BMS COLLEGE OF ENGINEERING, BENGALURU
Autonomous College under VTU

VISION
Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION
Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

SECOND YEAR SYLLABUS BOOK
With effect from A. Y. 2015 – 16

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DEPARTMENT VISION
To become a center of excellence in educating students to become successful Mechanical Engineers

DEPARTMENT MISSION
• To empower the students with the fundamentals for a successful career in the field of Mechanical engineering.
• To continue their education through post-graduation, Research & Development.
• To provide service to the society.

PROGRAM EDUCATIONAL OBJECTIVES
1. PEO1 - Graduates shall have successful careers as Mechanical Engineers, lead & manage teams.
2. PEO2 - Graduates shall be professional in engineering practice and socially responsible
3. PEO3 - Graduates shall be pursuing advanced education, research and engage in the process of life-long learning.

PROGRAM OUTCOMES

<table>
<thead>
<tr>
<th>PO</th>
<th>ABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO 1</td>
<td>Ability to apply knowledge of mathematics, science, and Mechanical engineering fundamentals to solve complex problems in engineering</td>
</tr>
<tr>
<td>PO 2</td>
<td>Ability to analyze mechanical engineering problems, interpret data and arrive at meaningful conclusions involving mathematical inferences</td>
</tr>
<tr>
<td>PO 3</td>
<td>Ability to design a mechanical system, component, or process to meet desired needs considering public health and safety, and the cultural, societal, and environmental considerations.</td>
</tr>
<tr>
<td>PO 4</td>
<td>Ability to understand and solve complex mechanical engineering problems by conducting experimental investigations.</td>
</tr>
<tr>
<td>PO 5</td>
<td>Ability to apply appropriate tools and techniques and understand utilization of resources appropriately to complex mechanical engineering activities.</td>
</tr>
<tr>
<td>PO 6</td>
<td>Ability to understand the effect of mechanical engineering solutions on legal, cultural, social and public health and safety aspects.</td>
</tr>
<tr>
<td>PO 7</td>
<td>Ability to develop sustainable solutions and understand their effect on society and environment.</td>
</tr>
<tr>
<td>PO 8</td>
<td>Ability to apply ethical principles to engineering practices and professional responsibilities.</td>
</tr>
<tr>
<td>PO 9</td>
<td>Ability to work as a member of a team, to plan and to integrate knowledge of various engineering disciplines and to lead teams in multidisciplinary settings.</td>
</tr>
<tr>
<td>PO 10</td>
<td>Ability to make effective oral presentations and communicate technical ideas to a broad audience using written and oral means</td>
</tr>
<tr>
<td>PO 11</td>
<td>Ability to lead and manage multidisciplinary teams by applying engineering and management principles.</td>
</tr>
<tr>
<td>PO 12</td>
<td>Ability to adapt to the changes and advancements in technology and engage in independent and life-long learning</td>
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## DEPARTMENT OF MECHANICAL ENGINEERING

Scheme & Syllabus for UG Programme - III & IV Semesters

### SCHEME OF INSTRUCTION FOR THIRD SEMESTER

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Code</th>
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<td>15MA3GC MAT</td>
<td>ENGINEERING MATHEMATICS-3</td>
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<td>3</td>
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<tr>
<td>4</td>
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<td>FOUNDRY AND WELDING TECHNOLOGY</td>
<td>3  0  1  0  4</td>
</tr>
<tr>
<td>5</td>
<td>15ME3DC BTD</td>
<td>BASIC THERMODYNAMICS</td>
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<tr>
<td>6</td>
<td>15ME3DC FME</td>
<td>FLUID MECHANICS</td>
<td>3  0  1  2  6</td>
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### SCHEME OF INSTRUCTION FOR FOURTH SEMESTER

<table>
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<td>APPLIED THERMODYNAMICS</td>
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<tr>
<td>3</td>
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<td>KINEMATICS OF MACHINES</td>
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<td>4</td>
<td>15 ME4DC DM1</td>
<td>DESIGN OF MACHINE ELEMENTS-I</td>
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<tr>
<td>5</td>
<td>15ME4DC MTM</td>
<td>MACHINE TOOLS &amp; MACHINING</td>
<td>3  0  1  2  6</td>
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<td>6</td>
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<td>18  1  2  4  25</td>
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### NOTATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AY</td>
<td>Academic Year</td>
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<tr>
<td>AAT</td>
<td>Alternative Assessment Tools</td>
</tr>
<tr>
<td>BOE</td>
<td>Board of Examiners</td>
</tr>
<tr>
<td>BOS</td>
<td>Board of Studies</td>
</tr>
<tr>
<td>CBCS</td>
<td>Choice Based Credit System</td>
</tr>
<tr>
<td>CGPA</td>
<td>Cumulative Grade Point Averages</td>
</tr>
<tr>
<td>CIE</td>
<td>Continuous Internal Evaluation</td>
</tr>
<tr>
<td>CO</td>
<td>Course Outcomes</td>
</tr>
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<td>DC</td>
<td>Departmental Core</td>
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<td>GC</td>
<td>Group Core</td>
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<td>HSS</td>
<td>Humanity and Social Science courses</td>
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<tr>
<td>IC</td>
<td>Institutional Core</td>
</tr>
<tr>
<td>IE</td>
<td>Institutional Elective</td>
</tr>
<tr>
<td>IL</td>
<td>Institutional Lab</td>
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<tr>
<td>LTPS</td>
<td>Lecture-Tutorial-Practical-Self Study</td>
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<td>NFTE</td>
<td>Not Fit for Technical Education</td>
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<tr>
<td>PCC</td>
<td>Professional Core Courses</td>
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<tr>
<td>PEC</td>
<td>Professional Elective Courses</td>
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<td>PO</td>
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<td>SEE</td>
<td>Semester End Examination</td>
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<td>SGPA</td>
<td>Semester Grade Point Average</td>
</tr>
<tr>
<td>ST</td>
<td>Studio</td>
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</table>
ASSESSMENT:

**Continuous Internal Evaluation (CIE)** includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

**Semester End Examination (SEE)** - A written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce).

Both CIE and SEE have equal (50:50) weightage. The Student’s performance in a course shall be judged individually and together based on the results of CIE and SEE.

**Breakup of CIE Components for Courses in General:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Test-1</th>
<th>Test-2</th>
<th>Quiz-1/AAT</th>
<th>Quiz-2/AAT</th>
<th>Total Marks</th>
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</thead>
<tbody>
<tr>
<td>Maximum Marks</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td>10</td>
<td>100</td>
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</table>

**Breakup of CIE Components for Integrated Courses:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Theory</th>
<th>Practical</th>
<th>Total Marks</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Test-1</td>
<td>Test-2</td>
<td>Quiz/AAT</td>
</tr>
<tr>
<td>Maximum Marks</td>
<td>20</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

**Breakup of CIE Components for Comprehensive Courses:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Theory</th>
<th>Practical</th>
<th>Self-Study</th>
<th>Total Marks</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Test-1</td>
<td>Test-2</td>
<td>Quiz/AAT</td>
<td>Lab Performance / Record</td>
</tr>
<tr>
<td>Maximum Marks</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

**Note:**

Alternate Assessment Tools, if any, will be announced by concerned Faculty at the beginning of the semester.

In case of Alternative Assessment Tools (such as term papers, assignments, problem solving, micro-projects, seminars, MOOCs etc.,) being used by a faculty for a particular course, a maximum of 40% of the total CIE marks can be utilized.
III Semester Syllabus
Course Credits: 03 Marks

<table>
<thead>
<tr>
<th>Name</th>
<th>Engineering Mathematics - 3</th>
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</thead>
<tbody>
<tr>
<td>Code</td>
<td>15MA3GCMAT</td>
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</tbody>
</table>

PRE-REQUISITES: Basic concepts of Trigonometry, Trigonometric formulas, methods of differentiation, methods of integration, partial derivatives, solution to ordinary differential equations.

SYLLABUS:

UNIT-1

Matrices

Suggested Reading: Inverse of a matrix using Gauss-Jordan method. Largest eigenvalue and corresponding eigenvector using Rayleigh power method.

8 hours

UNIT-2

Fourier Series
Introduction: Periodic function, Dirichlet’s condition, statement of Fourier Theorem, Fourier series of a periodic function of period 2l, Fourier series of functions having points of discontinuity.
Applications: Fourier series of typical waveforms—saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform. Practical harmonic analysis.

Suggested Reading: half range Fourier series, Fourier series of discrete functions, Complex Fourier series.

7 hours

UNIT-3

Partial Differential Equations
Applications: One-dimensional heat equation and wave equation (without proof), various possible solutions of these by the method of separation of variables.

Suggested Reading: Direct integration method, method of separation of variables, D’Alembert’s solution of wave equation.

7 hours
UNIT-4

Fourier Transforms

Suggested Reading: Convolution theorem, Parseval’s identities and physical significance of Parseval’s identities. 

UNIT-5

Calculus of Variations

Suggested Reading: Minimal surface of revolution, Geodesics of a right circular cone and sphere.

Mathematics Lab
• Solution of system of algebraic equations using Gauss Seidel method
• LU decomposition of matrices.
• Eigenvalues and eigenvectors of matrices.
• Largest eigenvalue, smallest eigenvalue and corresponding eigenvectors of a matrix.

REFERENCES:

Text Books

Reference Books

E-Books / Web References
   http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.
3. http://ocw.mit.edu/courses/mathematics/ (online course material)

MOOCs
1. http://nptel.ac.in/courses.php?disciplineId=111
2. https://www.khanacademy.org/
3. https://www.class-central.com/subject/math (MOOCs)
4. E-learning: www.vtu.ac.in

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Compute solution of a system of algebraic equations. |
| CO 2 | Demonstrate an understanding to Fourier series and Fourier transforms. |
| CO 3 | Formulate boundary value problems involving one dimensional heat and wave equation. |
| CO 4 | Employ analytical techniques to solve partial differential equations with appropriate boundary conditions. |
| CO 5 | Obtain the extremal of a functional. |

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from units 1, 2, 5 and two questions each from units 3 & 4.
PRE-REQUISITES:
Concepts of unit cell, space lattice, Unit cells for cubic crystals (Simple cubic, BCC & FCC) and HCP structure and calculations of radius, Coordination Number and Atomic Packing Factor. Miller indices, Point, line, surface defects and volume defects.

SYLLABUS:

UNIT – 1

**Mechanical behaviour:** Stress strain diagram for ductile and brittle materials, linear and non-linear elastic properties, properties in plastic range, engineering stress-strain and true stress & strain with problems

**Plastic deformation:** Slip & twinning, critically resolved shear stress, strain hardening, Bauschinger’s effect, strain ageing, recovery, recrystallization and grain growth.

**Diffusion in solids:** Diffusion Mechanism, Fick’s laws of diffusion, Factors affecting diffusion

06 Hours

**Fracture:** Brittle and ductile facture, Griffith’s criterion.

**Creep:** Creep curve, creep mechanism, factors affecting creep and creep test.

**Fatigue:** Fatigue cycles, Fatigue test, SN curve, Fatigue mechanism, Factors affecting fatigue life.

05 Hours

UNIT – 2

**Solidification** - Nucleation and grain growth in pure metals and alloys during freezing.

**Solid solutions:** Types of solids solutions, Rules for governing the formation of solid solutions and intermediate phases

**Cooling curves and phase diagrams:** Construction of phase diagrams, Gibbs phase rule and Lever rule, Phase diagrams of Isomorphous, Eutectic, Eutectoid, Peritectic and Peritectoid systems. Problems on Isomorphous and Eutectic systems.

06 Hours

UNIT – 3

**Iron- Iron carbide equilibrium diagram:** Equilibrium phases, invariant reactions, critical temperatures, slow cooling of steels (hypo, hyper and eutectoid steels).

**TTT diagram:** Construction of TTT diagram, TTT diagram for eutectoid, hypo and hyper eutectoid steels, continuous cooling curves, Effect of
alloying elements on steels

UNIT – 4
Heat treatment processes: Annealing and its types, normalizing, hardening, tempering, martempering, austempering, surface heat treatment methods and heat treatment of Non-ferrous materials (dispersion hardening and precipitation hardening)

Classification of materials, Ferrous materials: Composition, properties and applications of low, medium and high carbon steels, alloy steels, stainless steels and designation of steels.
Cast irons: Types, Composition, Properties and applications of Grey, Malleable, Nodular and White cast irons.
Non-ferrous materials: Aluminium and its alloys, Copper and its alloys, Titanium and its alloys
Polymers: Properties, types and applications
Ceramics: Properties, types and applications

UNIT – 5
Composite Materials: Definition, classification, properties and applications of FRP composites, MMCs and Ceramic composites.
Production methods of FRP Composites (Pultrusion, filament winding, hand lay-up, Autoclave/ Vacuum bag processes and Spray forming processes) and MMCs (Powder metallurgy, Stir casting, Squeeze casting and In-situ methods).

REFERENCES:

Text Books
2. Foundation of Material Science and Engineering, Smith, McGraw Hill

Reference Books

E-Books / Web References
   (http://phindia.com/bookdetails/materials-science-and-engineering-
   raghavan-v--isbn-978-81-203-5092-2)
3. http://nptel.ac.in/courses/Webcourse-
   contents/IIScBANG/Material%20Science/New_index1.html
   (https://iimtstudies.files.wordpress.com/2014/03/material-
   sciencekakani-2004.pdf)

MOOCs
1. https://legacy.saylor.org/me203/Intro/
2. https://courses.edx.org/courses/MITx/3.032x/3T2014/courseware/fa1
   56567e80a483ab833f2b1a581923c/8a344b60a6c04f8da5ebda9a0a7c40
   2e/

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Analyse the concepts of mechanical behaviour of materials and their testing. |
| CO 2 | Apply the concepts of solid solutions, cooling curves and phase diagrams. |
| CO 3 | Understand the concepts of Iron- Iron carbide equilibrium diagram and TTT diagrams. |
| CO 4 | List and Discuss ferrous and non-ferrous materials and their heat treatment processes. |
| CO 5 | Understand the various types, properties, applications and production methods of Composite materials. |

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from units 2, 3 and 5 and two questions each from units 1 and 4.
Course Credits : 06 Marks
Name Strength Of Materials L T P S CIE SEE
Code 15ME3DCSOM 3 0 1 2 100 100

PRE-REQUISITES:
1. Engineering Mechanics - Statics
2. Engineering Mathematics - Calculus

SYLLABUS:

UNIT – 1
Simple stress and strain: Introduction, stress, strain, mechanical properties of materials, Linear elasticity, Hooke’s Law and Poisson’s ratio, Stress-Strain behaviour in Tension for Mild steel and non-ferrous metals. Extension / Shortening of a bar, bars with cross sections varying in steps, bars with continuously varying cross sections (circular and rectangular), Principle of super position. Elongation due to self-weight for constant cross section, simple shear stress, shears strain, elastic constants and their relations. Stress in composite section subjected to external loads and temperature change, volumetric strain. 06 Hours

Compound stresses: Introduction, plane stress, stresses on inclined sections, principal stresses and maximum shear stresses, Graphical Method - Mohr’s circle for plane stress. 03 Hours

UNIT – 2
Bending moment and Shear forces in beams: Introduction, Types of beams, loads and reactions, shear forces and bending moments, rate of loading, sign conventions, relationship between shear force and bending moments, shear force and bending moment diagrams for different beams subjected to concentrated loads, uniformly distributed load, couple of different types of beams. 05 Hours

UNIT -3
Bending and shear stresses in beams: Introduction, theory of simple bending, assumptions in simple bending, relationship between bending stresses, radius of curvature and bending moment, moment carrying capacity of a section, shearing stresses in beams, shear stress across rectangular, circular. 05 Hours

Deflection of beams: Introduction, differential equation for deflection, equations for deflections, slope and moments, double integration method for cantilever and simply supported beams for point loads, UDL and Couple, Macaulay’s method. 05 Hours

UNIT - 4
Torsion of circular shafts: Introduction, pure torsion, assumptions,
derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts, power transmitted by solid and hollow circular shafts.

**05 Hours**

**UNIT - 5**

**Thick and Thin cylinders:** Stresses in thin cylinders, Lame’s equation for thick cylinders subjected to internal and external pressures, Changes in dimensions of cylinder (diameter, length and volume), Simple Numericals.

**05 Hours**

**Columns and Struts:** Introduction, Euler’s formula for critical load of columns for different end conditions, limitations of Euler’s theory, Rankine’s formula. Simple Numericals.

**05 Hours**

**Self-Study:** Students have to learn on their own, concepts related to the course suggested by course-faculty. Students’ work will be assessed by a committee for CIE.

**REFERENCES:**

**Text Books**

**Reference Books**

**E-Books / Web References**
MOOCs
1. https://www.edx.org/course/mechanical-behavior-materials-mitx-3-032x

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
Two questions each to be set from Units 1 and 3 and one question from units 2, 4, and 5.

STRENGTH OF MATERIALS LAB

List of Experiments

PART-A
1. Tensile, Shear and Compression tests of metallic specimen using Universal Testing Machine
2. Torsion test, Bending test on metallic specimen
3. Izod and Charpy test on various specimens
4. Brinell and Vicker’s hardness test on various specimens

PART-B
3. Demo on Non-destructive tests such as: Magnetic crack detection and Dye penetration testing to study the defects of casted and welded specimens.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Understand the basic concepts of stress and strain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Investigate various structural members subjected to different loading conditions.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Evaluate cylindrical shafts subjected to torsional loads.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyse cylindrical pressure vessels under various loadings.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Determine mechanical properties of materials related to tensile, compression, torsion, impact, bending and hardness.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Identify and evaluate microstructures of different materials.</td>
</tr>
<tr>
<td>CO 7</td>
<td>Understand heat treatment and Non Destructive Testing concepts.</td>
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## Course Information

<table>
<thead>
<tr>
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<th>Credits : 04</th>
<th>Marks</th>
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<tbody>
<tr>
<td>Name</td>
<td>Foundry and Welding Technology</td>
<td>L  T  P  S</td>
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<tr>
<td>Code</td>
<td>15ME3DCFWT</td>
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</tbody>
</table>

### PRE-REQUISITES:
1. Elements of Mechanical Engineering
2. Engineering Physics

### SYLLABUS:

#### UNIT-1

**Manufacturing process:** Introduction to basic manufacturing, Classification of manufacturing process, Applications.

**Metal Casting:** Introduction about metal casting, steps involved in making casting, Advantages and limitations, Applications.

**Pattern making:** Functions of pattern, Classification of pattern, Different pattern materials, various pattern allowances in design of pattern, Simple problems in design of pattern.

**Mould making:** Types of moulds, Mould making, Desirable properties of Sand mould.

**Core making:** Functions of cores, important factors in core design and making.

**Defects in casting:** Introduction, types of defects, causes and remedies.

#### UNIT-2

**Moulding sand ingredients:** Types of base sand, Properties of base sand, Types of binders and its functions, various types of additives and its functions.

**Gating system:** Concept of gating system, different types of gating systems, gating system design, risering design, numericals on gating and risering design.

**Solidification:** Solidification of pure metal and alloy, Mechanisms of solidification, types of nucleation, grain structures. Progressive and directional solidification, solidification variables. Methods of achieving directional solidification.

#### UNIT-3

**Special casting processes:** Shell moulding, investment casting, Gravity die casting, Pressure die casting, Centrifugal casting, Slush casting, Continuous casting, Injection moulding.

**Melting Furnaces:** Types of furnaces, constructional features & working of Cupola, Resistance furnace, Electric Arc furnace, Induction furnace.
UNIT-4

**Welding:** Weldability, Different types of weld joints, TIG Welding & MIG Welding, Laser Beam Welding, Friction stir welding, Explosive welding, Resistance welding, Thermit welding.

**Metallurgical aspect of Welding:** Metallurgical effects of welding, weld metal solidification, formation of different weld zones, Weld cracking, Corrosion of weld, defects in welding & remedies.  

7 Hours

UNIT-5

**Powder Metallurgy:** Introduction to powder metallurgy, Preparation of powders (Atomization, Electrolysis, and Granulation Process, Mechanical Alloying), Powder Blending, Powder Compaction, Sintering. Finishing operations, application of powder metallurgy products, advantages and limitations.  

5 Hours

REFERENCES:

**Text books**

**References**

**E-Books / Web References**
   (https://books.google.co.in/books?id=NOotk64Grx0C&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false)
4. http://efoundry.iitb.ac.in/Academy/index.jsp
5. http://nptel.ac.in/courses/112107145/

**Foundry and Sand Testing Lab component:**

- a) Lab exercises in Sand Testing Lab
- b) One Model involving Sand Casting

**Scheme of Examination (SEE):**

**SEE:** Answer five full questions selecting one from each unit.
Two questions each to be set from unit 1 & 2 and One question each from unit 3, 4 & 5

**Foundry and Sand Testing Lab**

**List of Experiments of lab component**

**Part A:**

Testing of molding sand and core sand
1. Compression, shear and permeability tests on green sand specimen
2. Tension and bending tests on core sand specimen
3. Sieve analysis to find grain fineness number of base sand
4. Clay content test

**Part B:**

1. Use of foundry tools and other equipments
2. Preparation of moulds using two moulding boxes with and without patterns (Split pattern, Core boxes)
3. Production of metal component using sand casting

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Understand fundamentals of foundry.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Understand sand moulding processes and the design of gating systems and risering.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Understand melting concepts and welding fundamentals.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Understand metallurgical aspects of welding and fundamentals of powder metallurgy.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Understand the importance of different test carried out on moulding sand and prepare casted component.</td>
</tr>
</tbody>
</table>
Course Credits : 04 Marks
Name Basic Thermodynamics L T P S CIE SEE
Code 15ME3DCBTD 3 1 0 0 100 100

PRE-REQUISITES:
1. Engineering Mathematics
2. Engineering Physics
3. Engineering Chemistry

SYLLABUS:

UNIT - 1
Introduction: Macroscopic and Microscopic approaches, Thermodynamic system: control volume and control mass, properties, process and cycles, Homogeneous & Heterogeneous systems, Thermodynamic Equilibrium, Quasi-static process, pure substance, Concept of continuum.
Temperature: Zeroth Law of Thermodynamics, Measurement of Temperature, Reference points, Ideal gas Temperature, Celsius Temperature scale and International Practical Temperature scale.
Work & Heat: Work transfer, pdV-work or displacement work, different forms of work transfer, Net work done by a system, Heat transfer-A path function, Specific heat and Latent heat. 10 hours

UNIT – 2
First Law of Thermodynamics: For a process, applied to closed and open systems undergoing a cycle, Steady Flow Energy Equation (SFEE). Enthalpy, Specific heat at constant volume, and at constant pressure, Energy of an isolated system, PMM1 and Limitations of the First Law. 06 hours

UNIT – 3
Second Law of Thermodynamics: Cyclic Heat engine, Kelvin-Planck and Clausius statements, Refrigerator and Heat pump, Equivalence of Kelvin-Planck and Clausius statements, Reversibility and Irreversibility, Causes for Irreversibility, Reversed Heat engine, Carnot’s Theorem, Absolute Thermodynamic Temperature scale, Efficiency of the Reversible heat engine, Equality of Ideal gas Temperature & Kelvin Temperature. 06 hours

Entropy: Introduction, Two reversible adiabatic paths cannot interact each other, Clausius Theorem, The property of Entropy, Principle of Caratheodory, Clausius Inequality, Entropy change in reversible and Irreversible process, Entropy principle, Entropy generation in a closed system and open system, First & Second Laws combined relations, Reversible adiabatic work in a steady flow system. 05 hours
UNIT – 4

Real and ideal gases: Introduction; Vander Waal’s Equation and its constants in terms of critical properties, law of corresponding states, compressibility factor and chart. Ideal gas; equation of state, internal energy and enthalpy as functions of Temperature, universal and particular gas constants, specific heats, perfect and semi-perfect gases. Evaluation of heat, work, change in internal energy, enthalpy and entropy in various quasi-static processes. 

07 hours

UNIT – 5

Exergy Analysis: Available and unavailable energy, concept of availability, availability of heat source at constant and variable Temperatures, Availability for non-flow and steady flow systems, Helmholtz and Gibbs function, irreversibility and second law efficiency.

05 hours

REFERENCES:

Text Books

Reference Books

E-Books / Web References
3. http://nptel.ac.in/courses/112104113/
4. http://nptel.ac.in/courses/112108148/
5. http://nptel.ac.in/courses/112105123/

**MOOCs**
1. https://www.coursera.org/course/introthermodynamics
2. https://www.iitbombayx.in/courses/IITBombayX/ME209xA15/2015_T1/about
3. https://legacy.saylor.org/me103/Intro/

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Understand the fundamentals concepts of system, control volume, property, state, process &amp; cycle.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Understand and analyse the concept of work, heat and the relationship between them.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Understand feasibility of the process using Second law and Entropy.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Understand and analyse the role of Real and Ideal gases in Energy exchanges.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Understand the concept of Availability &amp; Irreversibility.</td>
</tr>
</tbody>
</table>

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
Two questions each to be set from units 1 & 3 and one question each from units 2, 4 & 5.
**Course Credits : 06 Marks**

<table>
<thead>
<tr>
<th>Name</th>
<th>Fluid Mechanics</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>S</th>
<th>CIE</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>15ME3DCFME</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**PRE-REQUISITES:**
1. Vector Calculus
2. Engineering Mechanics

**SYLLABUS:**

**UNIT – 1**

**Fluid Pressure and its Measurements:** Concept of continuum, Newton’s law of viscosity, Pascal’s law, hydrostatic Law, manometry (simple, differential, inverted and inclined manometers). **04 Hours**

**UNIT - 2**

**Hydrostatic Forces on surfaces:** Concepts of center of pressure along a horizontal plane, vertical plane and inclined plane surface submerged in static fluid.

**Buoyancy and Flotation:** Buoyancy, center of buoyancy, meta center and meta centric height (analytical method). **04 Hours**

**UNIT -3**

**Fluid Kinematics:** Types of flows, Eulerian and Lagrangian representation, velocity and acceleration fields, stream lines, streak lines, time line and path lines, material derivative, linear motion and deformation, angular deformation, vorticity, strain rate. **06 Hours**

**Fluid Dynamics:** Continuity equation in 3D (cartesian coordinate only), Newton’s second law along a streamline and normal to streamline, Euler equation of motion and reduction to Bernoulli equation, venturi meter, orifice meter and pitot tube, Navier stokes equation. **08 Hours**

**UNIT 4**

**Impact of jets:** Force exerted on stationary and moving plates- vertical, inclined and curved (symmetrical and unsymmetrical) **06 Hours**

Viscous flow through pipes: Major and minor losses, Hagen poiseuille equation **07 Hours**

**UNIT – 5**

**Dimensional Analysis:** Rayleigh’s method, Buckingham Π theorem, dimensionless numbers (Reynolds Number, Mach number, Froude Number, Weber's Number, Knudsen Number). **04 Hours**
Self-Study: Students have to learn on their own, concepts related to the course suggested by course-faculty. Students’ work will be assessed by a committee for CIE.

REFERENCES:

Text Books

Reference Books

E-Books / Web References
3. http://nptel.ac.in/courses/112104118/
4. http://nptel.ac.in/courses/112105171/
6. https://legacy.saylor.org/me201/Intro/

MOOCS
2. https://legacy.saylor.org/me201/Unit01/

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from units 1, 2 and 5 and two questions each from units 3 and 4.
FLUID MECHANICS LAB

Part A
1. Determination of Coefficient of Friction of flow through a pipe.
2. Determination of Minor losses in the pipe.
4. Discharge measurement using Orifice, Nozzle, Venturi meter and V-notch.

Part B
5. Pressure distribution on symmetrical and cambered airfoil
6. Pressure distribution on cylinder and Sphere
7. Velocity measurement using Pitot static tube.
8. Coefficient of Lift and Drag on streamlined and bluff bodies

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Understand the concept of fluid and measure the static forces of the fluids. |
| CO 2 | Understand and apply the concepts of pressure distribution and buoyancy. |
| CO 3 | Understand and apply Newton’s law of motion applied to fluid element & pressure measuring devices. |
| CO 4 | Understand the concepts of laminar and turbulent flow. |
| CO 5 | Understand the concept of dimensional analysis and usage of dimensional numbers. |
IV Semester Syllabus
Course Credits : 03 Marks
Name Engineering Mathematics-4 L T P S CIE SEE
Code 15MA4GCMAT 3 0 0 0 100 100


SYLLABUS:

UNIT-1
Numerical Methods
Applications: Application of numerical methods to engineering problems.

UNIT-2
Numerical Solution of Partial Differential Equations
Finite-Difference formulas to partial derivatives.
Applications: Solution of one-dimensional heat equation using 2-level formula and Schmidt explicit formula and Crank-Nicolson two-level implicit formula. Solution of one-dimensional wave equation using explicit three level formula and implicit scheme.

UNIT-3
Complex Analysis 1
Function of a complex variable, limits, continuity and differentiability of a complex valued function, Analytic functions, properties of analytic functions, Cauchy-Riemann equations in cartesian and polar form, construction of analytic functions by Milne-Thomson method, Conformal mapping - Transformations - \( w=z^2 \) and \( w = z + \frac{a^2}{z} \ (z \neq 0) \), Bilinear transformations.

Suggested Reading: Standard transformations \( w=c+z \), \( w = cz \), \( w=1/z \), properties of bilinear transformations
UNIT-4

Complex Analysis 2
Complex integration: Line integral, Problems on line integral, Cauchy’s theorem, Cauchy’s integral formula.
Complex series: Taylor’s, Maclaurin’s and Laurent’s series (without proof).

Applications: Use of harmonic function to a heat transfer problem.

UNIT-5

Statistics and Probability
Curve fitting – Principle of least squares, fitting a straight line, fitting of a parabola, fitting of exponential curves of the form $y = a b^x$, $y = ae^{bx}$. Correlation and regression. Probability distributions: Discrete distribution - Poisson distribution. Continuous distribution- normal distribution.
Suggested Reading: Fitting the curve $y = a x^b$, exponential distribution and uniform distribution

Mathematics Lab

• Newton-Raphson method
• Numerical integration
• Solution of ordinary differential equations
• Solution of one dimensional heat and wave equation.
• Curve fitting for a given data
• Correlation and regression for a bivariate distribution.
• Probability distributions.

REFERENCES:

Text Books

Reference Books

E-Books / Web References
   http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.
   MOOCs
   1. http://nptel.ac.in/courses.php?disciplineId=111
   2. https://www.khanacademy.org/

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>Calculate numerical solutions of algebraic equations, transcendental equations and ordinary differential equations.</td>
</tr>
<tr>
<td>CO 2</td>
<td>Compute solution of one dimensional heat and wave equation using finite difference techniques.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Construct analytic functions and evaluate real and complex integrals.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Apply the principles of least squares to fit a straight line, parabolic and exponential curve for a given data.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Estimate the relation between two variables and perform regression analysis.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Apply the basic principles of probability and probability distributions.</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE): 
Answer five full questions selecting one from each unit. 
To set one question each from units 2, 3, 5 and two questions each from units 1 & 4.
Course Credits : 03 Marks
Name Applied Thermodynamics L T P S CIE SEE
Code 15ME4DCATD 3 0 0 0 100 100

PRE-REQUISITES:
Basic Thermodynamics

SYLLABUS:

UNIT – 1
Gas Power cycles:
Carnot cycle, Air standard cycles: Otto cycle, Diesel cycle and Dual cycle, Brayton cycle.

UNIT - 2
Pure substances: Mechanism of steam formation: Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapour states of a pure substance with water as example, Enthalpy of change of phase (Latent heat), Dryness factor (quality), representation in P-T, P-V, T-S and H-S diagrams. Steam tables, High pressure Boilers: Benson Boiler, Lamont Boiler, Velox Boilers (process diagram only)

Vapour Power cycles: Rankine Cycle, Actual Vapour Cycle processes, Reheat cycle, Ideal Regenerative cycle, Regenerative cycle.

UNIT – 3
Refrigeration: Reversed Heat engine cycle, Vapour Compression refrigeration cycle, Vapor Absorption refrigeration cycle, Heat pump system, Gas cycle refrigeration (only Reversed Brayton cycle), refrigerant properties, Standard Refrigerants.

Psychrometry: Atmospheric air, psychrometric properties; Dry bulb Temperature, wet bulb Temperature, dew point Temperature, partial pressures, specific and relative humidity and the relation between the two Enthalpy and adiabatic saturation Temperature. Construction and Use of psychrometric chart, Analysis of various processes: heating, cooling, dehumidifying and humidifying and adiabatic mixing of stream of moist air.

UNIT – 4
Nozzles and Diffusers: Types and utility of nozzles, Flow of steam through nozzles, Effect of friction, Nozzle efficiency, Critical pressure conditions for
maximum discharge. First law applied to Nozzles and diffusers, h-s and T-S plots on Nozzles

UNIT – 5

REFERENCES:

Text Books

Reference Books

E-Books / Web References
3. http://www.nptel.ac.in/syllabus/112106133/
MOOCs
1. https://www.coursera.org/course/introthermodynamics
2. https://www.edx.org/course/thermodynamics-iitbombayx-me209-1x
3. https://legacy.saylor.org/me103/Intro

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Understand the thermodynamic cycles to use for a given application and source of heat |
| CO 2 | Develop ability to plot P-T and P-V diagrams of pure substance and explain the influence of Temperature limits on performance of cycles. |
| CO 3 | Analyze problems of practical relevance pertaining to concepts of refrigeration & air conditioning |
| CO 4 | Understand and analyse the working of nozzle & diffuser. |
| CO 5 | Analyze the concepts and functioning of reciprocating compressors and their performance. |

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from units 1, 4 and 5 and two questions each from units 2 and 3.
Course Credits : 04 Marks
Name Kinematics of Machines L T P S CIE SEE
Code 15ME4DCKOM 3 0 0 1 100 100

PRE-REQUISITES:
1. Engineering Physics
2. Engineering Mechanics

SYLLABUS:

UNIT – 1
Introduction: Definitions: link or element, kinematic pairs, degrees of freedom, Grubler’s criterion (without derivation), kinematic chain, mechanism, structure, mobility of mechanism, Grashoff’s criterion, inversion, machine.
Kinematic Chains and Inversions: Inversions of four bar chain; single slider crank chain and double slider crank chain.
Mechanisms: Quick return motion mechanisms - Whitworth mechanism, crank-&-slotted lever mechanism, straight line mechanisms – Peaucellier’s mechanism, Tchebicheff mechanism, intermittent motion mechanisms – Geneva mechanism, ratchet-&-pawl mechanism; toggle mechanism; Davis & Ackerman steering gear mechanism

09 Hours

UNIT – 2
Velocity & Acceleration Analysis of Mechanisms (Graphical Methods)
Velocity and acceleration analysis of four bar mechanism and slider crank mechanism by vector polygons: relative velocity and acceleration of particles in a common link, relative velocity and accelerations of coincident particles on separate links – Coriolis component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.

10 Hours

UNIT – 3
Velocity Analysis by Instantaneous Center Method: Definition, Kennedy’s theorem, determination of linear and angular velocities using instantaneous center method.
Klein’s Construction: Analysis of velocity and acceleration of single slider crank mechanism.

03 Hours

Spur Gears: Gear terminology, law of gearing, characteristics of involute action, path of contact, arc of contact, contact ratio, interference in involute gears, methods of avoiding: interference, backlash, comparison of involute and cycloidal teeth.

04 Hours

UNIT – 4

05 Hours
Unit – 5

**Cams:** Types ofcams, types of followers, displacement, velocity and acceleration time curves for cam profiles. disc cam with reciprocating follower having knife-edge, roller and flat-faced follower, disc cam with oscillating roller follower, follower motions including shm, uniform velocity, uniform acceleration and retardation and cycloidal motion.  

08 Hours

**REFERENCES:**

**Text Books**

**Reference Books**

**E-Books / Web References**
   http://www.cs.cmu.edu/~rapidproto/mechanisms/tablecontents.html

**MOOCs**
1. Dynamics* (https://www.edx.org/course/dynamics-mitx-2-03x#!)
2. NPTEL Course: “Kinematics of Machines”  
   (http://nptel.ac.in/courses/112104121/1)

*Note: This MOOC is on an advanced topic, but contains some basic concepts related to this course.

**Self-Study:** Students have to learn on their own, concepts related to the course suggested by course-faculty. Students’ work will be assessed by a committee for CIE.
COURSE OUTCOMES:

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Apply knowledge of fundamentals of kinematics and common mechanisms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Analyze graphically, velocity and acceleration in various four bar mechanisms.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Compute various parameters of gear teeth for different gear profiles.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Design gear trains for power transmission.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Synthesize cam profiles for different applications.</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.
Course: Design of Machine Elements-I
Code: 15ME4DCDM1

PRE-REQUISITES:
1. Engineering Mechanics
2. Strength of Materials
3. Engineering Materials

SYLLABUS:

UNIT – 1
Introduction: Definitions: normal, shear, biaxial and triaxial stresses, Stress tensor, Principal stresses. Engineering materials and their mechanical properties. Stress-strain diagrams, Stress Analysis, Design considerations: Codes and Standards.


UNIT – 2
Design for Fatigue Strength: Introduction- S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, Endurance limit modifying factors: size effect, surface effect, Stress concentration effects; Fluctuating stresses, Goodman’s and Soderberg’s relationship; Stresses due to combined loading.

UNIT – 3
Design of Shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME & BIS codes for power transmission shafting, shafts under fluctuating loads and combined loads.

Couplings: Design of Flange Couplings, Bush and Pin type flexible coupling.

UNIT – 4
UNIT – 5

**Threaded Fasteners:** Stresses in threaded fasteners, Effect of initial tension, Design of threaded fasteners under static, dynamic loads.  

**Power Screws:** Mechanics of power screw, Stresses in power screws, efficiency and self-locking, Design of power screw.

**3 Hours**  
**5 Hours**

**REFERENCES:**

**Data Handbooks (allowed for reference during examinations also):**


**Textbooks**


**Reference Books**


**E-Books / Web References**

3. http://nptel.ac.in/courses/112105124/  
MOOCs

http://freevideolectures.com/free-college-courses-online/#MechanicalEngg

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Apply concepts of mechanics of materials to estimate the stresses in a machine element and predict failure of components based on theories of failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Understand fatigue failure in machine elements and factors affecting it</td>
</tr>
<tr>
<td>CO 3</td>
<td>Design shafts, keys, splines and couplings power transmission</td>
</tr>
<tr>
<td>CO 4</td>
<td>Design cotter, riveted &amp; welded joints</td>
</tr>
<tr>
<td>CO 5</td>
<td>Design power screws and threaded fasteners</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit. To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.
PREREQUISITES:
1. Elements of Mechanical Engineering
2. Engineering Physics

SYLLABUS:

UNIT – 1
Theory of Metal Cutting: Single point cutting tool nomenclature, Merchant's circle diagram, analysis and simple problems. Shear angle relationship, tool wear and tool failure, tool life, effects of cutting parameters on tool life, tool failure criteria, Taylor's tool life equation. 06 hours

Cutting tool materials: Desired properties, types of cutting tool materials – HSS, carbides coated carbides, ceramics, cutting fluids: Desired properties, types and selection. Heat generation in metal cutting, factors affecting heat generation, heat distribution in tool and work, measurement of tool tip temperature. 06 hours

UNIT-2
Production Lathe: Classification of Lathes, Specification, Engine lathe, Capstan & Turret lathe - constructional features, tool layout, tool & work holding devices and attachments. Lathe operations. 05 hours

Shaping, Slotting and Planning Machines Tools: Classification, constructional features of Shaper, Slotter, Planer. Driving mechanisms of Shaper, Slotter and Planer. Operations done on Shaper, Planer & Slotter. Difference between shaping and planning operations. 06 hours

UNIT-3
Drilling Machines: Classification, constructional features, drilling & related operations, types of drill & drill bit nomenclature, drill materials. Calculation of machining time
Milling Machines: Classification, constructional features, milling cutters nomenclature, milling operations, up milling and down milling concepts. Calculation of machining time.
Indexing: Simple, compound, differential and angular indexing calculations. Simple numerical on indexing. 06 hours

UNIT-4
Broaching machines: Classification, Construction and principle of operations
Grinding, Lapping and Honing machines: Types of abrasives, bonding process, classification, constructional features (cylindrical and surface
grinding, centre less grinding), selection of grinding wheel. Mounting and balancing of grinding wheel.

**Lapping and Honing:** Principles of operation, construction, applications

**UNIT-5**

**Non-traditional machining processes:** Principle, equipment, operation & applications of Ultrasonic Machining, Abrasive Water Jet Machining, Electro Discharge Machining, Electro Chemical Machining, Laser Beam Machining, Plasma Arc Machining.

**CNC Machine Tools:** Introduction to CNC machines, Construction and working of CNC milling centre, CNC Turning centre, Advantages and applications.

**Self-Study:** Students have to learn on their own, concepts related to the course suggested by course-faculty. Students’ work will be assessed by a committee for CIE.

**REFERENCES:**

**Text books**

**Reference Books**

**E-Books / Web references**
   (Link: https://books.google.co.in/books?id=Y0cRCFalmekC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false)
2. Nontraditional Machining Processes, J. Paulo Davim, Aveiro, Portugal, February 2013
MOOCs
1. http://nptel.ac.in/courses/112105126/

Scheme of Examination (SEE):
Answer FIVE full questions, each of 20 marks.
To set two questions each from Units 1 and 2 and one question each from units 3, 4, and 5.

MOBILE TOOLS AND MACHINING - LAB

List of Experiments

One Model each involving
   c) Lathe operations
   d) Milling operations
   e) Shaping operation

Part A:
   a) Preparation of one model on lathe involving plane Turing, taper turning, Step turning, facing, convex shape turning, external thread cutting, V-thread and square thread.

Part B
   b) Cutting of V-groove using a shaper, cutting of spur gear teeth, Helical gear using milling machine.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Understand the fundamentals of metal cutting and selection of cutting tools and materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Understand the constructional features and working of various machine tools.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Understand the basic and super finishing operations.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Compute machining time for various machining operations.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Understand the principles and operations of Non-conventional machining processes.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Produce simple components using various machine tools.</td>
</tr>
</tbody>
</table>
PRE-REQUISITES:
1. Engineering Physics
2. Engineering Mathematics

SYLLABUS:

UNIT-1

Introduction
Introduction to metrology & measurements, definition and objectives and classification of metrology, standards of length-wave length standard, subdivision of standards.  
02 Hours

Systems of Limits, Fits & Tolerancing
Definition of tolerance, tolerance specification in assembly, principle of interchangeability and selective assembly, limits of size, Indian standards, concepts of limits of size and tolerances, cost v/s tolerances, compound tolerances, accumulation of tolerances, definition of fits, types of fits and their designation (IS 919-1963), Geometrical Dimensioning and Tolerancing (GD&T), hole basis system, shaft basis system, simple problems.  
07 Hours

Gauges
Classification of gauges, Taylor’s principle, design of GO, NO GO gauges, wear allowance on gauges, types of gauges- plain plug gauges, ring gauges, snap gauge, limit gauge, simple problems.  
02 Hours

UNIT-2

Comparators
Introduction to comparators, classification, characteristics, systems of displacement amplification in mechanical comparators, Reed type, Sigma comparator, Zeiss ultra optimeter, Solex air gauge, ultrasonic gauges, LVDT.  
03 Hours

Line & End Standards
Line and end standard, slip gauges, wringing phenomena, numerical problems on slip gauges.  
04 Hours

Angular Measurements
Bevel protractor, sine bar, angular gauges, numerical on building of angles.  
03 Hours
UNIT-3
Measurements & Measurement Systems
Definition, generalized measurement system, accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system-response-time delay, errors in measurement.  
02 Hours

Transducers Intermediate & Terminating Devices
Primary & secondary transducers, classification, advantages, introduction to mechanical and electrical amplification, terminating devices, mechanical oscillographs, XY plotters.  
02 Hours

UNIT-4
Force, Torque & Pressure Measurements
Working principle of analytical balance, proving ring, pronybrake, hydraulic dynamometers, Pirani gauge, Mcleod gauge, Bridgeman gauge.  
03 Hours

Temperature & Strain Measurements
Resistance thermometer, thermocouple laws of thermocouple, materials used for construction, optical pyrometer, electrical strain gauge, Wheatstone bridge for strain measurement.  
03 Hours

UNIT-5
Measuring Machines
Universal measuring machine, profile projector, tool maker’s microscope, coordinate measuring machine and types, machine vision, autocollimator, laser interferometer.  
04 Hours

Metrology for Nano Measurements
Clean room technology, scanning electron microscopy, transmission electron microscopy, atomic force microscopy, confocal microscopy, focused ion beam, photoelectron spectroscopy, x-ray diffraction (working principles with block diagrams for all the concepts in this unit with advantages and limitations).  
05 Hours

Self-Study: Students have to learn on their own, concepts related to the course suggested by course-faculty. Students’ work will be assessed by a committee for CIE.

REFERENCES:
Text Books

**Reference Books**

**E-Books / Web References**
1. Cleanroom Technology, FESTO world wide
   (http://www.festo.com/net/SupportPortal/Files/8842/HB_CleanRoom_en.pdf)
2. Nanometrology, European Nanotechnology Gateway, Eighth Nanoforum Report
   (http://nanoparticles.org/pdf/nanometrology.pdf)
3. NPTEL course on Metrology & Measurements
   Link: http://nptel.ac.in/courses/112106138/
4. MIT Open courseware Lecture: Metrology, shot noise and Heisenberg limit

**Scheme of Examination (SEE):**
Answer FIVE full questions, each of 20 marks
Two questions each to be set from units 1 and 2 and one question each from units 3, 4, and 5.

**MECHANICAL MEASUREMENTS & METROLOGY LAB**

**Part A: Metrology**
1. Calibration of line and end standards equipment using slip gauges.
2. Calibration of pressure gauge
3. Calibration of load cell
4. Calibration of LVDT
5. Calibration of thermocouple
Part B

1. Measurement of angles using sine-bar, sine-center and bevel protractor
2. Measurement of screw thread using two wire and three wire method
3. Measurement of surface roughness using Talysurf and mechanical comparator
4. Measurement of gear tooth profile using gear tooth vernier
5. Measurement using optical profile projector and toolmaker’s microscope
6. Measurements of alignment using autocollimator (Demo)
7. Use of strain gauge for determining elasticity in specimen.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Understand the various standards of measurements and usage of different measuring devices.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Understand the system of limits, fits, tolerances and gauging.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Understand the measurement systems and transducing elements and intermediate devices.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Understand the principles and measurement of various phenomena like force, torque, pressure, temperature and strain.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Understand the application of measurement systems and nano measurements principles.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Demonstrate calibration of various physical parameters and phenomena.</td>
</tr>
</tbody>
</table>
B.M.S COLLEGE OF ENGINEERING, BENGALURU
Autonomous College under VTU-Belagavi, Karnataka

VISION
Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION
Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION
To become a center of excellence in educating students to become successful Mechanical Engineers

DEPARTMENT MISSION
• To empower the students with the fundamentals for a successful career in the field of Mechanical engineering.
• To continue their education through post-graduation, Research & Development.
• To provide service to the society.

V & VI Semester Scheme & Syllabus

&

VII & VIII Semester Scheme

With effect from A. Y. 2016 – 17
## FIFTH SEMESTER

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Teaching Department</th>
<th>Credits</th>
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<th>Contact Hours</th>
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<td>MANAGEMENT &amp; ENTREPRENEURSHIP</td>
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**Total Credits** 17 1 3 4 25 25 Total 600

### 16MESDE *** ELECTIVE – 1

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<tr>
<td>1. 16ME5DETOE</td>
<td>Theory of Elasticity</td>
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<tr>
<td>2. 16ME5DENTM</td>
<td>Non-Traditional Machining</td>
</tr>
<tr>
<td>3. 16ME5DEAMT</td>
<td>Advanced Material Technology</td>
</tr>
<tr>
<td>4. 16ME5DEIFD</td>
<td>Incompressible Fluid Dynamics</td>
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<tr>
<td>5. 16ME5DEENE</td>
<td>Energy Engineering</td>
</tr>
<tr>
<td>6. 16ME5DESQC</td>
<td>Statistical Quality Control</td>
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<tr>
<td>7. 16ME5DEAEμ</td>
<td>Applied Electronics and Microprocessors</td>
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<tr>
<td>8. 16ME5DEBHM</td>
<td>Biomechanics of Human Movement</td>
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<td>9. 16ME5DEICE</td>
<td>IC Engines</td>
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### SIXTH SEMESTER

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<th>Code</th>
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<th>SEE Hrs</th>
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<tr>
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<td>TURBO MACHINES</td>
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**Total Credits** 18 0 3 4 25 24 **Total 700**

16ME6DE ***

**ELECTIVE – 2**

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<td>Theory of Plasticity</td>
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<tr>
<td>2. 16ME6DEROB</td>
<td>Fundamentals of Robotics</td>
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<tr>
<td>3. 16ME6DECMT</td>
<td>Composite Material Technology</td>
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<td>4. 16ME6DESUE</td>
<td>Surface Engineering</td>
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<td>5. 16ME6DECFD</td>
<td>Computational Fluid Dynamics</td>
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<td>6. 16ME6DERES</td>
<td>Renewable Energy and Sustainability</td>
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<td>7. 16ME6DEPOM</td>
<td>Production and Operation Management</td>
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<td>16ME7DC MAA</td>
<td>MECHATRONICS AND AUTOMATION</td>
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<td>16ME7DC PMF</td>
<td>PROJECT MANAGEMENT &amp; FINANCIAL ACCOUNTING</td>
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<td>ELECTIVE- 3</td>
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<td>16ME7DE ***</td>
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<td>16ME7DL NML</td>
<td>NUMERICAL ANALYSIS LAB</td>
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<td>16ME7DL ICE</td>
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16ME7DE ***

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<tr>
<td>1. 16ME7DEFRM Fracture Mechanics</td>
<td>1. 16ME7DETBD Tribology and Bearing Design</td>
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<tr>
<td>2. 16ME7DEARB Advanced Robotics</td>
<td>2. 16ME7DETED Tool Engineering Design</td>
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<tr>
<td>3. 16ME7DEADM Additive Manufacturing</td>
<td>3. 16ME7DEPDM Product Design and Manufacturing</td>
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<tr>
<td>4. 16ME7DEHAP Hydraulics &amp; Pneumatics</td>
<td>4. 16ME7DENDT Non-Destructive Testing</td>
</tr>
<tr>
<td>5. 16ME7DEOPT Optimization</td>
<td>5. 16ME7DEETF Experimental Thermal and Fluid Systems</td>
</tr>
<tr>
<td>6. 16ME7DEDTS Design of Thermal Systems</td>
<td>6. 16ME7DERAC Refrigeration and Air Conditioning</td>
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<tr>
<td>7. 16ME7DECIM Computer Integrated Manufacturing</td>
<td>7. 16ME7DEESD Engineering System Design</td>
</tr>
<tr>
<td>8. 16ME7DEPSE Political Science In Engineering</td>
<td>8. 16ME7DEHRM Human Resource Management</td>
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<tr>
<td>9. 16ME7DECOG Computer Graphics</td>
<td>9. 16ME7DEAIN Artificial Intelligence</td>
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<td>OPERATIONS RESEARCH</td>
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<td>HSS CORE COURSE (PO 6, 8 &amp; 10)</td>
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<td>16ME8 _ _ ***</td>
<td>SOFT SKILLS (Placement – Done during the break after 6th Sem)</td>
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### 16ME8DE ***

#### ELECTIVE –5

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<td>1. 16ME8DEMBD</td>
<td>Multi Body Dynamics</td>
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<tr>
<td>2. 16ME8DEMTP</td>
<td>Machine Tool Design</td>
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<tr>
<td>3. 16ME8DEDOE</td>
<td>Design of Experiments</td>
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<tr>
<td>4. 16ME8DEAMC</td>
<td>Advanced Material Characterization Techniques</td>
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<tr>
<td>5. 16ME8DEPOD</td>
<td>Gas Dynamics</td>
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<td>6. 16ME8DEAHT</td>
<td>Advanced Heat Transfer</td>
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<tr>
<td>7. 16ME8DEORB</td>
<td>Organizational Behaviour</td>
</tr>
<tr>
<td>8. 16ME8DEMIS</td>
<td>Management Information Systems</td>
</tr>
<tr>
<td>9. 16ME8DEAUE</td>
<td>Automotive Engineering</td>
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V - Semester Syllabus
Course | Credits : 03 | Marks
--- | --- | ---
Name | Management & Entrepreneurship | L | T | P | S | CIE | SEE
Code | 16ME5DCMAE | 3 | 0 | 0 | 0 | 50 | 50

SYLLABUS:

**Unit – 1**

**Management:** Introduction, Meaning, Nature and functions of management, Roles of Manager, Managerial Skills, Management as a science, art or profession- Management & Administration, Development of Management thought-early management (Taylor & Henri Fayol) approaches and Modern Management (Qualitative, Contingency & Systems) approaches

**Planning:** Nature & importance of planning, Forms of planning, Types of plans, Importance of Planning, Steps in planning process, Planning premises, Limitations of planning Decision making, Types of decisions, Steps in decision making, Difficulties in decision making.

5 Hours

**Unit – 2**

**Organising:** Meaning, Characteristics and Process of organizing, Span of Management, Principles of Organizing, Organization structure, Types of Organizations

**Staffing:** Introduction, Functions of staffing, Importance, Short term, long term manpower planning, Recruitment, Selection, Placement, Induction, Training and Mentoring

6 Hours

**Unit – 3**

**Directing & Controlling:** Introduction, Requirements of effective direction, Motivation (Maslow, Hezberg, McGregor theory) Leadership styles (Autocratic, Democratic & Free rein)

**Communication:** Importance of Communication, Purposes of communication, Formal & Informal communication, Barriers to communication,

**Co-ordination and Control:** Techniques of co-ordination, Meaning and steps in control process, Essentials of effective control system.

7 Hours

**Unit – 4**

**Entrepreneurship:** Introduction, Characteristics of a successful entrepreneur, Classification of entrepreneurs, Stages of Entrepreneurship, Role of entrepreneur in economic development, Problems faced by entrepreneurs

6 Hours

**Unit – 5**

**Small Scale Industry:** Definitions of SSI, Importance of SSI, Definitions of SSI, Problems faced by SSI, Prospects of SSI in a free economy.

Institutions supporting SSIs central and state wise, Industry Associations, Different Schemes, TECKSOK, KIADB; KSSIDC; KSIMC; DIC Single Window Agency; SISI, NSIC, SIDBI, KSFIC.

5 Hours

**Setting up a small business enterprise:** business opportunities, formalities for setting up of a small business enterprise, Preparation of Business Plan, Sickness in SSI

5 Hours

**TEXT BOOKS:**


**REFERENCE BOOKS:**


**E-learning:**
- [https://india.gov.in/topics/industries/micro-small-medium-enterprises](https://india.gov.in/topics/industries/micro-small-medium-enterprises)

**MOOCS:**
- [https://www.class-central.com/subject/entrepreneurship](https://www.class-central.com/subject/entrepreneurship)

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>Compare various management approaches, planning and decision strategies</td>
</tr>
<tr>
<td>CO 2</td>
<td>Organize the staffing and structure for an organization</td>
</tr>
<tr>
<td>CO 3</td>
<td>Make use of communication methods, leadership styles for building effective control in an organization</td>
</tr>
<tr>
<td>CO 4</td>
<td>Develop entrepreneurial ideas</td>
</tr>
<tr>
<td>CO 5</td>
<td>Identify the institutions supporting the Small scale industries</td>
</tr>
<tr>
<td>CO 6</td>
<td>Plan the various steps involved in setting up a business enterprise</td>
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**Scheme of Examination: (SEE)**
Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 3 & 4 and two questions each from units 1 & 5.
**Course**: Design of Machine Elements-II  
**Code**: 16ME5DCDM2  
**Credits**: 04  
**Marks**: 50

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<th>Marks</th>
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<tr>
<td>Design of Machine Elements-II</td>
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</tr>
</tbody>
</table>

**PRE-REQUISITES:**  
Engineering Mechanics,  
Strength of Materials,  
Design of Machine Elements-I

**SYLLABUS:**

**UNIT – 1**

**Curved Beams**: Expressions for stress in curved beams of standard cross section, Closed rings and links (only numericals)  
6 Hours

**Springs**: Types of springs, Terminology for compression springs, Stresses and Energy stored in Helical coil springs of circular cross section, Stress and deflection in helical coil springs of non-circular cross sections. Tension and compression springs, springs under fluctuating loads, Leaf springs: Stress and deflection in leaf springs. Equalized stresses in spring leaves (nipping)  
7 Hours

**UNIT – 2**

7 Hours

**UNIT 3**

**Spur & Helical Gears**: Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, Design for strength, Dynamic load and wear load. Helical Gears: Definitions, formative number of teeth; Design based on strength, dynamic and wear loads.  
8 Hours

**Bevel and Worm Gears**: Bevel Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wear loads. Worm Gears: Definitions, Design based on strength, dynamic, wear loads and efficiency of worm gear drives.  
8 Hours

**UNIT 4**

**Lubrication and Bearings**: Lubrication: purpose and requirement, Lubricant types, properties and selection, Classification of Bearings, bearing characteristic number and bearing modulus, coefficient of friction, minimum oil film thickness, Heat generated, Heat dissipated, Numerical on journal bearing and thrust bearing design.  
8 Hours

**UNIT 5**

**Belts Ropes and Chains**: Flat belts: Length & cross section, Selection of V-belts, ropes and chains for different applications.  
8 Hours

**Design Data Hand Books (allowed for reference during examination also):**

Text Books:

Reference Books:

E-Books:

MOOCs:
1. [http://nptel.iitg.ernet.in/](http://nptel.iitg.ernet.in/)
2. [http://www.nptelvideos.in/2012/12/design-of-machine-elements.html](http://www.nptelvideos.in/2012/12/design-of-machine-elements.html)

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Solve for stresses in curved beams, springs, clutches and brakes |
| CO 2 | Deduce equations for stresses in curved beams, springs and gears |
| CO 3 | Estimate the load carrying capacities of curved beams, helical and leaf springs and bearings |
| CO 4 | Compare different types of clutches, brakes, springs, gears and power transmission elements |
| CO 5 | Design gears, springs, clutches, brakes and bearings |
| CO 6 | Choose power transmission elements like belt drives, chain drives, rope drives and the bearings for different applications |

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.
SYLLABUS:

UNIT – 1

Sections of Solids: Sectioning, Sectional view, Representation of section plane, Hatching, Sectioning of engineering objects when the axis is inclined to one plane of projection and perpendicular to the other. Solids involving Square, Pentagonal, Hexagonal prisms, Square, Pentagonal, Hexagonal pyramids, Cylinder, Cone and Tetrahedron. 10 Hours

UNIT – 2

GD & T: Terms and definitions, Common symbols & Terminology, Fundamental Rules (Drawing), Feature definition, With Size and Without Size, Material Condition (Maximum, Least, Regard of Material Condition), Limit Tolerancing, Dimension Origin, Limits of Size, Rule 1 or Envelope Principle, Go- No Go Gauges Datum Reference Frame, Form Tolerances, Orientation Tolerances, Profile Tolerances, Position Tolerances Overview 14 Hours

UNIT – 3

Assembly Drawing:
Part-1: Assembly of Socket and Spigot cotter joint, Protected type flanged coupling
Part-2: Machine vice, Plummer block, Tail stock, Steam stop valve, Ram’s bottom safety valve, Petrol engine connecting rod 28 Hours

LAB: Using Computer Aided Software (2 Hours Per week)
3D Modelling from Orthographic views: Given the 2 or 3 views of a machine component, Generation of the object in 3D environment using software. Assembly and extraction of views of the following assemblies in 3D using software.
(a) Socket and Spigot cotter joint
(b) Protected type flanged coupling
(c) Machine vice
(d) Plummer block 26 Hours

CIE:

Component-1
Test 1: Unit 1 (Manual Drafting).................................................15 Marks
Test 2: Unit 2 (Manual Drafting).................................................15 Marks
Test 3: Unit 3 (Manual Drafting).................................................15 Marks
**Average of best TWO tests is taken as component-1 for 15 Marks.**

Component-2
Self Study 10 Marks

Component-3
Lab Test: 15 Marks

Component-4
Assignment (Drawing Sheets) 10 Marks

Total 50 Marks
Text books:


Reference Books:
2. “Auto CAD 2006, for engineers and designers”. Sham Tickoo. Dream Tech 2005
3. Fundamentals of Geometric Dimensioning and Tolerancing by Alex Krulikowski 2012

SELF STUDY CAN BE CONSIDERED FROM
Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly), Proportions for square and hexagonal headed bolts & nuts, simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.
Assembly of Pin or Knuckle joint, Universal coupling, Screw Jack and Swivel Bearing

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Choose appropriate views to give information about machine parts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Sketch Sectional views to improve clarity and reveal interior features of Machine parts.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Identify relationships of each part to the others in Assemblies</td>
</tr>
<tr>
<td>CO 4</td>
<td>Construct Assembly drawings showing all parts in their operational positions</td>
</tr>
<tr>
<td>CO 5</td>
<td>Create Geometric Models of Mechanical Parts and assemblies employing CAD tools.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Apply principles of GD&amp;T to communicate Design intent unambiguously</td>
</tr>
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</table>

Scheme of Examination (SEE):
Unit 1 → 20 Marks
Unit 2 → 15 Marks
Unit 3 → Assembly from Part 2 only → 65 Marks
Total → 100 Marks
Course | Credits : 03 | Marks
--- | --- | ---
Name | Dynamics of Machines | L | T | P | S | CIE | SEE
Code | 16ME5DCDOM | 3 | 0 | 0 | 0 | 50 | 50

**PRE-REQUISITES:**
Intended for students who are familiar with:
- Kinematics of machines
- Engineering Mechanics

**SYLLABUS:**

**UNIT – 1**

**STATIC FORCE ANALYSIS:** Introduction, Static equilibrium, Equilibrium of two and three force members. Member with two forces and torque, Free-body diagrams, Static force analysis of simple mechanisms. Principle of virtual work. 6 Hours

**TURNING MOMENT DIAGRAM:** Turning moment diagram and flywheels, Fluctuation of Energy. Determination of size of a flywheel. 5 Hours

**UNIT – 2**

**FRICTION AND BELT DRIVES:** Definitions; Types of friction, laws of friction, Friction in pivot and collar bearings. Flat belt drive, ratio of belt tensions, centrifugal tension, power transmitted. Belt thickness and width calculations. 5 Hours

**GOVERNORS:** Types of governors; force analysis of Porter and Hartnell governors. Controlling force, stability, sensitiveness, isochronism, effort and power 5 Hours

**UNIT – 3**

**BALANCING OF ROTATING MASSES:** Static and dynamic balancing, Balancing of single rotating and many rotating masses by another mass in one plane. Effect of transferring rotating mass from one plane to another. Balancing of several rotating masses by balancing masses in different plane. 6 Hours

**UNIT – 4**

**BALANCING OF RECIPROCATING MASSES:** Inertia effect of crank and connecting rod, single cylinder engine, balancing in multi cylinder-inline engine (primary & Secondary forces), V-type engine; Radial engine – Direct and reverse crank method. 6 Hours

**UNIT – 5**

**GYROSCOPE:** Vectorial representation of angular motion, gyroscopic couple. Effect of gyroscopic couple on the movement of a Naval ship, plane disc, aeroplane, stability of a two wheeler and four wheeler taking a turn 6 Hours

**TEXT BOOKS:**


REFERENCE BOOKS:


MOOCs:

1. Dynamics* ([https://www.edx.org/course/dynamics-mitx-2-03x](https://www.edx.org/course/dynamics-mitx-2-03x))
2. NPTEL Course: “Dynamics of Machines”([http://nptel.ac.in/courses/112104114](http://nptel.ac.in/courses/112104114))

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Determine the forces in mechanisms for static equilibrium. |
| CO 2 | Design a flywheel based on energy fluctuation. |
| CO 3 | Estimate the power in bearings and belt drives and the power of engine using turning moment diagram |
| CO 4 | Analyze the effect of gyroscopic couple on rotors, ships, aero planes and automobiles and Governors for speed control. |
| CO 5 | Solve problems concerning static and dynamic balancing of systems involving rotating masses and partial balancing of reciprocating engines |
| CO 6 | Evaluate primary and secondary unbalanced forces in reciprocating engines. |

Scheme of Examination (SEE):
Answer Five full questions selecting one from each unit.
To set One question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.
**Course Credits : 06 Marks**

<table>
<thead>
<tr>
<th>Name</th>
<th>Fundamentals of Heat Transfer</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>S</th>
<th>CIE</th>
<th>SEE</th>
</tr>
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<tbody>
<tr>
<td>Code</td>
<td>16ME5DCFHT</td>
<td>3</td>
<td>0</td>
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<td>2</td>
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<td>50</td>
</tr>
</tbody>
</table>

**PRE-REQUISITES:**
1. Mathematics
2. Thermodynamics
3. Fluid Mechanics

**SYLLABUS:**

**UNIT -1**

**INTRODUCTION:** Modes of heat transfer-conduction, convection and radiation, Material properties of importance in heat transfer, Thermal conductivity, Specific heat capacity, Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation).

3 Hours

**CONDUCTION:** One dimensional conduction equations for plane wall, cylinder and sphere, Thermal contact resistance, Critical thickness of insulation.

3 Hours

**HEAT TRANSFER IN EXTENDED SURFACES:** Heat transfer through rectangular fin: Long fin, short fin with insulated tip and convective tip. Fin efficiency and effectiveness.

3 Hours

**TRANSIENT CONDUCTION:** Lumped parameter analysis, Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere.

3 Hours

**UNIT -2**

**CONVECTIVE HEAT TRANSFER:** Principle of heat flow in fluids, heat transfer coefficient, overall heat transfer coefficient, Velocity boundary layer, Thermal Boundary layer, drag coefficient, Significance of Reynold number, Prandtl number, Grashof Number, Stanton Number, Nusselt number, for internal and external flow (discussion only), Momentum and Energy equations for hydrodynamic and thermal boundary layer over a flat plate, Dimensional analysis for forced and natural convection

5 Hours

**NATURAL CONVECTION:** Empirical correlations for flow around flat vertical plate, horizontal flat surface, horizontal cylinder, sphere, enclosure.

4 Hours

**UNIT-3**

**FORCED CONVECTION**

**INTERNAL FLOW:** Laminar flow, Turbulent flow, thermal entrance region, full developed flow, Empirical correlations for flow through pipe.

3 Hours

**EXTERNAL FLOW:** Empirical correlations for flow over a flat plate, cylinders, flow across a cylinder and sphere.

3 Hours

**UNIT -4**

**RADIATION HEAT TRANSFER:** Basic definitions-Thermal radiation, Emissive power, radiosity, irradiation, absorptivity, reflectivity, transmissivity, black body and grey body, Basic laws: Planck's law, Wein's law, Stefan-Boltzman law, Kirchoff's law and Lambert's cosine law, Radiation heat exchange between two parallel infinite black surfaces, two parallel infinite gray surfaces and View factor algebra; Infinite long concentric cylinders,
small body in a large enclosure.

UNIT – 5


TEXT BOOKS:
3. A Textbook on Heat Transfer, Sukhatme S P,

REFERENCE BOOKS:
2. Principles of heat transfer, Kreith Thomas Learning 2001

E-Books/Web references:
2. NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/

MOOCs:
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

HEAT TRANSFER LABORATORY

PART - A
1. Determination of Thermal Conductivity of a Metal Rod.
3. Determination of Effectiveness on a Metallic fin.

PART - B
7. Determination of Stefan Boltzman Constant.
8. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<p>| CO 1 | Identify the mode of heat transfer |
| CO 2 | Apply principles of heat transfer to thermal systems |</p>
<table>
<thead>
<tr>
<th>CO 3</th>
<th>Analyze conduction heat transfer phenomenon for transient processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 4</td>
<td>Determine convective heat transfer for free and forced convection.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Formulate the heat transfer process in heat exchangers for parallel and counter flow arrangement</td>
</tr>
<tr>
<td>CO 6</td>
<td>Evaluate the parameters of radiative heat exchange process between surfaces.</td>
</tr>
</tbody>
</table>

**Scheme of Examination (SEE):**

Answer Five full questions selecting one from each unit.

To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2
Electives – Group 1

<table>
<thead>
<tr>
<th>Name</th>
<th>Theory of Elasticity</th>
<th>Credits : 03</th>
<th>Marks</th>
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<td>3</td>
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</tr>
</tbody>
</table>

SYLLABUS:

UNIT - 1

**Introduction**: Stress, Stress at a Point, Equilibrium Equations, Principal Stresses, Mohr’s Diagram, Maximum Shear Stress, Boundary Conditions.

**6 Hours**

UNIT - 2

**Strain at a point**: Compatibility Equations, Principal Strains, Generalized Hooke’s law, Methods of Solution of Elasticity Problems – Plane Stress & Plane Strain Problems.

Uniqueness theorem, Principle of super position, reciprocal theorem, Saint Venant principle.

**8 Hours**

UNIT - 3

**TWO DIMENSIONAL PROBLEMS**: Cartesian co-ordinates – Airy’s stress functions – Investigation of Airy’s Stress function for simple beam problems – Bending of a narrow cantilever beam of rectangular cross section under edge load.

**7 Hours**

UNIT - 4

**GENERAL EQUATIONS IN CYLINDRICAL CO-ORDINATES**: Thick cylinder under uniform internal and/or external pressure, shrink fit.

Stresses in an infinite plate with a circular hole subjected to uniaxial and biaxial loads, stress concentration, stresses in rotating discs and cylinders.

**6 Hours**

UNIT – 5

**TORSION OF CIRCULAR, ELLIPTICAL AND TRIANGULAR BARS**: membrane analogy, torsion of thin open sections and thin tubes.

**5 Hours**

TEXT BOOKS:


REFERENCES BOOKS:

1. Theory of Elasticity: Dr. Sadhu Singh, Khanna Publications, 1988
2. Elasticity, Theory, Applications & Numericals: Martin H Sadd, Elsevier. 2005
3. Applied Elasticity, Seetharamu & Govindaraju, Interline Publishing

E-Books:

1. Theory of Elasticity by L.D. Landau and E. M. Lifshitz
   [http://www.me.ust.hk/~meqpsun/Notes/Theory%20Of%20Elasticity(Landau-1959)]
2. Elasticity - theory, applications and applications by Martin H. Sadd
MOOCs:
   https://www.edx.org/course/mechanical-behavior-materials-part-1-mitx-3-032-1x
2. Mechanical Behavior of Materials, Part 2: Stress Transformations, Beams, Columns, and
   Cellular Solids
   https://www.edx.org/course/mechanical-behavior-materials-part-2-mitx-3-032-2x

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Apply basic concepts of continuum mechanics to elasticity problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Choose suitable solution strategies for boundary value problems</td>
</tr>
<tr>
<td>CO 3</td>
<td>Determine stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole</td>
</tr>
<tr>
<td>CO 4</td>
<td>Examine behavior of non-circular shafts and thin tubes under torsion</td>
</tr>
<tr>
<td>CO 5</td>
<td>Utilize MATLAB or equivalent software to simulate boundary value problems</td>
</tr>
<tr>
<td>CO 6</td>
<td>Develop analytical Solutions For Problems of Limited Complexity</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1 3 & 5 and two questions each from Units 2 & 4.
Course Credits : 03 Marks

<table>
<thead>
<tr>
<th>Name</th>
<th>Non-Traditional Machining</th>
<th>L</th>
<th>T</th>
<th>P</th>
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<th>CIE</th>
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</tbody>
</table>

SYLLABUS:

UNIT-1
INTRODUCTION- History, need, classification, comparison between conventional and non-conventional machining process and selection.
ULTRASONIC MACHINING (USM) - Introduction, equipment details, cutting tool system design, mechanism of metal removal, effect of parameters, USM process characteristics, applications, advantages & disadvantages of USM. 5 Hours

UNIT-2
ABRASIVE JET MACHINING (AJM) - Introduction, equipment details, variables in AJM, nozzle design, shape of cut, mechanism of metal removal, process characteristics, applications, advantages & disadvantages of AJM.
ABRASIVE WATER JET MACHINING (AWJM) -Principal, equipment, operation, mechanism of metal removal, application, advantages and limitations. 5 Hours

UNIT-3
ELECTROCHEMICAL MACHINING (ECM) - Introduction, study of ECM machine, elements of ECM process, mechanism of metal removal, process characteristics, Applications such as Electrochemical Grinding, Electrochemical Honing, Electrochemical deburring, advantages, limitations and applications. 6 Hours
CHEMICAL MACHINING (CHM)-Introduction, elements of process, mechanism of metal removal, chemical blanking process : Preparation of work piece, preparation of masters, masking with photo resists, etching for blanking, accuracy of chemical blanking, applications of chemical blanking, chemical milling (contour machining), Process steps – masking, Etching, process characteristics of CHM, , advantages, limitations & application of CHM. 6 Hours

UNIT-4
ELECTRICAL DISCHARGE MACHINING (EDM) -Introduction, mechanism of metal removal, dielectric fluid, spark generator, process parameter advantages, limitations & application of EDM. 6 Hours

PLASMA ARC MACHINING AND LASER BEAM MACHINING: Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, limitations & applications. Laser cutting (LC) – Laser drilling (LD) - Laser marking and engraving (LM) - Laser micromachining (LMM) - Laser engineered net shaping (LENS) - Applications - Limitations. 5 Hours

UNIT-5
ELECTRON BEAM MACHINING AND ION BEAM MACHINING: Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, limitations & applications
SPECIAL PROCESSING TECHNOLOGY - Rapid Prototyping - Methods - Fused Deposition
Modeling (FDM) - Laminated Object Manufacturing (LOM) - Selective laser sintering (SLA) - Solid Ground curing (SGC) - 3D printing (3DP) - Processing of integrated circuits - Micro and nano fabrication technologies.

6 Hours

TEXT BOOKS:
5. Non Traditional Manufacturing Processes, by Gary F Benedict, Taylor & Francis

REFERENCE BOOKS:

MOOC:
1. http://nptel.ac.in/courses/112105127/

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Classify the various Non-Traditional Machining process to machine new novel materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Choose an appropriate Non Traditional Machining technique to machine the given material</td>
</tr>
<tr>
<td>CO 3</td>
<td>Compare material removal rate for abrasive jet machining and abrasive water jet machining</td>
</tr>
<tr>
<td>CO 4</td>
<td>Identify the Process parameters affecting the functioning of various Non-Traditional Machines.</td>
</tr>
<tr>
<td>CO 5</td>
<td>List the advantages, limitations &amp; applications of different Non-Traditional Machines.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Inspect 3 D printing, laser engraving and water jet machining to experience a few Non Traditional process.</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit. To set one question each from Unit 1, 2 & 5 and two questions each from Units 3 & 4
Course: Advanced Materials Technology  
Code: 16ME5DEAMT  
Credits: 03  
Marks: 50

<table>
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<tr>
<th>Name</th>
<th>Code</th>
<th>Credits</th>
<th>Marks</th>
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<tr>
<td>Advanced Materials Technology</td>
<td>16ME5DEAMT</td>
<td>03</td>
<td>50</td>
</tr>
</tbody>
</table>

PRE-REQUISITES:
1. Material Science and Metallurgy

SYLLABUS:

UNIT - 1
6 Hours

UNIT - 2
Advanced structural ceramics, WC, TiC, TaC, Al2O3, SiC, Si3N4, CBN and diamond. Properties processing and applications.  
5 Hours

UNIT - 3
High temperature alloys: Classification of Titanium alloys, properties, microstructure and applications, heat treatment and machining of Ti alloys and Ti super alloys.  
5 Hours

UNIT - 4
Surface technology: Coatings for specific applications, coating materials and their selection, coating technologies and their merits and demerits, coating characterization, Use of LASER for coating life enhancement, hard facing.  
6 Hours

UNIT - 5
Nanotechnology: Definition, Types of nanomaterial, Nano powders and nanomaterial, methods of preparation – ball milling, atomization, chemical method, combustion method comparative studies of the advantages and disadvantages of Nano powder production technologies.  
Carbon nanotubes, types of nanotubes, formation of nanotubes, advantages of nanotubes over nano powders, fabrication technologies, characterization of nanomaterial and nanostructured materials, AFM, STEM, XRD, FTIR for nano characterization.  
5 Hours

Text Books:
2. Engineering Metallurgy - Raymond and Higgens - ELBS/EA
3. Titanium and Titanium Alloys: Fundamentals and Applications- Editor(s): Christoph Leyens, Manfred Peters .Published Online: 28 JAN 2005

REFERENCES:
1. Manufacturing Engineering and Technology (7th edition) by Serope Kalpak Jain and Steven Schmid
3. Titanium a technical guide, second addition, Mathew j Donnachie, Jr ASM International
4. Nanotechnology by Gregory Timp (ed.) Published by Springer-Verlag, New York, 1999
**E-Books / Web References**
   (https://iimtstudies.files.wordpress.com/2014/03/material-sciencekakani-2004.pdf)

**MOOCs:**
https://www.coursera.org/course/nanotech

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Classify based on the applications various types, properties of modern metallic materials</td>
</tr>
<tr>
<td>CO 2</td>
<td>Choose the different processing, properties, applications of polymers and ceramics</td>
</tr>
<tr>
<td>CO 3</td>
<td>Estimate machinability of Ti alloys and its Physical metallurgy.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Select various surface coating technologies, characterization based on their application in industry</td>
</tr>
<tr>
<td>CO 5</td>
<td>Build knowledge of nanotechnology principles, characterization and formation of carbon nanotubes.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Examine materials using AFM, STEM, XRD, FTIR (nano characterization)</td>
</tr>
</tbody>
</table>

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 4 and two questions each from Units 2 & 5.
Name | Incompressible Fluid Dynamics | Credits : 03 | Marks
---|---|---|---
Code | 16ME5DEIFD | L | T | P | S | CIE | SEE
3 | 0 | 0 | 0 | 50 | 50

**PRE-REQUISITES:**
1. Basic course in Fluid Mechanics.
2. Basic calculus and ODE

**SYLLABUS:**

**Unit 1**

**Fundamentals of Fluid Mechanics:** Continuity equation, conservation of linear momentum and energy. Some useful vector identities, differential and integral forms of conservation equations. Example problems.  

5 Hours

**Unit 2**

**Two-dimensional incompressible and irrotational flow:** General motion of a fluid element: rotation and deformation, introduction to vorticity and circulation, Kelvin’s circulation theorem, starting vortex, concept of velocity potential and stream function, Flow singularities and their superposition, lifting and nonlifting flows, Kutta-Joukowski’s theorem. Example problems.  

5 Hours

**Conformal transformations:** Analytic complex functions, complex potential and velocity functions for lifting and nonlifting flows, Blasius formula for complex load calculation on a body, Conformal maps, flow past symmetric Joukowski’s airfoil. Example problems.  

5 Hours

**Unit 3**

**Flow past airfoils:** Airfoil characteristics, standard airfoils and their nomenclature, Kutta condition, thin airfoil theory for symmetrical airfoils: lifting and nonlifting cases, Thin airfoil theory for cambered airfoils, numerical panel method.  

5 Hours

**Flow past finite wings:** Vorticity transport equations, vortex lines, filaments, horse-shoe vortex, Biot-Savart law, lifting line theory, Elliptic and non-elliptic wings, discussion on flow past low aspect ratio wings and delta wings. Example problems.  

6 Hours

**Unit 4**

**Viscous flow:** Viscosity and thermal conduction, Navier-Stokes equation, boundary layer, boundary layer of a flat plate, similarity in boundary layer flows, Momentum integral, flow separation.  

6 Hours

**Unit 5**

**Aerodynamic Design Considerations:**
1. High lift configurations - increasing the area and lift coefficient, flap systems, multi-element airfoils, power segmented lift.
2. Drag reduction – Variable twist, variable camber wings, laminar flow control and winglets
3. Circulation control wing d) Development of an Airframe Modification  

7 Hours

**Text Book:**

References:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Distinguish between the inviscid and viscous flow characteristics in the background of aerodynamics</td>
<td></td>
</tr>
<tr>
<td>CO 2</td>
<td>Explain the concepts of two dimensional incompressible and irrotational flow with the help of mathematical concepts</td>
<td></td>
</tr>
<tr>
<td>CO 3</td>
<td>Analyze the theoretical and practical design aspects involved in the aerodynamic systems</td>
<td></td>
</tr>
<tr>
<td>CO 4</td>
<td>Apply momentum principles for viscous flows</td>
<td></td>
</tr>
<tr>
<td>CO 5</td>
<td>Evaluate the low speed and high speed flow effect on aerodynamic systems</td>
<td></td>
</tr>
<tr>
<td>CO 6</td>
<td>Examine the design aspects during the flow over airfoils and finite span wing</td>
<td></td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4 & 5 and two questions each from Units 2 & 3.
Course | Credits : 03 | Marks
--- | --- | ---
Name | Energy Engineering | L T P S CIE SEE
Code | 16ME5DEENE | 3 0 0 0 50 50

PRE-REQUISITES:
1. Elementary calculus and Vector Calculus
2. Basic and Applied Thermodynamics
3. Fluid Mechanics

SYLLABUS:

UNIT - 1
STEAM POWER PLANT: Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, strokers, different types, Oil burners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures.

CHIMNEYS: Natural, forced, induced and balanced draft, Chimney design for a given draft, Cooling towers and Ponds. Accessories for the Steam generators such as Super-heaters, De-super heater, control of super-heaters, Economizers, Air pre-heaters and re-heaters. Co-generation concept.

UNIT - 2
HYDRO-ELECTRIC PLANTS: Hydrographs, flow duration and mass curves, unit hydrograph. Storage and Pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks, gates and valves. General layout of hydel power plants.

UNIT - 3
NUCLEAR POWER PLANT: Principles of release of nuclear energy; Fusion and fission reactions. Nuclear fuels used in the reactors. Multiplication and thermal utilization factors. Elements of the nuclear reactor; moderator, control rod, fuel rods, coolants. Brief description of reactors of the following types-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shieldings, Radioactive waste disposal.

UNIT - 4

UNIT – 5
ENERGY AND ENVIRONMENT: Air Pollution: Classification of air pollutants, sources of emission and air quality standards, Physical and chemical characteristics, Meteorological aspects of air pollutant dispersion, Temperature lapse rate and stability, Factors influencing dispersal of air pollutant, Air pollution dispersion models, Air pollution sampling and measurement, types, Ambient air sampling, Gaseous air pollutants,
Particulate air pollutants, Analysis of air pollutants.  

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**EBook:**

**MOOCs:**
*Introduction to Thermodynamics: Transferring Energy from Here to There*, coursera,  
[https://www.coursera.org/course/introthermodynamics](https://www.coursera.org/course/introthermodynamics)

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Analyze for air pollution using Meteorological aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>List different type of nuclear fuels and reactor related accessories in nuclear power plant.</td>
</tr>
<tr>
<td>CO</td>
<td>Apply the laws of thermodynamics to different power plant systems to maximise the performance of power plant.</td>
</tr>
<tr>
<td>CO</td>
<td>Estimate the boiler and reactor accessory parameters for general operating conditions and Factors affecting different types of pollutions</td>
</tr>
<tr>
<td>CO</td>
<td>Discuss clean and sustainable solutions for the environment.</td>
</tr>
<tr>
<td>CO</td>
<td>Survey waste heat recovery systems to improve boiler efficiency.</td>
</tr>
</tbody>
</table>

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 4 & 5 and two questions each from Unit 1& 3.
<table>
<thead>
<tr>
<th>Course</th>
<th>Credits : 03</th>
<th>Marks</th>
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<tbody>
<tr>
<td>Name</td>
<td>Statistical Quality Control</td>
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<tr>
<td>Code</td>
<td>16ME5DESQC</td>
<td>3 0 0 0 50 50</td>
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</table>

**Note:** Use of Statistical quality control table is permitted in the examination

**SYLLABUS:**

**UNIT - 1**
INTRODUCTION: The Meaning of Quality and Quality Improvement; Brief History of Quality Methodology; Statistical Methods for Quality Control and Improvement; Total Quality Management (quality philosophy, links between quality and productivity, quality costs, legal aspects of quality implementing, quality improvement).  
4 Hours

**UNIT - 2**
MODELING PROCESS QUALITY: Mean, Median, Mode, Standard deviation, Calculating area, The Deming funnel experiment, Normal distribution tables, Finding the Z score, Central limit theorem.  
6 Hours

METHODS OF STATISTICAL PROCESS CONTROL: Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, Average Run Length-ARL)
4 Hours

**UNIT - 3**
CONTROL CHARTS FOR VARIABLES: Control Charts for X-Bar and R- Charts, Statistical basis of the charts, Development and use of X bar and R charts, Interpretation of charts. Type I and Type II errors, the probability of Type II error. Numerical Problems.  
6 Hours

**UNIT - 4**
PROCESS CAPABILITY: The foundation of process capability, Natural Tolerance limits, $c_p$ – process capability index, $c_{pk}$, $p_p$ – process performance index, summary of process measures. Numerical problems  
4 Hours

**UNIT 5**
Control Charts For Attributes: Binomial distribution, Poisson distribution (from the point of view of Quality control) Control Chart for Fraction Nonconforming, Control Chart for number Nonconforming, Control Charts for Nonconformities or Defects, Control Chart for Number of non-conformities per unit. Numerical problems  
7 Hours

LOT-BY-LOT ACCEPTANCE SAMPLING FOR ATTRIBUTES: The acceptance sampling problem, single sampling plan for attributes, Double, Multiple, and Sequential sampling, AQL, LTPD, OC curves, Military Standard 105E, the Dodge-Romig sampling plans. Numerical problems  
8 Hours

**TEXT BOOKS:**
2. **Statistical Quality Control**, R C Gupta, Khanna Publishers, New Delhi, 2005
REFERENCE BOOKS:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Analyze different statistical methods for statistical process control.</td>
</tr>
<tr>
<td>CO 2</td>
<td>Assess general advantages and disadvantages for alternative process control methods</td>
</tr>
<tr>
<td>CO 3</td>
<td>Compare alternative process control methods</td>
</tr>
<tr>
<td>CO 4</td>
<td>Identify the different quality control techniques for varying sampling methods</td>
</tr>
<tr>
<td>CO 5</td>
<td>Formulate an adequate statistical control problem for a production or similar process.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Estimate the quality measures in general by means of modern and relevant statistical tools.</td>
</tr>
</tbody>
</table>

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 4 and two questions each from Units 2& 5.
Course Credits : 03 Marks

<table>
<thead>
<tr>
<th>Name</th>
<th>Applied Electronics and Microprocessors</th>
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**SYLLABUS:**

**UNIT - 1**
Digital logic families and comparison – MSI logic – multiplexers, decoders, encoders, adders, subtractors, JK flip flops and counters, D to A convertors, counter type and successive approximation type A to D convertors, Numerical.  
11 Hours

**UNIT - 2**
6 Hours

**UNIT - 3**
Introduction, Organization of 8085 processor interrupts and addressing modes available. 8085 programming – Instruction set, assembler directives, assembly language programming examples.  
11 Hours

**UNIT - 4**
Interfacing – Modes of data transfer, introduction to interfacing, memory mapped I/O and I/O mapped I/O, serial I/O data communication.  
6 Hours

**UNIT - 5**
Introduction to Microcontrollers – Classification, Components of a typical full featured microcontroller, the PIC16F84 microcontroller, PIC16F84 pin out and required external components.  
5 Hours

**Text Books:**
2. Thyristors and its applications, K.K. Sugandhi and R.K. Sugandhi
3. Digital Fundamentals, Floyd.

**Reference Books:**
1 An introduction to Mechatronics, David G. Alciatore and Michale B. Histand

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| CO 1 | Apply the basic concepts of logic families, IC’s and logic / digital devices along with timing diagrams involving selection of devices / performance characteristics including numericals |
| CO 2 | Discuss the regulation of power using SCR, triac and electrical actuators, principles and control along with numericals |
| CO 3 | Analyze 8085 architecture & to perform programming and the concepts involved in a processor internals like communication , data storage / memory and |
interpretations

| CO 4 | Select & explain the different modes of data transfer, communication and interfacing aspects |
| CO 5 | Prioritize the function / operation of microcontroller and its applications |
| CO 6 | Develop alternate approaches for logic circuits and 8085 programming |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 4, and 5 and two questions each from Units 1 & 3.
Course Credits : 03 Marks
Name Biomechanics of Human Movement L T P S CIE SEE
Code 16ME5DEBHM 3 0 0 0 50 50

PRE-REQUISITES:
Engineering Mechanics

SYLLABUS:

UNIT – 1
**Introduction to Biomechanics:** Basic terminology and concept of human musculoskeletal system, anatomy and overall function, structure and function of joints

UNIT – 2
**Measurement of Human Movement:** Direct motion measurement systems, Imaging systems electro goniometers, accelerometers, gyroscopes, force platforms, measuring energy consumption, kinematic systems, combined kinematic/kinetic systems, calculation limb and joint angles, calculation of velocity and acceleration, anthropometry, calculation of moments from kinematic and kinetic data.

UNIT – 3
**Work and Energy:** Introduction, efficiency, causes of inefficient movement, Calculation of internal and external work, power balance.
**Muscle Mechanics:** Introduction, Force length characteristics, force velocity characteristics, muscle modeling

UNIT – 4
**Biomechanics of Walking:** kinematics, kinetics and energetics of human walking, muscle activity during walking.

UNIT – 5
**Modeling and Simulation of Human Movement:** Need for models, Dynamic modeling of human movement, case studies.

Text Books:
2. J Rose, J G Gamble, Human Walking, Lippincott Williams & Wilkins, 2006

Reference Books
1. Nordin, M., & Frankel, V. H. Basic biomechanics of the musculoskeletal system, Lippincott Williams & Wilkins

Course Outcomes
Upon completion of this course, student will be able to:

| CO 1 | Apply principles of classical mechanics to the study of human motion |
| CO 2 | Analyze human movement from experimental data |
| CO 3 | Identify the muscle actions that cause movement |
| CO 4 | Discuss the internal and external forces acting on the body during typical human activities |
| CO 5 | Elaborate the methods and limitations of different experimental and analytical |
| techniques used |  
| CO 6 | Model simple human movements |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 4 & 5 and two questions each from Unit 2 & 3.
Course: INTERNAL COMBUSTION ENGINES  
Credits: 03  
Marks: CIE 50, SEE 50

SYLLABUS:

UNIT – 1

INTRODUCTION TO IC ENGINES: Testing of two-stroke and four-stroke SI and CI engines for performance, related numerical problems, heat balance, Morse test  
6 Hours

UNIT – 2

6 Hours

UNIT – 3

4 Hours

4 Hours

UNIT – 4

5 Hours

FUELS: Hydro carbons - chemical structure-influence of chemical structure on knock alternative fuels; Alcohols; vegetable oils; Biogas as Diesel engine fuels.  
6 Hours

UNIT – 5

EMISSION REGULATION AND CONTROL SYSTEMS: Mechanism of pollutant formation. Total emission control package thermal reactor package; catalytic converter package; control of NO X -Exhaust gas recirculation-Water injection.  
4 Hours

MODERN DEVELOPMENTS: Turbo charging and super charging of I.C Engines, Stratified charge engines (Lean burned SI engine) Multi fuel engines, Rotary piston engine, Two injector engines Pilot ignition engine, all ceramic swirl chamber engines  
4 Hours

Text Books:

Reference Books

Course Outcomes
Upon completion of this course, student will be able to:
### Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2 & 5 and two questions each from Unit 3 & 4.
VI Semester Syllabus
Course: Turbo Machines

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PRE-REQUISITES:
1. Fluid Mechanics
2. Thermodynamics
3. Vector Calculus

SYLLABUS:

UNIT – 1

INTRODUCTION:
Definition of a Turbomachine; Parts of a Turbomachine; Comparison with positive displacement machine; Classification; Application of First and Second Law to Turbomachines; Efficiencies, Dimensionless parameters (No Derivation only Discussion) and their physical significance; Specific speed, Stagnation and static properties and their relations.

THERMODYNAMIC ANALYSIS OF COMPRESSION AND EXPANSION PROCESSES:
Compression process – Overall isentropic efficiency; Stage efficiency; Comparison and relation between overall efficiency and stage efficiency; Polytropic efficiency; Preheat factor.
Expansion Process – Overall isentropic efficiency; Stage efficiency; Comparison and relation between overall efficiency and stage efficiency, polytropic efficiency; Reheat factor.

UNIT – 2

GENERAL ANALYSIS AND ENERGY TRANSFER IN TURBINES: Euler Turbine equation and its alternate forms – components of energy transfer; Degree of Reaction; Velocity triangles for different values of degree of reaction; General analysis of axial and radial flow turbines – Utilization factor; Vane efficiency; Relation between utilization factor and degree of reaction; condition for maximum utilization factor – optimum blade speed ratio for different types of turbines.

PUMPS AND COMPRESSORS: Euler Equation for power absorbing machine; General analysis of Axial flow Compressors, Radial flow compressors, Centrifugal pumps; Velocity triangles; Effect of blade discharge angle on Energy transfer, Theoretical head capacity relationship.

UNIT – 3

CENTRIFUGAL COMPRESSORS: Classification; Expression for overall pressure ratio; Blade angles at impeller eye root and eye tip; Slip factor and power input factor; width of the impeller channel; Compressibility effect – need for pre-whirl vanes; Diffuser design: Flow in the vane-less space, determination of diffuser inlet vane angle, width and length of the diffuser passages; Surging of centrifugal compressors.

AXIAL FLOW COMPRESSORS: Classification; Expression for Pressure ratio developed per stage – work done factor, radial equilibrium conditions.

UNIT – 4

CENTRIFUGAL PUMPS: Definition of terms used in the design of centrifugal pumps like manometric head, suction head, delivery head, pressure rise, manometric efficiency,
hydraulic efficiency, volumetric efficiency, overall efficiency, multistage centrifugal pumps, minimum starting speed, slip, priming, cavitation, NPSH.

**UNIT - 5**

**STEAM TURBINES:** Classification, Single stage impulse turbine; Condition for maximum blade efficiency, stage efficiency. Compounding – Need for compounding, method of compounding. Impulse Staging – Condition of maximum utilization factor for multi stage turbine with equiangular blades; effect of blades and nozzle losses. Reaction turbine; Parson’s reaction turbine, condition for maximum blade efficiency, reaction staging.

**HYDRAULIC TURBINES:** Classification: Pelton Turbine-velocity triangles, Design parameters, turbine efficiency, volumetric efficiency; Francis turbine–velocity triangles, runner shapes for different blade speeds, Design of Francis turbine; Function of a Draft tube, types of draft tubes; Kaplan and Propeller turbines – Velocity triangles and design parameters.

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**TURBOMACHINERY LABORATORY**

Performance testing of Turbomachines
1. Pelton wheel
2. Francis Turbine
3. Kaplan Turbines
4. Performance testing of Pumps
5. Multi stage centrifugal pumps
6. Performance test on an Air Blower

Performance testing of Positive Displacement Machines
7. Reciprocating pump
8. Performance test of a two stage Reciprocating Air Compressor

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| CO 1 | Classify typical designs of turbo machines. |
| CO 2 | Compare homologous machines by using dimensional analysis. |
| CO 3 | Apply Euler's equation for turbomachinery to analyze energy transfer in turbines and compressors. |
| CO 4 | Evaluate the performance parameters of pumps, compressors, turbines on a 1-D basis with the use of velocity triangles |
| CO 5 | Make use of laboratory equipments for conducting experiments. |
| CO 6 | Estimate the data in design and development of Turbomachines. |
Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 4 and two questions each from Units 2 & 5.
Course Credits : 03 Marks

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<thead>
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PRE-REQUISITES:
1. Engineering Mechanics
2. Engineering Physics
3. Engineering Mathematics (ODE and PDE)

SYLLABUS:

UNIT – 1

Introduction: Introduction to Vibrations

1 Hour

Undamped free vibrations:
Single degree of freedom systems. Undamped free vibration-natural frequency of free vibration, stiffness of spring elements, effect of mass of spring.

5 Hours

UNIT – 2

Damped free vibrations: Single degree freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.

5 Hours

UNIT – 3

Forced Vibration: Single degree freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, Reciprocating and rotating unbalance, vibration isolation, transmissibility ratio -harmonic exitation and support motion.

7 Hours

Vibration measuring instruments & Whirling of Shafts:
Vibrometer meter and accelerometer. Whirling of shafts with and without damping. Discussion of speeds above and below critical speeds.

5 Hours

UNIT – 4


6 Hours

UNIT 5


10 Hours

TEXT BOOKS:
1. Mechanical Vibrations (English) 8th Edition, G. K. Grover, Nem Chand and Brothers

REFERENCE BOOKS:

**MOOCs:**
1. Mechanical Vibrations - [http://nptel.ac.in/courses/112103112/](http://nptel.ac.in/courses/112103112/)

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| CO 1 | Analyze the vibratory systems for natural frequency |
| CO 2 | Predict the mode shapes for un-damped vibratory systems. |
| CO 3 | Solve differential equations concerned to different vibratory systems |
| CO 4 | Identify vibration measuring techniques for varying parameters |
| CO 5 | Formulate mathematical equations for different types of vibrations for single and multi-degree freedom systems. |
| CO 6 | Apply the governing equations to automotive applications, shafts, shafts with disc. |

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2, & 4 and two questions each from Units 3 & 5.
Course Credits : 06 Marks

<table>
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<tr>
<th>Name</th>
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PRE-REQUISITES:
1. Strength of Materials
2. Engineering Mathematics 1, 2 and 3

SYLLABUS:

UNIT – 1

Fundamental concepts: Principles of Elasticity: stresses-principal, maximum shear and von-Mises stresses, Equilibrium equations, strain displacement relationships in matrix form – Constitutive relationships for plane stress, plane strain, Axi-symmetric and 3D. Boundary conditions. Potential energy and equilibrium, Rayleigh-Ritz method and Galerkin method-applied to simple problems on axially loaded members, cantilever, simply supported beams, with point loads and distributed loads Gaussian quadrature-1pt, 2pt and 3pt formula.

5 Hours

Introduction to FEM, basic concept, historical background, general applicability, engineering applications, general description, comparison with other methods of analysis, commercial packages-preprocessor, solver and post processor.

1 Hour

UNIT – 2

One dimensional problems: Introduction; Finite Element Modeling – Element Division; Numbering Scheme; Coordinate and Shape Functions; The Potential Energy Approach; Assembly of Global Stiffness Matrix and Load Vector; Treatment of Boundary Conditions; Temperature Effects; Numericals. Stiffness matrix of bar element by direct method, Properties of stiffness matrix.

7 Hours

UNIT – 3


6 Hours

UNIT – 4

Formulation of triangular and quadrilateral elements. Introduction to axis symmetric-triangular elements.

7 Hours

Convergence criteria-requirements of convergence of a displacement model, Displacement models and shape functions for i. tetrahedral and hexahedral elements (Pascal pyramid) and ii. Higher order elements in bar, triangular, quadrilateral elements (no formulations).Lagrangian and serendipity elements. Iso parametric, sub parametric and super parametric elements.

2 Hours

UNIT – 5

HEAT TRANSFER PROBLEMS: Steady state heat transfer, 1D heat conduction governing equation, boundary conditions, One dimensional element, Galerkin approach for heat conduction, heat flux boundary condition, 1D heat transfer in thin fins. Numericals.

6 Hours

TEXT BOOKS:
REFERENCE BOOKS:

E-Books
1. INTRODUCTION TO THE FINITE ELEMENT METHOD by Evgeny Barkanov
2. Finite Element Procedures for Solids and Structures Linear Analysis by Klaus-JOrgen Bathe

MOOCs
1. Finite Element Method (FEM) Analysis and Applications -
   https://www.edx.org/course/finite-element-method-fem-analysis-tsinghuax-70120073x
2. A Hands-on Introduction to Engineering Simulations
   https://www.edx.org/course/hands-introduction-engineering-cornellx-engr2000x
3. http://nptel.ac.in/courses/112104115/
5. https://online-learning.tudelft.nl/courses/linear-modeling-fem/

MODELLING AND FINITE ELEMENT ANALYSIS Lab
No. of Practical Hrs/ Week: 02

Study of a FEA package and modeling stress analysis of
a) Trusses
b) Bars of constant cross section area, tapered cross section area and stepped bar
c) Beams -Simply supported, cantilever, beams with UDL, and beams with varying load etc.
d) Stress analysis of a rectangular plate with a circular hole, axisymmetric problems
e) Dynamic Analysis
   1) Fixed -fixed beam for natural frequency determination
   2) Bar subjected to forcing function
   3) Fixed -fixed beam subjected to forcing function

SELF-STUDY
a) Thermal Analysis -2D problem with conduction and convection boundary conditions
b) Fluid flow Analysis -Potential distribution in the 2 -D bodies

REFERENCE BOOKS:
1. ANSYS Workbench Tutorial Release 14, Structural and Thermal Analysis Using Ansys
Mechanical APDL Release 14 Environment, Kent Lawrence, Schroff Development Corporation, www.SDCpublications.com

Scheme for Evaluation:
One Question from Part A - 10Marks
One Question from Part B - 10 Marks
Viva-Voce - 05 Marks
Total 25 Marks

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

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<tr>
<th>CO</th>
<th>Description</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Apply basics of Theory of Elasticity to continuum problems.</td>
</tr>
<tr>
<td>CO 2</td>
<td>Formulate finite elements like bar, truss and beam elements for linear static structural analysis.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Develop models for 2D and axisymmetric finite elements and 1D heat transfer</td>
</tr>
<tr>
<td>CO 4</td>
<td>Solve problems of limited complexity in structural and heat transfer domain</td>
</tr>
<tr>
<td>CO 5</td>
<td>Utilize finite element software to simulate practical problems.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Identify the degree of freedom of elements to be modeled and boundary conditions to be incorporated.</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 3 & 5 and Two questions each from Units 1 & 4.
PRE-REQUISITES:
Manufacturing Technology

SYLLABUS:

UNIT – 1
INTRODUCTION AND CONCEPTS: Classification of metal working processes, Hot, Cold and Warm working, characteristics of wrought products, advantages and limitations of metal working processes
EFFECTS OF PARAMETERS: Temperature, strain rate, friction and lubrication, hydrostatic pressure in metalworking, Deformation zone geometry, workability of materials, Metallurgical structure, Residual stresses in forming. 6 Hours

UNIT – 2

UNIT – 3

UNIT – 4
DRAWING: Drawing equipment & dies, Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables, Tube drawing, drawing defects. Simple problems. 5 Hours

EXTRUSION: Types of extrusion processes, extrusion equipment & dies, deformation, lubrication & defects in extrusion. Extrusion of seamless tubes. Extrusion variables. Simple problems. 6 Hours

UNIT – 5
NON TRADITIONAL FORMING METHODS: Principles, advantages and applications, explosive forming, electro hydraulic forming, Electromagnetic forming, Laser forming. 10 Hours

TEXT BOOKS:

REFERENCE BOOKS:
2. **Principles of Industrial metal working process** - G.W. Rowe, CBSpub. 2002

**WEB REFERENCES:**
- [http://nptel.ac.in/courses/112106153/](http://nptel.ac.in/courses/112106153/)

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| CO 1 | Identify the various metal working processes, based on process parameters. |
| CO 2 | Discover the various process capabilities to establish the relation between them. |
| CO 3 | Solve relevant real world problems concerning Rolling, drawing and extrusion of metals. |
| CO 4 | Formulate mathematical equations for Rolling, drawing and extrusion of metals |
| CO 5 | Choose the appropriate die for the various functions of sheet metal working process |
| CO 6 | Categorize the different non-traditional forming processes. |

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2, 3 & two questions each from Units 4 & 5.
**Course**

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</tbody>
</table>

**PRE-REQUISITES:** Ordinary Differential Equations, Linear Algebra

**SYLLABUS:**

**UNIT - 1**

**INTRODUCTION TO CONTROL SYSTEMS & SYSTEM MODELLING:** Introduction, Basic Terminologies, Advantages of Control Systems, Open loop & Closed loop control systems, Real time applications, Analysis and design objectives, Properties of Feedback. Transfer Functions, models of mechanical systems (translational and rotational), Electrical Systems, Models of DC Motors, Block representation of control system elements, Modeling of mechanical & electrical systems in State Space. 9 Hours

**UNIT - 2**

**TIME RESPONSE ANALYSIS OF CONTROL SYSTEMS:** Types of standard test signals (inputs), poles and zeros. Analysis of first & second order system response to step input, pole-placement. Higher order system response, system response with zeros. Concept of stability: Rout-Hurwitz Criterion. Steady state errors, system type, static error constant. 10 Hours

**UNIT - 3**

**ANALYSIS AND DESIGN USING ROOT LOCUS:** Definition of root loci, general rules for constructing root loci, Analysis using root locus plots, Design of PI, PD and PID controllers using root locus 8 Hours

**UNIT - 4**

**FREQUENCY RESPONSE ANALYSIS:** Nyquist criterion, Sketching Nyquist Diagram, Stability, Gain Margin & Phase Margin via Nyquist plots. Sketching of Polar Plots. 6 Hours

**UNIT - 5**

**BODE PLOTS:** Introduction, Asymptotic Approximations: Bode Magnitude and Phase angle plots. Stability, Gain Margin & Phase Margin via Bode plot 6 Hours

**Text Books**


**Reference Books:**


**E-Books:**

MOOCs:
1. Dynamics and Control – edX: https://www.edx.org/course/dynamics-control-upvalenciax-dc201x-0

Course Outcomes
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Identify the components of control systems given real life situation</td>
</tr>
<tr>
<td>CO 2</td>
<td>Estimate the response characteristics and parameters related to stability of systems</td>
</tr>
<tr>
<td>CO 3</td>
<td>Develop transfer function models and state-space models of single input single output, linear time invariant systems</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyse the time response of first and second order systems</td>
</tr>
<tr>
<td>CO 5</td>
<td>Evaluate the stability of systems using various methods</td>
</tr>
<tr>
<td>CO 6</td>
<td>Design PID controllers</td>
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</table>

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 3, 4 & 5 and two questions each from Units 1 & 2.
### SYLLABUS:

#### PART - A

1. Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2. Determination of Frequencies and mode shapes of cantilever beam
3. Determination of Fringe constant of Photoelastic material using.
   a) Circular disc subjected to diametral compression.
   b) Pure bending specimen (four point bending)
4. Determination of stress concentration using Photoelasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook.

#### PART - B

5. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proel /Hartnel Governor.
7. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.
8. Determination of stresses in Curved beam using strain gauge.

### Course Outcomes

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Estimate the natural frequency for longitudinal, torsional and transverse systems.</th>
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<tbody>
<tr>
<td>CO 2</td>
<td>Make use of Photo elasticity principles for stress analysis.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Determine Principal stresses and strains in members subjected to combined loading</td>
</tr>
<tr>
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<td>using Strain rosettes and compare it with theoretical values</td>
</tr>
<tr>
<td>CO 4</td>
<td>Examine the balancing of rotating masses</td>
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<tr>
<td>CO 5</td>
<td>Experiment with different Governors and calculate equilibrium speed, sensitiveness,</td>
</tr>
<tr>
<td></td>
<td>power and effort</td>
</tr>
<tr>
<td>CO 6</td>
<td>Test for gyroscopic behavior under free and forced precession</td>
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### Scheme of Evaluation for SEE

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<tr>
<td>One question from Part B</td>
<td>20 Marks (05 Write-up +15)</td>
</tr>
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<td>Viva-voce</td>
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Electives – Group 2

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**PRE-REQUISITES:**
1. Engineering Mechanics
2. Strength of Materials
3. Theory of Elasticity

**SYLLABUS:**

**UNIT - 1**

**FUNDAMENTAL OF ELASTICITY:** Concept of stress, spherical and deviator stress tensors, octahedral stresses. Invariants, representative stress. Strain tensor, spherical and deviator strain, octahedral strain and representative strain, cubical dilation, true stress and strain, Generalized Hooke's law, elastic strain energy problems.  

**UNIT - 2**

**YIELD CRITERIA:** Introduction, yield or plasticity conditions, Von Mises and Tresca criteria, Geometrical representation, yield surface, yield locus (two dimensional stress space), experimental evidence for yield criteria, energy required to change the shape with basic principle, problems.  

**UNIT - 3**

**BENDING OF BEAMS:** Analysis for stresses, Non linear stress strain curve, Shear stress distribution, residual stresses in plastic bending, problems.  
**TORSION OF BARS:** Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, residual stresses and problems.  

**UNIT - 4**

**STRESS STRAIN RELATIONS:** Introduction, types of materials, empirical equations, theories of plastic flow, experimental verification of St.Venant’s theory of plastic flow, the concept of plastic potential.

**UNIT - 5**

**PLASTIC DEFORMATION OF METALS:** Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth, flow figures or luder's cubes.


**Text Books**

Reference Books:

E-Books:

MOOCs:
1. Mechanical Behavior of Materials, Part 3: Time Dependent Behavior and Failure
   https://www.edx.org/course

Course Outcomes
Upon completion of this course, student will be able to:

| CO 1 | Analyze stresses and strains that exist within a body subjected to general type of loading |
| CO 2 | Predict the failure of components under multi axial loading based on yielding criteria. |
| CO 3 | Solve analytically the elastic-plastic problems of bending and torsion loads |
| CO 4 | Examine the theories of plastic flow, stress-strain relationships in plastic flow and the mechanism of plastic deformation |
| CO 5 | Formulate 1-D elastic-plastic boundary value problems with basic knowledge of computational aspects. |
| CO 6 | Utilize finite element simulation tools to solve plasticity problems with limited complexities (using Alternate Assessment Tool-AAT). |

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set ONE question each from Units 1, 2 & 4 and TWO questions each from Units 3 & 5.
Name: Fundamentals of Robotics
Code: 16ME6DEROB

PRE-REQUISITES:
Kinematics of Machines, Matrix Algebra

SYLLABUS:

UNIT 1
Introduction: History of robotics, Applications, anatomy and classification
Spatial descriptions and Transformations: Description of position and orientation: position vector, Rotation matrix; Mapping: translation and rotation, homogeneous transform; transformation arithmetic, transform equations, other forms of representation of orientation: Euler angles, 2 -vector representation, angle – axis representation, Euler parameters
Forward Kinematics: Introduction, Link description, link connection description, Denavit-Hartenberg parameters, Derivation of link transformations, concatenating link transformations, actuator space, joint space and Cartesian space

UNIT 2
Inverse Kinematics: Introduction, Solvability: existence of solution, multiple solutions and method of solution; algebraic vs. geometric approach, algebraic solution by reduction to polynomial, workspace, Repeatability and accuracy
Instantaneous Kinematics: Jacobians, changing a Jacobian’s frame of reference, resolved rate motion control, singularities

UNIT 3
Trajectory Generation: Introduction, general considerations in path description and generation, Joint space schemes: cubic polynomial, cubic polynomial for a path with via points, linear function with parabolic blends, linear function with parabolic blends for a path with via points, Cartesian space schemes: Cartesian straight line motion, geometric problems with Cartesian paths, path generation at run time

UNIT 4
Linear Control: Feedback control, second order linear systems, PD control, control law portioning, trajectory following control, disturbance rejection and steady state error, PID control, continuous vs. discrete time control, modeling and control of a single joint, architecture of PUMA 560 robot controller

UNIT 5
Sensors: Introduction, Sensor characteristics, contact and noncontact type sensors

Text Book:
1. Introduction to robotics: mechanics and control, Craig J J, 3/E, Pearson Education India, 2008

Reference Books:

E-Books/Web References:
License: Creative Commons BY-NC-SA

MOOCs
1. https://www.edx.org/course/robot-mechanics-control-part-i-snu446-345-1x

Course Outcomes
Upon completion of this course, student will be able to:

| CO 1 | Develop representation of robots in workspace. |
| CO 2 | Solve for kinematics of robot manipulators |
| CO 3 | Plan trajectory for robot motion |
| CO 4 | Select actuators, sensors and controllers for robotic applications |
| CO 5 | Design simple robots |
| CO 6 | Build simple robots |

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.
**Course**: Composite Material Technology  
**Code**: 16ME6DECMT  
**Credits**: 03  
**Marks**: CIE 50, SEE 50

**PRE-REQUISITES:**  
Strength of Materials, Theory of Elasticity

**SYLLABUS**

**UNIT – 1**  
**INTRODUCTION TO COMPOSITE MATERIALS:** Definition, classification and characteristics of composite Materials – fibrous composites, laminated composites, particulate composites. Applications, future potential of composites.  
**FIBER REINFORCED PLASTIC PROCESSING:** Lay up and curing, fabricating process, open and closed mould process, hand lay up techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermoforming, injection molding, blow molding.

**UNIT – 2**  
**Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli by Rule of mixture, Numerical problems.  
**Macro Mechanics of a Lamina:** Hooke's law for different types of materials, Number of elastic constants, Two – dimensional relationship of compliance and stiffness matrix.

**UNIT – 3**  
**Biaxial Strength Theories:** Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory.

**UNIT – 4**  
**Macro Mechanical Analysis of Laminate:** Introduction, code, Kirchoff hypothesis, CLT, A, B, and D matrices (Detailed derivation), Special cases of laminates.

**UNIT – 5**  
**METAL MATRIX COMPOSITES:** Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application.  
**FABRICATION PROCESS FOR MMC'S:** Powder metallurgy technique, liquid metallurgy technique, diffusion bonding, squeeze technique and secondary processing.

**TEXT BOOKS:**  

**REFERENCE BOOKS:**  
York.

**E-Books:**
1. [http://www.ae.iitkgp.ernet.in/ebooks/](http://www.ae.iitkgp.ernet.in/ebooks/)

**Moocs:**
1. [http://nptel.ac.in/downloads/101104010/](http://nptel.ac.in/downloads/101104010/)

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Classify different composite materials based on the composition and structure of the composite material</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Choose from different manufacturing techniques for making of composites based on type of application</td>
</tr>
<tr>
<td>CO 3</td>
<td>Evaluate composite elastic properties based on micro-mechanical behaviour</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyze the composites for their mechanical properties based on macro-mechanical behaviour</td>
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<tr>
<td>CO 5</td>
<td>Examine the composite for their failure mechanisms</td>
</tr>
<tr>
<td>CO 6</td>
<td>Formulate A, B and D matrices of Composite laminates based on Kirchoff's hypothesis and propose different laminate types</td>
</tr>
<tr>
<td>CO 7</td>
<td>List different metal matrix reinforcements and base materials along with their applications</td>
</tr>
<tr>
<td>CO 8</td>
<td>Decide the manufacturing technique in the making of metal matrix composites</td>
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</tbody>
</table>

**Scheme of Examination (SEE):**
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.
Course Credits : 03 Marks

<table>
<thead>
<tr>
<th>Name</th>
<th>Surface Engineering</th>
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<td>Code</td>
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<tr>
<td>L T P S CIE SEE</td>
<td>3 0 0 0 50 50</td>
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</tbody>
</table>

**PRE-REQUISITES:**
- Engineering chemistry, Physics, Material science & Strength of materials

**SYLLABUS**

**Unit – 1**

**Fundamentals of surface engineering:** Surface engineering: classification, definition, scope and general principles, role and estimate of surface roughness. Surface engineering techniques: Cleaning, pickling, etching, grinding, polishing, buffing / puffing (principles only).

6 Hours

**Unit – 2**

**Surface engineering by material addition:** Surface engineering by material addition: From liquid bath - hot dipping (principle and its application with examples), Electro deposition/plating: theory and its scope of application.

**Surface modification of ferrous and non ferrous components:** Aluminizing, anodizing, calorizing, diffusional coatings (principle and scope of application).

**Surface modification using liquid/molten bath:** Cyaniding, liquid carburizing (principle, scope of application & diffusion from liquid state).

**Surface modification using gaseous medium:** Nitriding, carbo-nitriding (principle, scope of application).

10 Hours

**Unit 03**

**Surface coating techniques:**

**Thin film coatings:** PVD: Evaporation, sputtering (DC, RF, and Magentron), CVD and PECVD, Plasma and ion beam deposition.

**Thick film coatings:** Plasma spray coating, HVOF & cold spray (principle, process parameters and scope of application).

**Functional and Nano-structured coatings:** applications in photovoltaics, bio- and chemical sensors, Silicon wafer deposition (Principle and its applications).

10 Hours

**Unit – 4**

**Coating characterization:** Measurement of coatings thickness porosity & adhesion of surface coatings, measurement of residual stress & stability, surface microscopy & topography by scanning probe microscopy, spectroscopic analysis of modified surfaces, characterization of surface microstructure and properties (name of the techniques and brief operating principle).

7 Hours

**Unit – 5**

**Surface engineering by energy beams:** General classification, scope and principles, types and intensity/energy deposition profile.

Surface engineering by energy beams: Laser assisted microstructural modification – surface melting, hardening, shocking, surface cladding and surface alloying of steel, non-ferrous metals and alloys.

6 Hours

**Text Books**
- Surface Engineering for Corrosion and Wear Resistance. J. R. Davis.

Reference Books

MOOC’s/ WEB REFERENCES:
- http://nptel.ac.in/courses/112105053/.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Course Description</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Identify the various surface engineering techniques based on relevance applications.</td>
</tr>
<tr>
<td>CO 2</td>
<td>Categorize various surface addition methods based on mechanical &amp; chemical properties and its applications.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Select appropriate coating technique for thin films based on relevant applications.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Choose appropriate coating technique for thick films based on relevance applications.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Evaluate material properties using various coating characterization techniques.</td>
</tr>
<tr>
<td>CO 6</td>
<td>Analyze different energy beam methods of surface modification</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4, 5 & two questions each from Units 2 & 3.
Course | Credits : 03 | Marks
--- | --- | ---
Name | Computational Fluid Dynamics | L T P S CIE SEE
Code | 16ME6DECFD | 3 0 0 0 50 50

**PRE-REQUISITES:**
Fluid Dynamics, Vector Calculus, Calculus, Linear Algebra.

**SYLLABUS:**

**UNIT - 1**

*Introduction to CFD and Governing Equations*
Need of CFD as tool, role in R&D, continuum, material or substantial derivative or total derivative, gradient, divergence and curl operators, Linearity, Principle of Superposition.

- Derivation of Navier-Stokes equations in control volume (integral form) and partial differential form, Euler equations (governing inviscid equations).
- Mathematical classification of PDE (Hyperbolic, Parabolic, Elliptic).
- Method of characteristics, Introduction to Riemann Problem and Solution Techniques

**2 Hours**

**3 Hours**

**4 Hours**

**Unit – 2**

*One-dimensional Euler's equation*

**5 Hours**

**Introduction to Turbulence Modeling:** Derivation of RANS equations and k-epsilon model.

**3 Hours**

**Unit – 3**

*Representation of Functions on Computer*

**6 Hours**

**Unit – 4**

*Numerical methods applied to governing equations*
**Finite difference method** – Applied to Linear Convection equation, Laplace Equations, Convection Diffusion equations, Burgers equations, modified equations • Explicit methods and Implicit methods – as applied to applied to linear convection equation, Laplace equations, convection-diffusion equation• FTCS,FTFS,FTBS,CTCS • Jacobi Method, Gauss-Siedel, Successive Over Relaxation Method, TDMA • VonNaumann stability (linear stability) analysis. Upwind Method in Finite Difference method.

**9 Hours**

**Unit – 5**

**Finite volume method**
Finite volume method. Finding the flux at interface.

**Central schemes** - Lax-Friedrichs Method, Lax-Wendroff Method, Two-Step Lax-Wendroff Method and MacCormack Method

**Upwind Method in Finite Volume methods** - Flux Splitting Method Steger and Warming, vanLeer, Roe’s Method and finding Roe’s Averages.

**7 Hours**
Text Books
3. Computational Fluid Dynamics, Malalasekhara,

Reference Books:
5. Leveque, j., Numerical methods for conservation laws, lectures in mathematics, eth Zurich, birkhauser,199
6. Riemann Solvers and Numerical methods for Fluid Dynamics – A

MOOCs:
(1) Introduction to CFD by Prof M. Ramakrishna, Aerospace Engineering, IIT Madras.
(2) Computational fluid dynamics by Prof Suman Chakraborty, Mechanical Engineering, IIT Kharagpur

E-Books:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Understand mathematical characteristics of partial differential equations. |
| CO 2 | Learn how to classify and computationally solve Euler and Navier-Stokes equations. |
| CO 3 | Apply concepts like accuracy, stability, consistency of numerical methods for the governing equations. |
| CO 4 | Identify and implement numerical techniques for space and time integration of partial differential equations. |
| CO 5 | Conduct numerical experiments and carry out data analysis. |
| CO 6 | Acquire basic skills on programming of numerical methods used to solve the Governing equations. |

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2 & 3 and two questions each from Units 4 & 5.
PRE-REQUISITES:
1. THERMODYNAMICS
2. FLUID MECHANICS
3. HEAT AND MASS TRANSFER

SYLLABUS:

UNIT – 1

6 Hours

UNIT – 2
Measurement of Solar Radiation: Pyrnometer, Pyrhiometer, Sunshine recorder - schematic diagram and working principles of the devices. 

12 Hours

UNIT – 3
Solar cells and panels: performance of solar cell, estimation of power obtained from solar power, solar panels PV systems, components of PV systems, performance of PV systems, design of PV systems, application of PV systems, concentrating PV systems, PV power plants, Solar cell array system analysis and performance prediction; Shadow analysis: Solar cell array design concepts; Storage autonomy; Voltage regulation; Maximum tracking. Transmission.  

5 Hours

UNIT – 4
Wind energy: Principles of wind energy conversion, Site selection considerations, Wind power plant design, Types of wind power conversion systems - Horizontal Axis Wind Turbine (HAWT), Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower. Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, yawed operation and tower shadow, WECS control system, requirements and strategies. Operation, maintenance and economics.  

6 Hours

UNIT – 5
BIO-DIESEL: Production, Properties, environmental effects, esterification, transesterification and characterization of bio-diesel.  

10 Hours
TEXT BOOKS:

REFERENCE BOOKS:
2. **Non Conventional Energy Resources**, B.H. Khan- TMH

MOOCs:
1. **NPTEL Course**: http://nptel.ac.in/courses/112105051/#

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>Select the appropriate solar concentrators and tracking methods for harnessing solar energy</td>
</tr>
<tr>
<td>CO 2</td>
<td>Estimate solar flux received from sun on flat and tilted surfaces, efficiency of flat plate and parabolic collectors</td>
</tr>
<tr>
<td>CO 3</td>
<td>Flat plate and parabolic collectors for temperature distribution, Solar geometry and methods of measuring solar radiation and wind turbine designs</td>
</tr>
<tr>
<td>CO 4</td>
<td>Experiment with flat plate and parabolic collectors and P-V panel set up</td>
</tr>
<tr>
<td>CO 5</td>
<td>Alternate sources of energy and systems to generate power using them, methods of storing solar energy and methods of generating power using Bio Mass</td>
</tr>
<tr>
<td>CO 6</td>
<td>Examine the domestic and industrial applications of Solar energy.</td>
</tr>
</tbody>
</table>

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 and 5. Two questions each from Units 2 and 5.

**Solar Energy Data Handbook permitted**
Course | Credits : 03 | Marks
--- | --- | ---
Name | Production and Operation Management | L | T | P | S | CIE | SEE
Code | 16ME6DEPOM | 3 | 0 | 0 | 0 | 50 | 50

**SYLLABUS:**

**UNIT - 1**

**Operations Management and strategy:** Historical evolution, systems view of operations, managing the operations subsystem, framework for managing operations, problems of operation manager, strategic role of operations, contemporary operations management topics, operations/manufacturing strategy, strategic planning: for production and operations, framework, productivity and quality, simple numericals, technology and mechanization.

**6 Hours**

**UNIT - 2**

**Operations capacity:** Introduction, capacity planning environment, strategies for modifying, capacity planning modeling, and linear programming applied to product mix and capacity, computer simulation to evaluate capacity, decision tree analysis, tree diagramming, Numericals on the above topics

**4 Hours**

**UNIT - 3**

**Forecasting:** Introduction, forecasting in operations, forecasting and operation subsystem, characteristics of demand over time, elements of forecasting, useful forecasting models for operations, qualitative (Delphi, naïve), exponential smoothing, regression, behavioral dimensions of forecasting. Numericals on above topics

**6 Hours**

**Designing products, processes and operations scheduling:** New product design, manufacturing process technology, flexible manufacturing system, characteristics, goal, examples, design of services and service processes. Operations scheduling: intermittent systems, scheduling concepts and processes, operation planning and scheduling system, loading, priority sequencing, detailed scheduling, behavioral elements in intermittent systems, shop loading methods (index and assignment), sequencing or prioritization: Johnson’s rule, minimum critical ratio rule, nelsons study, LOB technique. Numericals on above topics

**6 Hours**

**UNIT - 4**

**Purchasing and inventory control:** Introduction, Bayesian analysis, value engineering, purchasing research, vendor relations, negotiations, price forecasting, forward buying, make or buy, Inventory control: introduction, demand and control system characteristics, inventory concepts and systems, costs, modeling. Numericals on above topics

Inventory control applications, deterministic, stochastic and single period model inventory models, inventory control applications, procedures, behavioral pitfalls, optimal order quantity, assumptions of EOQ formula, batch size and quantity, joint cycle for multiple products, inventory model with purchase discounts, approaches to determine buffer stock. Numericals on above topics

**6 Hours**

**UNIT - 5**

**Job design, production operation standards & work measurement:** Introduction, job design, behavioral dimensions, effective job design, production and operation standards, work measurement, techniques, compensation. Numericals on above topics

**5 Hours**
Text Books:

Reference Books:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Plan to use Operations Management And Strategies for managing operations |
| CO 2 | Identify suitable evaluation methods for capacity planning |
| CO 3 | Choose appropriate scheduling system for operations |
| CO 4 | Compare various types of inventory control |
| CO 5 | Develop various concepts for designing a product |
| CO 6 | Distinguish between several behavioral dimensions |

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 1, 2 & 5 and two questions each from Units 3 & 4
Course Credits : 03 Marks
Name CAD/CAM L T P S CIE SEE
Code 16ME6DECAM 3 0 0 0 50 50

PRE-REQUISITES:
Manufacturing Process, Engineering Mathematics

SYLLABUS:

Unit – 1
Introduction to CAD/CAM: Introduction to CAD/CAM, CAD/CAM input devices, CAD/CAM output devices, CAD/CAM Software. Transformations of geometry: Translation, Scaling, Reflection, Rotation, Homogeneous representation of transformation, Concatenation of transformations. 6 Hours

Unit – 2

Unit – 3
Computer Aided Manufacturing (CAM): Introduction to Computer Numerical Control (CNC), Structure of NC machine tools, Designation of axes, Drives & actuation systems, Feedback devices, CNC tooling, Automatic tool changers & Work holding devices. 6 Hours

Unit – 4

Unit – 5

Text Books:
Reference Books:

Moocs:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>Make use of CAD/CAM devices and transformation principles for geometry of parts</td>
</tr>
<tr>
<td>CO 2</td>
<td>Choose from various methods of modeling of geometries in space during CAD applications</td>
</tr>
<tr>
<td>CO 3</td>
<td>Evaluate the models using Finite element Analysis and rapid prototyping</td>
</tr>
<tr>
<td>CO 4</td>
<td>Select appropriate tools, machines for Computer Aided Manufacturing of designed parts</td>
</tr>
<tr>
<td>CO 5</td>
<td>Compile CNC/NC programs for generating toolpaths for machining the designed parts</td>
</tr>
<tr>
<td>CO 6</td>
<td>Plan manufacturing processes and equipment with the help of computers in industries</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Students to answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 & 5 and two questions each from Units 2 & 4.
B.M.S COLLEGE OF ENGINEERING, BENGALURU
Autonomous College under VTU-Belagavi, Karnataka

VISION
Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION
Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

VII & VIII Semester Scheme & Syllabus
With effect from A. Y. 2017 – 18
### VII Semester

<table>
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<th>Code</th>
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<th>Teaching Department</th>
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### 16ME7DE *** ELECTIVE – 3 & 4

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## VIII Semester

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**Total Credits**: 11 0 14 0 25 11

**Total Marks**: 700

### 16ME8DE *** ELECTIVE – 5

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<td>16ME8DEMTD</td>
<td>Machine Tool Design</td>
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<td>16ME8DEGAD</td>
<td>Gas Dynamics</td>
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<td>16ME8DEAHT</td>
<td>Advanced Heat Transfer</td>
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<tr>
<td>16ME8DEAUE</td>
<td>Automotive Engineering</td>
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<tr>
<td>16ME8DEPPE</td>
<td>Power Plant Engineering</td>
</tr>
<tr>
<td>16ME8DENDT</td>
<td>Non-Destructive Testing</td>
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VII - Semester Syllabus
Course | Credits : 06 | Marks
--- | --- | ---
Name | Mechatronics | L T P S CIE SEE
Code | 16ME7DCMCT | 3 0 1 2 50 50

**Syllabus:**

**UNIT-1**

**OVER VIEW OF MECHATRONICS:** Definition of mechatronics, Multi-disciplinary scenario, Origins, Evolution of mechatronics, an overview of mechatronics, Design of mechatronics system, Measurement system & function of main elements of measurement systems, Need for mechatronics in industries, Objectives, Merits & demerits of mechatronics, Microprocessor based controllers, Principle of working of automatic camera, engine management system, automatic washing machine

**06 Hours**

**UNIT-2**

**REVIEW OF TRANSDUCERS AND SENSORS:** Definition and classification of sensors and transducers, Performance terminologies of a transducer, working principle and application of piezoelectric sensors, pyroelectric sensors, proximity sensors, Hall effect sensor and light sensors, Infra-red sensors

**06 Hours**

**UNIT-3**

**ACTUATORS:** ELECTRICAL ACTUATORS - Actuators and classification with examples, mechanical switches and debouncing, relays, triacs and thyristors, principle, construction and working of AC (induction and synchronous) and DC motors, stepper motors, permanent magnet motors & servo motors and control system

HYDRAULIC AND PNEUMATIC ACTUATORS
Valves, classification, symbols, pressure control valves – pressure relief valve, pressure sequence valve, flow control valves – principle, needle valve, direction control valve – sliding spool valve, hydraulic cylinders – constructional features, classification and applications, hydraulic motors – vane motors and piston motors and applications

**10 Hours**

**UNIT-4**

**INTRODUCTION TO APPLIED ELECTRONICS & SIGNAL CONDITIONING:** MSI logic, logic elements, number systems, Flip-flops (S-R, D & J – K), counters (both synchronous and asynchronous up to 4-bit), counters for truncated series, half & full adders, half & full subtractors, MUX (4:1, 8:1) and DMUX (1:4, 1:8), Encoder, Decoder, DAC (weighted resistor type and R/2R ladder type), ADC (counter method and successive approximation register method), simple problems

Concept of signal conditioning, necessity, Op-amps, inverting, non – inverting, summing, integrating and differential Op – amps, Filters, wheat stone bridge, Data Acquisition system, Digital signals, sampling and hold theorem, pulse
width v/s pulse amplitude modulation

**UNIT-5**

**PROGRAMMING USING 8085 MICROPROCESSOR**
Addressing modes, Instruction set, simple programming, (8-bit addition, subtraction, multiplication and division)

07 Hours

**TEXT BOOKS:**
3. Ramesh S Gaonkar, “Microprocessor Architecture, programming and applications with the 8085 ,” Penram International Publishing[INDIA0 pvt Ltd., Mumbai

**REFERENCE BOOKS:**

**MOOCs:**
2. [https://ocw.mit.edu/courses/mechanical-engineering/2-737-mechatronics-fall-2014/](https://ocw.mit.edu/courses/mechanical-engineering/2-737-mechatronics-fall-2014/)

**Scheme of examination:**
Answer five full questions selecting one from each unit
One question to be set from units 1, 2, 5 and two questions from units 3 and 4

**LIST OF EXPERIMENTS FOR MECHATRONICS LAB**

**PART –A**

1. Calibration of proximity, infrared and optical sensors
2. Control of stepper motor
3. Control of hydraulic actuators (simulation)
4. Control of pneumatic actuators (simulation)
5. Actuation of various hydraulic valves
6. Actuation of various electro pneumatic valves

**PART-B**

1. Realization of following logic circuits using applied electronics trainer kit
   a) Basic gates
b) J-K Flip-flop
c) Half and Full Adders
d) Multiplexer

2. **8085 Programming**
   a) ALP for addition of 8-bit and 16-bit binary numbers
   b) ALP for subtraction of 8-bit and 16-bit binary numbers
   c) ALP for multiplication of 8-bit binary numbers
   d) ALP for division of 8-bit binary numbers
   e) ALP for block data transfer
   f) ALP to count number of 1’s or 0’s in a given 8-bit data

**Course Outcomes**
CO1: Summarize how mechatronics integrates knowledge from different disciplines in order to realize engineering and consumer products.
CO2: Understand the fundamentals of simple electromechanical sensors.
CO3: Analyze the general actuation elements of hydraulics, pneumatics & electrical systems.
CO4: Study of various logical elements involved in different multi vibrators.
CO5: Understand the functioning of various components of signal conditioning system.
CO6: Make use of 8085 microprocessor for simple programming.
<table>
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UNIT 1
INTRODUCTION TO PROJECT MANAGEMENT: Concepts & Categories of projects, Selection of projects, Phases of project life cycle, Roles and responsibilities of Project Manager, tools and techniques of project management

06 Hours

UNIT 2
ORGANIZING AND STAFFING: The Project Team: Skills / abilities required for project manager, Authorities and responsibilities of project manager, Project organization and types, Accountability in project execution, controls, tendering and selection of contractors

06 Hours

UNIT 3
PROJECT SCHEDULING: Project implementation scheduling, different scheduling techniques- Bar (GANTT) charts, Bar charts for combined activities. Network construction – AON & AOA diagrams Critical path method to find the expected completion time of a project, floats; Project Evaluation and Review Techniques (PERT), determining the probability of completing a project, predicting the completion time of project; crashing of simple projects. Numericals.

11 Hours

UNIT 4

06 Hours

ECONOMIC PROJECT APPRAISAL: Introduction, evaluation, rate of return, net present value, benefit cost ratio, internal rate of return & simple numericals

04 Hours

UNIT 5
BUDGETING: Types of budgets – Flexible budgets, preparation of cash budgets, purchase and production budgets and master budget, Budgetory control, advantages & limitations of budgeting.

06 Hours

TEXT BOOK:
2. Project Management, A systems approach to planning scheduling and
controllingby
Harold kerzner, CBS publication.
3. **Project Management:** S.Choudhury, McGraw Hill Publications

**REFERENCE:**
1. **Project Management Refer,** Pennington Lawrence, McGraw hill
3. **Project Management,** Bhavesh M. Patal, Vikas publishing House.

**Course Outcomes**
Upon completion of this course, the student will be able to
CO1: Classify projects and identify the phases of the life cycle of project.
CO2: Plan a project, identify and estimate the resources required for its completion
CO3: Create scheduling charts for projects and estimate critical path and project completion time.
CO4: Analyze the project with the aid of economic tools.
CO5: Prepare various types of budgets.

**Scheme of Examination:** Answer Five full questions selecting one from each unit.
To set one question each from Unit 1, 2 & 5 and Two questions each from Units 3 & 4.
Syllabus

PART – A Introduction to MATLAB – As Programming Language
1. Introduction to Simple Calculations with MATLAB
   a) Data Types (Numeric, String) and their conversion
   b) Scalar Quantities and Variables
   c) Mathematical Functions
      • Arithmetic Functions +,-,/,*
      • Bitwise Operators, Relational Operators, Logical Operators
      • Trigonometric and inverse trigonometric Functions
   d) Vectors and Matrices
      • Matrix Multiplication (scalar and Matrix Multiplications, division)
      • Sum, Transpose, Diagonal and Inverse of a Matrix.
      • LU decomposition, QR Factorization
2. Introduction to User Defined Functions, and Scripts
3. 2D and 3D plots (including contour plots)
4. Flow Control
   a) Loops (For Loop, While Loop, Do while loop)
   b) Conditional Statements if else
   c) Switch statement
   d) Vectorization
5. Polynomials
   a) Inbuilt functions - root, polyfit, polyval, etc.,
   b) Root Finding by Bisection, Newton-Raphson Method, Secant Methods
6. Numerical Integration Methods
   a) Trapezoidal Rule
   b) Simpsoons rules (1/3rd and 3/8th Rule)
7. Solving ODE using - Runge-Kutta Methods
8. Introduction to Laplace Transform

PART B – Application of MATLAB to Mechanical Engineering
1. Engineering Mechanics
   1. Statics- Forces in Structures (Trusses, Friction etc)
   2. Dynamics
      1. Path of Projectile
      2. Moving Rigid bodies
2. Fluid Mechanics
   1. Statics - Pascal Law
   2. Dynamics
      1. Applications of Bernoulli principle
      2. Stream function and Potential functions
3. Mechanical Vibrations
   1. Free Vibrations with and without damping
   2. Forced Vibrations with damping
4. Strength of Materials
   1. Plot Shear Force, Bending moment and Deflection diagrams for different beams
      1. Cantilever
      2. Simply supported beam
5. Finite Element Method
   1. Heat transfer through Fin
   2. Stress Analysis for Bars, Truss and Beams
6. Kinematics and Kinetics of Four Bar Mechanism

References:
2. An Engineer’s Guide to MATLAB, Edward B. Magrab, MD Shapour Azarm, MD Balakumar Balachandran, MD James H. Duncan, MD Keith E. Herold Fischell, MD Gregory C. Walsh Leica
3. Essential MATLAB for Engineers and Scientists by Brian D. Hahn and Daniel T. Valentine
6. Numerical Methods in MATLAB, Center for Interdisciplinary Research and Consulting, Department of Mathematics and Statistics University of Maryland, Baltimore County
8. APPLIED NUMERICAL METHODS USINGMATLAB, Won Young Yang, Wenwu Cao, John Wiley & Sons, Publications.

COURSE OUTCOMES:
Upon completion of this course, the student will be able to:

| CO1 | APPLY algorithmic problem solving skills | PO5 |
| CO2 | CREATE functions, scripts, programs which solve medium complex engineering tasks. | PO3 |
| CO3 | DEVELOP solutions to mathematical models applied to practical Mechanical engineering problems. | PO2 |
| CO4 | UTILIZE Matlab software to simulate practical problems | PO5 |
Pre-Requisites
Basic and Applied Thermodynamics

IC Engines Theory:

Discussion: Flash & Fire point of fuel and lubricating oils, its importance, Kinematic and Dynamic Viscosity of lubricating oils using Viscometers, Higher and Lower Calorific values of solid, liquid and gaseous fuels.

04 Hours

Combustion of SI and CI Engine, Testing of Two-stroke and Four-stroke SI and CI Engines, Valve timing diagrams, Heat balance sheet analysis

06 Hours

Syllabus:

PART - A
1. Determination of Flash point and Fire point of lubricating oil using Abel Pensky, Martin (closed) and Cleavland (Open Cup) Apparatus.
2. Determination of Calorific value of solid, liquid and gaseous fuels.
5. Determination of area of P-V diagram using planimeter.

21 Hours

PART - B
1. Performance Tests on Internal Combustion Engines:
   Calculations of Indicated Power, Brake Power, Thermal efficiencies, Specific Fuel Consumption, Frictional Power and heat balance sheet for
   (a) Four stroke Diesel Engine
   (b) Four stroke Petrol Engine
   (d) Two stroke Petrol Engine
   (e) Variable Compression Ratio Engine.
2. Morse test for multi Cylinder Diesel/Petrol Engine

21 Hours

Course Outcomes
Upon completion of this course, the student will be able to:

1. CO1: Determine of flash point, fire point and viscosity of different lubricating oils.
2. CO2: Construct the valve timing diagram for 4-stroke diesel engine and measure irregular areas.
3. **CO3: Examine** the performance of different I.C. Engines and plot the operating characteristics

**Assessment Scheme for Examination:**

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<td>Part B</td>
<td>25 (05 Writeup + 20 Calculations)</td>
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<td>Viva-voce</td>
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Total Marks: 50
1. Every student in a group shall take up a project in the beginning of seventh semester in consultation with the guide and the project must be completed in eighth semester.

2. Maximum group size is 4 students in a group. However, if the project complexity demands a maximum group size of 5 students, then, it is subject to approval from a project evaluation committee, which should be convinced about such complexity and scope of the work.

3. A project proposal must be submitted to the department in this semester. While submitting project proposal care should be taken that project will be completed within the available time of two terms i.e., 8 hours per week for seventh semester and 20 hours per week for eighth semester (a total time of 8*13 + 20*13 = 364 hours per project group student).

4. The final title of the project work should be submitted by the end of seventh semester. The project title should be precise and clear.

5. Selection and approval of the topic:
   a. Topic should be related to real life application in the field of Mechanical, OR
   b. Investigation of the latest development in a specific field of Mechanical, OR
   c. Software development project related to Mechanical OR
   d. Interdisciplinary. (Interdisciplinary projects will be whole-heartedly encouraged and supported.)

6. The group should maintain a logbook of activities. It should have entries related to the work done, problems faced, solution evolved etc., duly signed by the guide.

7. The group is expected to complete, literature review, problem definition, detailed project plan, methodology of work and estimated project cost, in seventh semester, and submit the same in the form of a report (one report per group). The project report must be submitted in the prescribed format only. No variation in the format will be accepted.

8. One guide will be assigned at the most two project groups.

9. The guides should regularly monitor the progress of the project work.

10. Assessment of the project for the award of CIE marks shall be done by the guide and a departmental committee as per the guidelines given below:
Title of the Project: ____________________________________________________
Name of the Guide: ____________________________________________________

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<th>Sl.No</th>
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<td>Documentation (15)</td>
<td>Presentation (20%)</td>
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Sign of Guide    Sign. Of Committee Members    Sign of HOD

11. The guide should be an internal examiner for oral examination.
12. The other examiner (external) should be from the related area of the concerned project.
13. The evaluations of the final oral examination should be done jointly by both the examiners.

**Course Outcomes:**
Upon successful completion of the course, student will be able to:

1. Apply critical thinking in identifying problems & develops innovative and creative ideas/solutions/options employing appropriate quantitative methods and use relevant information technology
2. Exhibit honesty and integrity and sensitive to ethical and diversity issues and behaves in an ethical and professional manner
3. Demonstrate effective leadership abilities for the purpose of organizational growth and change.
4. Effective interpersonal skills and the ability to work successfully in teams of diverse composition
5. Construct coherent written forms of communication and present effective oral forms of communication.
6. Understand the implication of solutions provided on society and environment.
Elective – Group 3

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Syllabus:

**UNIT - 1**

**Political Theory:** Meaning and approaches.

**Justice and Equality:** Social, political and economic; relationship between equality and freedom; Affirmative action.

**Rights:** Meaning and theories; different kinds of rights; concept of Human Rights.

06 Hours

**UNIT - 2**

**Democracy:** Classical and contemporary theories; different models of democracy – representative, participatory and deliberative.

**Political Ideologies:** Liberalism, Socialism, Marxism, Fascism, Gandhism and Feminism.

**Indian Political Thought:** M.K. Gandhi, AND Dr. B.R. Ambedkar.

06 Hours

**UNIT - 3**

**Nationalism:**
(a) Political Strategies of India’s Freedom Struggle: Constitutionalism to mass Satyagraha, Non-cooperation, Civil Disobedience; Militant and revolutionary movements, Peasant and workers’ movements.
(b) Perspectives on Indian National Movement: Liberal, Socialist and Marxist; Radical humanist and Dalit.

**Salient Features of the Indian Constitution:** The Preamble, Fundamental Rights and Duties, Directive Principles; Parliamentary System and Amendment Procedures; Judicial Review and Basic Structure doctrine.
(a) Principal Organs of the Union Government: Envisaged role and actual working of the Executive, Legislature and Supreme Court.
(b) Principal Organs of the State Government: Envisaged role and actual working of the Executive, Legislature and High Courts.

10 Hours

**UNIT - 4**

**Grassroots Democracy:** Panchayath Raj and Municipal Government; significance of 73rd and 74th Amendments; Grass root movements.


**UNIT – 5**

**Party System:** National and regional political parties, ideological and social bases of parties; patterns of coalition politics; Pressure groups, trends in electoral behaviour; changing socio- economic profile of Legislators.

**Social Movements:** Civil liberties and human rights movements; women’s movements; environmentalist movements.

**Text Books:**
1. An Introduction to Political Theory - O. P. Gauba
2. The Constitution of India – P. M. Bakshi

**Course Outcomes:**
1. Understanding of the institutions, processes, constitutional background, and policy outcomes of the government.
2. Knowledge of key theories and concepts, historical developments, organizations, and modern issues in politics.
3. Understanding of government institutions, electoral processes, and policies and the ability to compare the effectiveness or impact of differing political arrangements across countries.
4. Knowledge of some of the philosophical underpinnings of modern politics and government and the legal principles by which political disputes are often settled.

**Scheme of Examination:** Answer five full questions selecting one from each unit. To set one question each from unit 1, 2, & 5 and two questions from unit 3 & 4.
Pre-Requisites:

Syllabus:

UNIT-1
Fracture Mechanics Principles: Introduction, Mechanisms of fracture, a crack in a structure, Griffith’s theorem, modern design, strength, stiffness and toughness, Stress Intensity approach

06 Hours
Stress Analysis for Members with Cracks: Linear elastic fracture mechanics, crack tip stress and deformations, relation between stress intensity factor and fracture toughness, stress intensity based solutions. Crack tip plastic zone estimation, plane stress and plane strain concepts. The Dugdale approach, the thickness effect.

07 Hours
UNIT-2
Elastic-Plastic Fracture Mechanics: Introduction, elastic-plastic criteria, crack resistance curve, J-integral, crack opening displacement, crack tip opening displacement, importance of R-curve in fracture mechanics, experimental determination of J-integral, COD and CTOD.

05 Hours
UNIT-3
Dynamics and Crack Arrest: Introduction, the dynamic stress intensity and elastic energy release rate, crack branching, the principles of crack arrest.

06 Hours
Fatigue and Fatigue Crack Growth Rate: Fatigue loading, various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws.

06 Hours
UNIT-4
Testing of Fracture toughness of metals: Specimen size requirements, various test procedures, effect of temperature, loading rate and plate thickness on fracture toughness, fracture testing in shear modes, fatigue testing, NDT methods.

05 Hours
UNIT-5
Fracture resistance of materials: Fracture criteria, fatigue cracking criteria, effect of alloying and second phase particles, effect of processing and anisotropy,
effect of temperature, closure.

04 Hours

TEXT BOOKS:

REFERENCE BOOKS:
1. Elements of Fracture Mechanics, Prashant Kumar, Tata Mcgraw Hill, Mar-09, ISBN 007056967

E-Books:

COURSE OUTCOMES
Upon completion of this course, student will be able to:
CO1: Understand the concept of linear elastic fracture mechanics and apply it to stress analysis of a cracked body
CO2: Compute crack tip stress intensity factor for 2-D and 3-D cracked bodies made up of linear elastic materials
CO3: Understand the concept of elastic plastic fracture mechanics
CO4: Understand energy approach and apply to stress analysis of fatigue cracks
CO5: Understand various crack growth laws and apply to spectrum loading
CO6: Understand the various fracture toughness measuring techniques and correlate with fracture mechanics

Scheme of Examination:
Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 4 & 5 and two questions each from Units 1 & 3.
Pre-Requisites:
Fundamentals of Robotics

Syllabus:

UNIT - 1
Velocities and Static Forces: linear velocity, angular velocity, velocity propagation, velocity ellipse, static force analysis, Jacobians in the force domain
Dynamics: Newton- Euler Formulation: Linear and angular acceleration, linear and angular momentum, Inertia tensor, Newton’s equation, Euler’s equation, iterative newton -euler dynamic formulation
Lagrangian formulation: Lagrange equations, Kinetic energy, potential energy, equations of motion, Christoffel symbols, Cartesian space dynamics
12 Hours

UNIT - 2
Control: nonlinear dynamic decoupling, feedforward control, task oriented control, force control, hybrid force – position control, adaptive control
8 Hours

UNIT - 3
Vision: Digital images, histograms, thresholding, convolution mask, connectivity, noise reduction, edge detection, segmentation, binary and grey morphology operations, object recognition by features, depth measurement, applications, computational stereo
8 Hours

UNIT - 4
Design: Task requirements, kinematic configuration, quantitative measure of workspace attributes, mechanism considerations, selection of actuators and sensors, control hardware, interfacing, microprocessor control, pulse width modulation, directional control with H-bridge
6 Hours

UNIT - 5
Case studies: Case studies of real world robots
5 Hours

Text Books:
1. Introduction to robotics: mechanics and control, Craig J J, 3/E,Pearson Education India,2008
Reference Books:

E-Books:

MOOCs:
1. [https://www.edx.org/course/robot-mechanics-control-part-i-snu4-46-345-1x](https://www.edx.org/course/robot-mechanics-control-part-i-snu4-46-345-1x)

Course Outcomes
Upon completion of this course, student will be able to:

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<th>CO</th>
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<tbody>
<tr>
<td>CO 1</td>
<td>Solve for velocity and static forces in manipulators</td>
</tr>
<tr>
<td>CO 2</td>
<td>Formulate dynamic equations of robot manipulators</td>
</tr>
<tr>
<td>CO 3</td>
<td>Design controllers for robot motion</td>
</tr>
<tr>
<td>CO 4</td>
<td>Apply the techniques of computer vision to robot manipulation</td>
</tr>
<tr>
<td>CO 5</td>
<td>Select proper actuators, drives and sensors for robot design</td>
</tr>
<tr>
<td>CO 6</td>
<td>Design and build simple robots</td>
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Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 3, 4 & 5 and two questions each from Units 1 & 2.
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**UNIT – 1**

**Introduction:**
Definition of Additive Manufacturing (AM), Need for AM, Applications of AM, Steps in Additive Manufacturing, Benefits of AM, Comparison of CNC with AM Development of AM, CAD Technology, Classification of AM processes

**03 Hours**

**UNIT – 2**

Vat polymerization process: Introduction, Vat Polmerization materials, Reaction Rates, Laser Scan Vat Polymerization, Polymerization process model, Vector Scan VP Machines, Scan patterns in VP, Vector Scan micro-Vat Polymerization, Mask Projection Vat Polymerization Technology, Two Photon Polymerization, Benefits and Drawbacks

**08 Hours**


**05 Hours**

**UNIT – 3**

Extrusion based Systems: Basic Principles, Plotting and Path Control, Materials, Limitations of FDM

Bioextrusion, Contour Crafting, Nonplanar Systems, RepRap

**03 Hours**

**UNIT – 4**

Material Jetting: Introduction, Materials for Jetting, Material process fundamentals, MJ process modelling, Material jetting machines

**04 Hours**


**04 Hours**

**UNIT – 5**

Sheet Lamination Process: Introduction, Materials, Material processing Fundamentals, Ultrasonic Additive Manufacturing

**04 Hours**

Direct Write technologies: Ink based DW, laser transfer DW, Thermal Spray DW, Beam Deposition DW, Liquid Phase Direct DW, Intellectual Property issues with AM, Preparation of CAD models:STL File, Problems with STL File, Direct Digital Manufacturing, Cost Models, Future of DDM.

**05 Hours**
TEXT BOOKS:
2. *Additive Manufacturing Technologies*, Dr. Ian Gibson, Dr. David W. Rosen, Dr. Brent Stucker

REFERENCE BOOKS:

MOOCS:
1. NPTEL
   http://www.nptel.ac.in/syllabus/112104156/

Scheme of Examination:
Answer Five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 5 and two questions each from Units 2 & 4.
Course Credits : 03 Marks

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Pre-Requisites:
1. Fluid Mechanics
2. Engineering Mechanics

Syllabus:

UNIT-1
HYDRAULIC SYSTEMS
Introduction to fluid power systems, structure of fluid power systems, working medium and its properties.
Hydraulic Power Generators – Hydraulic Pumps: Pumping theory, Pump classification, Gear pumps (external and internal), Vane pumps (balanced and unbalanced), Piston pumps (radial, bent axis and swash plate), Pump performance, Pump selection and numericals.
Linear and Rotary Actuators – classification, Constructional details of single and double cylinders, Telescopic cylinder, Mechanics of Hydraulic Cylinder loading; Rotary Actuators: Classification, Gear motors, Vane motors, Piston motors, Hydraulic motor performance and related numericals.

08 Hours

UNIT-2
CONTROL AND REGULATING ELEMENTS
Classification, Pressure control valves: relief valve (direct and pilot operated types), sequence valve, pressure reducing valve (direct and pilot operated types), unloading valve, counterbalance valve. Flow control valves: needle valve, globe valve and pressure and temperature compensated valve, check valve. Directional Control Valves: Constructional features, sliding and rotary types

07 Hours

UNIT-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 circuit, hydraulic cylinder sequencing and synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, hydraulic braking circuit and accumulator circuits, earth mover circuits - design and selection of components - safety and emergency mandrels.

08 Hours

UNIT-4
PNEUMATIC SYSTEMS AND CIRCUITS
Compressed air: Characteristics and Production of compressed air – compressors, preparation of compressed air; Driers, Filters, Regulators,

**UNIT-5**

**ELECTROPNEUMATICS AND MAINTENANCE OF FLUID POWER SYSTEMS**

Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve, Servo valves, and use of microprocessors for sequencing - PLC, Low cost automation. Accumulators (mechanical and hydro-pneumatic types), filters (disc and cartridge types), reservoir system, pressure switches, sealing devices, heaters and heat exchangers, hydraulic oils- desirable properties and type of fluids. Problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control, trouble shooting.

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**E-RESOURCES**
1. www.redoaksys.com (for animations)
2. www.boschrexroth.com
3. www.eaton.in (Vickers)

**Course Outcomes:**
Upon completion of this course, a student will be able to:
1. Understanding the operating principle, performance and selection procedure of hydraulic elements and evaluate pump and actuator performance and justify selection of pumps and actuators for various applications.

2. Understand the working principle of various control elements and applying them for designing a circuit for a given application.

3. Design and analyze hydraulic circuits.

4. Understand the working of pneumatic systems and their control.

5. Identify various components of Electro-pneumatic system & troubleshooting of the pneumatic and hydraulic systems.

6. Design of pneumatic and hydraulic circuits for the industrial applications.

7. Virtual simulation of safety circuits and its effectiveness.

8. Evaluation of performances of fluid power components.

**Scheme of Examination:** Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 3 & 4 and Two questions each from Units 1 & 5.
Pre-Requisites
Basic and Applied Thermodynamics
Fundamentals of Heat Transfer

Syllabus

UNIT – 1
Thermal Performance Analysis of Heat Exchangers:
Compact, cross flow, liquid to gas, and double pipe heat exchangers. Film coefficients for tubes and annuli, equivalent diameter of annuli. Fouling factors, caloric or average fluid temperature, true temperature difference. Design calculation of double pipe heat exchanger. Double pipe exchangers in series-parallel arrangements

07 Hours

UNIT – 2
Shell and Tube Heat Exchangers:

Direct contact Heat Exchangers:
Classification of cooling towers, wet-bulb and dew point temperatures. Lewis number, cooling-tower internals. Heat balance, heat transfer by simultaneous diffusion and convection.

10 Hours

UNIT – 3
Design and analysis of Cooling towers:
Determination of the number of diffusion units. Performance evaluation of cooling towers. Influence of process conditions & operating variables on their design.

07 Hours

UNIT – 4
Heat Pipe:

Heat pipe design:
pipes in cooling microelectronics – micro and mini heat pipes.

UNIT – 5

Applications:
Heat exchangers for special services – Fired heaters – Plate and spiral plate heat exchanger – plate heat exchanger for Diary industry.
Thermal design of heat exchange equipments such as Air pre-heaters, Economizer, Super heater and condensers – horizontal and vertical condensers.

Text Books:
3. Dunn, P and Reay , D A, Heat pipes, Pergamon

Reference Books:
1. Heat Pipe Theory and Practice – A Source Book, Chi,S.W., Mcgraw-Hill
5. Design and technology of heat pipes for cooling and heat exchange, Calvin c. Silverstein Taylor and francis,

COURSE OUTCOMES:
Upon completion of this course, student will be able to:
CO 1 Evaluate the performance of Heat Exchangers
CO 2 Examine the compact heat exchangers under variable load conditions
CO 3 Design the cooling tower for different working conditions
CO 4 Analyze the Heat Pipe based on its heat capacity
CO 5 Design the Heat Pipe for difference heat load conditions
CO 6 Compare the heat transfer devices used in different applications

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3,& 5 and two questions each from Units 2 & 4
Course Credits : 03 Marks

<table>
<thead>
<tr>
<th>Name</th>
<th>Computer Graphics</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>S</th>
<th>CIE</th>
<th>SEE</th>
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</tbody>
</table>

Pre-Requisites: Computer fundamentals.

**Syllabus**

UNIT – 1
SCAN CONVERSION AND CLIPPING REPRESENTATION: of points, lines, line drawing algorithms: DDA algorithm, Bresenham integer line algorithm, Bresenham circle algorithm, mid point line and circle algorithms, polygon filling algorithms: scan conversion, seed filling, scan line algorithm. Viewing transformation, clipping algorithm—points, lines, text, polygon, Cohen-Sutherland line clipping, Sutherland—Hodgman algorithm.

**07 Hours**

TWO DIMENSIONAL TRANSFORMATIONS: Representation of points, homogeneous transformations: rotation, reflection, scaling, translations and concatenations. A geometric interpretation of homogeneous coordinates, over all scaling, points at infinity, rotation about an arbitrary point, reflection through an arbitrary line, problems.

**03 Hours**

UNIT – 2
THREE DIMENSIONAL TRANSFORMATIONS and projections, 3D Transformation matrix: general matrix, translation, scaling, shearing, rotation, reflection, multiple transformations, rotation about an axis parallel to coordinate axis, rotation about an arbitrary axis in space, reflection through an arbitrary plane, orthographic, parallel projection transformations, perspective projections—-one point, two point and three point.

**04 Hours**

PLANE AND SPACE CURVES: representation, non—parameteric curves, parametric curves, parametric representation and generation of line, circle, ellipse, parabola, hyperbola, cubic spline, normalized cubic splines, problems, Bezier curves: blending function, properties, generation, B-spline curves, Cox-Deboor recursive formula, properties, open uniform basis functions, non-uniform basis functions, periodic b-spline curve.

**06 Hours**

UNIT – 3

**06 Hours**

UNIT – 4
VIRTUAL REALISM-II: shading, shading models—-diffuse reflection, specular reflection, ambient light, shading surfaces—-constant shading, Gourand shading, Phong shading, shading enhancements, shading solids—-ray tracing for CSG, z-buffer algorithm for
b-representation and CSG, octree encoded objects, colouring---RGB, CMY, HSV, HSL colour models.

UNIT – 5

COMPUTER ANIMATION: Introduction, conventional animation-key frame, in betweening, line testing, painting, filming, computer animation---entertainment and engineering animation, animation system hardware, software architecture, animation types---frame buffer, colour table, zoom-pan-scroll, cross bar, real time play back, animation techniques-key frame, skeleton. Path of motion and p-curves.

07 Hours

Text Books:

Reference Books:

E-Books:

MOOCs:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Understanding and application of formulations to render primitive graphical entities. |
| CO 2 | Application of transformations for manipulation of graphic elements. |
| CO 3 | Generation/design/modelling of 2D and 3D graphical elements. |
| CO 4 | Recognition and implementation for virtual realism. |
| CO 5 | Understanding the concepts of animation, underlying hardware and software implementations. |
| CO 6 | Problem solving approaches and implementation of algorithms for practical case studies. |
**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 4 & 5 and two questions each from Units 2 & 3.
Elective – Group 4

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits : 03</th>
<th>Marks</th>
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<tbody>
<tr>
<td>Name: Tribology and Bearing Design</td>
<td>L T P S</td>
<td>CIE SEE</td>
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<td>Code 16ME7DETBD</td>
<td>3 0 0 0</td>
<td>50 50</td>
</tr>
</tbody>
</table>

UNIT 1


06 Hours

UNIT 2

Concept of lightly loaded bearings, Petroff’s equation, Numerical problems. Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds’s 2D equation with assumptions.

06 Hours

UNIT 3

Hydrodynamic Bearings: Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, Numerical problems.


06 Hours

UNIT 4


06 Hours

UNIT 5


03 Hours
TEXT BOOKS:
2. Tribology in Industry, Susheel Kumar Srivasthava, S. Chand and Co.

REFERENCE BOOKS:
2. Principles and applications of Tribology, Moore, Pergamon press.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Describe engineering significance of tribology, regimes of lubrication and understand the principle of viscosity measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Design concept of lightly loaded journal bearing and pressure development mechanism.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Apply the Reynolds 2D equation for full journal bearing and slider bearings operating under hydrodynamic condition and estimate design parameters.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Estimate the design parameters of Hydrostatic bearings</td>
</tr>
<tr>
<td>CO 5</td>
<td>Choosing the materials for bearing construction</td>
</tr>
<tr>
<td>CO 6</td>
<td>Understand the working principle of Magnetic bearings and develop design solutions.</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 2 & 5 and two questions each from Units 3 & 4.
Use of Tool Design Data Handbook is permitted in the examination

Unit-1
Design of SINGLE POINT Cutting Tools: Force and power requirement in turning, Drilling and Milling. Types of single point tools, design of shank dimensions based on strength and rigidity, numerical problems on shank dimensions, tool signature (ASA), selection of tool geometry, influence of tool geometry on tool life, inserts and chip breakers. 

06 Hours

Unit-2
Design of DRILL: Force and power requirement in drilling, Types of drills, tool angles, design of twist drill, numerical problems on design of twist drill, influence of tool geometry on tool life.

Design of MILLING CUTTER: Force and power requirement in milling, Types of milling cutters, tool angles, design of plain milling cutter, numerical problems on design of plain milling cutter, influence of tool geometry on tool life.

DESIGN OF TOOLS FOR INSPECTION AND GAUGING: Introduction, work piece quality criteria, principles of gauging, types of gages and their applications, amplification and magnification of error, gage tolerances, selection of material for gages, indicating gages, automatic gages, gauging positionally tolerance parts, problems.

14 Hours

Unit-3
JIGS AND FIXTURES: Differences between jigs and fixtures, Design principles, Economic analysis, Principles of location: 3-2-1 and 4-1-1 types of location, types of locators, redundant location, Clamping: clamping principles, types of clamps, devices - mechanical, hydraulic, vacuum and magnetic.

DRILL JIGS: template, plate, channel, diameter, leaf, box, pot, local, angular, turnover, indexing jigs. Drill bushes, turning and milling fixtures.

FIXTURES: Turning and milling fixtures, indexing type of fixtures.

08 Hours

Unit-4
PRESS TOOLS: Sheet metal operations, Classification, components of simple die, drive Mechanisms, die accessories, press features, press working dies- simple, progressive, and compound, and combination, punch and die clearances, shear action.

08 Hours

Unit-5
PRESS TOOLS DESIGN: Center of pressure. Scrap strip layout, Computation of capacities/tonnage requirements, Design of blanking die and progressive die

Bending - bend allowance, spring back, edge bending die design

Drawing - Single, double and triple action dies, factors affecting drawing, drawing die design, forming limit criteria, deep drawing & redrawing methods, defects in formed parts.
16 Hours

**Self-study topics:**
A. Drawing of single point tool, drill bit and milling cutter as per the design
B. Drawing of one type jig and fixture as per the design
C. Drawing of cutting die as per the design
D. Drawing of bending die as per the design
E. Drawing of drawing die as per the design

**TEXT BOOKS:**

**REFERENCE BOOKS:**
1. *Metal cutting theory and Tool Design* - Arshinav MIR Publications

**MOOCS:**
[http://nptel.ac.in/courses/112105126/35](http://nptel.ac.in/courses/112105126/35)

**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Analyze cutting forces in turning, milling and drilling, describe tool angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Design drill bit and milling cutter and select tool signature based on work material.</td>
</tr>
<tr>
<td>CO3</td>
<td>Choose inspection tools and describe materials for gauges</td>
</tr>
<tr>
<td>CO4</td>
<td>Design and draw jigs and fixtures based on work part geometry</td>
</tr>
<tr>
<td>CO5</td>
<td>Analyze press tool operations</td>
</tr>
<tr>
<td>CO6</td>
<td>Design and draw press tools based on operations</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**
Answer five full questions selecting one from each unit. To set one question each from units 1, 3 and 4 and two questions each from units 2 and 5.
UNIT – 1
INTRODUCTION: Characteristics of successful product development who Designs and develops products, duration and cost of product development, the challenges of product development. A generic development process, concept development: the front-end process, adapting the generic product development process

PRODUCT PLANNING: The product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process.

IDENTIFYING CUSTOMER NEEDS: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

UNIT – 2
PRODUCT SPECIFICATIONS: What are specifications, when are specifications established, establishing target specifications setting the final specifications.

CONCEPT GENERATION: The activity of concept generation clarify the problem search externally, search internally, explore systematically, reflect on the results and the process.

UNIT – 3
CONCEPT SELECTION: Overview of methodology, concept screening, concept scoring, caveats.

CONCEPT TESTING: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process.

PRODUCT ARCHITECTURE: What is product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues.

INDUSTRIAL DESIGN: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, is assessing the quality of industrial design.

UNIT – 4
DESIGN FOR MANUFACTURING: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors.
03 Hours

**PROTOTYPING:** Prototyping basics, principles of prototyping, technologies, planning for prototypes.

03 Hours

**UNIT – 5**

**PRODUCT DEVELOPMENT ECONOMICS:** Elements of economic analysis, base case financial model, sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

06 Hours

**TEXT BOOK:**


**REFERENCE BOOKS:**

1. **Product Design and Manufacturing:** A C Chitale and R C Gupta, PH1
3. **Product Design for Manufacture and Assembly:** Geoffrey Boothroyd, Peter Dewhurst and Winston Knight.

**Course Outcomes**

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO1</th>
<th>Understand the characteristics of successful product development</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Identify and collect customer needs</td>
</tr>
<tr>
<td>CO3</td>
<td>Generate concepts, select and test</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand the importance of Architecture and industrial design</td>
</tr>
<tr>
<td>CO5</td>
<td>Decide for prototype</td>
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<tr>
<td>CO6</td>
<td>Understand economics of projects</td>
</tr>
</tbody>
</table>

**Scheme of Examination:** Answer Five full questions selecting one from each unit.

To set one question each from Unit 2, 4 & 5 and two questions each from Units 1& 3.
Syllabus

UNIT – 1
COMPUTER INTEGRATED MANUFACTURING SYSTEMS:

05 Hours

UNIT – 2
HIGH VOLUME PRODUCTION SYSTEM:

05 Hours

UNIT – 3
ANALYSIS OF AUTOMATED FLOW LINE & LINE BALANCING:
General terminology and analysis, Analysis of Transfer Line without storage upper bound approach, lower bound approach and problems, Analysis of Transfer lines with storage buffer, Effect of storage, buffer capacity with simple problem, Partial automation-with numerical problems, flow lines with more than two stages, Manual Assembly lines, line balancing problem.

MINIMUM RATIONAL WORK ELEMENT:

10 Hours

UNIT – 4
AUTOMATED ASSEMBLY SYSTEMS:
Design for automated assembly systems, types of automated assembly system, Parts feeding devices-elements of parts delivery system-hopper, part feeder, Selectors, feedback, escapement and placement analysis of Multi-station Assembly Machine analysis of single station assembly.

AUTOMATED GUIDED VEHICLE SYSTEM:

10 Hours
UNIT – 5

CNC MACHINING CENTERS:
Introduction to CNC, elements of CNC, CNC machining centers, part programming, fundamental steps involved in development of part programming for milling and turning.

ROBOTICS: Introduction to Robot configuration, Robot motion, Robot Programming, end effectors, Robot sensors and Robot applications.

09 Hours

Text Books:

Reference Books:
2. CAD/CAM by Zeid, Tata McGraw Hill.

E-Books:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1   Design automation lines, AGVs, Layouts in Industrial setup
CO 2   Analyze line balancing issues, manufacturing time, material handling in automation
CO 3   Select various mechanisms, robotic configurations, methods of automation for specific purposes in industries
CO 4   Develop CNC programs, machining methods, process plans during automation
CO 5   Apply assembly line techniques, manufacturing models in automation of manufacturing processes
CO 6   Plan production facilities, processes and material handling equipments during automation

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2,& 5 and two questions each from Units 3 & 4
Prerequisite: Fluid Mechanics, Mathematics III & IV

Syllabus:

UNIT - 1

07 Hours

UNIT - 2
Measurement of Flow Parameters I N Wind Tunnels

08 Hours

UNIT - 3

08 Hours

UNIT - 4
Strain gage force balances, Pressure measurement, steady - Capacitance and piezo resistive strain gage transducers, Unsteady - Piezoelectric transducers for rapidly varying signals

08 Hours

UNIT - 5
Flow visualization (smoke, hydrogen bubbles and schlieren imaging)
1. Thermal anemometry- Hot wires, Hot films, Vector sensors
2. Laser-Doppler velocimetry
3. Optical Techniques- Shadowgraph, Schlieren, Interferometry, particle-image velocimetry

08 Hours
Textbooks:
3. Wind Tunnels and their instrumentation - S. M. GORLIN and I. I. SLEZINGER

References:

Course Outcomes
After successful completion of this course the students will
1. Design and develop wind tunnels.
2. Get familiarise with common measurement and analysis techniques in the field of Fluid Mechanics.
3. Conduct and design experiments independently.
4. Visualize the flow fields with various techniques
5. Acquire and process the data and analyze the data to get insights of flow physics.
Prerequisites

1. Basic and Applied Thermodynamics
2. Fundamentals of Heat Transfer
3. Fluid mechanics

Syllabus

UNIT – 1

Refrigerants: Types of Refrigerants, Comparative study of Ethane and Methane derivatives, selection of Refrigerants, Requirements of Refrigerants, Effects of lubricants in Refrigerants, substitutes of CFC Refrigerants, Mixture Refrigerants - azeotropic mixtures

05 Hours

UNIT – 2

Method of Refrigeration and Non-conventional refrigeration system: Ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, thermo electric refrigeration, pulse tube refrigeration, thermo acoustic refrigeration, refrigeration by throttling of gas, steam jet refrigeration system, refrigeration by using liquid using liquid gases, vortex refrigeration, cooling by adiabatic demagnetization. Defrosting in refrigerators, Mine air conditioning and ventilation.

06 Hours

Transmission And Distribution Of Air: Room air distribution, friction losses and dynamic loss in ducts, Air flow through simple Duct system, air duct design.

05 Hours

UNIT – 3

Psychometry: Psychometry and psychometric properties, psychometric relations, psychometric chart, psychometric processes, requirements of comfort air conditioning, comfort chart, design consideration, summer air conditioning system, winter air conditioning.

04 Hours

Applied Psychrometry: Psychometric processes: its representation psychometric chart; Adiabatic mixing of air streams; coil bypass factor, Air conditioning process. ADP, ventilation and infiltration. Use of Air conditioning calculation format.

04 Hours

UNIT – 4

Design Load Conditions Calculations: Design Conditions: Outside design conditions, choice of inside conditions, comfort chart. Choice of supply design condition. Load Calculations and Applied Psychrometries: Internal heat gains, system heat gains, break up of ventilation load and effective sensible heat factor, Bypass factor, cooling load estimate. Psychometric calculations for cooling. Air conditioning systems, DX system, all water system, all air system, air water
system, central and unitary systems, fan coil system. automatic controls of air conditioning systems, Cooling load calculations and design of air conditioning system: Different heat sources, conduction heat load, radiation load of sun, occupants load, equipment load, infiltration air load, miscellaneous heat sources, fresh air load, design of air conditioning system, bypass factor consideration, effective sensible heat factor, cooling coils and dehumidifying air washers.

UNIT – 5
Refrigeration and air conditioning equipments: Refrigeration Equipments- Compressors, condensers and cooling towers, evaporators, expansion devices, electric motors. Air conditioning Equipments- air cleaning and air filters, humidifiers, de-humidifiers heating and cleaning equipments, fans and blower types, performance. Selection of Air conditioning apparatus for cooling and dehumidification, evaporative cooling.

09 Hours

06 Hours

Text Books:

Reference Books:
7. Refrigeration and Air conditioning by Jain V. K.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO  | Evaluate the performance of refrigerants in different refrigeration process. |
| CO 2 | Examine the refrigerants under variable load conditions |
| CO 3 | Design the air duct for different working conditions |
| CO 4 | Analyze the Heat load based on heat source |
| CO 5 | Design the air duct for difference heat load conditions |
| CO 6 | Compare the heat transfer devices used in different applications |
Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 & 5 and two questions each from Units 2 & 4.
<table>
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<tr>
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<th>Credits : 03</th>
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<td>Name Introduction to Microfluidics</td>
<td>L T P S</td>
<td>CIE</td>
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<tr>
<td>Code 16ME7DEIMF</td>
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</table>

**Syllabus**

**UNIT – 1**

**Introduction to Microfluidics:** Introduction, Origin, Definition, microfluidics in nature, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

03 Hours

**UNIT – 2**

**Hydrodynamics of Microfluidic System:** Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Hypotheses of hydrodynamics, Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects, Microfluidics involving inertial effects, surface tension, interfacial energy, Laplace law, wetting, capillary effect with surfactants

10 Hours

**UNIT – 3**


10 Hours

**UNIT – 4**


10 Hours

**UNIT – 5**

**Microfluidic Particle Separation and Microfluidics Application:** Microfluidic separation techniques: Active and passive techniques, Magnetic separation, acoustic separation, electric field, hydrodynamic separation (bi-furcation law, zweifach-fung effect), pinched flow fractionation, deterministic lateral flow displacement, cell focusing
Microfluidics application: Drug delivery, cell culture and point-of-care diagnostics

06 Hours

Text Books:

Reference Books:

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Understand the microfluidics in nature, basic concepts and scaling laws and develop ability to analyse its benefits compared to existing systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Understand and differentiate the physics of fluid flows in micro and macrodevices</td>
</tr>
<tr>
<td>CO 3</td>
<td>Analyse the hydrodynamics of gas and liquid flows at microscale and develop ability to design a simple microfluidic system</td>
</tr>
<tr>
<td>CO 4</td>
<td>Understand the fabrication techniques of microdevices and develop ability to prototype with relevance materials</td>
</tr>
<tr>
<td>CO 5</td>
<td>Understand various platforms in microfluidics and analyse its applicability for the problems pertaining to practical relevance</td>
</tr>
<tr>
<td>CO 6</td>
<td>Understand the microfluidics application and separation concepts pertaining to drug discovery, cell culture and point of care diagnostics.</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 2 & 5 and two questions each from Units 3 & 4.
VIII - Semester Syllabus
Course | Credits : 03 | Marks
--- | --- | ---
Name | Operations Research | L T P S CIE SEE
Code | 16ME8DCORE | 3 0 0 0 50 50

**Syllabus:**

**UNIT - 1**

**INTRODUCTION:** Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR.

**Solution of Linear Programming Problems:** Introduction, linear programming (LP) problem formulation and solution by graphical method. The simplex method-canonical and standard form of an LP problem, slack, surplus and artificial variables, big M method and concept of duality, dual simplex method, Degeneracy in simplex method, numerical on dual simplex method.

**10 Hours**

**UNIT - 2**

**TRANSPORTATION PROBLEM:** Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, degeneracy in transportation problems, application of transportation problem concept for maximization cases, Assignment Problem-formulation, types, application to maximization cases and travelling salesman problems, numerical on travelling salesman problems.

**10 Hours**

**UNIT – 3**

**GAME THEORY:** Introduction, formulation of games, types, solution of games with saddle point, graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games.

**06 Hours**

**UNIT - 4**

**SEQUENCING:** Introduction, basic assumptions, 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 2 jobs on “m” machines using graphical method.

**06 Hours**

**UNIT - 5**

**REPLACEMENT THEORY:** Introduction, replacements of items that deteriorate with time, case 1: value of money does not change with time, case 2: value of money changes with time, to find the optimal replacement policy, replacement of equipment that fails suddenly, individual and group replacement of items that fails completely.

**07 Hours**
Text Books

Reference Books
2. Operations Research, Paneerselvan, PHI

E-Books

Course Outcomes:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Understand and apply the LPP method for practical problems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Analyse and apply the transportation and assignment methods for practical problems.</td>
</tr>
<tr>
<td>CO 3</td>
<td>Analyse and develop appropriate models for gaming problem.</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyse sequencing of machines using Johnson’s rule and graphically.</td>
</tr>
<tr>
<td>CO 5</td>
<td>Analyse replacements of items that deteriorate with time.</td>
</tr>
<tr>
<td>CO 6</td>
<td></td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.
Course | Credits : 02 | Marks
--- | --- | ---
Name | Intellectual Property Rights | L | T | P | S | CIE | SEE
Code | 16HS8DCIPR | 2 | 0 | 0 | 0 | 50 | 50

**Syllabus:**

**UNIT - 1**

**Basic principles of IP laws:** Introduction, Concept of property, Need for a holistic approach, Constitutional aspects of IP, Evolution of the patent system in UK, US and India, Basis for protection, Invention, Criteria for patentability, Non – patentable inventions.

**04 Hours**

**UNIT - 2**

**Patents:** Introduction, Origin and meaning of the term patent, Objective of a patent law, the legislative provisions regulating patents, principles underlying the patent law in India, patentable invention. Procedure for obtaining patent: Submission of application, Filing provisional and complete specification, Examination of the application, advertisement of the acceptance, opposition, Grant and sealing of patent, Term of the patent, compulsory license.

Provisional and complete specification: Definition of Specification, Kinds of specification, provisional specification, complete specification, Claims, Conditions for amendment

**04 Hours**

**UNIT – 3**


**Infringement of patents:** Construction of claims and infringement, patents held to be infringed, patents held to be not infringed.

**Action for Infringement:** Where a suit is to be instituted, procedure followed in the suit, Onus of establishment infringement, Defense by the defendant, The Relief’s, Injunction, Damages or account of profits, patent agents, patent drafting, database searching, and Case studies.

**07 Hours**

**UNIT - 4**

**Copy Right:** Meaning and characteristics of copy right, Indian copy right law, requirement of copy right, Illustrations copy right in literary work, Musical work, Artistic work, work of architecture, Cinematograph film, sound recording.

**Author and Ownership of copy right:** Ownership of copy right, Contract of service, Contract for service, rights conferred by copy right, terms of copy right, license of copy right.

**Infringement of copy right:** Acts which constitute infringement, general principle, direct and indirect evidence of copying, Acts not constituting infringements, Infringements in literary, dramatic and musical works, Remedies
against infringement of copyright, Case studies

UNIT - 5

**Trade Marks:** Introduction, Statutory authorities, procedure of registration of trade marks, rights conferred by registration of trade marks, licensing in trade mark, infringement of trade mark and action against infringement

07 Hours

04 Hours

**Text Books**

1. Basic Principles and Acquisition of Intellectual Property Rights, Dr. T Ramakrishna, CIPRA, NSLIU – 2005.

**Reference Books**

1. Intellectual Property Law (Bare Act with short comments), Universal Law Publishing Co. Ltd. 2007
2. The Trade marks Act 1999 (Bare Act with short comments), Universal Law Publishing Co. Ltd., 2005

**Course Outcomes:**

Upon completion of this course, student will be able to:

| CO 1 | Ability to comprehend the importance of IPR, Constitutional aspects of IP, Patent Systems of various countries |
| CO 2 | Explain Patent system in India, procedure to obtain Patent, Patentable and non-patentable inventions, transfer of Patent and Infringement of Patent |
| CO 3 | Illustrate Copyrightable works, understand Indian Copyright Law and infringement of Copyright |
| CO 4 | Appreciate Trademark System, procedure for registering Trademark and infringement of Trademark |
| CO 5 | |
| CO 6 | |

**Scheme of Examination (SEE):**

- Students to answer five full questions selecting one from each unit.
- To set one question each from Unit 1, 2 & 5 and two questions each from Units 3 & 4.
Course Credits: 12 Marks

<table>
<thead>
<tr>
<th>Name</th>
<th>Project Work – Phase 2</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>S</th>
<th>CIE</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>16ME8DCPW2</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

1. The project group formed in seventh semester will continue their project work in eighth semester and complete the project in all respects (fabrication / simulation, assembly / analysis, testing, tabulation, test results etc.)
2. The group should maintain a logbook of activities. It should have entries related to the work done, problems faced, solutions evolved etc., duly signed by the guide.
3. The guides should regularly monitor the progress of the project work.
4. The project work along with project report should be submitted as part of the term work in eighth semester on or before the last day of the semester.
5. Project report must be submitted in the prescribed format only. No variation in the format will be accepted.
6. Assessment of the project for the award of CIE marks shall be done by the guide and a departmental committee as per the guidelines given in the following table:

**Assessment of 16ME8DCPW2 Project Work Phase 2**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>USN</th>
<th>Name of the student</th>
<th>Assignment by Guide (70%)</th>
<th>Assessment by Departmental Committee (30%)</th>
<th>Grand Total (50)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Execution (10)</td>
<td>Results &amp; Discussions (10)</td>
<td>Project Report (10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sign of Guide</th>
<th>Sign. Of Committee Members</th>
<th>Sign of HOD</th>
</tr>
</thead>
</table>

7. The guide should be an internal examiner for oral examination.
8. The other examiner (external) should be from the related area of the concerned project.
9. The evaluations of the final oral examination should be done jointly by both the examiners.

**Course Outcomes:**

Upon successful completion of the course, student will be able to:

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apply critical thinking in identifying problems &amp; develops innovative and creative ideas/solutions/options employing appropriate quantitative methods and use relevant information technology</td>
</tr>
<tr>
<td>2</td>
<td>Exhibit honesty and integrity and sensitive to ethical and diversity</td>
</tr>
<tr>
<td></td>
<td>issues and behaves in an ethical and professional manner</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>3</td>
<td>Demonstrate effective leadership abilities for the purpose of organizational growth and change.</td>
</tr>
<tr>
<td>4</td>
<td>Effective interpersonal skills and the ability to work successfully in teams of diverse composition</td>
</tr>
<tr>
<td>5</td>
<td>Construct coherent written forms of communication and present effective oral forms of communication.</td>
</tr>
<tr>
<td>6</td>
<td>Understand the implication of solutions provided on society and environment.</td>
</tr>
</tbody>
</table>
Elective – Group 5

<table>
<thead>
<tr>
<th>Name</th>
<th>Multibody Dynamics</th>
<th>Credits : 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>16ME8DEMBD</td>
<td>L T P S CIE SEE</td>
<td>50 50</td>
</tr>
</tbody>
</table>

Pre-Requisites:
Engineering Mechanics, Kinematics and Dynamics of Machines

Syllabus:

UNIT - 1
07 Hours

UNIT - 2
08 Hours

UNIT – 3
08 Hours

UNIT - 4
Kane’s Method: Preliminaries, Generalized coordinates and speeds, partial velocities, accelerations, Generalized inertia forces, active forces, equations of motion, examples.
08 Hours

UNIT - 5
08 Hours
Text Books:
Advanced Engineering Dynamics, J. H. Ginsberg, Harper and Row

Reference Books:

Course Outcomes:
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO</th>
<th>Demonstrate an understanding of principles of dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Apply the principles of rigid body dynamics</td>
</tr>
<tr>
<td>CO 3</td>
<td>Formulate dynamic equations of multi body systems</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyze the stability of motions of systems</td>
</tr>
<tr>
<td>CO 5</td>
<td>Implement and analyze methods of formulating equations of motion for interconnected bodies</td>
</tr>
<tr>
<td>CO 6</td>
<td>Analyse multi body systems using software packages such as MSC Adams</td>
</tr>
</tbody>
</table>

Scheme of Examination (SEE):
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 1, 4 & 5 and two questions each from Units 2 & 3.
### Course Details

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits : 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Machine Tool Design</td>
<td>L  T  P  S</td>
<td>CIE</td>
</tr>
<tr>
<td>Code: 16ME8DEMTD</td>
<td>3  0  0  0</td>
<td>SEE 50</td>
</tr>
</tbody>
</table>

### Pre-Requisites
- Elements of Mechanical Engineering
- Engineering Mechanics
- Kinematics of Machines

### Syllabus:

#### UNIT - 1

**Principles of machine tool design:** General requirements of machine tool design - design process machine tool layout general requirements of machine tool design – design process machine tool layout.

02 Hours

**Cutting force analysis and power requirement:** In Turning, Milling, Drilling, operation with simple problems.

03 Hours

#### UNIT - 2

**Machine tool drives and mechanisms:** Working and auxiliary motion. Drives-Electric drives, Hydraulic transmission, Kinematic structure, Regulation of speed and feeds, stepped regulation, standardization of speed and feed, stepless regulation of speeds and feeds.

05 Hours

**Design of machine tool structures:** Functions-Requirements-Design criteria Material used – static and dynamic stiffness – Profile and basic design procedure for machine tool structures. Design of beds, columns, housing, bases, tables, cross-rails, arms saddle, carriages.

06 Hours

#### UNIT - 3

**Design of guide ways and power screws:** Function and types of guide ways – Design and lubrication of slide ways - aerostatic slide ways - antifriction guide ways, combination guide ways - protecting devices, design of power screws.

06 Hours

#### UNIT - 4

**Design of spindle and spindle bearings:** Functions-Requirements and materials for spindle compliance and machining accuracy. Design of spindles, antifriction bearing, Hydrodynamic and Hydrostatic bearing, Air lubricated bearing.

06 Hours

#### UNIT - 5

**Dynamics of machine tools:** Concept of dynamic cutting process, Physical causes of chatter and vibrations, Types of Chatter. Stability chart, chatter

UNIT - 6

Control systems in machine tools: Functions, requirements and classification. Control system for speed and feeds centralized control pre selective control, control system for forming and auxiliary motions –Mechanical control–Ergonomic consideration and compatibility – Automatic control system – Electric Hydraulic and pneumatic systems.

06 Hours

Text books:

Reference books:

E-Books:

MOOCs:
Not available

Course outcomes:
Upon completion of this course, student will be able to:

| CO1 | Apply the concepts of design process to machine tool design |
| CO2 | Analyse the cutting forces in Turning, Milling, Drilling, operations |
| CO3 | Design the machine tool structures, drives and mechanisms |
| CO4 | Develop guide ways, power screws, spindle and spindle bearings |
| CO5 | Examine the problems of dynamics in machine tools |
| CO6 | Model the control systems in machine tools |

Scheme of Examination:
- Answer FIVE full questions selecting ONE from each unit.
- To set ONE question each from Unit 1, 3 & 4 and TWO questions each from Units 2& 5.
<table>
<thead>
<tr>
<th>Course</th>
<th>Credits : 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Gas Dynamics</td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>16ME8DEGAD</td>
<td></td>
</tr>
</tbody>
</table>

UNIT – 1

**Fundamental equations of steady flow:** Definition of Compressible Flow, Flow Regimes, Continuity and momentum equation and energy equation.

**Isentropic flow:** Acoustic velocity, Mach number, Mach cone and Mach angle. Flow parameters, stagnation temperature, pressure and density.

08 Hours

UNIT - 2

**Variable area flow:** Velocity variation with Isentropic flow, Criteria for acceleration and deceleration. Flow through nozzle, Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle. Effect of back pressure on nozzle flow. Isothermal flow functions and Flow Generalized one dimensional flows.

08 Hours

UNIT - 3

**Flow with normal shock waves:** Development of shock wave, Rarefaction wave, Governing equations, Prandtl-Meyer relation, Mach number downstream, Static pressure rise, Density ratio, Temperature ratio, Tables and charts for normal shock.

08 Hours

UNIT - 4

**Flow with oblique shock waves:** Fundamental relations, Prandtl’s equation, Rankine-Hugoniot equation, Variation of flow parameters and Gas tables for oblique shocks. Over-expanded and under expanded flows.

07 Hours

UNIT – 5

**Flow in constant area with heat transfer:** Stagnation temperature change. Rayleigh line, Pressure ratio and temperature ratio, Entropy considerations and maximum heat transfer.

**Flow in constant area with friction:** Fanno curves, The fanning equation, Friction factor and friction parameter, Fanno line and Fanno flow equations.

08 Hours

TEXT BOOKS:
2. Gas Dynamics, E Radhakrishnan PHI-2006

REFERENCE BOOKS:
1. Introduction to Gas Dynamics: Rolty, wiley 1998
**Course Outcomes:**
Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO1</th>
<th>Apply continuity, momentum and energy equations to compressible flows and Analyze the compelling similarities between compressible and incompressible flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Solve problems involving isentropic and non-isentropic flows including flows across normal shock waves</td>
</tr>
<tr>
<td>CO3</td>
<td>Solve compressible flow problems involving heat transfer and friction</td>
</tr>
<tr>
<td>CO4</td>
<td>Design a convergent divergent nozzle using ANSYS Fluent</td>
</tr>
<tr>
<td>CO5</td>
<td>Estimate shock angle of a wedge using CFD. Compare the CFD results with the corresponding analytical results</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**
- Answer five full questions selecting one from each unit.
- To set one question each from Unit 2, 3 & 4 and two questions each from Units 1 & 5.
Course Credits : 03 Marks
Name Advanced Heat Transfer L T P S CIE SEE
Code 16ME8DEAHT 3 0 0 0 50 50

Pre-Requisites:
1. Basic and Applied Thermodynamics
2. Fundamentals of Heat Transfer
3. Fluid Mechanics

Syllabus:

UNIT – 1
Conduction: Derivation of energy equation for conduction in three dimensions, Initial and boundary conditions. Transient conduction - Concept of Biot number, Lumped capacitance, formulation unsteady conduction from a semi -infinite solid-solution by similarity transformation method. Solution of the general 1D unsteady problem by separation of variables, Laplace equation - solution by variable separable method –concept of superposition and homogeneous boundary condition
Numerical solution for 1-D and 2-D conduction problems -Basic ideas of finite difference method, forward, backward and central differences, Discretization for the unsteady heat equation. 10 Hours

UNIT – 2
Convection: Derivation of governing equation for convection. 2D laminar coquette flow and non-dimensional numbers. Concept of Adiabatic wall temperature. Integral methods for momentum and thermal boundary layers. Pipe flow –concept of developed temperature profile and solutions for constant wall flux and constant wall temperature boundary conditions. Solution of entry length problem for constant wall and constant wall flux boundary conditions.
Natural convection –governing equation, integral solution for flat surface. 10 Hours

UNIT – 3
Radiation: Introduction. Concept of black body, derivation of black body radiation laws from first principles Need for view factors, concept of view factors, mathematical definition. Shape factor calculations. Radiosity, Irradiation method for gray diffuse enclosures, Gas Radiation, Radiation combined with conduction and convection. 07 Hours

UNIT – 4
Boiling & Condensation: Heat transfer during boiling, Boiling of saturated liquid, Boiling regimes, bubble growth, nucleate boiling, critical heat flux, film pool boiling, forced convection boiling. Heat transfer during condensation, Film wise and drop wise condensation, laminar film condensation on vertical plate, turbulent film condensation, film condensation on horizontal and vertical tubes. 06 Hours

UNIT – 5
Applications:
1. Condensation for fluidized and packed bed
2. Numerical solution of energy equation using Lattice Boltzmann formulation
3. Heat Transfer in Electronic Equipments
4. Gas Turbine blade cooling – Impingement cooling, Film cooling and Transpiration cooling

06 Hours

Text Books:
1. Heat transfer, a practical approach, Yunus A Cengel, Mc Graw Hill

Reference:
1. Poulikakos, Conduction Heat transfer, Prentice Hall.

E-Books:
2. NPTEL Heat Transfer course for Mechanical Engineering, 
   [http://nptel.ac.in/courses/112101097/](http://nptel.ac.in/courses/112101097/)

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

| CO 1 | Analyze the concept of unsteady heat transfer |
| CO 2 | Solve heat transfer problem using numerical techniques |
| CO 3 | Discuss free and forced convection heat transfer |
| CO 4 | Inspect the radiation shape factors for different orientations |
| CO 5 | Compare different boiling and condensation phenomenon |
| CO 6 | Apply the concepts of heat transfer to various applications |

Scheme of Examination (SEE):
- Answer Five full questions selecting one from each unit.
- To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2
UNIT 1

06 Hours

UNIT 2
Vehicle performance: Resistance, power and torque curve, driving force against vehicle speed, acceleration and grade-ability in different gears for a typical car or truck plotted from specifications. Calculation and plotting the curves of air, rolling and gradient resistances, driving force, engine power, speed, rear axle ratio. Torque and mechanical efficiency at different vehicle speeds.

06 Hours

UNIT 3

10 Hours

UNIT 4
Propeller shaft and final drive: Functional and design characteristics of propeller shaft, selection criteria for material and cross section of propeller shaft, need for differential and final drive. WHEELS AND TYRES: Use of different types of wheels and tyres, specification, materials. STEERING AND SUSPENSION: Effort multiplication and geometry in steering, types of springs used in suspension system, need for damping. BRAKES: Distribution of braking force on front and rear wheels, stopping distance and braking efficiency, introduction to ABS.

10 Hours

UNIT 5
07 Hours

**Text books:**

**References:**
Course | Credits : 03 | Marks
---|---|---
Name | Power Plant Engineering | L T P S CIE SEE
Code | 16ME8DEPPE | 3 0 0 0 50 50

Pre-Requisites:
1. Basic & Applied Thermodynamics
2. Fundamentals of Heat Transfer

Syllabus:

UNIT – 1
Steam Power Plant: Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, stokers, different types, Oil burners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures.

Chimneys: Natural, forced, induced and balanced draft, Calculations and numericals involving height of chimney to produce a given draft. Cooling towers and Ponds. Accessories for the Steam generators such as Superheaters, Desuperheater, control of superheaters, Economizers, Air pre-heaters and re-heaters.

UNIT – 2

UNIT – 3
Hydro-Electric Plants: Hydrographs, flow duration and mass curves, unit hydrograph and numericals. Storage and pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks, gates and valves. General layout of hydel power plants.

Nuclear Power Plant: Principles of release of nuclear energy; Fusion and fission reactions. Nuclear fuels used in the reactors. Multiplication and thermal utilization factors. Elements of the nuclear reactor; moderator, control rod, fuel rods, coolants. Brief description of reactors of the following types-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor.

UNIT – 4
Energy, Economic And Environmental Issues Of Power Plants: Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants.

UNIT – 5
Environmental Aspects of Power Generation:

Constituents of Atmosphere: Oxides of
sulphur, nitrogen, carbon; Greenhouse effect, Acid precipitation, particulate matter. FGD systems, Electrostatic precipitators, Thermal pollution, nuclear power and environment, Radiation hazards, Shieldings, Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

**Text Books:**
3. **Power Plant Engineering**, Domakundawar, Dhanpath Rai sons. 2003

**Reference:**

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| CO 1 | Understand the working of various components used in steam power plant, diesel power plant, hydroelectric power plant and nuclear power plant and the effect of power and wastes produced on society, public health and environment. |
| CO 2 | Identify various equipment required for power generation in various power plants. |
| CO 3 | Design chimneys for power generation in steam power plant and layout of diesel engine power plants. |
| CO 4 | Determine condenser efficiency, quantity of cooling water in steam power plant, cost of diesel power plants, power produced by diesel power plants, hydroelectric power plants and nuclear power plants. |
| CO 5 | Select appropriate devices for storage of fuel, combustion of fuel, handling of fuel, and improve the plant performance. |
| CO 6 | Estimate load factors, plant capacity, utilization factor, demand and supply. |
| CO 7 | Examine the feasibility of project. |
| CO 8 | Comparison of site selection criteria for various power plants |
| CO 9 | Elaborate an environmental effects of power generation |
| CO 10 | Literature survey on latest developments on power generation. |

**Scheme of Examination (SEE):**
- Answer Five full questions selecting one from each unit.
- To set one question each from Unit 2, 4 & 5 and two questions each from Units 1 & 3.
Syllabus:

UNIT-1
VISUAL INSPECTION AND EDDY CURRENT TESTING

09 hours

UNIT-2
LIQUID PENETRANT TESTING

09 hours

UNIT-3
MAGNETIC PARTICLE TESTING

09 hours

UNIT-4
RADIOGRAPHIC TESTING

09 hours

UNIT-5
ULTRASONIC TESTING
Introduction, Principle of operation Type of Ultrasonic Propagation – Ultrasonic

05 hours

TEXT BOOKS


REFERENCES

3. www.ndt-ed.org
4. www.krautkramer.com.au