric Discharge Machining (PAEDM).	
Teaching-Learning Process	1. Power-point Presentation, 2. Video/ Simulations demonstration, 3. Chalk and Talk are used for Problem Solving (In-general).

MODULE 5	8 HOURS
Jigs and Fixtures: Importance of jigs and fixtures; the difference between jigs and fixtures; types of jigs and fixtures; essential features of jigs and fixtures, Materials used. Factors to be considered for the design of Jigs and Fixtures; Jigs: Template, Plate, Channel, Diameter, Leaf, Rung, Box, Fixtures: Turning, Milling, Broaching, Grinding, Boring, Indexing, Tapping, Duplex, Welding, and Assembly fixtures.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video/ Simulations demonstration, 3. Chalk and Talk are used for Problem Solving (In-general).

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments

1	One Job on Lathe machine with simple operations (turning, facing, Thread cutting and tapering) on low carbon steel and/or heat-treated low carbon steel, and Demonstration of tungsten carbide cutting tool inserts.
2	Operations and One Job each on shaping/milling machine
3	Simple operations and One Job on the drilling and grinding machine.
4	Demonstration/Experimentation of simple programming of CNC machine operations.
5	To study the tool geometry of a single point turning tool (SPTT) in the American Standards Association (ASA) system.
6	Cutting force measurement with dynamometers (Demonstration) for turning, drilling, grinding operations.
7	Application of cutting fluids in turning operations and case study on optimizing process parameters on turning operation.
8	Analysis of chip formation and chip reduction coefficient in turning of mild steel by HSS tool with different depth of cut, speed, and feed rate.
9	Experiment on tool wears and tool life on anyone conventional machining process.
10	Experiment on anyone advanced machining process
11	Design of Jigs and Fixture for any one application using any software tool.
12	Experiment using Drill/template Jig and Demonstration on turning and grinding fixtures.
13	Experiment using milling Indexing fixtures.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Demonstrate the Conventional CNC machines and advanced manufacturing process operations
- Determine tool life, cutting force, and economy of the machining process.
- Analyze the influence of various parameters on machine tools' performance.
- Select the appropriate machine tools and process, the Jigs, and fixtures for various applications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester
- Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

13. The question paper will have ten questions. Each question is set for 20 marks.
14. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
15. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Textbook:

1. Shaw, M C, (2014), Metal Cutting Principles, Oxford University Press.
2. McGeough, J A, (1988), Advanced Methods of Machining, Springer.
3. Boothroyd, G., and Knight, W. A., Fundamentals of Machining and Machine Tools, CRC Press.
4. Chattopadhyay, A B, (2013), Machining and Machine Tools, Wiley India.
5. Mikell P. Groover, (2019), Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley Publications.
6. Rao P. N., Manufacturing Technology II, Tata McGraw Hill.

Web links and Video Lectures (e-Resources):

1. V. K. Jain, Advanced Machining Processes, NPTEL Course Department of Mechanical Engineering, IIT Kanpur, Link: http://nptel.ac.in/courses/112104028/.
2. U. S. Dixit, Mechanics of Machining, NPTEL Course Department of Mechanical Engineering Guwahati, Link: http://nptel.ac.in/courses/112103248/.
3. A. B. Chattopadhyay, Manufacturing Processes II, NPTEL Course of Department of Mechanical Engineering, IIT Kharagpur, https://nptel.ac.in/courses/112/105/112105126/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Visit any one machining center or machining industry and/or

Case study on process parameter influence on anyone advanced machining process and hybrid machining process.

Semester - 04

FLUID MECHANICS (IPCC)			
Course Code	**21ME43**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 12 Lab slots	Total Marks	100
Credits		Exam Hours	40

**** One additional hour may be considered if required***

Course Learning objectives:

The course will enable the students to

- Acquire a basic understanding of properties of fluids and the measurement of pressure and fluid kinematics.
- Acquire a basic understanding of fundamentals fluid dynamics, and Benoulli's equation and flow meters.
- Acquire the basic concepts of flow through pipes and losses in pipe flows.
- Understand the basic concepts of flow over bodies and usefulness of dimensionless analysis.
- Acquire the fundamentals of compressible flow and the basic knowledge of working of CFD packages.
- Acquire the knowledge of simple fluid mechanics experimental setups and carry out the necessary analysis of these experiemts
- Acquire knowledge experimental errors and the ability to estimate the experimental uncertainties.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

- Adopt different type of teaching methods to develop the outcomes through Power-Point Presentation and Video demonstration or Simulations.
- Chalk and Talk method for Problem Solving.
- Arrange visits to show the live working models other than laboratory topics.
- Adopt collaborative (Group Learning) Learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information.
- Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

MODULE-1 **8 HOURS**

Introduction: Definition and properties, types of fluids, pressure at a point in static fluid, variation of pressure, Pascals Law, (To be reviewed in class but not for examination)

Pressure- absolute, gauge, vacuum, pressure measurement by manometers and gauges, hydrostatic pressure on plane submerged bodies. Buoyance and metacentre, Stability of submerged bodies

Fluid Kinematics: Velocity of fluid particle, types of fluid flow, streamlines, pathlines and streaklines continuity equation, acceleration of fluid particle, strain rate, vorticity, stream function, potential function, Circulation, Reynolds transport theorem

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4. Laboratory Demonstrations and Practical Experiments

MODULE-2 **8 HOURS**

Fluid Dynamics: Introduction, Forces acting on fluid in motion, Linear momentum equation, Impact of jets, Moment of momentum equation, Euler's equation of motion along a streamline,

Bernoulli's equation – assumptions and limitations. Introduction to Navier Stokes equation, Venturimenters, orificemeters, rectangular and triangular notches, pitot tubes, Rota meter, electromagnetic flow meter

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4. Laboratory Demonstrations and Practical Experiments

MODULE-3 **8 HOURS**

Laminar and Turbulent flow: Flow through circular pipe, between parallel plates, Power absorbed in viscous flow in bearings, Poiseuille equation Loss of head due to friction in pipes, Major and minor losses, pipes in series and parallel.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4. Laboratory Demonstrations and Practical Experiments
MODULE-4	**8 HOURS**
Flow over bodies: Development of boundary layer, Lift and Drag, Flow around circular cylinders, spheres, aerofoils and flat plates, Streamlined and bluff bodies, boundary layer separation and its control. Dimensional Analysis: Derived quantities, dimensions of physical quantities, dimensional homogeneity, Rayleigh method, Buckingham Pi-theorem, dimensionless numbers, similitude, types of similitude.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4. Laboratory Demonstrations and Practical Experiments
MODULE 5	**8 HOURS**
Compressible flows: Speed of sound, adiabatic and isentropic steady flow, Isentropic flow with area change stagnation and sonic properties, normal and oblique shocks, flow through nozzles. Introduction to CFD: Necessity, limitations, philosophy behind CFD, applications	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4. Laboratory Demonstrations and Practical Experiments

PRACTICAL COMPONENT OF IPCC

Modern computing techniques are preferred for estimation and analysis.

Sl.NO	Experiments
1	Determine the viscosity of oil using Red wood viscometer and Say-bolt viscometer.
2	Measurement of pressure using different Manometers for high and low pressure measurements (manometers using different manometric fluids).
3	Working principle of different flow meters and their calibration (orifice plate, venture meter, turbine, Rota meter, electromagnetic flow meter)
4	Working principle of different flow meters for open channel and their calibration
5	Determination of head loss in pipes and pipe fittings having different diameters, different materials and different roughness
6	Reynolds apparatus to measure critical Reynolds number for pipe flows
7	Effect of change in cross section and application of the Bernoulli equation
8	Impact of jet on flat and curved plates
9	Measurement of coefficient of pressure distribution on a cylinder at different Reynolds Numbers
10	Wind tunnel calibration using Pitot static tube

11	Determination of drag and lift co-efficients of standard objects using wind tunnel.
12	Use any CFD package to study the flow over aerofoil/cylinder

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

CO 1. Understand the basic principles of fluid mechanics and fluid kinematics

CO 2. Acquire the basic knowledge of fluid dynamics and flow measuring instruments

CO 3. Understand the nature of flow and flow over bodies and the dimensionless analysis

CO 4. Acquire the compressible flow fundamental and basics of CFD packages and the need for CFD analysis.

CO 5. Conduct basic experiments of fluid mechanics and understand the experimental uncertainties.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

16. The question paper will have ten questions. Each question is set for 20 marks.
17. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
18. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Reference Books

11. Fox, R. W., Pitchard,P. J.,and McDonald, A. T., (2010), Introduction to Fluid Mechanics, 7thEdition, John Wiley & Sons Inc.
12. Cimbala, J.M., Cengel, Y. A. (2010),Fluid Mechanics: Fundamentals and Applications, McGraw-Hill
13. Frank M White., (2016), Fluid Mechanics, 8thEdition , McGraw-Hill

Additional References:

1. A text book of Fluid Mechanics and Hydraulic Machines, Dr. R K Bansal, Laxmi publishers
2. .Fndamentals of Fluid Mechanics, Munson, Young, Okiishi & Hebsch, John Wiley Publicationss, 7th Edition

Web links and Video Lectures (e-Resources):

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

IV Semester

MECHANICS OF MATERIALS			
Course Code	**21ME44**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2-2-0-0	SEE Marks	50

Total Hours of Pedagogy	26+26	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

Students will be able

- To know the different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.
- To know behaviour & properties of engineering materials.
- To understand the stresses developed in bars, compounds bars, beams, shafts, and cylinders.
- To understand the concepts of calculation of shear force and bending moment for beams with different supports.
- To expose the students to concepts of Buckling of columns and strain energy.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information..

Module-1

Stresses and Strains: Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Analysis of Stress and Strain: Introduction to three-dimensional state of stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear stress, Mohr circle for plane stress conditions.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Shear Force and Bending Moment: Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads, uniformly distributed constant / varying loads. **Concept of shear center.**

Stress in Beams: Bending and shear stress distribution in rectangular, I and T section beams.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Deflection of Beams: Relationship between moment, slope and deflection, Moment area method, Macaulay's method. Problems to calculate slope and deflection for determinant beams, Beams of uniform strength, Leaf springs. **Torsion**: Circular solid and hallow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections,	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-5	
Thick & Thin Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations. **Columns**: Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns, Secant formula for columns. **Introduction to Strain Energy**: Strain energy due to axial, shear, bending, torsion and impact load. Castigliano's theorem I and II and their applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

1. Understand simple, compound, thermal stresses and strains their relations and strain energy.
2. Analyse structural members for stresses, strains and deformations.
3. Analyse the structural members subjected to bending and shear loads.
4. Analyse shafts subjected to twisting loads.
5. Analyse the short columns for stability.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

13. First test at the end of 5th week of the semester
14. Second test at the end of the 10th week of the semester
15. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

16. First assignment at the end of 4th week of the semester
17. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

18. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

19. The question paper will have ten questions. Each question is set for 20 marks.
20. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Mechanics of Materials J M Gere, B J Goodno, Cengage Eighth edition 2013
2. Fundamentals of Strength of Materials P N Chandramouli PHI Learning Pvt. Ltd 2013
3. Strength of Materials R K Rajput S. Chand and Company Pvt. Ltd 2014
4. Strength of Materials R. Subramanian Oxford 2005
5. Strength of Materials S. S. Ratan Tata McGraw Hill 2nd Edition, 2008
6. Mechanics of materials and Strength of Materials S C Pilli and N Balasubramanya Cengage 2019
7. Mechanics of Materials Ferdinand Beer, Russell Johston, John Dewolf, David Mazurek McGraw Hill Education (India) Pvt. Ltd Latest edition
8. Mechanics of Materials R C Hibbeler Pearson Latest edition

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

Semester IV

MECHANICAL MEASUREMENTS AND METROLOGY LABORATORY			
Course Code	**21ME45**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0-0-2*-0	SEE Marks	50
Credits	01	Exam Hours	03

**** Additional one hour may be considered for instructions, if required***

Course objectives:

Students will be able

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To illustrate the use of various measuring tools & measuring techniques.
- To understand calibration techniques of various measuring devices.

Modern computing techniques are preferred in estimation and analysis.

Sl.NO	Experiments
1	Study of instruments for Liner measurement and angular measurements: Slip gauges- Measurement of angle- sine bar, Sine centre, Angle gauges, Optical instruments for angular measurements.
2	Study of Autocollimator-Applications for measuring straightness and squareness.
3	Study of different Comparators and calibration of Dial indicator, Electrical comparators, LVDT, Pneumatic comparators
4	Study of Terminology of screw threads and Measurement of major diameter, Minor diameter, Pitch, Angle and Effective diameter of screw threads by 2- wire and 3-wire methods
5	Gear tooth measurement using Gear tooth Vernier and Parkinson Gear Tester
6	Various parameter measurement using computerized profile projector
7	Surface topology measurement using Surface Roughness Tester
8	Calibration of Pressure gauge, Thermocouple and Load cell
9	Determination of modulus of elasticity and modulus of rigidity of a mild steel specimen using strain gauges
10	Calibration of Micrometer and Vernier caliper using slip gauges
11	Circularity measurement using Electronic and Mechanical comparator
12	Demonstration of Measurement using Coordinate Measuring Machine (CMM) / Laser Scanner
13	Choose any product used in the day to day life based on his/her choice, prepare a measurement plan and implement the measurement with existing tools)

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Understand Calibration of pressure gauge, thermocouple, LVDT, load cell, micrometer.
- Apply concepts of Measurement of angle
- Demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.
- Analyse Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometre
- Understand the concepts of measurement of surface roughness.
- Demonstrate the use of Coordinate Measuring Machine (CMM) / Laser Scanner

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 35% (18 Marks out of 50) in the semester-end examination(SEE).

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability. Rubrics suggested in Annexure-II of Regulation book
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

Engineering Metrology and Measurements, N.V.Raghavendra and L. Krishnamurthy, Oxford University Press

Semester - V

THEORY OF MACHINES			
Course Code	**21ME51**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2-2-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand the concept of machines, mechanisms and to analyze a mechanism for displacement, velocity and acceleration at any point in a moving link.
- To understand the force-motion relationship in components subjected to external forces and analysis of standard mechanisms
- To understand the theory of gears and gear trains.
- To understand the undesirable effects of unbalances resulting from prescribed motions in mechanism.
- To understand the principles in mechanisms used for speed control and stability control.
- To compute the natural and damped frequencies of free 1-DOF mechanical systems and to analyze the vibrational motion of 1-DOF mechanical systems under harmonic excitation conditions.

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

6. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
7. Chalk and Talk method for Problem Solving.
8. Adopt flipped classroom teaching method.
9. Adopt collaborative (Group Learning) learning in the class.
10. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction: Mechanisms and machines, Kinematic pairs-types, degree of freedom, Kinematic chains and their classification, Kinematic inversions,

Velocity and Acceleration analysis of planar mechanisms Graphical method: Velocity and Acceleration Analysis of Mechanisms Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.

Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Static force analysis: Static equilibrium, analysis of four bar mechanism, slider crank mechanism.

Dynamic force analysis: D'Alembert's principle, analysis of four bar and slider crank mechanism.

Flywheel: Introduction to Flywheel and calculation of its size for simple machines like punching machine, shearing machine

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, condition and expressions for minimum number of teeth to avoid interference. **Gear Trains**: Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains. Discussions on applications of gear trains.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-4	
Balancing of Rotating Masses: Static and Dynamic Balancing, Balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes. Discussions on applications. **Balancing of Reciprocating Masses**: Inertia Effect of crank and connecting rod, Single cylinder Engine, Balancing in multi cylinder-inline engine (primary and secondary forces). Discussions on applications **Governors:** Types of Governors; Force Analysis of Porter and Hartnell Governors. Controlling Force, Stability, Sensitiveness, Isochronism, Effort and Power. Discussion on applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-5	
Free vibrations: Basic elements of vibrating system, Types of free vibrations, Longitudinal vibrations- Equilibrium method, D'Alembert's principle, Determination of natural frequency of single degree freedom systems, Damped free vibrations: Under damped, over damped and critically damped systems. Logarithmic decrement. **Forced vibrations**: Undamped forced vibration of spring mass system, Damped forced vibrations, Rotating unbalance, Reciprocating unbalance, Vibration isolation, Critical speed. Discussions on applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Knowledge of mechanisms and their motion and the inversions of mechanisms
- Analyse the velocity, acceleration of links and joints of mechanisms..
- Analyse the mechanisms for static and dynamic equilibrium.
- Carry out the balancing of rotating and reciprocating masses
- Analyse different types of governors used in real life situation.
- Analyze the free and forced vibration phenomenon.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

19. First test at the end of 5th week of the semester
20. Second test at the end of the 10th week of the semester
21. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

22. First assignment at the end of 4th week of the semester
23. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

24. At the end of the 13th week of the semester
25. The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

21. The question paper will have ten questions. Each question is set for 20 marks.
22. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

1 Theory of Machines Kinematics and Dynamics Sadhu Singh Pearson Third edition 2019

2 Mechanism and Machine Theory G. Ambekar PHI 2009

Reference Books

1 Theory of Machines Rattan S.S Tata McGraw-Hill Publishing Company 2014

2 Mechanisms and Machines- Kinematics, Dynamics and Synthesis Michael M Stanisic Cengage Learning 2016

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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THERMO-FLUIDS ENGINEERING (IPCC)			
Course Code	**21ME52**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 13 Lab slots*	Total Marks	100
Credits	04	Exam Hours	03

**** Additional one hour may be considered as Instructional duration wherever required***

Course objectives:

Student will be able

- To understand the concepts of testing of I. C. Engines and methods to estimate Indicated, Brake and Frictional Power and efficiencies.
- To understand theory and performance Calculation of Reciprocating compressor and positive displacement pumps.
- To understand the concepts related to Refrigeration, refrigeration cycles and Air conditioning and get conversant with Psychrometric Charts, Psychrometric processes, human comfort conditions.
- Understand typical construction of a Turbo machine, their working principle, application and conversion of fluid energy to mechanical energy in Turbo machine with utilization factor and degree of reaction.
- Understand the working principle of hydraulic turbines and steam turbine

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

MODULE-1 **8 HOURS**

Performance Testing of IC Engines: Two-stroke and Four-stroke I.C. engines - Measurement of speed, air flow, fuel consumption, Measurement of Brake Power and Indicated Power, Performance curves, Heat Balance sheet., Frictional power: various methods – Willan's line, Morse test, motoring etc.

Reciprocating Air Compressors: Operation of a single stage reciprocating compressors: work input through p-v diagram, effect of clearance and volumetric efficiency, adiabatic, isothermal and mechanical efficiencies. Multi-stage compressor, saving in work, optimum intermediate pressure, inter-cooling, minimum work for compression. Discussion on application.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board

MODULE-2 **8 HOURS**

Refrigeration: Vapour compression refrigeration system; description, analysis, refrigerating effect, capacity, power required, units of refrigeration, COP, reversed Carnot cycle, vapour absorption refrigeration system and Air refrigeration system. Use of refrigeration tables and p-h chart. Classification of Refrigerants. Desirable properties of refrigerants.

Psychrometries: Atmospheric air and Psychrometric properties: DBT, WBT, DPT, partial pressure, specific and relative humidity and relation between the enthalpy and adiabatic saturation temperatures. Construction and use of psychrometric chart. Analysis of various processes: Heating, cooling, dehumidifying and humidifying. Adiabatic mixing of stream of moist air. Analysis of summer and winter air-conditioning systems. Discussion on commercial Air conditioning systems.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

MODULE-3	**8 HOURS**
Introduction to Turbo machines: Classification of Turbomachines, Basic constructional details, Euler's equation for a Turbo machine, Impulse & Reaction machine - Axial flow and radial flow machines, utilization factor, degree of reaction & efficiencies of Turbo machines, **Introduction to positive displacement machines:** Classification, comparison with turbomachines. Construction and working of reciprocating pump, gear and vane pumps. Discussion on engineering applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board

MODULE-4	**8 HOURS**
Hydraulic Turbines: Classification of hydraulic turbines, Various heads and efficiencies, working principle, Velocity triangles, work done, efficiencies etc in Pelton wheel, Francis turbine and Kaplan turbine. Draft tubes, Cavitation in reaction turbines, characteristic curves. Significance of Specific speed and Unit quantities. **Centrifugal Pumps:** Main Parts of centrifugal pump, Various heads and efficiencies, work done, minimum speed for starting centrifugal pump, Classifications- Performance characteristics of centrifugal pumps, Cavitation in pumps and NPSH. Pumps in series and parallel, casings. Discussion on engineering applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board

MODULE 5	**8 HOURS**
Centrifugal Fans, Blowers & Compressors: types; velocity triangles, work done and degree of reaction, size & speed; vane shape & efficiency; vane shape & characteristics; actual performances characteristics; Concept of slip and slip coefficient. Discussion on engineering applications. **Steam and gas Turbines:** Impulse turbines, Staging - expression for work done in a 2-stage velocity compounded turbine-effect of blade & nozzle losses- Reaction staging- reheat factor- performance characteristics, problems using Mollier's chart & introduction to gas turbines.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

PRACTICAL COMPONENT OF IPCC

Use of modern computing tools preferred in analysis of performance and estimations

Sl.NO	**Experiments**
1	Determination of calorific value of solid/liquid fuels using Bomb Calorimeter
2	Determination of calorific value of gaseous fuels using Junker's Gas Calorimeter.
3	Performance test on single cylinder engine four/two stroke and draw Heat balance sheet
4	Performance test on multi cylinder engine, draw Heat balance sheet and perform Morse test
5	Performance test on Vapour compression refrigeration -test rig.
6	Performance test on Air conditioning-test rig.
7	Performance test on single/multi stage Reciprocating compressor.
8	Performance test on single / multi-stage centrifugal pump.
9	Performance test on Pelton turbine and draw main and operating characteristics.
10	Performance test on Franci's turbine and draw main and operating characteristics.
11	Performance test on Kaplan turbine and draw main and operating characteristics.

12	Performance test on centrifugal blower and draw performance characteristics for different vane shapes.
13	Demonstration on Computerised IC Engine test rig for its performance and analysis.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- To apply the concepts of testing of I. C. Engines and methods to estimate Indicated, Brake and Frictional Power and efficiencies.
- To apply theory and performance Calculation of Reciprocating compressor and positive displacement pumps .
- To apply the concepts related to Refrigeration, refrigeration cycles and Air conditioning and get conversant with Psychrometric Charts, Psychrometric processes, human comfort conditions.
- To understand typical construction of a Turbo machine, their working principle, application and conversion of fluid energy to mechanical energy in Turbo machine with utilization factor and degree of reaction.
- To Understand the working principle of hydraulic turbines and steam turbine

Course Outcomes:

At the end of the course the student will be able to:

- Apply the concepts of testing of I. C. Engines and evaluate their performance, and evaluate the performance of Reciprocating compressor.
- Apply and analyse the concepts related to Refrigeration and Air conditioning, and get conversant with Psychrometric Charts, Psychrometric processes, human comfort conditions.
- Explain the construction, classification and working principle of the Turbo machines and apply of Euler's turbine equation to evaluate the energy transfer and other related parameters. Compare and evaluate the performance of positive displacement pumps.
- Classify, explain and analyse the various types of hydraulic turbines and centrifugal pumps.
- Classify, explain and analyse various types of steam turbines and centrifugal compressor.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.

- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the

experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

23. The question paper will have ten questions. Each question is set for 20 marks.
24. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
25. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Text Books

1. Engineering Thermodynamics P.K. Nag Tata McGraw Hill 6th Edition 2018
2. Applications of Thermodynamics V.Kadambi, T. R.Seetharam, K. B. Subramanya Kumar Wiley Indian Private Ltd 1st Edition 2019
3. Turbo machines M. S. Govindegowda and A. M. Nagaraj M. M. Publications 7Th Ed, 2012
4. Thermodynamics Yunus A, Cengel, Michael A Boles Tata McGraw Hill 7th Edition
5. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad New Age International Publishers reprint 2008
6. Turbo Machines B.U.Pai Wiley India Pvt, Ltd 1st Edition

Reference Books

1. Principles of Engineering Thermodynamics Michael J, Moran, Howard N. Shapiro Wiley 8th Edition
2. An Introduction to Thermodynamics, Y.V.C.Rao Wiley Eastern Ltd 2003.
3. Thermodynamics Radhakrishnan PHI 2nd revised edition
4. I.C.Engines M.L.Mathur& Sharma. Dhanpat Rai& sons- India
5. Turbines, Compressors & Fans S. M. Yahya Tata McGraw Hill Co. Ltd 2nd edition, 2002
6. Principals of Turbo machines D. G. Shepherd The Macmillan Company 1964
7. Fluid Mechanics & Thermodynamics of Turbo machines S. L. Dixon Elsevier 2005

Web links and Video Lectures (e-Resources):

E- Learning

- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Semester - V

FINITE ELEMENT ANALYSIS			
Course Code	**21ME53**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2-0-2*-0	SEE Marks	50
Total Hours of Pedagogy	25 hrs +13 practical sessions	Total Marks	100
Credits	03	Exam Hours	03
**** Additional One hour may be considered for instructions if required***			

Course objectives:

Students will be able

- To learn the basic principles of finite element analysis procedure
- To understand heat transfer problems with application of FEM.
- Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

MODULE-1 **8 HOURS**

Introduction to Finite Element Method: General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method.

Potential energy method, Displacement method of finite element formulation. Convergence criteria, Discretization process, ***Rayleigh Ritz method, Galerkin's method (for study purpose only)***

Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain- displacement relations, Stress-strain relations, Plain stress and Plain strain conditions, temperature effects.

Interpolation models: Simplex, complex and multiplex elements, linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

MODULE-2 **8 HOURS**

Introduction to the stiffness (Displacement) method: Introduction, One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 3 8), 2D iso-parametric element,

Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

MODULE-3 **8 HOURS**

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions , Beam stiffness matrix based on Euler-Bernoulli beam theory, Numerical problems on simply supported, fixed straight and cantilever beams, propped cantilever beams with concentrated and uniformly distributed load.

Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

MODULE-4	8 HOURS
Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, 1D finite element formulation using variational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins. **Fluid Flow**: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic networks.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
MODULE 5	**8 HOURS**
Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels. **Dynamic Considerations**: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, triangular element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

PRACTICAL COMPONENT

Sl.NO	Experiments
1	**Introduction to FEA software , Pre-processing tools, Solver tools and Post-processing tools.**
2	Analysis of Bars of constant cross section area, tapered cross section area and stepped bar subjected to Point forces, Surface forces and Body forces (Minimum 2 exercises of different types)
3	Analysis of trusses (Minimum 2 exercises of different types)
4	Analysis of Beams – Simply supported, cantilever, Propped cantilever beams with point load , UDL, beams with varying load etc.
5	
6	Stress analysis of a rectangular plate with a circular hole.
7	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 2 exercises of different types)
8	
9	Dynamic Analysis to find: Natural frequency of beam with fixed – fixed end condition, Response of beam with fixed – fixed end conditions subjected to forcing function
10	Dynamic Analysis to find: Natural frequency of bar, Response of Bar subjected to forcing functions
11	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver.
12	Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
13	Demonstrate at least two different types of example to model and analyze bars or plates made from composite material.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements.
- Develop element characteristic equation and generation of global equation.
- Formulate and solve Axi-symmetric and heat transfer problems.
- Apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi-symmetric and dynamic problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

26. The question paper will have ten questions. Each question is set for 20 marks.
27. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
28. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component

of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.

- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Textbooks

1. A first course in the Finite Element Method, Logan, D. L, Cengage Learning, 6th Edition 2016.
2. Finite Element Method in Engineering, Rao, S. S, Pergaman Int. Library of Science 5th Edition 2010.
3. Finite Elements in Engineering Chandrupatla T. R PHI 2nd Edition 2013

Referencebooks

1. Finite Element Method, J.N.Reddy, McGraw -Hill International Edition.
2. Finite Elements Procedures Bathe K. J PHI

Web links and Video Lectures (e-Resources):

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

V Semester

MODERN MOBILITY & AUTOMOTIVE MECHANICS			
Course Code	21ME54	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To understand the different chassis design & main components of automobile
- To understand the working of transmission and control system employed in automobiles
- To understand the automotive pollution and alternative automotive technologies under trail
- To understand the upcoming electric vehicle technology

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

7. Explain clearly through Power Point presentations
8. showing live Videos for working of components
9. Demonstration of live working of components through cut section models
10. Inspecting live vehicles
11. Visiting nearby service centres

Module-1	Chassis & Power Plant
History of Automobile, Classification of Automobile w.r.t Usage, Chassis, Body, Power Sources, capacity, main components of Internal Combustion Engines and their Functions, Fuel supply system, Cooling System, Lubrication System & Ignition System, Engine Management System, super charged engines, hybrid engines, modern GT engines	
Teaching-Learning Process	Power Point presentations Live Videos for working of components Explaining through live components in class room

Module-2	Transmission & Suspension System
Clutches; Plate Clutches, Cone Clutch, Centrifugal Clutch, Fluid Flywheel **Gear Box;** Gear Shifting mechanism, synchromesh Gear box, Torque converter, Automatic Manual Transmission (AMT), Automatic Transmission (AT), intelligent manual Transmission (IMT) Continuously Variable Transmission (CVT), Infinitely Variable Transmission (IVT)- Working of Differential, Rear Axle types &construction. **Suspension** – layout & working of Hydraulic& Air suspension, Independent suspension, Functions& advantages of Leaf Spring, Coil Spring, Telescopic Shock Absorber, Torsion Bar	
Teaching-Learning Process	Power Point presentations Live Videos for working of components Explaining through live components in class room

Module-3	Control & Safety systems
Steering system- mechanisms & Linkages, Steering gear boxes- Rack & pinion, worm & wheel construction & working,, power Steering construction & working, steering geometry, Wheel balancing **Braking System**- Mechanism and Linkages; Mechanical Brakes, Hydraulic Brakes, Power Brakes, Parking brakes, ABS, **Safety system** – Safety measures in modern vehicle – safety frames – working of - air bags, seat belt, collapsible steering, spoilers, defoggers, fire safety measures in heavy vehicles, bullet proof vehicles	
Teaching-Learning Process	Power Point presentations Live Videos for working of components Explaining through live components in class room

Module-4	Automotive Emission & Alternate Vehicles
Exhaust gas pollutants and their effects on environment, Emission norms, IC engine fuels types, extraction& availability, BIO Fuels – Production and impact. Ethanol engines, CNG vehicles- operation, advantages& disadvantages, over view of Hydrogen - fuel cell vehicles, advantages & disadvantages, IC engine/ electric hybrid vehicles over view, layout, transmission & control system, solar powered vehicles- wind powered vehicles, super capacitors, supply rails	
Teaching-Learning Process	Power Point presentations Live Videos for working of components

Module-5	Electric Vehicles& Storage Batteries

Electric vehicles principle and components- layout of two & 4 wheeler, Motors used in Electric vehicles –types- over view of construction and working, power transmission & control system in Electric vehicles. Batteries –construction & working principle of Lead acid, nickel based, sodium based, Lithium & Metal Air batteries. Battery charging types and requirements, battery cooling, fire safety measures in EV vehicles

Teaching-Learning Process	Power Point presentations Live Videos for working of components

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

5. Understand the working of different systems employed in automobile
6. Analyse the limitation of present day automobiles
7. Evaluate the energy sources suitability
8. Apply the knowledge for selection of automobiles based on their suitability

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

26. First test at the end of 5th week of the semester
27. Second test at the end of the 10th week of the semester
28. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

29. First assignment at the end of 4th week of the semester
30. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

31. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(To have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

29. The question paper will have ten questions. Each question is set for 20 marks.
30. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

14. Electric Vehicle Technology Explained James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK
15. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011 2
16. Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.

17. Automotive Systems & Modern Mobility by Dr T Madhusudhan, et al., Cengage publications
18. Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007.
19. Modren Electric, Hybrid Electric, and Fuel Cell Vehicles,MehrdadEhsani, YiminGao, CRC Press, Taylor & Francis Group
20. Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
21. . Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd. 4.
22. Automobile Engineering, R. B. Gupta, SatyaPrakashan,(4th Edition) 1984.

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/107/106/107106088/
https://onlinecourses.nptel.ac.in/noc20_de06/preview
https://www.digimat.in/nptel/courses/video/107106088/L01.html
https://nptel.ac.in/courses/107106088
https://www.youtube.com/watch?v=LZ82iANWBL0&list=PLbMVogVj5nJTW50jj9_gvJmdwFWHaqR5J

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Operate the cut section models of complete vehicle chassis and observe the working of all components
- Dismantle & Assemble the Automotive Engine, Gear Box, Clutch, brakes
- Prepare the posters of automobile chassis & display
- Visit nearby automobile showrooms/ service station
- Prepare a comparison statement of different automobiles using specification provided by respective manufacturers
- Visit auto expo

Semester V

DESIGN LAB			
Course Code	**21MEL55**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0-0-2*-0	SEE Marks	50
Credits	01	Exam Hours	03

**** Additional one hour may be considered for instructions if required.***

Course objectives:

The students will be able

- To understand the concepts of natural frequency, logarithmic decrement, damping and damping ratio.
- To understand the techniques of balancing of rotating masses and influence of gyroscopic couple.
- To verify the concept of the critical speed of a rotating shaft.
- To illustrate the concept of stress concentration using Photo elasticity.
- To appreciate the equilibrium speed, sensitiveness, power and effort of a Governor.
- To illustrate the principles of pressure development in an oil film of a hydrodynamic journal bearing.
- To visualize different mechanisms and cam motions

Modern computing techniques are preferred to be used wherever possible.

Sl.NO	**Experiments**
1	Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2	Balancing of rotating masses
3	Determination of critical speed of a rotating shaft
4	Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell /Hartnel Governor.
5	Determination of Pressure distribution in Journal bearing
6	Study the principle of working of a Gyroscope and demonstrate the Effect of gyroscopic Couple on plane disc
7	Determination of Fringe constant of Photo-elastic material using. a) Circular disc subjected to diametral compression. b) Pure bending specimen (four-point bending).
8	Determination of stress concentration using Photo-elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression,
	Demonstration Experiments (For CIE)
9	**Demonstration and study of operation of different Mechanisms and their Inversions:**

10	Slider crank chain, Double slider crank chain and its inversions, Quick return motion mechanisms- Peaucellier's mechanism. Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, Ackerman steering gear mechanism.
11	Demonstration and Study of different types of cams, types of followers and typical follower motions. Obtain cam profile for any two types of follower motions and types of follower
12	

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Compute the natural frequency of the free and forced vibration of single degree freedom systems, critical speed of shafts.
- Carry out balancing of rotating masses and gyroscope phenomenon.
- Analyse the governor characteristics.
- Determine stresses in disk, beams and plates using photo elastic bench.
- Determination of Pressure distribution in Journal bearing
- Analyse the stress and strains using strain gauges in compression and bending test
- To realize different mechanisms and cam motions

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 35% (18 Marks out of 50) in the semester-end examination(SEE).

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of the semester and the second test shall be conducted after the 14^{th} week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability. Rubrics suggested in Annexure-II of Regulation book
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

1. Theory of Machines, Rattan S.S , Tata McGraw-Hill Publishing Company, 2014
2. Experimental Stress analysis, M. M. Frotch, McGraw-Hill

Semester - VI

PRODUCTION AND OPERATIONS MANAGEMENT			
Course Code	**21ME61**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

Students will be able to

- Use of decision making tools such as break even analysis, linear programming, statistical analysis, simulation, etc. demands a strong knowledge of mathematics, science and engineering fundamentals.
- Forecasting models are basically mathematical equations. Formulating these models and solving them requires skill and a strong knowledge of mathematics, science, engineering & management fundamentals.
- Facility location and Capacity planning can be made by the use various mathematical models. Use of these models and solving them subsequently for arriving at a decision demands skill and knowledge on mathematics, science, engineering & management fundamentals.
- Preparation of aggregate plans and master schedule in an organization requires a strong background of mathematics, science, engineering & management fundamentals.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction, Production of Goods Versus Providing Services, the operation management function, The Scope of Operations Management, Types and Characteristics of Manufacturing and Service Systems, Productivity, its improvement and factors affecting productivity and topic related numerical.

Operations Decision Making: Characteristics of Decisions, Framework for Decision Making, Decision Methodology, decision making environments, Economic Models and Statistical Models. Breakeven- analysis and trade-offs. (Topic related numerical)

Tutorial Components:

1. *Why manufacturing matters?*
2. *Productivity improvement **Case Studies**.*

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Forecasting: Introduction, Features Common to All Forecasts, Elements of a Good Forecast, Steps in the Forecasting Process, Approaches to Forecasting, choosing a Forecasting Technique, Accuracy and Control of Forecasts, Using Forecast Information, Operations Strategy and related numerical on various approaches.

Product and Service Design: Introduction, Sources of Ideas for New or Redesigned Products and Services, Legal, Ethical, and Environmental Issues, Designing for Manufacturing, and services.

Tutorial Components:

1. *High level forecasts can be bad news* ***-Case Studies***
2. *Managing poor forecast***.**

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board.

Module-3

Capacity & Location Planning: Introduction, Importance of Capacity Decisions, Defining and Measuring Capacity, Determinants of Effective Capacity, Determining Capacity Requirements, Developing Capacity Strategies, Evaluating Alternatives, Planning Service Capacity and related numerical.

Location Planning and Analysis: The Need for Location Decisions, The Nature of Location Decisions, General Procedure for Making Location Decisions, Identifying a Country, Region, Community, site and related numerical.

Facility Layout: Designing Product Layouts: Line Balancing, Designing Process Layouts.

Tutorial Components: Case studies

1. *Managing higher capacities or thinking of OUTSOURCING*
2. *Any increase in efficiency also increases utilization. Although the upper limit on efficiency is 100 percent, what can be done to achieve still higher levels of utilization?*

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Aggregate Planning: Introduction, The Purpose and Scope of Aggregate Planning, Basic Strategies for Meeting Uneven Demand, Techniques for Aggregate Planning, Aggregate Planning in Services, Disaggregating the Aggregate Plan and related numerical on the techniques.

Master Scheduling: The Master Scheduling Process, Planning Horizons, Master Scheduling Format, Available-to-Promise Quantities and related numerical

Tutorial Components: Case Studies

1. *Duplicate orders can lead to excess capacity*
2. *Service operations often face more difficulty in planning than their manufacturing counterparts. However, service does have certain advantages that manufacturing often does not.*

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

MRP and ERP: Introduction, MRP Inputs, processing, outputs, MRP in Services, Benefits and Requirements of MRP, numerical, Capacity Requirements Planning, MRP II and ERP.

Purchasing and Supply Chain Management (SCM): Introduction, Importance of purchasing and SCM, the procurement process, Concept of tenders, Approaches to SCM, Vendor development.

Tutorial Components:

1. *The ABCs of ERP.*
2. *How can ERP Improve a Company's Business Performance? -* ***Case Studies***

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

- Apply the necessary tools for decision making in operations management.
- Examinevariousapproachesforforecastingthesalesdemandforanorganization.
- Listvariouscapacityandlocationplanstodeterminethesuitablecapacityrequiredformeetingtheforecastdemandofan organization.
- Analyse the aggregate plan and master production schedule for an organization, given its periodic demand.
- Apply MRP, purchasing and SCM techniques into practice.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Sl. No.	Author/s	Title	Publisher	Edition & Year
1.	William J stevenson	Production and Operations management	Tata McGraw Hill.	13th edition, 2018
2.	Joseph G. Monks	Operations Management	Tata McGraw Hill.	2nd Edition, 2020
3.	B. Mahadevan	Operations Management: Theory and Practice	Pearson	3rd Edition, 2015
4.	Gregory Frazier and Norman Gaither	Operations Management: Concepts, Techniques & Applications	Cengage Learning India	9th edition, 2015

Web links and Video Lectures (e-Resources):

- NOC: Production and Operation Management, IIT Roorkee: https://nptel.ac.in/courses/110107141
- Case studies in operations management: https://www.tandfonline.com/doi/full/10.1080/09537287.2011.554736?scroll=top&needAccess=true
- OPERATIONS MANAGEMENT course by MIT Open Courseware: https://ocw.mit.edu/courses/15-760a-operations-management-spring-2002/pages/syllabus/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Operations Management Outside of the Classroom

- Video 1. Introduction to inventory management by Professor Srikanth Jagabathula (New York University, 2014b). The video is available at: https://www.youtube.com/watch?v=kGPr9oeN0MQ
- Video 2. Problem-solution demonstration by Professor Jagabathula (New York University, 2014c). The video is available at: https://www.youtube.com/watch?v=JCt1IVSjsuM
  Video 3. Introduction by Professor Jagabathula to a practice exercise for students to solve based on the video referenced in Figure 2. (New York University, 2014a). The video is available at: http://youtu.be/pIOzdftXsXc

Semester - VI

HEAT TRANSFER (IPCC)			
Course Code	**21ME62**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

Student will be able to learn

- Principles of heat transfer.
- Steady and transient heat transfer, obtain the differential equation of heat conduction in various coordinate system.
- Physical mechanism of convection and visualize the development of velocity and thermal boundary layers during flow over a surface.
- Radiation heat transfer mechanism
- The mechanisms of boiling and condensation and understand performance parameters of heat exchangers.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

MODULE-1	**8 HOURS**
Introductory Concepts and definition: Review of basics of Modes of Heat Transfer **Conduction-Basic Equations:** General form of one-dimensional heat conduction equation. Boundary conditions of first, second and third kinds; **One dimensional Steady state conduction with and without heat generation**: Steady state conduction in slab, cylinder and sphere with engineering applications. **Steady state conduction:** Overall heat transfer coefficient for a composite medium; thermal contact resistance; critical thickness of insulation, Discussion on engineering applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
MODULE-2	**8 HOURS**

Extended surfaces; Steady state conduction in fins of uniform cross section long fin, fin with insulated tip and fin with convection at the tip; fin efficiency & effectiveness, Discussion on engineering applications. **One dimensional Transient conduction:** Conduction in solids with negligible internal temperature gradients (lumped system analysis) Use of transient temperature charts (Heisler's charts) for Transient conduction in slab, long cylinder and sphere; concept of semi-infinite solids, Discussion on engineering applications.	
Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
MODULE-3	**8 HOURS**
Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction and one Dimensional unsteady conduction, boundary conditions, and solution methods. **Radiation Heat transfer:** (Review of basic laws of thermal radiation) Intensity of radiation and solid angle; Concept of thermal radiation resistance, Radiation network, view factor, Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; Effect of radiation shield; Discussion on engineering applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
MODULE-4	**8 HOURS**
Concepts and Basic Relations in Boundary layers: Flow over a flat plate -Velocity boundary layer, Thermal boundary layer; Prandtl number; general expression for local heat transfer coefficient; Average heat transfer coefficient. **Forced Convection**: Physical significance of Dimensionless numbers. Use of various Correlations for hydro dynamically and thermally developed flows; Use of correlations for flow over a flat plate, cylinder, sphere and flow inside the duct. **Free or Natural Convection**: Physical significance of dimensionless numbers. Use of correlations for free convection from or to vertical, horizontal and inclined flat plates, vertical and inclined cylinder.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
MODULE 5	**8 HOURS**
Boiling and Condensation; Film, dropwise condensation theory, Pool boiling regimes, Use of correlations for film and dropwise condensation on tubes. **Heat Exchangers:** Classification of heat exchangers; Overall heat transfer coefficient, Fouling, Scaling factors; LMTD and NTU methods of analysis of heat exchangers, Compact heat exchangers.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Modern computing tools are preferred to be used for analysis wherever possible.

Sl.NO	Experiments
1	Determination of Thermal Conductivity of a Metal Rod.
2	Determination of Overall Heat Transfer Coefficient of a Composite wall.
3	Determination of Effectiveness on a Metallic fin.
4	Determination of Heat Transfer Coefficient in free Convection

5	Determination of Heat Transfer Coefficient in a Forced Convention
6	Determination of Emissivity of a Surface and Determination of Stefan Boltzmann Constant.
7	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
8	Experiments on Boiling of Liquid and Condensation of Vapour.
9	Experiment on Transient Conduction Heat Transfer.
10	Use of CFD for demonstrating heat transfer mechanism considering practical applications , Minimum two exercises
11	
12	Using one dimensional transient conduction, experimentally demonstrate estimation of thermal conductivity and thermal diffusivity

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Solve steady state heat transfer problems in conduction.
- Solve transient heat transfer problems
- solve convection heat transfer problems using correlations
- Solve radiation heat transfer problems
- Explain the mechanisms of boiling and condensation. And Determine performance parameters of heat exchangers.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester
- Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the

experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Books

1 Principals of heat transfer Frank Kreith, Raj M. Manglik, Mark S. Bohn Cengage learning Seventh Edition 2011.

2 Heat transfer, a practical approach Yunus A. Cengel Tata Mc Graw Hill Fifth edition

Reference Books

1 Heat and mass transfer Kurt C, Rolle Cengage learning second edition

2 Heat Transfer A Basic Approach M. NecatiOzisik McGraw Hill, New York 2005

3 Fundamentals of Heat and Mass Transfer Incropera, F. P. and De Witt, D. P John Wiley and Sons, New York 5th Edition 2006

4 Heat Transfer Holman, J. P. Tata McGraw Hill, New York 9th Edition 2008

Web links and Video Lectures (e-Resources):

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Semester - VI

MACHINE DESIGN			
Course Code	**21ME63**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2-2-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course objectives:

The student will be able:

- To explain the principles involved in design of machine elements, subjected to different kinds of forces, from the considerations of strength, rigidity.
- To understand and interpret different failure modes and application of appropriate criteria for design of machine elements.
- Develop the capability to design elements like shafts, couplings and springs, welded joints, screwed joints.
- To learn transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue.
- To produce assembly and working drawings of various mechanical systems involving machine elements like clutches and brakes.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction and Review: Review of engineering materials and their properties and manufacturing processes; use of codes and standards, selection of preferred sizes. Review of axial, bending, shear and torsion loading on machine components, combined loading, two- and three dimensional stresses, principal stresses, stress tensors, Mohr's circles.

Design for static strength: Factor of safety and service factor. Failure mode: definition and types. , Failure of brittle and ductile materials; even and uneven materials; Theories of failure: maximum normal stress theory, maximum shear stress theory, distortion energy theory, strain energy theory, Columba –Mohr theory and modified Mohr's theory. Stress concentration, stress concentration factor

Impact Strength: Introduction, Impact stresses due to axial, bending and torsion loads.

Fatigue loading: Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Design of shafts: Torsion of shafts, solid and hollow shaft design with steady loading based on strength and rigidity, ASME and BIS codes for power transmission shafting, design of shafts subjected to combined bending, torsion and axial loading, Discussion on engineering applications.

Design of couplings: Design of Flange coupling, and Bush and Pin type coupling.

Springs: Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads. Leaf Springs: Stresses in leaf springs, equalized stresses, and nipping of leaf springs, Discussion on engineering applications.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Riveted joints: Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints, riveted brackets, Discussion on engineering applications.

Welded joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints, Discussion on engineering applications.

Threaded Fasteners: Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints, Discussion on engineering applications.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.

Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.

Worm Gears: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Design of Clutches and Brakes: Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories. Design of band brakes, block brakes and internal expanding brakes

Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated.

Antifriction bearings: Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship, Discussion on engineering applications.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Apply codes and standards in the design of machine elements and select an element based on the Manufacturer's catalogue.
- Analyse the performance and failure modes of mechanical components subjected to combined loading and fatigue loading using the concepts of theories of failure.

- Demonstrate the application of engineering design tools to the design of machine components like shafts, springs, couplings, fasteners, welded and riveted joints, brakes and clutches
- Design different types of gears and simple gear boxes for relevant applications.
- Apply design concepts of hydrodynamic bearings for different applications and select Anti friction bearings for different applications using the manufacturers, catalogue.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester
- Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)
- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1 Shigley's Mechanical Engineering Design Richard G. Budynas,and J. Keith Nisbett McGraw-Hill Education 10th Edition, 2015

2 Fundamentals of Machine Component Design Juvinall R.C, and Marshek K.M John Wiley & Sons Third Edition 2007 Wiley student edition

3 Design of Machine Elements V. B. Bhandari Tata Mcgraw Hill 4th Ed 2016.

Reference Books:

1 Machine Design- an integrated approach Robert L. Norton Pearson Education 2nd edition

2 Design and Machine Elements Spotts M.F., ShoupT.E Pearson Education 8th edition, 2006

3 Machine design Hall, Holowenko, Laughlin (Schaum's Outline Series adapted by S.K.Somani Tata McGraw Hill Publishing Company Ltd Special Indian Edition, 2008

4 Elements of Machine Design H.G.Patil, S.C.Pilli, R.R.Malagi, M.S.Patil IK International First edition,2019

6 Hand book of Mechanical Design G. M. Maithra and L.V.Prasad Tata McGraw Hill 2nd edition, 2004

Design Data Books:

Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.

Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.

Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010

PSG Design Data Hand Book, PSG College of technology, Coimbatore

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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SUPPLY CHAIN MANAGEMENT & INTRODUCTION TO SAP			
Course Code	**21ME641**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	03	Exam Hours	3 hours

Course objectives:

- To acquaint with key drivers of supply chain performance and their inter-relationships with strategy.
- To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems.
- To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.
- To understand the usage of SAP material management system

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Adopt different type of teaching methods to develop the outcomes through Power-Point Presentation and Video demonstration or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Discuss the case studies and how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
4. Adopt collaborative (Group Learning) Learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information.

Module-1

Introduction: Supply Chain – Fundamentals –Evolution- Role in Economy - Importance - Decision Phases – Supplier Manufacturer-Customer chain. - Enablers/ Drivers of Supply Chain Performance. Supply chain strategy - Supply Chain Performance Measures.

Strategic Sourcing Outsourcing – Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy - Supplier Selection and Contract Negotiation. Creating a world class supply base- Supplier Development - World Wide Sourcing.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk Method

Module-2

Warehouse Management Stores management-stores systems and procedures-incoming materials control stores accounting and stock verification Obsolete, surplus and scrap-value analysis-material handling transportation and traffic management -operational efficiency-productivity-cost effectiveness-performance measurement.

Supply Chain Network Distribution Network Design – Role - Factors Influencing Options, Value Addition – Distribution Strategies - Models for Facility Location and Capacity allocation. Distribution Center Location Models.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk Method

Module-3

Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design, decisions using Decision trees. Planning Demand, -multiple item -multiple location inventory management.

Pricing and Revenue Management.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk Method

Module-4

Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain restructuring, Supply Chain Mapping - Supply Chain process restructuring, Postpone the point of differentiation – IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- EBusiness in supply chain.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk Method

Module-5

Introduction to SAP, SAP Material Management, Procurement process, Organization structure, Enterprise structure, Master data management, purchase Info record, source list, procurement cycle, purchase requisition, request for quotation, purchase order, inventory management, invoice verification, service management, transaction code

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk Method

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Understand the framework and scope of supply chain management.
- Build and manage a competitive supply chain using strategies, models, techniques and information technology.
- Plan the demand, inventory and supply and optimize supply chain network.
- Understand the emerging trends and impact of IT on Supply chain.
- Understand the basics of SAP material management system

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester
- Two assignments each of **10 Marks**
- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester
- Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)
- At the end of the 13th week of the semester
- The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Janat Shah, Supply Chain Management– Text and Cases, Pearson Education, 2nd edition
2. Sunil Chopra and Peter Meindl, Supply Chain Management-Strategy Planning and Operation, PHI Learning / Pearson Education, 6th edition.
3. David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, Designing and Managing the Supply Chain: Concepts, Strategies, and Cases, Tata McGraw-Hill.
4. Ballou Ronald H, Business Logistics and Supply Chain Management, Pearson Education
5. Ashfaque Ahmed, The SAP Materials Management Handbook, CRC Press Publication. 2014 edition.
6. Martin Murray & Jawad Akhtar, Materials Management with SAP ERP: Functionality and Technical Configuration, SAP Press; Fourth edition.
7. P. Gopalakrishanan, M. Sundaresan, Materials Management: An Integrated Approach, Prentice Hall India

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_mg45/preview
- https://nptel.ac.in/courses/110106045
- https://www.udemy.com/course/sap-mm-training/
- https://www.udemy.com/course/sap-s4hana-mm-sourcing-and-procurement/
- https://nptel.ac.in/courses/110105095

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case study of companies example Amazon, Flipkart, Parle, DMart, Reliance etc can be discussed

MECHATRONICS SYSTEM DESIGN			
Course Code	**21ME642**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:
1. Gain knowledge of basics of Mechatronics system design and sensors.
2. Understanding various techniques of Mechatronics system design for solving engineering problems.
3. Understanding Dynamic responses of systems and Fault detection techniques
4. Determination of optimization solutions, effective decision making, Convert the data in real time interfacing.
5. Understand real time mechatronic system design through case study

Teaching-Learning Process (General Instructions)
These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Arrange visits to show the live working models other than laboratory topics.
4. Adopt collaborative (Group Learning) Learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1 **8 HOURS**

Introduction to mechatronics System Design: Mechatronics Definition, integrated design issues in Mechatronics, the Mechatronics design process, the key elements, Application of Mechatronics.
Sensors in Mechatronics: sensors for motion and position measurement. Force and pressure sensors. Sensors for temperature measurements.

Teaching-Learning Process	1. PowerPoint Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving (In-general).

Module-2 **8 HOURS**

Modeling and Simulation of Physical Elements: Operator notation and transfer functions, Block diagrams, manipulations and simulation, block diagram modeling- Direct method and analogy approach, Electrical systems, Mechanical systems **(Rotational and Translational),** electrical Mechanical Coupling, Fluid systems

Teaching-Learning Process	1. . PowerPoint Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving (In-general).

Module-3 **8 HOURS**

Dynamic responses of systems and Fault Finding. Modelling of dynamic systems, Terminology, first order systems and second order systems. Fault detection techniques, Parity and error coding checks, Common hardware faults. Microprocessor systems. Emulation and simulation**.**

Teaching-Learning Process	1. PowerPoint Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving (In-general).

Module-4 **8 HOURS**

Signal Conditioning and Real time Interfacing: Introduction, elements of Data Acquisition and Control System, Transducers and Signal Conditioning, Devices for data conversion, Data conversion process, Application software.	
Teaching-Learning Process	1. PowerPoint Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving (In-general).
Module-5 **8 HOURS**	
Case Studies: Comprehensive and Data acquisition case studies, data acquisition and control case studies.	
Teaching-Learning Process	1. PowerPoint Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving (In-general).

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO1. Discuss about Mechatronics design process and select the sensor and Actuator for a Mechatronics application

CO2. Explain Modeling and Simulation of mechanical Elements, electrical Elements and fluid system the sensors in mechatronics systems and Fault detection techniques in Mechatronics.

CO3. Understand the elements of Data Acquisition and Control System, Convert the data in real time interfacing

CO4. Model the dynamic response of first order and second order systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be **scaled down to 50 marks**

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Mechatronics System Design by Devdas Shetty and Richard A Kolk, Second edition, Thomson Learning Publishing Company, Vikas publishing house, 2001.

2. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999.
3. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quiz
- Presentations
- Group Activity

VI Semester

AUTONOMOUS VEHICLES			
Course Code	**21ME643**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50

Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

1. Introduce the fundamental aspects of Autonomous Vehicles.
2. Gain Knowledge about the Sensing Technology and Algorithms applied in Autonomous vehicles.
3. Understand the Connectivity Aspects and the issues involved in driverless cars.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information..

Module-1

Introduction :

Evolution of Automotive Electronics -Basic Control System Theory applied to Automobiles -Overview of the Operation of ECUs -Infotainment, Body, Chassis, and Powertrain Electronics-Advanced Driver Assistance Systems-Autonomous Vehicles

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Sensor Technology for Autonomous Vehicles:

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology and Systems -Camera Technology -Night Vision Technology -Use of Sensor Data Fusion -Kalman Filters

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Computer Vision and Deep Learning for Autonomous Vehicles:

Computer Vision Fundamentals -Advanced Computer Vision -Neural Networks for Image Processing –Tensor Flow - Overview of Deep Neural Networks -Convolutional Neural Networks

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Connected Car Technology:

Connectivity Fundamentals - DSRC (Direct Short Range Communication) - Vehicle-to-Vehicle Technology and Applications -Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications -Security Issues.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5	
Autonomous Vehicle Technology: Driverless Car Technology-Different Levels of Automation -Localization - Path Planning. Controllers to Actuate a Vehicle - PID Controllers -Model Predictive Controllers, ROS Framework	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

1. Describe the evolution of Automotive Electronics and the operation of ECUs.
2. Compare the different type of sensing mechanisms involved in Autonomous Vehicles.
3. Discuss about the use of computer vision and learning algorithms in vehicles.
4. Summarize the aspects of connectivity fundamentals existing in a driverless car.
5. Identify the different levels of automation involved in an Autonomous Vehicle.
6. Outline the various controllers employed in vehicle actuation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

32. First test at the end of 5th week of the semester
33. Second test at the end of the 10th week of the semester
34. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

35. First assignment at the end of 4th week of the semester
36. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

37. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

31. The question paper will have ten questions. Each question is set for 20 marks.
32. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Shaoshan Liu, Liyun Li, "Creating Autonomous Vehicle Systems", Morgan and Claypool Publishers, 2017.
2. Marcus Maurer, J.ChristianGerdes, "Autonomous Driving: Technical, Legal and Social Aspects" Springer, 2016

3. Ronald.K.Jurgen, “Autonomous Vehicles for Safer Driving”, SAE International, 2013.

4. James Anderson, KalraNidhi, Karlyn Stanly, “Autonomous Vehicle Technology: A Guide for Policymakers”, Rand Co, 2014.

5. Lawrence. D. Burns, ChrostopherShulgan, “Autonomy – The quest to build the driverless car and how it will reshape our world”, Harper Collins Publishers, 2018

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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VI Semester

ECONOMICS FOR ENGINEERS			
Course Code	21ME644	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Economic Decisions Making – Overview, Problems, Role, Decision making process.
Engineering Costs & Estimation – Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types Of Estimate, Estimating Models - Per- Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve, Benefits.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Cash Flow, Interest and Equivalence: Cash Flow – Diagrams, Categories & Computation, Time Value Of Money, Debt repayment, Nominal & Effective Interest.
Present Worth Analysis : End-Of-Year Convention, Viewpoint Of Economic Analysis Studies, Borrowed Money Viewpoint, Effect Of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Cash Flow & Rate Of Return Analysis – Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate Of Return, Calculating Rate Of Return, Incremental Analysis; Best Alternative Choosing An Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity And Breakeven Analysis. Economic Analysis In The Public Sector - Quantifying And Valuing Benefits & drawbacks.

Uncertainty In Future Events - Estimates And Their Use In Economic Analysis, Range Of Estimates, Probability, Joint Probability Distributions, Expected Value, Economic Decision Trees, Risk, Risk vs Return, Simulation, Real options

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Depreciation - Basic Aspects, Deterioration & Obsolescence, Depreciation And Expenses, Types Of Property, Depreciation Calculation Fundamentals, Depreciation And Capital Allowance Methods, Straight-Line Depreciation Declining Balance Depreciation, Common Elements Of Tax Regulations For Depreciation And Capital Allowances.

Replacement Analysis - Replacement Analysis Decision Map, Minimum Cost Life Of A New Asset, Marginal Cost, Minimum Cost Life Problems.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Inflation And Price Change – Definition, Effects, Causes, Price Change With Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In Engineering Economic Analysis, Cash Flows that inflate at different rates

Accounting – Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation. Multiple Alternatives.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

9.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

38. First test at the end of 5th week of the semester
39. Second test at the end of the 10th week of the semester
40. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

41. First assignment at the end of 4th week of the semester
42. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

43. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

33. The question paper will have ten questions. Each question is set for 20 marks.
34. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. James L.Riggs,David D. Bedworth, Sabah U. Randhawa : Economics for Engineers 4e , Tata McGraw-Hill
2. Donald Newnan, Ted Eschembach, Jerome Lavelle : Engineering Economics Analysis, OUP
3. John A. White, Kenneth E.Case,David B.Pratt : Principle of Engineering Economic Analysis, John Wiley
4. Sullivan and Wicks: Engineering Economy, Pearson
5. R.Paneer Seelvan: Engineering Economics, PHI
6. Michael R Lindeburg : Engineering Economics Analysis, Professional Pub.

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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VI Semester

PROJECT MANAGEMENT			
Course Code	21ME651	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand how to break down a complex project into manageable segments and use of effective project management tools and techniques to arrive at solution and ensure that the project meets its deliverables and is completed within budget and on schedule.
- To impart knowledge on various components, phases, and attributes of a project.
- To prepare students to plan, develop, lead, manage, and successfully implement and deliver projects within their chosen practice area.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

6. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
7. Chalk and Talk method for Problem Solving.
8. Arrange visits to show the live working models other than laboratory topics.
9. Adopt collaborative (Group Learning) Learning in the class.
10. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1	
Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles Project Selection and Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects.	
Teaching-Learning Process	• PowerPoint Presentation, • Video demonstration or Simulations, • Chalk and Talk are used for Problem Solving (In-general).

Module-2	
Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system. Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart.	
Teaching-Learning Process	• . PowerPoint Presentation, • Video demonstration or Simulations, • Chalk and Talk are used for Problem Solving (In-general).

Module-3	
Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control. Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kick off: Development of quality concepts, project quality management plan, project quality tools, kick off project, baseline and communicate project management plan, using Microsoft Project for project baselines.	
Teaching-Learning Process	• PowerPoint Presentation, • Video demonstration or Simulations, • Chalk and Talk are used for Problem Solving (In-general).

Module-4	
Performing Projects: Project supply chain management: - Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management. Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge management, perform administrative and contract closure.	
Teaching-Learning Process	• PowerPoint Presentation, • Video demonstration or Simulations, • Chalk and Talk are used for Problem Solving (In-general).
Module-5	
Network Analysis: Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.	
Teaching-Learning Process	• PowerPoint Presentation, • Video demonstration or Simulations, • Chalk and Talk are used for Problem Solving (In-general).

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Understand the selection, prioritization and initiation of individual projects and strategic role of project management.
- Understand the work breakdown structure by integrating it with organization.
- Understand the scheduling and uncertainty in projects.
- Understand risk management planning using project quality tools.
- Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.
- Determine project progress and results through balanced scorecard approach
- Draw the network diagram to calculate the duration of the project and reduce it using crashing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

44. First test at the end of 5th week of the semester
45. Second test at the end of the 10th week of the semester
46. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

47. First assignment at the end of 4th week of the semester
48. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

49. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

35. The question paper will have ten questions. Each question is set for 20 marks.
36. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1 Project Management Timothy J Kloppenborg Cengage Learning Edition 2009

2 Project Management -A systems approach to planning scheduling and controlling Harold kerzner CBS publication

3 Project Management S Choudhury McGraw Hill Education (India) Pvt. Ltd. New Delhi 2016

Reference Books

1 Project Management Pennington Lawrence Mc Graw Hill

2 Project Management A Moder Joseph and Phillips New Yark Van Nostrand Reinhold

3 Project Management, Bhavesh M. Patel Vikas publishing House

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

RENEWABLE ENERGY POWER PLANTS (OPEN ELECTIVE)			
Course Code	21ME652	**CIE Marks**	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	**SEE Marks**	50
Total Hours of Pedagogy	40	**Total Marks**	100
Credits	02	**Exam Hours**	03

Course objectives:

- To introduce the concepts and principles of solar energy, its radiation, collection, storage and application.
- To understand application aspects of Wind, Biomass, Geothermal, hydroelectric and Ocean energy.
- To examine energy sources and systems, including fossil fuels and nuclear energy, and then focus on other forms of alternate energy sources.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

Module-1

Introduction: Energy sources (including fossil fuels and nuclear energy), India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, Indian and global energy scenario.
Solar Radiation & Measurement: Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Pyrometer, shading ring Pyrheliometer, sunshine recorder, schematic diagrams, and principle of working, actinometer and bolometer.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-2

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle, expressions for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time, apparent motion of sun, day length, numerical problems.
Solar Thermal Systems: Flat plate collector, Evacuated Tubular Collector, Solar air collector, Solar concentrator, Solar distillation, Solar cooker, Thermal energy storage systems, Solar Pond, Solar Chimney (Tower).
Solar Photovoltaic Systems: Introduction, Solar cell Fundamentals, Characteristics and classification, Solar cell: Module, panel and array construction.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-3

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles; coefficient of performance of a windmill rotor, design aspects, numerical examples.
Energy from Biomass: Energy plantation, biogas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems associated with bio-gas production, application of biogas, application of biogas in engines, cogeneration plant, advantages & disadvantages.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-4

Hydroelectric plants: Advantages & disadvantages of waterpower, Hydrographs and flow duration curves-numericals, Storage and pondage, General layout of hydel power plants- components such as Penstock, surge tanks, spill way and draft tube and their applications, pumped storage plants, Detailed classification of hydroelectric plants.
Tidal Power: Tides and waves as energy suppliers and their mechanics, fundamental characteristics of tidal power, harnessing tidal energy, limitations of tidal energy.
Energy from ocean waves: Wave energy conversion, Wave energy technologies, advantages, and disadvantages.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-5

Ocean Thermal Energy Conversion: Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC, case studies.
Geothermal energy: Introduction, Principle of working, types of geothermal stations with schematic diagram Estimates of Geothermal Power, Nature of geothermal fields, Geothermal resources, Hydrothermal, Resources Geo pressured resources, Hot dry rock resources of petro-thermal systems, Magma Resources-Interconnection of geothermal fossil systems, Advantages, and disadvantages of geothermal energy over other energy forms, Geothermal stations in the world

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Describe the various forms of non-conventional energy resources.
- Apply the fundamental knowledge of mechanical engineering to design various renewable energy systems
- Analyze the implications of renewable energy forms for selecting an appropriate system for a specific application
- Discuss on the environmental aspects and impact of non-conventional energy resources, in comparison with various conventional energy systems, their prospects and limitations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

At the beginning of the semester, the instructor/faculty teaching the course must announce the methods of CIE for the course.

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students must answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

1. Solar Energy Principles, Thermal Collection &Storage, S.P.Sukhatme: Tata McGraw Hill Pub., NewDelhi.
2. Non-Conventional Energy Sources, G.D.Rai, NewDelhi.
3. Renewable Energy, power for a sustainable future, Godfrey Boyle,2004,
4. The Generation of electricity by wind, E.W.Golding.
5. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub.,2009.

Reference Books

1. Fundamentals of Renewable Energy Resources by G.N.Tiwari, M.K.Ghosal, Narosa Pub., 2007.
2.Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009.
3. Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India., 2016
4. Environmental Justice in India: The National Green Tribunal, By Gitanjali Nain Gill, Routledge (2016).
5. Ref: The Oxford Handbook of Comparative Environmental Law, edited by Emma Lees, Jorge E. ViÒuales, Oxford University Press (2019).

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=iZyzvDj6Y3c&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=2
- https://www.youtube.com/watch?v=Og4LEc7SpdQ&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=3
- https://www.youtube.com/watch?v=L3AEXdvtIkk&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=19
- https://www.youtube.com/watch?v=TUu40kDqcEc&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=24
- https://www.youtube.com/watch?v=k7LX0a67V8A&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=37

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case studies
- Quiz
- Topic Seminar presentation
- Assignments

VI Semester

MECHATRONICS			
Course Code	21ME653	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100

Credits	03	Exam Hours	03

Course objectives:

- To acquire a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
- To understand the evolution and development of Mechatronics as a discipline.
- To substantiate the need for interdisciplinary study in technology education
- To understand the applications of microprocessors in various systems and to know the functions of each element.
- To demonstrate the integration philosophy in view of Mechatronics technology
- To be able to work efficiently in multidisciplinary teams.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

Module-1

Introduction: Scope and elements of mechatronics, mechatronics design process, measurement system, requirements and types of control systems, feedback principle, Basic elements of feedback control systems, Classification of control system. Examples of Mechatronics Systems such as Automatic Car Park system, Engine management system, Antilock braking system (ABS) control, Automatic washing machine.

Transducers and sensors: Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors,Potentiometers, LVDT, Capacitance sensors, force and pressure sensors, Strain gauges, temperature sensors, proximity switches and Hall Effect sensors.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-2

Signal Conditioning: Introduction – Hardware – Digital I/O, Analog to digital conversions, resolution, Filtering Noise using passive components – Registers, capacitors, amplifying signals using OP amps. Digital Signal Processing – Digital to Analog conversion, Low pass, high pass, notch filtering. Data acquisition systems (DAQS), data loggers, Supervisory control and data acquisition (SCADA), Communication methods.

Electro Mechanical Drives: Relays and Solenoids – Stepper Motors – DC brushed motors – DC brushless motors – DC servo motors – 4-quadrant servo drives, PWM's – Pulse Width Modulation.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-3

Microprocessor & Microcontrollers: Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers.

Microprocessor Architecture: Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel 's 8085A Microprocessor.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-4

Programmable Logic Controller: Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, PLC programming language, ladder diagram, ladder diagrams circuits, timer counters, internal relays, master control, jump control, shift registers, data handling, and manipulations, analogue input and output, selection of PLC for application.

Application of PLC control: Extending and retracting a pneumatic piston using latches, control of two pneumatic pistons, control of process motor, control of vibrating machine, control of process tank, control of conveyer motor etc.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-5

Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines – Machine Elements: Different types of guide ways, Linear Motion guideways. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing. Re-circulating ball screws. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools.

Mechatronics Design process: Stages of design process – Traditional and Mechatronics design concepts –

Case studies of Mechatronics systems – Pick and place Robot – Automatic car park barrier.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Illustrate various components of Mechatronics systems.
- Assess various control systems used in automation.
- Design and conduct experiments to evaluate the performance of a mechatronics system or component with respect to specifications, as well as to analyse and interpret data.
- Apply the principles of Mechatronics design to product design.
- Function effectively as members of multidisciplinary teams.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

50. First test at the end of 5th week of the semester
51. Second test at the end of the 10th week of the semester
52. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

53. First assignment at the end of 4th week of the semester
54. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

55. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

37. The question paper will have ten questions. Each question is set for 20 marks.
38. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1 Mechatronics-Principles Concepts and Applications Nitaigour Premchand Mahalik Tata McGraw Hill 1stEdition, 2003

2 Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering, W.Bolton Pearson Education 1stEdition, 2005

Reference Books

1 Mechatronics HMT Ltd Tata Mc Graw Hill 1st Edition, 2000 ISBN:978007 4636435

2 Mechatronics: Integrated Mechanical Electronic Systems K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram. Wiley India Pvt. Ltd. New Delhi 2008

3 Introduction to Mechatronics and Measurement Systems David G. Aldatore, Michael B. Histand McGraw-Hill Inc USA 2003

4 Introduction to Robotics: Analysis, Systems, Applications. Saeed B. Niku, Person Education 2006

5 Mechatronics System Design Devdas Shetty, Richard A. kolk Cengage publishers. Second edition

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

VI Semester

MODERN MOBILITY			
Course Code	**21ME654**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To understand the different chassis design & main components of automobile
- To understand the working of transmission and control system employed in automobiles
- To understand the automotive pollution and alternative automotive technologies under trail
- To understand the upcoming electric vehicle technology

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

12. Explain clearly through Power Point presentations
13. showing live Videos for working of components
14. Demonstration of live working of components through cut section models
15. Inspecting live vehicles
16. Visiting nearby service centres
17. Expert Talks

Module-1	**Mobility Systems**
History of Automobile, Classification of Automobile w.r.t Usage, Chassis, Body, Power Sources, capacity, main components of Internal Combustion Engines and their Functions, Modern Fuel supply system, Cooling System, Lubrication System & Ignition System, Engine Management System	
Teaching-Learning Process	Power Point presentations Live Videos for working of components Explaining through live components in class room
Module-2	**Power Transmission**
Clutches; Plate Clutches, Cone Clutch, Centrifugal Clutch, Fluid Flywheel **Gear Box;** Gear Shifting mechanism, synchromesh Gear box, Torque converter, Automatic Manual Transmission (AMT), Automatic Transmission (AT), Continuously Variable Transmission (CVT), Infinitely Variable Transmission (IVT)& IMT, Working of Differential.. **Types Of Tyres**- Radial & Conventional, Tubeless Tyres, Tubed Tyres- Puncture patching	
Teaching-Learning Process	Power Point presentations Live Videos for working of components Explaining through live components in class room
Module-3	**Direction Control & Braking**
Steering system- mechanisms & Linkages, Steering gear boxes- Rack & pinion, worm & wheel construction & working,, power Steering construction & working, steering geometry, Wheel balancing **Braking System**- Mechanism and Linkages; Mechanical Brakes, Hydraulic Brakes, Power Brakes, Parking brakes, ABS, **Suspension** – layout & working of Hydraulic& Air suspension, Independent suspension,	
Teaching-Learning Process	Power Point presentations Live Videos for working of components Explaining through live components in class room
Module-4	**Exhaust Emission & Alternate Sources**

Exhaust gas pollutants and their effects on environment, Emission norms, IC engine fuels types, extraction& availability, BIO Fuels – Production and impact. Ethanol engines, CNG vehicles- operation, advantages& disadvantages, over view of Hydrogen - fuel cell vehicles, advantages & disadvantages, IC engine/ electric hybrid vehicles over view, layout, transmission & control system, solar powered vehicles- wind powered vehicles, super capacitors, supply rails	
Teaching-Learning Process	Power Point presentations Live Videos for working of components
Module-5	**Electrical Vehicles**
Electric vehicles principle and components- layout of two & 4 wheeler, Motors used in Electric vehicles –types- over view of construction and working, power transmission & control system system in Electric vehicles. Batteries –construction & working principle of Lead acid, nickel based, sodium based, Lithium & Metal Air batteries. Battery charging types and requirements	
Teaching-Learning Process	Power Point presentations Live Videos for working of components

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

10. Understand the working of different systems employed in automobile
11. Analyse the limitation of present day automobiles
12. Evaluate the energy sources suitability
13. Apply the knowledge for selection of automobiles based on their suitability

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

56. First test at the end of 5th week of the semester
57. Second test at the end of the 10th week of the semester
58. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

59. First assignment at the end of 4th week of the semester
60. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

61. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

39. The question paper will have ten questions. Each question is set for 20 marks.
40. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

23. Electric Vehicle Technology Explained James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK
24. 1. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011 2
25. Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.
26. Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007.
27. Modren Electric, Hybrid Electric, and Fuel Cell Vehicles,MehrdadEhsani, YiminGao, CRC Press, Taylor & Francis Group
28. Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
29. . Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd. 4.
30. Automobile Engineering, R. B. Gupta, SatyaPrakashan,(4th Edition) 1984.

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/107/106/107106088/
https://onlinecourses.nptel.ac.in/noc20_de06/preview
https://www.digimat.in/nptel/courses/video/107106088/L01.html
https://nptel.ac.in/courses/107106088
https://www.youtube.com/watch?v=LZ82iANWBL0&list=PLbMVogVj5nJTW50jj9_gvJmdwFWHaqR5J

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Operate the cut section models of complete vehicle chassis and observe the working of all components
- Dismantle & Assemble the Automotive Engine, Gear Box, Clutch, brakes
- Prepare the posters of automobile chassis & display
- Visit nearby automobile showrooms/ service station
- Prepare a comparison statement of different automobiles using specification provided by respective manufacturers
- Visit auto expo

CNC PROGRAMMING AND 3-D PRINTING LAB			
Course Code	21MEL66	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2*:0	SEE Marks	50
Credits	01	Exam Hours	03

**** Additional one hour may be considered for Instructions if required***

Course objectives:

- To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes.
- To educate the students on the usage of CAM packages.
- To expose the students on the usage of 3D Printing Technology
- To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics.

Sl.NO	Experiments
1	Manual CNC part programming using ISO Format G/M codes for 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path using CNC program verification software.
2	CNC part programming using CAM packages : Simulation of Turning simulations to be carried out using simulation packages like: CademCAMLab-Pro, Master-CAM.
3	CNC part programming using CAM packages : Simulation of Drilling simulations to be carried out using simulation packages like: CademCAMLab-Pro, Master-CAM.
4	CNC part programming using CAM packages : Simulation of Milling simulations to be carried out using simulation packages like: CademCAMLab-Pro, Master-CAM.
5	Internal and external threading : Write a CNC program to create internal and external threading on a cylindrical block.s
6	Simple 3D Printing Model : Creating Simple 3D model (example cube, gear, prism etc) in CAD software and printing the model using any 3D Printer (FDM/SLA/SLS printer)
7	Assembly Model-1: Creating an 3D CAD model of NUT and Bolt (example size M12x50), print the model using any 3D Printer and Check the assembly
8	Assembly Model-2: Creating an 3D CAD assembly model containing four or more parts (example Screw jack, plumber block etc) print the model using any 3D Printer and Check the assembly
	Demonstration Experiments (For CIE)
9	Robot programming: Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs).
10	Pneumatics and Hydraulics, Electro-Pneumatics: 3 typical experiments on Basics of these topics to be conducted.
11	FMS (Flexible Manufacturing System): Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components.
12	Simple strength testing of 3D Printed Parts

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Students will have knowledge of G-code and M-code for machining operations.
- Students will able to perform CNC programming for turning, drilling, milling and threading operation.
- Students will able to visualize the 3D models using CAD software's
- Students will able to use 3D printing technology
- Students are able to understand robotic programming and FMS

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 35% (18 Marks out of 50) in the semester-end examination(SEE).

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability. Rubrics suggested in Annexure-II of Regulation book
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

- https://nptel.ac.in/courses/112102103
- https://onlinecourses.nptel.ac.in/noc19_me46/preview
- https://nptel.ac.in/courses/112103306
- https://archive.nptel.ac.in/courses/112/105/112105211/
- https://onlinecourses.nptel.ac.in/noc20_me50/preview

Semester -VII

AUTOMATION AND ROBOTICS (PCC)			
Course Code	**21ME71**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

Students will be able :

- To identify potential areas for automation and justify need for automation.
- To select suitable major control components required to automate a process or an activity
- To study the various parts of robots and fields of robotics.
- To study the various kinematics and inverse kinematics of robots.
- To study the control of robots for some specific applications.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to automation:

Basic elements of an automated system, advanced automation functions, levels of automation, process industries versus discrete manufacturing industries, continuous versus discrete control, computer process control. Hardware components for automation and process control, sensors, actuators, analogue to digital converters, digital to analog converters, input/output devices for discrete data

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Automated production lines:

Fundamentals of automated production lines, application of automated production lines, analysis of transfer lines, automated assembly systems, fundamentals of automated assembly systems, quantitative analysis of assembly systems, automatic identification methods, barcode technology, radio frequency identification, other AIDC technologies

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Industrial Robotics Robotic configuration, robot anatomy and related attributes, robot control systems, end effectors, sensors in robotics, industrial robot applications, robot accuracy and repeatability, different types of robots, various generations of robots, degrees of freedom – Asimov's laws of robotics, dynamic stabilization of robots.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-4	
Spatial descriptions and transformations Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison. Position sensors –potentiometers, resolvers, encoders –Velocity sensors, Tactile sensors, Proximity sensors. Manipulator Kinematics: Homogeneous transformations as applicable to rotation and translation -D-H notation, Forward and inverse kinematics.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-5	
Robot programming: Introduction, levels of robot programming, requirements of robot programming language, problems pertaining to robot programming languages, offline programming systems, central issues in OLP systems, automating subtasks in OLP systems, simple programs on robot applications.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Translate and simulate a real time activity using modern tools and discuss the Benefits of automation.
- Identify suitable automation hardware for the given application.
- Recommend appropriate modelling and simulation tool for the given manufacturing Application.
- Explain the basic principles of Robotic technology, configurations, control and Programming of Robots.
- Explain the basic principles of programming and apply it for typical Pick & place, Loading & unloading and palletizing applications

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

62. First test at the end of 5th week of the semester
63. Second test at the end of the 10th week of the semester
64. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

65. First assignment at the end of 4th week of the semester
66. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

67. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

41. The question paper will have ten questions. Each question is set for 20 marks.
42. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
43. The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1 Computer Integrated Manufacturing Mikell P. Groover Pearson 3rd edition, 2009

2 Introduction to robotics mechanics and control John J. Craig Pearson 3rd edition, 2009

Reference Books

1 Robotics for Engineers Yoram Koren McGraw Hill International 1st edition, 1985.

2 Industrial Robotics Weiss, Nagel McGraw Hill International 2nd edition, 2012

3 Robotic Engineering – An Integrated approach Klafter, Chmielewski and Negin PHI 1st edition, 2009

4 Computer Based Industrial Control Krishna Kant EEE-PHI 2nd edition,2010

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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Semester -VII

CONTROL ENGINEERING			
Course Code	**21ME72**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	30	Total Marks	100
Credits	02	Exam Hours	02

Course objectives:

- To develop comprehensive knowledge and understanding of modern control theory, industrial automation, and systems analysis.
- To model mechanical, hydraulic, pneumatic and electrical systems.
- To represent system elements by blocks and its reduction techniques.
- To understand transient and steady state response analysis of a system.
- To carry out frequency response analysis using polar plot, Bode plot.
- To analyse a system using root locus plots.
- To study different system compensators and characteristics of linear systems.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

6. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
7. Chalk and Talk method for Problem Solving.
8. Adopt flipped classroom teaching method.
9. Adopt collaborative (Group Learning) learning in the class.
10. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction: Components of a control system, Open loop and closed loop systems.
Types of controllers: Proportional, Integral, Differential, Proportional-Integral, and Proportional- Integral- Differential controllers.
Modelling of Physical Systems: Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic Systems

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Time domain performance of control systems: Typical test signal, Unit step response and time domain specifications of first order, second order system. Steady state error, error constants.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Block diagram algebra, Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graphs, State diagram from differential equations.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Stability of linear control systems: Routh's criterion, Root locus, Determination of phase margin and gain margin using root locus.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Stability analysis using Polar plot, Nyquist plot, Bode plot, Determination of phase margin and gain margin using Bode plot.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Identify the type of control and control actions and develop the mathematical model of the physical systems.
- Estimate the response and error in response of first and second order systems subjected standard input signals.
- Represent the complex physical system using block diagram and signal flow graph and obtain transfer function.
- Analyse a linear feedback control system for stability using Hurwitz criterion, Routh's criterion and root Locus technique in complex domain.
- Analyse the stability of linear feedback control systems in frequency domain using polar plots, Nyquist and Bode plots.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

At the beginning of the semester, the instructor/faculty teaching the course has to announce the methods of CIE for the course.

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester
- Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**) At the end of the 13th week of the semester
- The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

44. The question paper will have ten questions. Each question is set for 20 marks.
45. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

46. The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1 Automatic Control Systems Farid G., Kuo B. C McGraw Hill Education 10th Edition,2018
2 Control Systems Engineering IjNagrath, M Gopal New Age International (P) Ltd 2018
3 Control systems Manik D. N Cengage 2017

Reference Books

1 Modern control Engineering K. Ogata Pearson 5th Edition, 2010
2 Control Systems Engineering Norman S Nice Fourth Edition, 2007
3 Modern control Systems Richard C Dorf Pearson 2017
4 Control Systems Engineering S Palani Tata McGraw Hill Publishing Co Ltd ISBN-13 9780070671935

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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Semester –VII **Professional Elective - II**

ADDITIVE MANUFACTURING	11

Course Code	**21ME731**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To know the principle methods, areas of usage, possibilities and limitations of the Additive Manufacturing technologies.
- To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
- To know the principles of polymerization and powder metallurgy process, extrusion-based system printing processes, sheet lamination processes, beam deposition processes, direct write technologies Direct Digital Manufacturing.
- To get exposed to process selection, software issues and post processing.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction and basic principles: Need for Additive Manufacturing, Generic AM process, stereo lithography or 3dprinting, rapid proto typing, the benefits of AM, distinction between AM and CNC machining, other related technologies- reverse engineering technology.

Development of Additive Manufacturing Technology: Introduction, computers, computer-aided design technology ,other associated technologies, the use of layers, classification of AM processes, metals systems, hybrid systems, milestones in AM development.

Additive Manufacturing Process chain: Introduction, the eight steps in additive manufacture, variations from one AM machine to another ,metal systems, maintenance of equipment, materials handling issues, design for AM, and application areas.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Photo polymerization processes: Stereo lithography (SL), Materials, SL resin curing process, Micro- Stereo lithography, Process Benefits and Drawbacks, Applications of Photo polymerization Processes.

Powder bed fusion processes: Introduction, Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Extrusion-based systems: Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3	
Printing Processes: evolution of printing as an additive manufacturing process, research achievements in printing deposition, technical challenges of printing, printing process modeling, material modification methods, three-dimensional printing, advantages of binder printing Sheet Lamination Processes: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications. Beam Deposition Processes: introduction, general beam deposition process, description material delivery, BD systems, process parameters, typical materials and microstructure, processing–structure–properties relationships, BD benefits and drawbacks. Direct Write Technologies: Background, ink –based DW, laser transfer, DW thermals pray, DW beam deposition, DW liquid-phase direct deposition.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-4	
Guidelines for Process Selection: Introduction, selection methods for apart, challenges of selection, example system for preliminary selection, production planning and control. Software issues for Additive Manufacturing: Introduction, preparation of cad models – the STL file, problems with STL files, STL file manipulation. Post- Processing: Support material removal, surface texture improvements, preparation for use as a pattern, property enhancements using non-thermal techniques and thermal techniques.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-5	
The use of multiple materials in additive manufacturing: Introduction, multiple material approaches, discrete multiple material processes, porous multiple material processes, blended multiple material processes, commercial applications using multiple materials, future directions. AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Remanufacturing. Application: Examples for Aerospace, defense, automobile, Bio-medical and general engineering industries. Direct digital manufacturing: Align Technology, Siemens and phonak, DDM drivers, manufacturing vs. prototyping, life-cycle costing, future of direct digital manufacturing.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
- Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
- Understand the various software tools, processes and techniques that enable advanced/additive manufacturing.
- Apply the concepts of additive manufacturing to design and create components that satisfy product development/prototyping requirements, using advanced/additive manufacturing devices and processes.
- Understand characterization techniques in additive manufacturing.

- Understand the latest trends and business opportunities in additive manufacturing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

68. First test at the end of 5th week of the semester
69. Second test at the end of the 10th week of the semester
70. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

71. First assignment at the end of 4th week of the semester
72. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

73. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

47. The question paper will have ten questions. Each question is set for 20 marks.
48. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1 Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing I. Gibson l D. W. Rosen l B. Stucker Springer New York Heidelberg Dordrecht, London ISBN: 978-1- 4419-1119-3 e-ISBN: 978- 1-4419- 1120-9 DOI 10.1007/978 -1-4419- 1120-9

2 "Rapid Prototyping: Principles & Applications Chua Chee Kai, Leong Kah Fai World Scientific 2003

3 Rapid Prototyping: Theory & Practice Ali K. Kamrani, Springer 2006 Emand Abouel Nasr,

4 Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling" D.T. Pham, S.S. Dimov Springer 2001

5 Rapid Prototyping: Principles and Applications in Manufacturing Rafiq Nooran John Wiley & Sons 2006

6 Additive Manufacturing Technology Hari Prasad, A.V. Suresh Cengage 2019

7 Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing Andreas Gebhardt Hanser Publishers 2011

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

VII Semester

TOTAL QUALITY MANAGEMENT	12

Course Code	**21ME732**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

Students will be able to :

- Understand various approaches to TQM
- Understand the characteristics of quality leader and his role.
- Develop feedback and suggestion systems for quality management.
- Enhance the knowledge in Tools and Techniques of quality management

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Principles and Practice: Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM. Quality Management Systems: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making,

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Customer Satisfaction and Customer Involvement: Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies. Statistical Process Control: Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Total Productive Maintenance (TPM): Definition, Types of Maintenance, Steps in introduction of TPM in an organization, Pillars of TPM – 5S, Jishu Hozen, Quality Maintenance, Planned Maintenance.

Quality by Design (QbD): Definition, Key components of QbD, Role of QbD in Pharmaceutical Industry, Benefits and Challenges of QbD.

Environmental Management Systems (EMS): Definition, Basic EMS, EMS under ISO 14001, Costs and Benefits of EMS

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Explain the various approaches of TQM
- Infer the customer perception of quality
- Analyse customer needs and perceptions to design feedback systems.
- Apply statistical tools for continuous improvement of systems
- Apply the tools and technique for effective implementation of TQM.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

74. First test at the end of 5th week of the semester
75. Second test at the end of the 10th week of the semester
76. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

77. First assignment at the end of 4th week of the semester
78. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

79. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

49. The question paper will have ten questions. Each question is set for 20 marks.
50. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

1 Total Quality Management Dale H. Besterfield Pearson Education India, Edition 03. ISBN: 8129702606,

2 Total Quality Management for Engineers M. Zairi Wood head Publishing ISBN:185573024

3 Managing for Quality and Performance Excellence James R. Evans and William M Lindsay Cengage Learning. 9th edition

4 Four revolutions in management Shoji Shiba, Alan Graham, David Walden Oregon 1990

5 Organizational Excellence through TQM H. Lal New age Publications 200864 Engineering Optimization Methods and Applications A Ravindran, K, M. Ragsdell Willey India Private Limited 2nd Edition,2006

6 Introduction to Operations Research- Concepts and Cases F.S. Hillier. G.J. Lieberman Tata McGraw Hill 9th Edition,

Web links and Video Lectures (e-Resources):

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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REFRIGERATION AND AIR-CONDITIONING			
Course Code	21ME733	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

Students will be able to:

- Study the basic definition, ASHRAE Nomenclature for refrigerating systems.
- Understand the working principles and applications of different types of refrigeration systems.
- Study the working of air conditioning systems and their applications.
- Identify the performance parameters and their relations of an air conditioning system.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Sterling cycles for liquefaction of air.

Industrial Refrigeration-Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle – liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems, Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly. Practical problems – crystallization and air leakage, Commercial systems

Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermos-acoustic refrigeration systems

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropic mixtures

Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

Transport air conditioning Systems: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Illustrate the principles, nomenclature and applications of refrigeration systems.
- Explain vapour compression refrigeration system and identify methods for performance improvement
- Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermoacoustic refrigeration systems.
- Estimate the performance of air-conditioning systems using the principles of psychrometry.
- Compute and Interpret cooling and heating loads in an air-conditioning system.
- Identify suitable refrigerant for various refrigerating systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

80. First test at the end of 5th week of the semester
81. Second test at the end of the 10th week of the semester
82. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

83. First assignment at the end of 4th week of the semester
84. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

85. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

51. The question paper will have ten questions. Each question is set for 20 marks.
52. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1 Refrigeration and Air conditioning Arora C.P Tata Mc Graw –Hill, New Delhi 2ndEdition, 2001

2 Principles of Refrigeration Roy J. Dossat Wiley Limited

3 Refrigeration and Airconditioning Stoecker W.F., and Jones J.W., Mc Graw - Hill, New Delhi 2nd edition, 1982.

Reference Books

1 Heating, Ventilation and Air Conditioning McQuistion Wiley Students edition 5th edition2000.

2 Air conditioning PITA Pearson 4th edition 2005

3 Refrigeration and Air- Conditioning S C Arora& S Domkundwar Dhanpat Rai Publication

4 Principles of Refrigeration Dossat Pearson 2006

5 Refrigeration and Air- Conditioning Manohar prasad

6 Handbook of Air Conditioning and Refrigeration Shan K. Wang McGraw-Hill Education 2/e,2001

Data Book:

1. Mathur M.L. & Mehta, Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, F.S., Jain Brothers,2008

Web links and Video Lectures (e-Resources):

http://nptel.ac.in/courses/112105128/# VTU, E- learning, MOOCS, Open courseware
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

Semester VII

MEMS AND MICROSYSTEM TECHNOLOGY			
Course Code	**21ME734**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning Objectives:

- To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices.
- To educate on the rudiments of Microfabrication techniques.
- To introduce various sensors and actuators.
- To introduce different materials used for MEMS.
- To educate on the applications of MEMS to disciplines beyond Electrical and Mechanical engineering.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

8 HOURS

Intrinsic Characteristics of MEMS – Energy Domains and Transducers- Sensors and Actuators – Introduction to Microfabrication - Silicon-based MEMS processes – New Materials – Review of Electrical and Mechanical concepts in MEMS – Semiconductor devices – Stress and strain analysis – Flexural beam bending- Torsional deflection.

Teaching-Learning Process	1. Power Point Presentation, 2. Chalk and Talk are used for Derivations and Correlations (In-general). 3. Video demonstration or Simulations.

Module-2

8 HOURS

Engineering Mechanics for Microsystems Design: Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermo-mechanics, Fracture Mechanics, and Thin Film Mechanics. Assembly and System Integration. Packaging- Multi-Chip Modules, Passivation, and Encapsulation.

Teaching-Learning Process	1. Power Point Presentation, 2. Chalk and Talk are used for Derivations and Correlations (In-general). 3. Video demonstration or Simulations.

Module- 3

8 HOURS

Electrostatic sensors – Parallel plate capacitors -Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors - Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph - Applications – Magnetic Actuators – Micromagnetic components

Piezoresistive sensors – Piezoresistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile, and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia, Acoustic, Tactile and Flow sensors.

Teaching-Learning Process	1. Power Point Presentation, 2. Chalk and Talk are used for Derivations and Correlations (In-general). 3. Video demonstration or Simulations.

Module-4

8 HOURS

Photolithography, Materials for Micromachining- Substrates, Additive Films, and Materials; Bulk Micromachining - Wet Etching, Dry Etching, Plasma Etching, Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching – Gas-Phase Etchants; Surface Micromachining- Fusion Bonding; High-Aspect-Ratio-Micromachining – LIGA, Laser Micromachining; Computer-Aided Design; Assembly and System Integration; Packaging - Multi-Chip Modules, Passivation, and Encapsulation

Teaching-Learning Process	1. Power Point Presentation, 2. Chalk and Talk are used for Derivations and Correlations (In-general). 3. Video demonstration or Simulations.

Module-5

8 HOURS

POLYMER AND OPTICAL MEMS: Polymers in MEMS– Polyimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon - Application to Acceleration, Pressure, Flow, and Tactile sensors- Optical MEMS – Lenses and Mirrors – Actuators for Active Optical MEMS.

Teaching-Learning Process	1. Power Point Presentation, 2. Chalk and Talk are used for Derivations and Correlations (In-general). 3. Video demonstration or Simulations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Explain MEMS Technology, Present, Future, and Challenges.
- Explain micro-sensors, micro-actuators, their types, and applications.
- Explain fabrication processes for producing micro-sensors and actuators.
- Apply Reliability and Failure Analysis Testing.
- Understand the operation of microdevices, microsystems, and their applications.
  Design the microdevices and microsystems using the MEMS fabrication process.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Allen James J, Micro-Electromechanical System Design, First edition, Taylor and Francis, FL (USA), 2005.
2. Dilip Kumar Bhattacharya, Brajesh Kumar Kaushik, Microelectromechanical Systems (MEMS), Cenage Learning.
3. Hans H. Gatzen, Volker Saile, JurgLeuthold, Micro and Nano Fabrication: Tools and Processes, Springer, 2015.
4. Maluf Nadim and Williams Kirt, An Introduction to Microelectromechanical Systems Engineering, Second Edition, ARTECH House, MA (USA), 2004.
5. N. Maluf," An Introduction to Micro-electro Mechanical System Engineering," Artech. House
6. S. Senturia," Microsystem Design", Springer
7. Tai-Ran Hsu, MEMS, and Microsystems: Design, Manufacture and Nanoscale Engineering, 2nd Ed, Wiley.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Students are segregated in groups of 5members made to Prepare models of FCC structure of Silicon and Patterns to demonstrate the process of Photolithography.

2. Students are segregated in groups of 5members made to Prepare models of Cantilever Beam to analyze the vibration control and Patterns to demonstrate the process of Etching.

3.Quiz

DESIGN FOR MANUFACTURING & ASSEMBLY			
Course Code	**21ME735**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To educate students on factors to be considered in designing parts and components with focus on manufacturability.
- To expose the students to dimensional tolerances, geometric tolerances and true position tolerance techniques in manufacture.
- To impart the knowledge on design considerations for designing components produced using various machining operations like turning, drilling, milling, grinding etc.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction: Engineering design process and its structure, Steps in design process, Morphology of design, Mechanical engineering design, Traditional design methods, Design synthesis, Aesthetic and ergonomic considerations in design, Use of standards in design, Selection of preferred sizes, design for Maintenance (DFM), design for manufacture, assembly, shipping, maintenance, use, and recyclability.

Design checks for clarity, simplicity, modularity and safety, Design organisation and communication, technical reports, drawings, presentations and models.

Design features to facilitate machining: datum features – functional and manufacturing. Component design – machining considerations, redesign for manufacture, examples. Form design of castings and weldments.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Tolerance Analysis: Process capability, process capability metrics, Tolerance – cost aspects, feature tolerances, geometric tolerances, relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerances – sure fit law, normal law and truncated normal law.

Interchangeable part manufacture and selective assembly – control of axial play – introducing secondary machining operations, laminated shims – examples.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Datum Systems: Degrees of freedom, grouped datum systems – computation of translational and rotational accuracy – geometric analysis and applications.

True Position Theory: Co-ordinate and conventional method of feature location, tolerance and true position tolerance, virtual size concept, floating and fixed fasteners, projected tolerance zone, assembly with gasket, zero true position tolerance, functional gauges, paper layout gauging – examples.

Principles of Design for Assembly, Minimize Part Count, Standardization and Minimize Part Variety, Design guidelines for manual assembly, DFA analysis, DFA index, Design for Automated Assembly. Introduction to usage of DFMA software.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Component Design-I: Machining Consideration: Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility, Design for assembly.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Design for assembly: Design for assembly, design for reassembly, design for automated assembly, Assembled Parts Design: Welded parts, arc, resistance, brazed and soldered parts, gear box assembly, bearing assembly. Retention, bolted connection, screwed connections, press fitted connections, heat treated parts, product design requirements

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

14. have knowledge on design principles for manufacturability
15. have knowledge Influencing factors on Design.
16. have knowledge on Machining consideration while design.
17. have knowledge on casting consideration while design.
18. have knowledge on environment consideration while design.
19. have ability to understand contemporary issues and their impact on design for manufacturing and assembly.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

86. First test at the end of 5th week of the semester
87. Second test at the end of the 10th week of the semester
88. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

89. First assignment at the end of 4th week of the semester
90. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

91. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

53. The question paper will have ten questions. Each question is set for 20 marks.
54. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

31. Boothroyd G., Dewhurst P. and Knight W. – 'Product Design for Manufacture and Assembly' – Marcel Dekker, New York – 2012 – 4th Edition
32. Peck H. – 'Designing for Manufacture' – Pitman Publications – 1983
33. Handbook of Products Design for Manufacturing: A Practical Guide to Low-cost Production Bralla, James G. McGraw Hill, New York 1986.
34. Spotts M. F. – 'Dimensioning and Tolerance for Quantity Production'- Prentice Hall Inc. -1983
35. Wade O. R. – 'Tolerance Control in Design and Manufacturing' – Industrial Press Inc., New York – 1967
36. Creveling C. M. – 'Tolerance Design – A Hand Book for Developing Optimal Specifications' – Addison Wesley Longman, Inc, – 1997
37. K G Swift and J D Booker, Process selection : from design to manufacture, London: Arnold, 1997.
38. Ashby M.F., Materials Selection in Mechanical Design, Butterworth-Heinemann, (2016).

Web links and Video Lectures (e-Resources):

- . 1. https://nptel.ac.in/courses/112/107/112107217/
- 2. https://www.edx.org/learn/product-design
-

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- 1. Study and report on design principles for manufacturability
- 2. Study and report Influencing factors on Design.
- 3. Case study on Machining consideration
- 4. Case study on casting consideration
- 5. Case study on Life cycle assessment of product.
- 6. Case study on Environmental Aspects on Design of Product

VII Semester **Professional Elective**

ADVANCED VIBRATIONS AND CONDITION MONITORING			
Course Code	**21ME741**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50

Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course objectives:

Students will be able:

- To introduce to vibration systems
- Understand the vibration analysis
- To understand vibration control & condition monitoring
- To get exposed to vibration measurements and basics of acoustics

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

18. Power Point presentation
19. Solving problems on boards with clear explanations
20. Use of appropriate Videos
21. Use of learning aid models
22. Use of live instruments & models

Module-1	**Basics of Vibration**
Basic Concept of Vibration, Importance of study of Vibration, conversion of vibration to sound by human ear, Elementary parts of vibrating systems, number of degrees of freedom, discreet and continuous system, Classification of vibration, vibration analysis procedure, Mathematical modelling of motor cycle, Spring elements- Damping Elements – Harmonic motion	
Teaching-Learning Process	**1.** Power Point presentation **2.** Use of appropriate Videos 3. Use of learning aid models

Module-2	**Free & Forced Vibration**
Free Vibration: Free vibration of single degree freedom systems- Undamped transisitional system, undamped torsional system, Rayleigh's method, free vibration with viscous damping - solve of problems of practical relevance **Forced Vibration**: Analysis of forced vibration, with constant harmonic excitation, magnifiction factor, rotating and reciprocating unbalances, - solve of problems of practical relevance	
Teaching-Learning Process	**1.** Power Point presentation **2.** Solving problems on boards with clear explanations **3.** Use of appropriate Videos

Module-3	**Multi Degree Freedom System**
Two degree freedom system: principle modes of vibration, cases of simple two degrees of freedom systmes – two masses fixed on a tightly stretched string, double pendulum & torsional systemsystems with damping, undamped forced vibration with harmonic excitation, undamped dynamic vibration absorber, - solve of problems of practical relevance **Multi degree freedom system**: modelling of continuous systems as multi degree of freedom system, , Rayleighs method, Dunkerleys method, stodola method, Rayleigh-ritz method, matrix iteration method, holzers method- solve of problems of practical relevance	
Teaching-Learning Process	**1.** Power Point presentation **2.** Solving problems on boards with clear explanations **3.** Use of appropriate Videos

Module-4	**Condition monitoring & Vibration Control**
Modal analysis and condition monitoring: signal analysis, dynamic testing of machines & structures, experimental modal analysis, machine conditioning monitoring and diagnosis **Vibration control & isolation**: Control of vibration control of natural frequencies, vibration isolation, typical isolators & mount types, vibration isolation and transmissibility- force transmissibility, motion transmissibility, vibration absorbers: undamped dynamic vibration absorber, damped dynamic vibration absorber, solve of problems of practical relevance	

Teaching-Learning Process	**1.** Power Point presentation **2.** Use of appropriate Videos 3. Use of learning aid models 4. Use of live instruments & models

Module-5	**Vibration Measurement & Acoustics**

Vibration measurements: Transducers –Types, Vibration Pickups – types, Frequency measuring instruments , vibration exciters, signal analysis

Acoustics: Concepts of sound intensity, sound power & sound pressure, Introduction to sound in rooms, sound absorbers, sound absorbing materials, noise of gas flows, machinery noise

Teaching-Learning Process	**1.** Power Point presentation **2.** Use of appropriate Videos 3. Use of learning aid models 4. Use of live instruments & models

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

20. Identify & classify the vibration systems
21. Analyse the vibration parameters through different theoretical methods
22. Apply the knowledge of vibration measurement instruments and control system
23. Understand the sound generation and propagation arising through vibration

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

92. First test at the end of 5th week of the semester
93. Second test at the end of the 10th week of the semester
94. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

95. First assignment at the end of 4th week of the semester
96. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

97. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

55. The question paper will have ten questions. Each question is set for 20 marks.
56. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

39. Mechanical Vibrations by Singiresu S Rao, Pearson publications, sixth edition
40. Mechanical Vibrations by G K Grover, nem Chand & Bros publication
41. Noise & Vibration Control Engineering, Istvan L ver Leo L Beranek, wiley publications
42. S Graham Kelly, Fundamentals of mechanical Vibrations- McGrraw hill
43. Theory of Vibration with Application – William T Thomson, Marie Dillon Dahleh, pearson publications
44. C Sujatha, Vibration and Acoustics – Measurements & Signal Analysis, Tata Mc Graw Hill

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/112107212
https://ocw.mit.edu/courses/2-003sc-engineering-dynamics-fall-2011/
https://www.youtube.com/watch?v=TkExfl4Vm_4
https://www.youtube.com/watch?v=bX_m53Xexvk&list=PLAC668A0566953FB5&index=1
https://www.youtube.com/channel/UCTRZX5Ie1ONHsstzLcFpMKw/videos
https://www.youtube.com/watch?v=oOvJlG6IqxI

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Measure the vibrations using appropriate instruments
- Measure the sound using appropriate sound measuring instruments
- Appreciate the sound controlling in rooms by providing different types barricades
- Appreciate the concept by solving live numerical problems / application problems

Theory and Design of IC Engines			
Course Code	21ME742	**CIE Marks**	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	**SEE Marks**	50
Total Hours of Pedagogy	40	**Total Marks**	100
Credits	03	**Exam Hours**	03

Course objectives:

- To present a problem oriented in depth knowledge of Internal Combustion Engine.
- To address the underlying concepts, methods, and application of Internal Combustion Engine.
- To understand the operation of internal combustion engines.
- To perform theoretical calculations to obtain thermodynamic efficiencies and then assess operating losses.
- To calculate engine operating parameters.
- To understand the implications of a trade-off between performance, efficiency, emissions.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

11. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
12. Chalk and Talk method for Problem Solving.
13. Adopt flipped classroom teaching method.
14. Adopt collaborative (Group Learning) learning in the class.
15. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

Module-1

Basic characteristics of engines: Compression ratio – energy supply to an engine – power developed by engine – specific weight and specific volume – cylinder pressures – IMEP determination – torque characteristics – cylinder arrangement and their relative merits. Engine cooling systems: types of cooling – cooling of critical engine components – recooling the coolant – comparison of air cooled and liquid cooled engines.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Module-2	
Fuels and its supply system for SI and CI engine: Important qualities of IC engine fuels, rating of fuels, Carburetion, mixture requirement for different loads and speeds, simple carburetor and its working, types of carburetors, MPFI, types of injection systems in CI engine, fuel pumps and injectors, types of nozzles, spray formation.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-3	
Combustion in SI and CI Engines: Combustion equations, calculations of air requirement in I C Engine, stoichiometric air fuel ratio, proximate and ultimate analysis, enthalpy of formation, adiabatic flame temperature. Stages of combustion in SI engines, abnormal combustion and knocking in SI engines, factors affecting knocking, effects of knocking, control of knocking, combustion chambers for SI engines, Stages of combustion in CI engines, detonation in C.I. engines, factors affecting detonation, controlling detonation, combustion chamber for SI and CI engine	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board
Module-4	
Emission of IC Engine: Emission from SI engine, effect of engine maintenance on exhaust emission control of SI engine, diesel emission, diesel smoke and control, diesel and control comparison of gasoline and diesel emission. Measurement and calculation for of emission constituents.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board
Module-5	
Unconventional Engines &Alternative Fuels for IC Engine: Working principle of stratified charge engines sterling engine, Wankel engine Methanol, Ethanol, vegetable oils, biogas, biofuels, hydrogen, and comparison of their properties with Diesel and petrol.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. /White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Understand various types of I.C. Engines, Cycles of operation and Identify fuel metering, fuel supply systems for different types of engines.
- Understand combustion phenomena in SI and CI engines and Analyze the effect of various operating variables on engine performance.
- Evaluate performance Analysis of IC Engine and Justify the suitability for different applications.
- Understand the conventional and non-conventional fuels and effects of emission formation of IC engines, its effects, and the legislation standards

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

At the beginning of the semester, the instructor/faculty teaching the course has to announce the methods of CIE for the course.

Three Unit Tests each of **20 Marks (duration 01 hour**)

98. First test at the end of 5th week of the semester
99. Second test at the end of the 10th week of the semester
100. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

101. First assignment at the end of 4th week of the semester
102. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

103. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

57. The question paper will have ten questions. Each question is set for 20 marks.
58. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
59. The students must answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

1. Internal combustion engines fundamentals by by John B. Heywood. McGraw – Hill international editions.
2. Internal combustion engines by V. Ganesan, Tata McGraw Hill book cop. 1995
3. Internal combustion engines and air pollutions by Edward F. Obert, Intext education publishers.
4. Introduction to internal combustion engines by Richard stone 3rd edition, society of automotive engineers .

Reference Books

1. A course Internal combustion engines by V.M.A. Domkundwar, Dhanapat Rai publications.
2. A course internal combustion engines by M.L.Mathur and R.P.Sharma, Dhanapat Rai publications.
3. Internal combustion engines by K.k Ramalingam, Scitech Publications (India) Pvt.Ltd, 2000
4. A Textbook of Internal combustion engines by R.K. Rajput, Laxmi Pub, Pvt., 2006

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=sRu-majrRmM&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=2
- https://www.youtube.com/watch?v=q-CfzNh99sQ&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=3
- https://www.youtube.com/watch?v=SU5VTGR2giY&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=4
- https://www.youtube.com/watch?v=eZCuV4ygLA4&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=5
- https://www.youtube.com/watch?v=03aVTKQeXNY&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=6
- https://www.youtube.com/watch?v=9H01exiYCYc&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=7
- https://www.youtube.com/watch?v=1I7jRI2dmgc&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=10
- https://www.youtube.com/watch?v=XT-DjBqkiJU&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=11
- https://www.youtube.com/watch?v=gbID5bHlAzU&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=15
- https://www.youtube.com/watch?v=y8FN-TV3eSw&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC&index=16

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case studies on Emission standards
- Quiz
- Topic Seminar presentation
- Assignment

7 Semester **Professional Elective**

ADVANCED TURBOMACHINES			
Course Code	**21ME743**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40 hours	Total Marks	100
Credits	03	Exam Hours	3 hrs

Course objectives:

Students will

- Study the various thermodynamic processes involved in turbomachines, the application of 1st and 2nd law of Thermodynamics to evaluate the energy transfer and efficiencies,
- Understand of the concept and application of law of conservation of energy for the flow of steam and gas through nozzle and diffuser.
- Understand the concept of two-dimensional cascading for the evaluation of cascade performance in compressor and turbines.
- Learn on how to apply the concepts of thermodynamics to analyse its performance and characteristics in the axial flow turbines.
- Understand the concepts of thermodynamics to analyse its performance and characteristics in the axial flow compressors and fans.
- Study the radial equilibrium and understand the various vortex flow concepts for designing the blades.
- Understand the different process of control and maintenance aspects of turbomachines.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teacher can use to accelerate the attainment of the various course outcomes.

11. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
12. Chalk and Talk method for Problem Solving.
13. Adopt flipped classroom teaching method.
14. Adopt collaborative (Group Learning) learning in the class.
15. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1 14

Thermodynamics of fluid flow: Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Sonic Velocity and Mach Number, overall isentropic efficiency, stage efficiency and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process Preheat factor for compression. **Flow through Nozzles and Blade passages:** Introduction, steady flow through nozzles, Area changes in one-dimensional isentropic flow, Effects of friction in flow passages, characteristics of converging-diverging nozzles, flow of wet steam/gas through nozzles, diffusers.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board
Module-2	
Two-dimensional Cascades: Introduction, Cascade nomenclature, Analysis of cascade forces, Energy losses, Lift and drag, Circulation and lift, Efficiency of a compressor cascade, Performance of two-dimensional cascades, The cascade wind tunnel, Cascade test results, Compressor cascade performance, Turbine cascade performance, Compressor cascade correlations, Fan blade design (McKenzie), Turbine cascade correlation (Ainley), Comparison of the profile loss in a cascade and in a turbine stage, Optimum space-chord ratio of turbine blades (Zweifel)	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board
Module-3	
Analysis of Axial-flow Turbines: Introduction, work done, Velocity diagrams of the axial turbine stage, Thermodynamics of the axial turbine stage, Stage losses and efficiency, Soderberg's correlation, Types of axial turbine design, Stage reaction, Diffusion within blade rows, Choice of reaction and effect on efficiency, Design point efficiency of a turbine stage, Maximum total-to-static efficiency of a reversible turbine stage, Stresses in turbine rotor blades, Turbine flow characteristics.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board
Module-4	
Analysis of Axial-flow Compressors and Fans Introduction, Two-dimensional analysis of the compressor stage, Velocity diagrams of the compressor stage, Thermodynamics of the compressor stage, Stage loss relationships and efficiency, Reaction ratio, Choice of reaction, Stage loading, Simplified off-design performance, Stage pressure rise, Pressure ratio of a multistage compressor, Estimation of compressor stage efficiency, surge, choking and Stall phenomena in compressors, Control of flow instabilities, Axial-flow ducted fans, Blade element theory, Blade element efficiency, Lift coefficient of a fan aerofoil, blade twist and design considerations for supersonic flow.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board
Module-5	

Three-dimensional Flows in Axial Turbomachines:
Introduction, Theory of radial equilibrium, the indirect problem, the direct problem, Compressible flow through a fixed blade row, Constant specific mass flow, Off-design performance of a stage, Blade row interaction effects, Secondary flows.
Testing and control of Turbo Machines: Performance testing, noise control, speed control, throttling control at discharge and inlet and maintenance of fans, blowers, compressors and turbines.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/White board

Course outcome (Course Skill Set)

After learning the course, the students will be able to:

1. Explain the various thermodynamic processes involved in turbomachines with the application of 1st and 2nd law of Thermodynamics and also apply of the concept of law of conservation of energy for the flow through nozzle and diffuser.
2. Demonstrate the concept of two-dimensional cascading and evaluating the cascade performance in compressor and turbines.
3. Explain the thermodynamics of axial flow turbines and analyse its performance and characteristics.
4. Explain the thermodynamics of axial flow compressor and fans and analyse its performance and characteristics.
5. Explain and apply the various vortex flow concepts for designing the blades and describe the process of control and maintenance aspects of turbomachines.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

104. First test at the end of 5th week of the semester
105. Second test at the end of the 10th week of the semester
106. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

107. First assignment at the end of 4th week of the semester
108. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

109. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods/question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

60. The question paper will have ten questions. Each question is set for 20 marks.
61. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
62. The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Text Books:

1. Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier, 2005
2. Principals of Turbo machines, D. G. Shepherd, The Macmillan Company, 1964
3. A text of Turbo machines, M. S. Govinde Gowda and A. M. Nagaraj, M. M. Publications, 7th Edn, 2012

Reference Books:

1. Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd, 2nd edition, 2002
2. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008
3. Fundamentals of Turbo machinery, William W Perg, John Wiley & Sons
4. A Treatise on Turbo Machines, G.Gopal Krishnan & D.Prithviraj, Sci Tech Publishers,
5. Theory and practice of Steam Turbines/ WJ Kearton/ELBS Pitman/London

Web links and Video Lectures (e-Resources):

- http://nptel.ac.in/
- VTU, E- learning
- MOOCS
- Open courseware

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning
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7 Semester

PRODUCT DESIGN & ERGONOMICS			
Course Code	**21ME744**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understanding the user-centred design process including form and colour theory.
- Understanding product metamorphosis, and ergonomics..
- Implement the principles of ergonomics and how to apply the principles to industrial design.
- Understand the importance and techniques of human biological data collection and experiments.
- Obtain a knowledge and ability towards Accident Investigation and Safety Management.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to Product Design: Asimows Model : Definition of product design, Design by Evaluation, Design by Innovation, Essential Factors of Product Design, Flow and Value Addition in the Production-Consumption Cycle. The Morphology of Design (The seven Phase), Primary Design phase and flowcharting, role of Allowance, Process Capability.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Ergonomics and Industrial Design: Introduction -general approach to the man- machine relationship- workstation design-working position.

Ergonomics and Production: ergonomics and product design –ergonomics in automated systems- expert systems for ergonomic design. Anthropometric data and its applications in ergonomic, design- limitations of anthropometric data- use of computerized database. Case study.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Aesthetic Concepts: Concept of unity- concept of order with variety - concept of purpose style and environment- Aesthetic expressions. Style components of style- house style, observation style in capital goods, case study.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Visual Effects of Line and Form: The mechanics of seeing- psychology of seeing general influences of line and form.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-5

Office Systems and Ergonomics, Ergonomics of Technology Management. Consumer Ergonomics, Ergonomics Quality and Safety, Quality of Life

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

24. To learn the concept of product design and the ergonomics.
25. Design the various controls and displays by knowing the anthropometric data's.
26. To learn the psychology of visuals effects.
27. Learning the different colour combinations for optimal design of engineering equipments.
28. Realize the importance of environmental factors and aesthetics in industrial design.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

110. First test at the end of 5th week of the semester
111. Second test at the end of the 10th week of the semester
112. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

113. First assignment at the end of 4th week of the semester
114. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

115. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

63. The question paper will have ten questions. Each question is set for 20 marks.
64. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

1. Human Factors in Engineering and Design By Sanders & Mccormick (McGrawHill Publication)
2. Occupational Ergonomics – Principles and Applications By Tayyari & Smith (Chapman & Hall Publication)
3. The Power of Ergonomics as a Competitive Strategy By Gross & Right (Productivity Press)
4. Industrial Design for Engineers - Mayall W.H. - London Hiffee books Ltd. -1988.
5. Applied Ergonomics Hand Book - Brain Shakel (Edited) - Butterworth scientific. London - 1988. 6. Introduction to Ergonomics - R. C. Bridger - McGraw Hill Publications - 1995.
6. Human Factor Engineering - Sanders & McCormick – McGraw Hill Publications – 6th edition, 2002.
7. Ulrich, Karl T, Eppinger, Steven D, 'Product Design and Development', McGraw-Hill, 2004.

8. Bridger RS, 'Introduction to Human Factors & Ergonomics', Fourth Edition, Taylor & Francis, 2010.
9. Dul. J and Weerdmeester B, 'Ergonomics for beginners, a quick reference guide, Taylor & Francis, 2008

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Anthropometry
- Hand strength and Back strength
- Measurement of Environmental Factors
- Grip Strength – Hand and Pinch

VII Semester **OPEN ELECTIVE II**

NON-TRADITIONAL MACHINING			
Course Code	**21ME751**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To learn various concepts related to modern machining processes & their applications.
- To appreciate the differences between conventional and non-conventional machining processes.
- To acquire a functional understanding of non-traditional manufacturing equipment.
- To know about various process parameters and their influence on performance and their applications.
- To impart knowledge on various types of energy involved in non-traditional machining processes.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

16. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
17. Chalk and Talk method for Problem Solving.
18. Adopt flipped classroom teaching method.
19. Adopt collaborative (Group Learning) learning in the class.
20. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters:
Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material.
Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.

Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

ELECTROCHEMICAL MACHINING (ECM): Introduction, Principle of electro chemical machining, ECM, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM:
Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

CHEMICAL MACHINING (CHM): Elements of the process, Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-4	
ELECTRICAL DISCHARGE MACHINING (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM. PLASMA ARC MACHINING (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-5	
LASER BEAM MACHINING (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations. ELECTRON BEAM MACHINING (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Understand the compare traditional and non-traditional machining process and recognize the need for Non-traditional machining process.
- Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.
- Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.
- Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.
- Understand the LBM equipment, LBM parameters, and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

116. First test at the end of 5th week of the semester
117. Second test at the end of the 10th week of the semester
118. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

119. First assignment at the end of 4th week of the semester
120. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

121. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

65. The question paper will have ten questions. Each question is set for 20 marks.
66. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1 Modern Machining Process by P.C Pandey and H S Shah McGraw Hill Education India Pvt. Ltd. 2000

2 Production technology HMT McGraw Hill Education India Pvt. Ltd 2001

Reference Books

1 New Technology Dr. Amitabh Bhattacharyya The Institute of Engineers (India) 2000

2 Modern Machining process Aditya 2002

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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Course Code	21ME752	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

This course will enable students to:

- Gain knowledge of basics of hydraulic and pneumatic systems.
- Understanding the working principles of hydraulics and pneumatics components.
- Engineering application of hydraulic and pneumatic systems.

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to Hydraulic Power: Definition of hydraulic system, advantages, limitations, applications, Pascal's law, structure of hydraulic control system, problems on Pascal's law.

The source of Hydraulic Power: Pumps Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump Selection factors, problems on pumps.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration. 3. Chalk and Talk .

Module-2

Hydraulic Actuators and Motors: Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, mounting arrangements, cushioning, special types of cylinders, problems on cylinders, construction and working of rotary actuators such as gear, vane, piston motors, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems, symbolic representation of hydraulic actuators (cylinders and motors).

Control Components in Hydraulic Systems: Classification of control valves, Directional Control Valves- Symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, check valves, Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration. 3. Chalk and Talk .

Module-3

Hydraulic Circuit Design And Analysis: Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Double Pump Hydraulic System, Counter balance Valve Application, Hydraulic Cylinder Sequencing Circuits, Automatic cylinder reciprocating system, Locked Cylinder using Pilot check Valve, Cylinder synchronizing circuit using different methods, factors affecting synchronization, Speed Control of Hydraulic Cylinder, Speed Control of Hydraulic Motors, Safety circuit, Accumulators, types, construction and applications with circuits.

Maintenance of Hydraulic System: Hydraulic Oils - Desirable properties, general type of Fluids, Sealing Devices, Reservoir System, Filters and Strainers, wear of Moving Parts due to solid - particle Contamination,temperature control (heat exchangers), Pressure switches, trouble shooting.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration. 3. Chalk and Talk .

Module-4

Introduction to Pneumatic Control: Definition of pneumatic system, advantages, limitations, applications, Choice of working medium Characteristic of compressed air. Structure of Pneumatic control System,fluid conditioners and FRL unit. Pneumatic Actuators: Linear cylinder - Types, Conventional type of cylinder- working, End position cushioning, seals, mounting arrangements- Applications. Rod - Less cylinders types, working, advantages, Rotary cylinders- types construction and application, symbols.

Pneumatic Control Valves: DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and Exhaust air throttling and Exhaust air throttling.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration. 3. Chalk and Talk .

Module-5

Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications. Practical Examples involving the use of logic gates, Pressure dependant controls- types - construction - practical applications, Time dependent controls principle, Construction, practical applications.

Multi- Cylinder Application: Coordinated and sequential motion control, Motion and control diagrams. Signal elimination methods, Cascading method- principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves).

Electro- Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of directional control valves, Use of relay and contactors. Control circuitry for simple signal cylinder application.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration. 3. Chalk and Talk .

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

29. Have knowledge of hydraulic and pneumatic system and its components.
30. Understand the working principle of various hydraulic and pneumatic components.
31. Apply working principles of Hydraulic and Pneumatic Systems for various applications.
32. Determine cause for hydraulic and pneumatic system break down and performance of hydraulic pumps, motors.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

122. First test at the end of 5th week of the semester
123. Second test at the end of the 10th week of the semester
124. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

125. First assignment at the end of 4th week of the semester
126. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

127. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

67. The question paper will have ten questions. Each question is set for 20 marks.
68. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Textbooks

4. Fluid Power with Applications, Anthony Esposit, Pearson Education Inc., 6th Edition 2000.
5. Pneumatics and Hydraulics, Andrew Parr, Jaico Publishing Co, 1993.

Reference books

3. Industrial Hydraulics, Pippenger Hicks, McGraw Hill, New York
4. Hydraulic & Pneumatic Power for Production, HarryL. Stewart, Industrial Press US, 1997.
5. Pneumatic Systems, S. R. Majumdar, TATA McGraw Hill Publish, 1995.
6. Hydraulic & Pneumatics' CMTI Data Book.

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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OPERATIONS RESEARCH			
Course Code	21ME753	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
- To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

21. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
22. Chalk and Talk method for Problem Solving.
23. Adopt flipped classroom teaching method.
24. Adopt collaborative (Group Learning) learning in the class.
25. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and two-phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

Teaching-Learning Process	. 1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. Assignment Problem-Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-4

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems.

Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board
Module-5	
Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulation of games. Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of 2 jobs on 'm' machines using graphical method.	
Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

- Understand the meaning, definitions, scope, need, phases and techniques of operations research.
- Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
- Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
- Solve problems on game theory for pure and mixed strategy under competitive environment.
- Solve waiting line problems for M/M/1 and M/M/K queuing models.
- Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks

Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3 machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

128. First test at the end of 5th week of the semester
129. Second test at the end of the 10th week of the semester
130. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

131. First assignment at the end of 4th week of the semester
132. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

133. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

69. The question paper will have ten questions. Each question is set for 20 marks.
70. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Textbook/s

1 Operations Research P K Gupta and D S Hira S. Chand and Company LTD. Publications, New Delhi 2007
2 Operations Research, An Introduction Hamdy A. Taha PHI Private Limited Seventh Edition, 2006

Reference Books

1 Operations Research, Theory and Applications J K Sharma Trinity Press, Laxmi Publications Pvt.Ltd. Sixth Edition, 2016
2 Operations Research Paneerselvan PHI
3 Operations Research A M Natarajan, P Balasubramani Pearson Education, 2005
4 Introduction to Operations Research Hillier and Lieberman McGraw Hill 8thEd

Web links and Video Lectures (e-Resources):

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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