Revised syllabus (Rev- 2016) from Academic Year 2016 -17
Under
FACULTY OF TECHNOLOGY

Mechanical Engineering
Second Year with Effect from AY 2017-18
Third Year with Effect from AY 2018-19
Final Year with Effect from AY 2019-20

As per Choice Based Credit and Grading System
with effect from the AY 2016–17.
Co-ordinator, Faculty of Technology

Preamble:
To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEOs) and give freedom to affiliated Institutes to add few (PEOs). It is also resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner’s learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Choice based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner’s performance.

Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Choice based Credit and grading system is implemented from the academic year 2016-17 through optional courses at department and institute level. This will be effective for SE, TE and BE from academic year 2017-18, 2018-19 and 2019-20 respectively.

Dr. S. K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai
Chairman's Preamble:

Engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of the University of Mumbai, I am happy to state here that, the Program Educational Objectives for Undergraduate Program were finalized in a brainstorming session, which was attended by more than 40 members from different affiliated Institutes of the University. They are either Heads of Departments or their senior representatives from the Department of Mechanical Engineering. The Program Educational Objectives finalized for the undergraduate program in Mechanical Engineering are listed below;

1. To prepare the Learner with a sound foundation in the mathematical, scientific and engineering fundamentals
2. To motivate the Learner in the art of self-learning and to use modern tools for solving real life problems
3. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner’s thought process
4. To prepare the Learner for a successful career in Indian and Multinational Organisations

In addition to Program Educational Objectives, for each course of the program, objectives and expected outcomes from a learner’s point of view are also included in the curriculum to support the philosophy of outcome based education. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stakeholders.

Dr. S. M. Khot

Chairman, Board of Studies in Mechanical Engineering, University of Mumbai
Program Structure for
B.E. in Mechanical Engineering
University of Mumbai
(With Effect from 2017-2018)

Semester III

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* Common with Automobile Engineering
** Common with Automobile Engineering, Production Engineering and Civil Engineering
$ Theory for entire class to be conducted
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* Common with Automobile Engineering  
** Common with Automobile Engineering, Production Engineering and Civil Engineering  
$ Theory for entire class to be conducted
### Semester V

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*Theory classes shall be conducted for entire class

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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<tr>
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### Department Level Optional Course III

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<tr>
<td>MEDLO7031</td>
<td>Mechanical Vibrations</td>
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<td>MEDLO7032</td>
<td>Automobile Engineering</td>
<td>ILO7012 Reliability Engineering</td>
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<tr>
<td>MEDLO7033</td>
<td>Pumps, Compressors and Fans</td>
<td>ILO7013 Management Information System</td>
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<td>MEDLO7034</td>
<td>Computational Fluid Dynamics</td>
<td>ILO7014 Design of Experiments</td>
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<td>ILO7015 Operation Research</td>
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<td>ILO7016 Cyber Security and Laws</td>
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<td>ILO7017 Disaster Management and Mitigation Measures</td>
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<td>ILO7018 Energy Audit and Management</td>
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<td>ILO7019 Development Engineering</td>
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# Common with all branches
### Semester VIII

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<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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<th>Credits Assigned</th>
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<tr>
<td>MEC801</td>
<td>Design of Mechanical Systems</td>
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<td>MEC802</td>
<td>Industrial Engineering and Management</td>
<td>04</td>
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### Examination Scheme

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Internal Assessment</th>
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<th>End Sem Exam</th>
<th>Exam Duration (Hrs)</th>
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### Department Level Elective Course IV

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<td>MEDLO8041</td>
<td>Power Plant Engineering</td>
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<td>Project Management</td>
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<td>MEDLO8042</td>
<td>Rapid Prototyping</td>
<td>ILO8022</td>
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<td>MEDLO8043</td>
<td>Renewable Energy Systems</td>
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<td>Entrepreneurship Development and Management</td>
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<td>ILO8028</td>
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<td>ILO8029</td>
<td>Environmental Management</td>
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# Common with all branches
### Course Code: MEC301
### Course Name: Applied Mathematics III
### Credits: 04

#### Objectives
1. To provide sound foundation in the mathematical fundamentals necessary to formulate, solve and analyse engineering problems.
2. To study the basic principles of Laplace Transform, Fourier Series, Complex variables.

#### Outcomes: Learner will be able to...
1. Demonstrate the ability of using Laplace Transform in solving the Ordinary Differential Equations and Partial Differential Equations
2. Demonstrate the ability of using Fourier Series in solving the Ordinary Differential Equations and Partial Differential Equations
3. Solve initial and boundary value problems involving ordinary differential equations
4. Identify the analytic function, harmonic function, orthogonal trajectories
5. Apply bilinear transformations and conformal mappings
6. Identify the applicability of theorems and evaluate the contour integrals.

#### Module	Detailed Contents	Hrs
1	**Laplace Transform**
   1.1 Function of bounded variation, Laplace Transform of standard functions such as 1, $t^n$, $e^{at}$, $\sin at$, $\cos at$, $\cosh at$.
   1.2 Linearity property of Laplace Transform, First Shifting property, Second Shifting property, Change of Scale property of L.T. (without proof).
   $L\{t^n f(t)\}, L\left\{\frac{f(t)}{t}\right\}, L\left\{\int_0^t f(u)\,du\right\}, L\left\{\frac{d^n f(t)}{dt^n}\right\}$ Laplace Transform of Periodic functions.
   1.3 Inverse Laplace Transform: Linearity property, use of theorems to find inverse Laplace Transform, Partial fractions method and convolution theorem (without proof).
   1.4 Applications to solve initial and boundary value problems involving ordinary differential equations with one dependent variable.
   12

2	**Complex variables:**
   2.1 Functions of complex variable, Analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof), Cauchy-Riemann equations in polar coordinates.
   2.2 Milne-Thomson method to determine analytic function $f(z)$ when it’s real or imaginary or its combination is given. Harmonic function, orthogonal trajectories.
   2.3 Mapping: Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations such as Rotation and magnification, inversion and reflection, translation.
   08

3	**Complex Integration:**
   3.1 Line integral of a function of a complex variable, Cauchy’s theorem for analytic functions (without proof) Cauchy’s integral formula (without proof). Singularities and poles.
   3.2 Taylor’s and Laurent’s series development (without proof).
   3.3 Residue at isolated singularity and its evaluation.
   3.4 Residue theorem, application to evaluate real integral of type
   $$\int_0^{2\pi} f(\cos \theta, \sin \theta)\,d\theta, \quad \int_{-\infty}^{\infty} f(x)\,dx$$
   08

4	**Fourier Series:**
   4.1 Orthogonal and orthonormal functions, Expressions of a function in a series of orthogonal functions. Dirichlet’s conditions. Fourier series of periodic function with period $2\pi$ and $2l$.
   10
4.2 Dirichlet’s theorem (only statement), even and odd functions, Half range sine and cosine series, Parseval’s identities (without proof)
4.3 Complex form of Fourier series

| 5 | **Partial Differential Equations:**
|   | 5.3. Heat equation, steady-state configuration for heat flow
|   | 5.4. Two and Three dimensional Laplace equations

**5.0**

| 6 | **Correlation and curve fitting**
|   | 6.1. Correlation-Karl Pearson’s coefficient of correlation problems, Spearman’s Rank correlation problems, Regression analysis- lines of regression (without proof) – problems
|   | 6.2. Curve Fitting: Curve fitting by the method of least squares- fitting of the curves of the form, \( y = ax + b, \ y = ax^2 + bx + c \) and \( y = ae^{bx} \)

**6.0**

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved.**

**References:**

1. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
5. Integral Transforms and their Engineering Applications, Dr B. B. Singh, Synergy Knowledgeware, Mumbai
6. Numerical Methods, Kandasamy, S. Chand & CO
<table>
<thead>
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<th>Course Name</th>
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</thead>
<tbody>
<tr>
<td>MEC302</td>
<td>Thermodynamics*</td>
<td>04</td>
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</table>

**Objectives**
1. To familiarize the concepts of Energy in general and Heat and Work in particular
2. To study the fundamentals of quantification and grade of energy
3. To study the effect of energy transfer on properties of substances in the form of charts and diagrams
4. To familiarize application of the concepts of thermodynamics in vapour power, gas power cycles

**Outcomes:** Learner will be able to…
1. Demonstrate application of the laws of thermodynamics to wide range of systems.
2. Write steady flow energy equation for various flow and non-flow thermodynamic systems
3. Compute heat and work interactions in thermodynamics systems
4. Demonstrate the interrelations between thermodynamic functions to solve practical problems.
5. Use steam table and mollier chart to compute thermodynamics interactions
6. Compute efficiencies of heat engines, power cycles etc.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>01</td>
<td><strong>Basic Concepts &amp; definitions:</strong> Thermodynamics and its importance, Macroscopic and Microscopic view point, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Control Volume approach and Systems approach, Equilibrium – Thermal ,Chemical, Mechanical and thermodynamic, Pure Substance, Property – Intensive and Extensive, State, Path, Process and Cycle. Point Function and Path Function, Quasi Static Process and processes like Isobaric, Isochoric, Isothermal, Polytropic Process, Temperature and different scales, Zeroth Law of Thermodynamics, Energy, sources of energy; forms of energy, Energy transfer by work and forms of work ; free Expansion, Energy transfer by heat ; Adiabatic Process, Equations of state, Ideal gas Equation--; Specific gas constant and Universal Gas Constant</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td><strong>Thermodynamic Relations:</strong> Reciprocal Relation, Cyclic Relation Property relations, Maxwell Relations, TdS equations, Heat capacity relations, Volume Expansivity, Isothermal Compressibility, Clausius-Clapeyron Equation <strong>Availability:</strong></td>
<td>10</td>
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</tbody>
</table>
High grade and Low Grade Energy, Available and Unavailable Energy, Dead State, Available energy with respect to a process and a cycle, Decrease of Available Energy When heat is transferred through a finite temperature Difference, Second Law efficiency

**Properties of Pure Substance:**
Pure substance and Phase changes: Phase change processes of pure substance, Property diagrams for phase change process (T-v, T-s and p-h diagrams), Understanding of Steam Table and Mollier chart with suitable examples.

**Compressors:**
Reciprocating Air Compressor, Single stage compressor – computation of work done, isothermal efficiency, effect of clearance volume, volumetric efficiency, Free air delivery, Theoretical and actual indicator diagram, Multistage compressors – Constructional details of multistage compressors, Need of multistage, Computation of work done, Volumetric efficiency, Condition for maximum efficiency, Inter cooling and after cooling (numerical), Theoretical and actual indicator diagram for multi stage compressors, Rotary Air Compressors- Classification, Difference between compressors and blowers, Working and constructional details of roots blower, Screw type and vane type compressors

**Vapour Power cycle:**
Carnot cycle and its limitations as a vapour cycle, Rankine cycle with different turbine inlet conditions, Mean temperature of heat addition, Methods to improve thermal efficiency of Rankine cycle – Reheat cycle and Regeneration Cycle.

**Gas Power cycles:**
Assumptions of Air Standard Cycle, Otto cycle, Diesel Cycle and Dual cycle, Brayton Cycle, Sterling Cycle and Ericsson Cycle and Lenoir cycle and Atkinson cycle

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**Assessment:**

**Internal Assessment for 20 marks:**
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

**Reference Books:**
1. Thermodynamics: An Engineering Approach by Yunus A. Cengel and Michael ABoles, 7th edition, TMH
2. Basic Engineering Thermodynamics by Rayner Joel, Longman Publishers Engineering
3. Engineering Thermodynamics by P Chattopadhyay, 2nd edition, Oxford University Press India
4. Thermodynamics by P K Nag, 5th edition, TMH
5. Thermodynamics by Onkar Singh, New Age International
6. Thermodynamics by C P Arora, TMH
7. Engineering Thermodynamics through Examples by Y V C Rao, Universities Press (India) Pvt Ltd
8. Fundamentals of Thermodynamics by Moran & Shapiro
Course Code | Course Name | Credits
---|---|---
MEC303 | Strength of Materials* | 04

* Course common to Mechanical and Automobile Engineering

**Objectives:**
1. To study different types of stresses, strain and deformation induced in the mechanical components due to external loads.
2. To study distribution of various stresses in the mechanical elements or bodies of finite dimensions that deform under loads.
3. To study the effects of component dimensions, materials and shapes on stresses and deformations.

**Outcomes:** Learner will be able to…
1. Demonstrate fundamental knowledge about various types of loading and stresses induced.
2. Draw the SFD and BMD for different types of loads and support conditions.
3. Analyse the stresses induced in basic mechanical components.
4. Estimate the strain energy in mechanical elements.
5. Analyse the deflection in beams.
6. Analyse buckling and bending phenomenon in columns, struts and beams.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1 | **Moment of Inertia:**
Area moment of Inertia, Principal Axes and Principal Moment of Inertia, Parallel Axis theorem, Polar moment of Inertia.
**Stresses and Strains:**
Definition – Stress, Strain, Hooke’s law, elastic limit, uni-axial, bi-axial and tri-axial stresses, tensile & compressive stresses, shear stress, Principal stresses and strains, Mohr’s circle.
**Elastic Constants:**
Poisson’s ratio, Modulus of elasticity, Modulus of rigidity, Bulk Modulus, yield stress, Ultimate stress.
Factor of safety, state of simple shear, relation between elastic constants, volumetric strain, volumetric strain for tri-axial loading, deformation of tapering members, deformation due to self –weight, bars of varying sections, composite sections, thermal stress and strain. | 12 |
| 2 | **Shear Force and Bending Moment in Beams:**
Axial force, shear force and bending moment diagrams for statically determinate beams including beams with internal hinges for different types of loading, relationship between rates of loading, shear force and bending moment. | 08 |
| 3 | **Stresses in Beams:**
Theory of pure bending, Assumptions, Flexural formula for straight beams, moment of resistance, bending stress distribution, section modulus for different sections, beams for uniform strength, Flitched beams.
**Direct and Bending Stresses:**
Core of sections, Chimneys subjected to wind pressure.
**Shear Stress in Beams:**
Distribution of shear stress, across plane sections used commonly for structural purposes, shear connectors. | 08 |
| 4 | **Torsion:**
Torsion of circular shafts- solid and hollow, stresses in shafts when transmitting power, shafts in series and parallel.
**Strain Energy:**
Resilience, Proof Resilience, strain energy stored in the member due to gradual, sudden and impact loads, Strain energy due to shear, bending and torsion. | 08 |
Deflection of Beams:
Deflection of Cantilever, simply supported and overhang beams using double integration and Macaulay’s Method for different types of loadings

Thin Cylindrical and Spherical Shells:
Cylinders and Spheres due to internal pressure, Cylindrical shell with hemi spherical ends

Columns and Struts:
Buckling load, Types of end conditions for column, Euler’s column theory and its limitations, Rankine and Johnson formula

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References:

2. Strength of Materials by Ryder, Macmillan
10. Introduction to Solid Mechanics by Shames, PHI
11. Strength of Materials by Nag and Chandra, Wiley India
Course Code | Course Name | Credits
--- | --- | ---
MEC304 | Production Process* | 04

**Objectives**
1. To study basic production processes.
2. To study how to select appropriate production processes for a specific application.
3. To study machine tools

**Outcomes:** Learner will be able to…
1. Demonstrate understanding of casting process
2. Illustrate principles of forming processes
3. Demonstrate applications of various types of welding processes.
4. Differentiate chip forming processes such as turning, milling, drilling, etc.
5. Illustrate the concept of producing polymer components and ceramic components.
6. Distinguish between the conventional and modern machine tools.

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<tr>
<th>Module</th>
<th>Detailed Contents</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>1.1 Metal casting:</strong> Classification of Production Processes: Examples and field of applications Pattern materials and allowances, Types of pattern, Sand properties, Sand moulding, Machine moulding Gating system :Types of riser, types of gates, solidification Melting- cupola&amp; induction furnaces</td>
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<tr>
<td>1</td>
<td><strong>1.2 Special casting processes:</strong> CO2 and shell moulding, Investment casting, Die casting, Vacuum casting, Inspection &amp; casting defects and remedies</td>
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<td><strong>2.1 Joining processes:</strong> Welding: Classification of welding, Oxy-acetylene welding, types of flames, equipment used, welding methods &amp; applications, Arc welding principle and working of metal arc welding, TIG &amp; MIG welding, submerged arc welding, electro-slag welding &amp; stud welding PAM welding. Applications merits &amp; demerits of above welding processes, fluxes used, Thermit welding, Resistance welding, Friction welding, ultrasonic, explosive, LASER, electron beam welding, Welding defects and remedies Soldering and brazing techniques &amp; applications Fastening processes</td>
<td>10</td>
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<td>3</td>
<td><strong>3.1 Forming processes:</strong> Principles and process characteristics, Rolling types, Rolling parameters: Draught, spread, elongation, roll pressure, torque, work and power in rolling, Effect of front and back tension on rolling load and capacities, Rolling defects, Thread rolling roll forging, production of seamless tubes, Forging, Extrusion and Wire Drawing processes</td>
<td>08</td>
</tr>
<tr>
<td>4</td>
<td><strong>4.1 Moulding with polymers:</strong> Moulding with polymers: Basic concepts related to Injection Moulding, Compression moulding, Transfer moulding, Blow Moulding, Rotational Moulding, Thermoforming and Extrusion. Applications of plastics in Engineering field</td>
<td>06</td>
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<tr>
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<td><strong>4.2 Moulding with ceramics:</strong> Blow moulding and extrusion of glass.</td>
<td></td>
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<tr>
<td>6</td>
<td><strong>Classification, Selection and application of Machine Tools:</strong> 5.1 Lathe Machines, Milling Machines, Drilling Machines, and Grinding Machines, Broaching machines, Lapping/Honing machines and shaping/slotting/planning Machines. 5.2 Gear Manufacturing -Gear milling, standard cutters and limitations, gear hobbing, gear shaping, gear shaving and gear grinding processes</td>
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</tr>
<tr>
<td>6</td>
<td><strong>5.1 Modern Machine Tools:</strong> CNC machines: Introduction, principles of operation, Types – Vertical machining centres and horizontal machining centres, major elements, functions, applications, controllers, open loop and closed loop systems 5.2 Types of automatic machines, Transfer machines</td>
<td>04</td>
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Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
1. Question paper will comprise of total six questions, each carrying 20 marks
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3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References
1. Workshop Technology By W. A. J. Chapman part I, II & III
2. A Textbook of Foundry Technology by M. Lal
3. Production Technology by R. C. Patel and C. G. Gupta Vol I, II.
4. Production Technology by Jain & Gupta
5. Manufacturing, Engineering and Technology SI by Serope Kalpakjian, Steven R. Schmid, Prentice Hall
6. Production Technology by HMT
7. Elements of Workshop Technology Hazra Chaudhary Vol I, II.
8. Foundry technology by P.L. Jain
9. Production Technology by P.C. Sharma
10. Manufacturing processes by P. N. Rao, Vol. 1 and 2
<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>1.1 Classification of Materials:</strong> Metallic materials, Polymeric Materials, Ceramics and Composites: Definition, general properties, applications with examples</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td><strong>1.2 Lattice Imperfections:</strong> Definition, classification and significance of Imperfections Point defects: vacancy, interstitial and impurity atom defects, Their formation and effects, Dislocation - Edge and screw dislocations Burger’s vector, Motion of dislocations and their significance, Surface defects - Grain boundary, sub-angle grain boundary and stacking faults, their significance, Generation of dislocation, Frank Reed source, conditions of multiplication and significance.</td>
<td></td>
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<tr>
<td></td>
<td><strong>1.3 Deformation:</strong> Definition, elastic and plastic deformation, Mechanism of deformation and its significance in design and shaping, Critical Resolved shear stress, Deformation in single crystal and polycrystalline materials, Slip systems and deformability of FCC, BCC and HCP lattice systems.</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td><strong>1.4 Strain Hardening:</strong> Definition importance of strain hardening, Dislocation theory of strain hardening, Effect of strain hardening on engineering behaviour of materials, Recrystallization Annealing: stages of recrystallization annealing and factors affecting it</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>Failure mechanisms:</strong> <strong>1.1 Fracture:</strong> Definition and types of facture, Brittle fracture: Griffith’s theory of fracture, Orowan’s modification, Dislocation theory of fracture, Critical stress and crack propagation velocity for brittle fracture, Ductile fracture: Notch effect on fracture, Fracture toughness, Ductility transition, Definition and significance</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td><strong>1.2 Fatigue Failure:</strong> Definition of fatigue and significance of cyclic stress, Mechanism of fatigue and theories of fatigue failure, Fatigue testing, Test data presentation and statistical evolution, S-N Curve and its interpretation, Influence of important factors on fatigue, Notch effect, surface effect, Effect of pre-stressing, corrosion fatigue, Thermal fatigue.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>1.3 Creep:</strong> Definition and significance of creep, Effect of temperature and creep on mechanical behaviours of materials, Creep testing and data presentation and analysis, Mechanism and types of creep, Analysis of classical creep curve and use of creep rate in designing of products for load bearing applications, Creep Resistant materials</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>3.1 Theory of Alloys &amp; Alloys Diagrams:</strong> Significance of alloying, Definition, Classification and properties of different types of alloys, Solidification of pure metal, Different types of phase diagrams (Isomorphous, Eutectic,</td>
<td>08</td>
</tr>
</tbody>
</table>
Peritectic, Eutectoid, Peritectoid) and their analysis, Importance of Iron as engineering material, Allotropic forms of Iron, Influence of carbon in Iron-Carbon alloying Iron-Iron carbide diagram and its analysis, TTT diagram, CCT diagram Hardenability concepts and tests, Graphitization of Iron- Grey iron, white iron, Nodular and malleable irons, their microstructures, properties and applications

**4.1 Heat treatment Process:**
Technology of heat treatment, Classification of heat treatment process, Annealing- Principle process, properties and applications of full annealing, Diffusion annealing, process annealing and Cyclic annealing, Normalizing, Hardening heat treatment, Tempering, Subzero treatment, Austempering, Martempering, Maraging and Ausforming process, Surface hardening: Hardening and surface Hardening methods, Carburizing, Nitriding, Cyaniding, Carbonitriding, induction hardening and flame hardening processes

**5.1 Effect of Alloying Elements in Steels:**
Limitation of plain carbon steels, Significance of alloying elements, Effects of major and minor constituents, Effect of alloying elements on phase transformation Classification of tool steels and metallurgy of tool steels and stainless steel

**6.1 Composites:** Basic concepts of composites, Processing of composites, advantages over metallic materials, various types of composites and their applications

**6.2 Nano Materials:** Introduction, Concepts, synthesis of nanomaterials, examples, applications and Nano composites

**6.3 An overview to Smart materials (e.g.: Rheological fluids)**

**Assessment:**

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3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

**References**
1. Materials Science and Engineering by William D. Callister, Jr. – Adapted by R.Balasubramaniam, Wiley India (P) Ltd
### Objectives:
1. To familiarise conversion of an object into a drawing
2. To study conventional representation of various machining and mechanical details as per IS
3. To become conversant with 2-D and 3-D drafting

### Outcomes:
Learner will be able to…
1. Visualize and prepare detail drawing of a given object.
2. Read and interpret the drawing
3. Draw details and assembly of different mechanical systems.
4. Convert detailed drawing into assembly drawing using modelling software
5. Convert assembly drawing into detailed drawing using modelling software
6. Prepare detailed drawing of any given physical object/machine element with actual measurements

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Theory</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>1.1 Machine Elements</strong>: Preparation of 2-D drawings of standard machine elements (nuts, bolts, keys, cotter, screws, spring etc)</td>
<td>02</td>
<td>04</td>
</tr>
<tr>
<td></td>
<td><strong>1.2 Conventional representation of threaded parts, Types of threads; thread designation, Conventional representation of machine components and materials, Designation of standard components</strong></td>
<td>01</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><strong>1.3 Solid Geometry</strong>: Intersection of surfaces and interpenetration of solids- Intersection of prism or cylinder with prism; cylinder or cone, both solids in simple position only. Primary auxiliary views</td>
<td>04</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td><strong>2.1 Geometric Dimensioning and Tolerancing (GD&amp;T)</strong>: Dimensioning with tolerances indicating various types of fits,</td>
<td>02</td>
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</tr>
<tr>
<td></td>
<td><strong>2.2 Details and assembly drawing</strong>: Types of assembly drawings, part drawings, drawings for catalogues and instruction manuals, patent drawings, drawing standards,</td>
<td>02</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><strong>2.3 Introduction to unit assembly drawing, steps involved in preparing assembly drawing from details and vice-versa,</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>2.4 Preparation of details and assembly drawings of any three from</strong>: Clapper block, Single tool post, Lathe and Milling tail stock, jigs and fixtures</td>
<td>02</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td><strong>2.5 Cotter, Knuckle joint, Keys</strong>: keys-sunk, parallel woodruff, saddle, feather etc.</td>
<td>01</td>
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<tr>
<td></td>
<td><strong>2.6 Couplings</strong>: simple, muff, flanged Protected flange coupling, Oldham’s coupling, Universal coupling</td>
<td>02</td>
<td>06</td>
</tr>
<tr>
<td>3</td>
<td><strong>3.1 Preparation of details and assembly drawings of Bearings</strong>: Simple, solid, Bushed bearing, I.S. conventional representation of ball and roller bearing, Pedestal bearing, footstep bearing</td>
<td>02</td>
<td>06</td>
</tr>
<tr>
<td>4</td>
<td><strong>4.1 Preparation of details and assembly drawings of pulleys, Pipe joints</strong>: Classification of Pulleys, pipe joints</td>
<td>02</td>
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</tr>
<tr>
<td></td>
<td><strong>4.2 Pulleys</strong>: Flat belt, V-belt, rope belt, Fast and loose pulleys.</td>
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<td>06</td>
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<td></td>
<td><strong>4.3 Pipe joints(any two): Flanged joints, Socket and spigot joint, Gland and stuffing box, expansion joint</strong></td>
<td></td>
<td>06</td>
</tr>
<tr>
<td>5</td>
<td><strong>5.2 Preparation of details and assembly drawings of Valves, I.C. Engine parts</strong>: Types of Valves, introduction to I.C. Engine</td>
<td>02</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><strong>5.3 Preparation of details and assembly drawings(any three): Air cock; Blow off cock, Steam stop valve, Gate valve, Globe valve, Non return Valve, I.C. Engine parts: Piston, Connecting rod, Cross head, Crankshaft, Carburettor, Fuel pump, injector, and Spark plug</strong></td>
<td></td>
<td>08</td>
</tr>
</tbody>
</table>
6.1 Reverse Engineering of a physical model: disassembling of any physical model having not less than five parts, measure the required dimensions of each component, sketch the minimum views required for each component, convert these sketches into 3-D model and create an assembly drawing with actual dimensions

Assessment:

Term work
A. Minimum two questions from theory part of each module should be solved as a home work in A-3 size sketch book.
B. A-3 size Printouts/plots of the problems solved in practical class from the practical part of each module. Problems from practical parts of each module should be solved using any standard CAD packages like IDEAS, PRO-E, CATIA, Solid Works, Inventor etc.

The distribution of marks for Term work shall be as follows:
- Home work sketch book 20 marks
- Printouts/Plots 20 marks
- Attendance 10 marks

End Semester Practical/Oral examination:
To be conducted by pair of Internal and External Examiner
1. Practical examination duration is three hours, based on Part-B of the Term work, and should contain two sessions as follows:
   Session-I: Preparation of 3-D models of parts, assembling parts and preparing views of assembly from given 2-D detailed drawing.
   Session-II: Preparation of minimum five detailed 3-D part drawings from given 2-D assembly drawing.
   Oral examination should also be conducted to check the knowledge of conventional and CAD drawing.
2. Questions provided for practical examination should contain minimum five and not more than ten parts.
3. The distribution of marks for practical examination shall be as follows:
   - Session-I …… ….20 marks
   - Session-II …… …20 marks
   - Oral …… ………10 marks
4. Evaluation of practical examination to be done based on the printout of students work
5. Students work along with evaluation report to be preserved till the next examination

References:
8. Autodesk Inventor 2011 for Engineers and Designers by ShamTickoo and SurinderRaina, Dreamtech Press
9. Engineering Drawing by P J Shah
10. Engineering Drawing by N D Bhatt
Objectives:
1. To familiarise material behaviour under different loading conditions
2. To acquaint with surface hardness measurement method
3. To familiarise with impact test methods for different materials

Outcomes: Learner will be able to…
1. Analyse the stress - strain behaviour of materials
2. Measure ultimate tensile/compression strength of material
3. Measure torsional strength of material
4. Perform impact test using Izod and Charpy method
5. Measure the hardness of materials.
6. Perform flexural test with central and three point loading conditions

a) List of Experiments (Minimum Eight)

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Laboratory Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tension test on mild steel bar (stress-strain behaviour, determination of yield strength and modulus of elasticity)</td>
<td>2 Hrs</td>
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<tr>
<td>2</td>
<td>Bending test on UTM</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>3</td>
<td>Torsion test on mild steel bar / cast iron bar</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>4</td>
<td>Impact test on metal specimen (Izod test)</td>
<td>2 Hrs</td>
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<tr>
<td>5</td>
<td>Impact test on metal specimen (Charpy test)</td>
<td>2 Hrs</td>
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<tr>
<td>6</td>
<td>Hardness test on metals - Brinell Hardness Number</td>
<td>2 Hrs</td>
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<tr>
<td>7</td>
<td>Hardness test on metals - Rockwell Hardness Number</td>
<td>2 Hrs</td>
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<tr>
<td>8</td>
<td>Flexural test on beam (central loading)</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>9</td>
<td>Flexural test on beam ( three point loading)</td>
<td>2 Hrs</td>
</tr>
</tbody>
</table>

b) Assignments: Atleast one problem on each of the following topics:
1. Simple stress strain
2. SFD and BMD
3. Stresses in beams
4. Strain energy and deflection.
5. Torsion, Columns and struts

Note: Preferably, the assignments shall be based on live problems. **Project Based Learning may be incorporated by judiciously reducing number of assignments.**

Assessment:

**Term Work:** Including Part a and b both
Distribution of marks for Term Work shall be as follows:
- Part a : 15 marks.
- Part b : 05 Marks
- Attendance : 05 marks.

**End Semester Practical/oral Examination:**
Pair of Internal and External Examiner should conduct practical examination followed by Oral
Course Code | Course Name | Credits  
--- | --- | ---  
MEL303 | Materials Technology* | 03  

**Objectives:**
1. To familiarise with use of optical laboratory microscope  
2. To acquaint with microstructures of ferrous (steel and cast iron) metals  
3. To familiarise with microstructures of steel under different heat treated conditions  
4. To study hardenability, fatigue test for fatigue strength and corrosion rate test  

**Outcomes:** Learner will be able to…
1. Demonstrate the understanding of the procedure to prepare samples for studying microstructure using microscope (metallography)  
2. Interpret different phases present in different plain carbon steels and cast irons.  
3. Perform different heat treatment processes for a steel and observe microstructures in these conditions  
4. Identify effects of Annealing, Normalizing and Hardening on microstructure of medium carbon steel  
5. Determine hardenability of steel using Jominy end Quench test  
6. Determine S-N curve by Fatigue Test.  

<table>
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<tr>
<th>Sr No</th>
<th>Details</th>
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<tbody>
<tr>
<td>1</td>
<td>Study of metallurgical microscope</td>
</tr>
<tr>
<td>2</td>
<td>Metallographic sample preparation and etching</td>
</tr>
<tr>
<td>3</td>
<td>Microstructures of plain carbon steels</td>
</tr>
<tr>
<td>4</td>
<td>Microstructures of cast irons</td>
</tr>
<tr>
<td>5</td>
<td>Annealing, Normalizing and Hardening of medium carbon steel and observation of microstructures</td>
</tr>
<tr>
<td>6</td>
<td>Study of tempering characteristics of hardened steel</td>
</tr>
<tr>
<td>7</td>
<td>Determination of hardenability of steel using Jominy end Quench Test</td>
</tr>
<tr>
<td>8</td>
<td>Fatigue test – to determine number of cycles to failure of a given material at a given stress</td>
</tr>
</tbody>
</table>

**Assignments:** Assignment on following topics
1. Crystal imperfections-deformation-strengthening mechanisms  
2. Fracture-failure of metals  
4. Heat treatment processes  
5. Alloy steels (e. g. alloy steels, tool steels)  
6. New materials  

Note: Preferably, the assignments shall be based on live problems. **Project Based Learning may be incorporated by judiciously reducing number of assignments**

**Assessment:**

**Term Work:** Including Laboratory Work and Assignments both  
Distribution of marks for Term Work shall be as follows:  
- Laboratory work: 15 marks  
- Assignments: 05 Marks  
- Attendance: 05 marks
Objectives:
1. To study basic machining processes.
2. To familiarise various machining operations and machine protocols.

Outcomes: Learner will be able to...
1. Operate various machines like lathe, shaper etc.
2. Perform plain turning, taper turning, and screw cutting etc. on lathe machine.
3. Perform machining operations on shaper.
4. Demonstrate metal joining process like compressive welding.
5. Perform forging operations.
6. Perform shaping operations.

<table>
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<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Lathe Machine, demonstration of various machining processes performed on lathe machine. One Job on Plain and Taper Turning One job on Precision Turning, Taper Turning and Screw Cutting</td>
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</tr>
<tr>
<td>2</td>
<td>Introduction to Shaping Machine and various machining processes performed on Shaping Machine One job on shaping machine to make horizontal and inclined surface</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Introduction to various forging tools Two jobs on Forging of Cutting Tools used on Lathe Machine</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>One simple exercise on Welding, Preparation of a component using Compressive Welding Joint</td>
<td>6</td>
</tr>
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</table>

Assessment:

Term Work:
1. All the jobs mentioned above
2. Complete Work-Shop Book giving details of drawing of the job and time sheet

The distribution of marks for Term work shall be as follows:

- Job Work with complete workshop book …..40 marks
- Attendance …..10 marks
Course Code | Course Name | Credits
--- | --- | ---
MEC401 | Applied Mathematics IV** | 04

Objectives:
1. To inculcate an ability to relate engineering problems to mathematical context
2. To provide a solid foundation in mathematical fundamentals required to solve engineering problems
3. To study the basic principles of Vector analyses, complex integration, probability, test of hypothesis and correlation between data.
4. To prepare students for competitive exams

Outcomes: Learner will be able to…
1. Solve the system of linear equations using matrix algebra with its specific rules
2. Demonstrate basics of vector calculus
3. Apply the concept of probability distribution and sampling theory to engineering problems
4. Apply principles of vector calculus to the analysis of engineering problems
5. Identify, formulate and solve engineering problems
6. Illustrate basic theory of correlations and regression

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1 | Matrices:  
1.1 Brief revision of vectors over a real field, inner product, norm of a vector  
1.2 Eigen values and Eigen vectors: Characteristic polynomial, characteristic equation, characteristic roots and characteristic vectors of a square matrix, properties of characteristic roots and vectors of different types of matrices such as orthogonal matrix, Hermitian matrix, Skew-Hermitian matrix, Cayley Hamilton theorem (without proof). Similarity of matrices. Functions of a square matrix | 08 |
| 2 | Matrices:  
2.1 Minimal polynomial and Derogatory matrix  
2.2 Quadratic forms: Linear transformations of a quadratic form, congruence of a square matrix, reduction to Canonical form under congruent transformations, orthogonal transformations, determining the nature of a quadratic form, Applications of Eigen Values and Eigen Vectors  
**Vector calculus**  
2.3 Brief revision of Scalar and vector point functions. Gradient of a scalar function, Divergence and curl of a vector function  
2.4 Line integrals, circulation of a vector, condition for independence of the path in the line integral | 09 |
| 3 | **Vector calculus:**  
3.1 Green’s theorem(without proof) for plane regions and properties of line integrals, Stokes theorem (without proof), Gauss divergence theorem (without proof) related identities and deductions. (No verification problems on Stoke’s Theorem and Gauss Divergence Theorem)  
**Linear Programming problems**  
3.2 Types of solutions to linear programming problems, standard form of L.P.P. Simplex method to solve L.P.P | 09 |
| 4 | **Linear Programming problems Probability Distributions:**  
4.1 Big M method (Penalty method) to solve L.P.P, Duality, Dual simplex method and Revised simplex method to solve L.P.P.  
**Probability Distributions**  
4.2 Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, Expected value, Variance.  
4.3 Probability Distributions: Binomial, Poisson and Normal Distributions | 09 |
Sampling theory:
5.1. Sampling theory: Sampling distribution. Test of Hypothesis. Level of significance, critical region. One tailed and two tailed tests. Interval Estimation of population parameters. Large and small samples
5.3. Test of significance for Large samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two samples.
5.4. Student’s t-distribution and its properties. Test of significance of small samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two Samples, paired t-test

Sampling theory and ANOVA
6.1. Chi-square test, Test for the Goodness of fit, Association of attributes and Yate’s correction
6.2. Analysis of Variance (F-Test): One way classification, Two-way classification (short-cut method)

Assessment:

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4. Only Four questions need to be solved.

References:
4. Vector Analysis by Murray R. Spiegel, Schaum Series
5. Operations Research, S.D. Sharma, S. Chand & CO.
9. Operations Research, Kantiswearup, Manmohan, P K Gupta, S. Chand & CO
Course Code | Course Name | Credits
--- | --- | ---
MEC402 | Fluid Mechanics* | 04

**Objectives:**
1. To study fluid statics and fluid dynamics
2. To study application of mass, momentum and energy equations in fluid flow.
3. To learn various flow measurement techniques.

**Outcomes:** Learner will be able to…
1. Define properties of fluids and classification of fluids
2. Evaluate hydrostatic forces on various surfaces and predict stability of floating bodies
3. Formulate and solve equations of the control volume for fluid flow systems
4. Apply Bernoulli’s equation to various flow measuring devices
5. Calculate resistance to flow of incompressible fluids through closed conduits and over surfaces
6. Apply fundamentals of compressible fluid flows to relevant systems

<table>
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<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>1</td>
<td>1.1 Fluid Definition and properties, Newton’s law of viscosity concept of continuum, Classification of fluids 1.2 Fluid Statics: Definition of body and surface forces, Pascal’s law, Basic hydrostatic equation, Forces on surfaces due to hydrostatic pressure, Buoyancy and Archimedes’ principle</td>
<td>06</td>
</tr>
<tr>
<td>2</td>
<td><strong>Fluid Kinematics:</strong> 2.1 Eulerian and Lagrangian approach to solutions; Velocity and acceleration in an Eulerian flow field; Definition of streamlines, path lines and streak lines; Definition of steady/unsteady, uniform/non-uniform, one-two and three dimensional flows; Definition of control volume and control surface, Understanding of differential and integral methods of analysis 2.2 Definition and equations for stream function, velocity potential function in rectangular and cylindrical co-ordinates, rotational and irrotational flows; Definition and equations for source, sink, irrotational vortex, circulation</td>
<td>06</td>
</tr>
<tr>
<td>3</td>
<td><strong>Fluid Dynamics:</strong> 3.1 Integral equations for the control volume: Reynold’s Transport theorem, equations for conservation of mass, energy and momentum, Bernoulli’s equation and its application in flow measurement, pitot tube, venture, orifice and nozzle meters. 3.2 Differential equations for the control volume: Mass conservation in 2 and 3 dimension in rectangular, Euler’s equations in 2,3 dimensions and subsequent derivation of Bernoulli’s equation; Navier-Stokes equations (without proof) in rectangular Cartesian co-ordinates; Exact solutions of Navier-Stokes Equations to viscous laminar flow between two parallel planes (Couette flow and plane Poiseuille flow)</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td><strong>Real fluid flows:</strong> 4.1 Definition of Reynold’s number, Laminar flow through a pipe (Hagen-Poiseuille flow), velocity profile and head loss; Turbulent flows and theories of turbulence-Statistical theory, Eddy viscosity theory and Prandtl mixing length theory; velocity profiles for turbulent flows-universal velocity profile, 1/7th power law; Velocity profiles for smooth and rough pipes 4.2 Darcy’s equation for head loss in pipe (no derivation), Moody’s diagram, pipes in series and parallel, major and minor losses in pipes</td>
<td>08</td>
</tr>
<tr>
<td>5</td>
<td><strong>Boundary Layer Flows:</strong> 5.1 Concept of boundary layer and definition of boundary layer thickness, displacement, momentum and energy thickness; Growth of boundary layer,</td>
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</tbody>
</table>
laminar and turbulent boundary layers, laminar sub-layer; Von Karman Momentum Integral equation for boundary layers (without proof), analysis of laminar and turbulent boundary layers, drag, boundary layer separation and methods to control it, streamlined and bluff bodies
5.2 Aerofoil theory: Definition of aerofoil, lift and drag, stalling of aerofoils, induced drag

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<th>Compressible Fluid flow:</th>
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<tr>
<td>6.1</td>
<td>Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Application of continuity, momentum and energy equations for steady state conditions; steady flow through nozzle, isentropic flow through ducts of varying cross-sectional area, Effect of varying back pressure on nozzle performance, Critical pressure ratio</td>
</tr>
<tr>
<td>6.2</td>
<td>Normal shocks, basic equations of normal shock, change of properties across normal shock</td>
</tr>
</tbody>
</table>

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

**Reference Books:**

2. Fluid Mechanics and Machinery by C S P Ojha, Chandramouli and R Berndtsson, Oxford University Press
3. Introduction to Fluid Mechanics by Fox and McDonald
4. Fluid Mechanics by R K Bansal
6. Fluid Mechanics by K. L. Kumar
7. Introduction to Fluid Mechanics by James A. Fay
8. Fluid Mechanics by B. M. Massey
9. Mechanics of Fluids by Irving Shames
### Objectives
1. To study power electronic switches and circuits and their applications
2. To familiarise Op amp and digital circuits and their applications
3. To acquaint with basics of microprocessor and microcontroller
4. To study structure, working and characteristics of different types of industrial electric motors and their selection for a particular application

### Outcomes: Learner will be able to...
1. Illustrate construction, working principles and applications of power electronic switches
2. Identify rectifiers and inverters for dc and ac motor speed control
3. Develop circuits using OPAMP and timer IC555
4. Identify digital circuits for industrial applications
5. Illustrate the knowledge of basic functioning of microcontroller
6. Analyse speed-torque characteristics of electrical machines for speed control

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 1      | **Semiconductor Devices:**  
Diodes: Principles V-I characteristics and Application of: rectifier diode, zener diode, LED, photodiode,  
SCR V-I characteristics, UJT triggering circuit, turning-off of a SCR (preliminary discussion), basics of Gate Turn-off thyristor (GTO).  
Structure and V-I characteristics of Triac (modes of operation not needed) and Diac, Applications of Triac-Diac circuit.  
Characteristics and principle of Power BJT, power MOSFET, IGBT, comparison of devices, MOSFET/IGBT Gate driver circuit  
Comparison of SCR, Triac, Power BJT, power MOSFET, IGBT | 08 |
| 2      | **Phase controlled rectifiers and Bridge inverters:**  
Full wave controlled rectifier using SCR’s(semi controlled, fully controlled) with R load only, Derivation of output voltage  
Block diagram of closed loop speed control of DC motors, Necessity of inner current control loop  
Basic principle of single phase and three phase bridge inverters , block diagrams including rectifier and inverter for speed control of AC motors (frequency control only) | 07 |
| 3      | **Operational amplifiers and 555 Timer:**  
Operational amplifier circuits, Ideal OPAMP behaviour, common OPAMP ICs; Basic OPAMP circuits- Inverting amplifier, Non-inverting amplifier, Voltage follower (Buffer), Instrumentation Amplifier, Active first order filter; Low pass and high pass filter; Power Op Amps, Optical Isolation amplifier; 555 timer-Operating modes: monostable, astable multivibrator | 04 |
| 4      | **Digital logic and logic families:**  
Digital signals, combinational and sequential logic circuits, clock signals, Boolean algebra and logic gates.  
Integrated circuits and logic families: Logic Levels, Noise Immunity, Fan Out, Propagation Delay, TTL logic family CMOS Logic family, comparison with TTL family  
Flip flops: Set Reset(SR),Trigger(T), clocked F/Fs; Registers, decoders and encoders, Multiplexer and Demultiplexer, applications | 04 |
| 5      | **Microprocessor and Microcontrollers:**  
Overview of generic microprocessor, architecture and functional block diagram, Comparison of microprocessor and microcontroller | 08 |
MSP430 architecture, assembly language programming, C compiler programming, basics of interfacing with external input / output devices (like reading external analog voltages, digital input output)
Applications of microcontroller: Temperature measurement, Speed Measurement using Proximity Sensor, Piezoelectric Actuator Drive

| 6 | **Motors:**
|   | Review and comparison of DC motors and AC induction motors, Basic principles of speed control of AC induction motor
|   | Basics of BLDC motor, Linear Actuator motor, Servo Motor
|   | Motor Specifications, suitability of each motor for various industrial applications, Selection and sizing of motors for different applications. Applications for pumps, conveyors, machine tools, Microcontroller based speed control for Induction Motor. |

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

**Reference Books:**
1. Power Electronics M.H. Rashid, Prentice-Hall of India
2. Power Electronics, P S Bhimbra
3. Power Electronics, Vedam Subramanyam, New Age International
4. Power Electronics, Ned Mohan, Unedland, Robbins, John Wiley Publication
5. Electronic Devices and Circuits, Robert Boylestad and Louis Nashelsky, Prentice-Hall
6. Industrial Electronics and Control by S K Bhattacharya, S Chatterjee, TITI Chandigarh
Objectives
1. To study sheet metal forming as well as mechanical behavior of stress system in metal forming processes.
2. To Acquaint to basic principles of design of jigs and fixtures
3. To give exposure to Non-traditional machining operations.
4. To acquaint with fundamentals of metal cutting and tool engineering

Outcomes: Learner will be able to…
1. Demonstrate understanding of metal cutting principles and mechanism
2. Identify cutting tool geometry of single point and multipoint cutting tool
3. Demonstrate various concepts of sheet metal forming operations
4. Demonstrate concepts and use of jigs and fixtures
5. Illustrate various non-traditional machining techniques
6. Illustrate concepts and applications of additive manufacturing

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1 | Metal Cutting:  
1.1 Features of machining processes, concept of speed and cutting, mechanism of chip formation, concept of shear plane, chip reduction coefficient force analysis, Merchant’s circle of cutting forces, expression for shear plane angle and coefficient of friction in terms of cutting forces and tool angles, Merchant’s theory-original and modified, effect of various parameters on cutting forces  
1.2 Different types of dynamometers and their operations, Tool life definition, mechanism of tool wear and measurement, preliminary and ultimate feature, factors influencing tool life such as speed, feed, depth of cut, tool material, cutting fluids etc., Machinability, factors affecting surface finish | 16 |
| 2. | Tool Engineering:  
2.1 Cutting Tool geometry and definition of principles tool angles of single point cutting tools, Types of milling cutters and their geometry, Geometry of drill, broach  
2.2 Specification & Selection of grinding wheel, dressing & truing and balancing of grinding wheels | 06 |
| 3. | Sheet Metal Forming:  
3.1 Sheet metal operations, Classification of presses, Types of Dies: compound, combination, progressive, bending, forming and drawing dies, scrap strip layout, centre of pressure, selection of die sets, stock guides, strippers | 06 |
| 4. | Jigs and Fixtures:  
4.1 Elements of Jigs and fixtures, principles of location, types of locating and clamping elements, Drill bushes-their types and applications indexing devices, auxiliary elements, Types of jigs, Milling fixture and turning fixture | 06 |
| 5. | Non-traditional Machining:  
5.1 Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Water Jet Machining, Electrochemical Machining (ECM), Chemical Machining (CHM), Electrical Discharge Machining (EDM), Plasma Arc Machining (PAM), Laser Beam Machining (LBM), Electron Beam Machining (EBM) | 06 |
6. **Additive Manufacturing:**


6.2 New AM Classification Schemes as per ASTM F42 and ISO TC 261: Vat photo polymerization, Powder bed fusion, Material extrusion, Material jetting, Binder jetting, Sheet lamination and Directed energy deposition.


**Assessment:**

**Internal Assessment for 20 marks:**

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. **Question 1** will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

**References**

1. Tool Design by Donaldson
2. Machining Process by H.L. Juneja
3. Production Technology - HMT
4. Manufacturing, Engineering and Technology SI by Serope Kalpakjian, Steven R Schmid, Prentice Hall
5. Fundamentals of Tool Design by ASTME
6. Metal cutting Theory & Cutting Tool Designing by V. Arshinov, G Alekseev
7. Principle of Metal cutting by Sen & Bhattacharya
8. Manufacturing science by Ghosh and Mallick
9. Production Engg by P.C.Sharma
# Course Code: MEC405  
## Course Name: Kinematics of Machinery*  
## Credits: 04

## Objectives:
1. To acquaint with basic concept of kinematics and kinetics of machine elements  
2. To familiarise with various basic mechanisms and inversions  
3. To study basics of power transmission

## Outcomes:
Learner will be able to…
1. Define various components of mechanisms  
2. Develop mechanisms to provide specific motion  
3. Draw velocity and acceleration diagrams of various mechanisms  
4. Draw Cam profile for the specific follower motion  
5. Analyse forces in various gears  
6. Select appropriate power transmission for specific application

## Module Details

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
</tr>
</thead>
</table>
| 1      | **1.1 Kinetics of Rigid Bodies:**  
Mass M.I. about centroidal axis and about any other axis, Radius of Gyration, D’Alembert’s Principle of bodies under rotational motion about a fixed axis and plane motion, Application of motion of bars, cylinders and spheres only  
Kinetics of Rigid bodies: Work and Energy  
Kinetic energy in translating motion, Rotation about fixed axis and in general plane motion, Work Energy Principle and Conservation of energy |
| 2      | **1.2 Basic Kinematics:**  
Structure, Machine, Mechanism, Kinematic link & its types, Kinematic pairs, Types of constrained motions, Types of Kinematic pairs, Kinematic chains, Types of joints, Degree of freedom (mobility), Kutzbach mobility criterion, Grüber's criterion & its limitations  
Four bar chain and its inversions, Grashoff's law, Slider crank chain and its inversions, Double slider crank chain and its inversions |
| 3      | **2.1 Special Mechanisms:**  
**Straight line generating mechanisms:** Introduction to Exact straight line generating mechanisms - Peaucillier's and Hart's Mechanisms, Introduction to Approximate Straight line generating mechanisms- Watt's,Grashopper mechanism, Tchebicheff's mechanisms  
**Offset slider crank mechanisms** - Pantograph, Hook-joint (single and double).  
**Steering Gear Mechanism** - Ackerman, Davis steering gears |
| 3      | **3.1 Velocity Analysis of Mechanisms (mechanisms up to 6 links):**  
Velocity analysis by instantaneous center of rotation method (Graphical approach),  
Velocity analysis by relative velocity method (Graphical approach) Analysis extended to find rubbing velocities at joints, mechanical advantage (Graphical approach)  
Velocity analysis of low degree complexity mechanism (Graphical approach), Auxiliary point method |
| 4      | **3.2 Velocity and Acceleration Analysis of Mechanism:**  
Velocity and Acceleration- analysis by relative method (mechanism up to 6 link) including pairs involving Coriolis acceleration (Graphical Approach) |
| 4      | **4.1 Cam Mechanism:**  
Cam and its Classification, Followers and its Classification, Motion analysis and plotting of displacement - time, velocity-time, acceleration-time, jerk-time graphs for uniform velocity, UARM, SHM, and Cycloid motions (combined motions during one stroke excluded), Motion analysis of simple cams - R-R cam, D-R-R and D-R-D-R Cam operating radial translating follower, Pressure angle |

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University of Mumbai,  
B. E. (Mechanical Engineering),  
Rev 2016  
33
Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of content and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the syllabus.
1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References:
1. Theory of Mechanisms and Machines by Amitabh Ghosh and A. Kumar Mallik
2. Theory of Machines and Mechanism by Uicker Jr, Garden Pennock & J.F. Shigley, OXFORD University Press
3. Theory of Machines by P L Ballaney
4. Theory of Machines by S S Ratan
5. Kinematics of Machines by R T Hinckle, Prentice Hall Inc
8. Kinematics and Dynamics of Planer mechanisms by Jeremy Hirshham, McGraw Hill
9. Theory of Machines by W. G. Green, Bluckie & Sons Ltd

5.1 Belts, Chains and Brakes:
Belts: Introduction, types and all other fundamentals of belting, Dynamic analysis –belt tensions, condition of maximum power transmission
Chains: types of chains, chordal action, variation in velocity ratio, length of chain
Brakes: Introduction, types and working principles, Introduction to braking of vehicles

6.1 Gears and Gear Trains:
Gears- Introduction, types, Law of gearing, Construction of Involute and Cycloid gear tooth profile, Details of gear terminology, involutes and cycloidal tooth profile, Interference in involutes gears, Critical numbers of teeth for interference free motion Methods to control interference in involutes gears, Static force analysis in gears - spur, helical, bevel, worm & worm wheel
Gear Trains: Kinematics and dynamic analysis of simple and compound gear trains, reverted gear trains, epi-cycle gear trains with spur or bevel gear combination
Objective:
1. To acquaint with data modelling/database design using the entity-relationship
2. To study use of Structured Query Language (SQL) and learn SQL syntax
3. To familiarise Graphical User Interface techniques to retrieve information from database
4. To study needs of database processing and controlling the consequences of concurrent data access

Outcomes: Learner will be able to…
1. Identify data models and schemes in DBMS
2. Demonstrate the features of database management systems and Relational database
3. Use SQL- the standard language of relational databases
4. Demonstrate understanding of functional dependencies and design of the database
5. Design graphical user Interface for specific application
6. Create visual software entities

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Database Concept:</strong> What is a database?, Characteristics of database, Example of database, File system V/s Database system, What is DBMS?, Users of database system, Advantage of using an enterprise database, Concerns when using an enterprise database, Data independence, DBMS systems architecture, Database administrator</td>
<td>02</td>
</tr>
<tr>
<td>02</td>
<td><strong>Entity-Relationship Data Model:</strong> Introduction, Benefits of Data Modelling, Types of Models, Phases of Database Modelling, The Entity-Relationship (ER) Model, Generalisation, Specialization and Aggregation, Extended Entity-Relationship (EER) Model</td>
<td>04</td>
</tr>
<tr>
<td>03</td>
<td><strong>Rational Model and Algebra:</strong> Introduction, Mapping the ER and EER Model to the relational Model, Data Manipulation, Data Integrity, Advantages of Relational Model, Relational Algebra, Relational Algebra Queries, Relational Calculus</td>
<td>04</td>
</tr>
<tr>
<td>04</td>
<td><strong>Structured Query Language (SQL):</strong> Overview of SQL, Data definition commands, set operations, aggregate functions, null values, Data manipulation commands, Data control commands, Views- using virtual tables in SQL, Nested and complex queries</td>
<td>04</td>
</tr>
<tr>
<td>05</td>
<td><strong>Introduction to Transactions Management and Co-currency:</strong> Transaction concept, transaction states, ACID properties, Implementation of atomicity and durability, Concurrent Executions, Serializability, Recoverability, Co-currency Control: Lock-based, Timestamp-based, Validation-based protocols, Deadlock handling, Recovery system, Failure classification, Storage structure, Recovery and atomicity, Log based recovery, Shadow paging</td>
<td>04</td>
</tr>
<tr>
<td>06</td>
<td><strong>Graphical User Interface:</strong> Murphy’s law of GUI design, Features of GUI, Icons and graphics, Identifying visual cues, clear communication, colour selection, GUI standard, planning GUI Design Work <strong>Visual Programming:</strong> <strong>Sharing Data and Code:</strong> Working with projects, introduction to basic language, Using inbuilt controls and ActiveX controls, creating and using classes, introduction to collections, usinif and creating ActiveX components, dynamics data exchange, Object linking and embedding, Creating visual software entities: Working with text, graphics, working with files, file management, serial communication, multimedia control interfaces</td>
<td>06</td>
</tr>
</tbody>
</table>
Assessment:

Term Work:
Assign minimum two case studies for each student. On their case studies following exercises to be performed
1. Problem Definition and draw ER/EER diagram
2. Design Relational Model
3. Perform DDL operation
4. Perform DML and DCL operations
5. Design Forms using Visual programming
6. Retrieve the information through GUI.

Distribution of Term work Marks
Laboratory work 40 Marks
Attendance 10 Marks

End Semester Practical/Oral Examination:
1. Practical examination of 2 hours duration followed by viva to be conducted by Pair of Internal and External Examiner based on contents
2. Evaluation of practical examination to be done by examiner based on the printout of students work
3. Distribution of marks
   Practical examination: 40 marks
   Viva based on practical examination 10 marks

4. Students work along with evaluation report to be preserved till the next examination

Reference Books:
3. GUI Design for dummies, IDG books
5. SQL and PL/SQL for Oracle 10g,Black Book, Dr P S Deshpande, Dreamtech Press
6. Introduction to Database Management, Mark L Gillenson, Paulraj Ponniah, Wiley
7. Oracle for Professional, Sharaman Shah, SPD.
8. Database Management Systems, Raghu Ramkrishnan and Johannes Gehrke, TMH
9. Fundamentals of Database Management System, Mark L Gillenson, Wiley India
Objectives:
1. To study measurement as well as calibration principles
2. To practically verify the concepts learnt in theory course

Outcomes: Learner will be able to…
1. Calibrate different gauges
2. Measure hydrostatic forces
3. Verify the Archimedes Principle
4. Calibrate Venturimeter, Orificemeter and Pitot tube
5. Verify the Bernoulli’s Principle
6. Read manometers and maintain them.

(a) List of Experiments: Any 6 experiments to be performed.

<table>
<thead>
<tr>
<th>Expt no</th>
<th>Experiment</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calibration of Pressure Gauges</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Measurement of Hydrostatic Pressures</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Verification of Archimedes’ Principle</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Calibration of Venturimeter/ Orificemeter/Nozzlemeter/ Pitot tube</td>
<td>2</td>
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<tr>
<td>5</td>
<td>Determine the friction factor for Pipes</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Determination of major and minor losses in Pipe systems</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Verification of Bernoulli’s Equation</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Experiment on Laminar flow in pipes</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Calculation of Lift and Drag over an aerofoil</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>Determine the pressure profile over an aerofoil</td>
<td>2</td>
</tr>
</tbody>
</table>

(b) Mini Project: A mini project along with a brief report in which a group of students (maximum 4) will design/ fabricate/ assemble a unit or software based simulation to demonstrate any principle in Fluid Mechanics.

Assessment:
Term work Mark distribution will be as follows:
- Laboratory work 15 marks
- Mini Project 05 marks
- Attendance 05 marks

End Semester Practical/Oral Examination:
1. Pair of Internal and External Examiner should conduct practical/viva based on contents. Distribution of marks for practical/viva examination shall be as follows:
   - Practical performance 15 marks
   - Viva 10 marks
2. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination
3. Students work along with evaluation report to be preserved till the next examination
Objectives
1. To study operational characteristics of various electrical and electronics components
2. To study microcontroller based applications and its programming

Outcomes: Learner will be able to…
1. Demonstrate characteristics of various electrical and electronics components
2. Develop simple applications built around these components
3. Identify use of different basic gates
4. Identify and use digital circuits for industrial applications
5. Built and demonstrate basic parameter measurement using microcontroller
6. Test and Analyse speed-torque characteristics of electrical machines for speed control.

List of Experiment: Minimum six from 1-9 and four from 10-15, in all minimum ten experiments need to be performed

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Detailed Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOSFET / IGBT as a switch</td>
</tr>
<tr>
<td>2</td>
<td>V-I characteristics of SCR</td>
</tr>
<tr>
<td>3</td>
<td>Triggering circuit of SCR (UJT)</td>
</tr>
<tr>
<td>4</td>
<td>Full wave Rectifier using SCR</td>
</tr>
<tr>
<td>5</td>
<td>Single phase Bridge inverter with rectifier load</td>
</tr>
<tr>
<td>6</td>
<td>OPAMP as integrator</td>
</tr>
<tr>
<td>7</td>
<td>555 timer as astable multivibrator</td>
</tr>
<tr>
<td>8</td>
<td>Implementing study of gates and Logic Operations like, NOT, AND, OR</td>
</tr>
<tr>
<td>9</td>
<td>Realization of basic gates using universal gates</td>
</tr>
<tr>
<td>10</td>
<td>Light dimmer circuit using Diac-Triac</td>
</tr>
<tr>
<td>11</td>
<td>Speed control of DC motor</td>
</tr>
<tr>
<td>12</td>
<td>Speed control of induction motor</td>
</tr>
<tr>
<td>13</td>
<td>Simple programs using microcontroller</td>
</tr>
<tr>
<td>14</td>
<td>Simple microcontroller based application like Temp Measurement/ Speed Measurement using Proximity Sensor/ Piezoelectric Actuator Drive</td>
</tr>
<tr>
<td>15</td>
<td>Microcontroller based speed control for Induction Motor</td>
</tr>
</tbody>
</table>

Learners (in a group) may be encouraged for Project Based Learning. Appropriate Weightage may be given in term work assessment

Assessment:

Distribution of marks for term work
Laboratory work 20 Marks
Attendance 05 Marks

End Semester Practical/Oral Examination:
1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Distribution of marks for practical/viva examination shall be as follows:
   - Practical performance 15 marks
   - Viva 10 marks
3. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination
4. Students work along with evaluation report to be preserved till the next examination

University of Mumbai, B. E. (Mechanical Engineering), Rev 2016
Objectives:
1. To familiarise with various mechanisms and inversions
2. To acquaint with basics of power transmission systems

Outcomes: Learner will be able to...
1. Draw velocity diagram by instantaneous center method
2. Draw velocity and acceleration diagrams for four bar mechanism by relative method.
3. Draw velocity and acceleration diagrams for Slider crank mechanism by relative method
4. Draw Cam profile for the specific follower motion
5. Plot displacement-time, velocity-time, acceleration-time cam profiles
6. Develop and build mechanisms to provide specific motion

Term Work: (Comprises a and b)

a) List of Experiments

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Details</th>
<th>Lab Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analysis of velocity of mechanisms by Instantaneous Center of Rotation – 3 to 5 problems</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>2</td>
<td>Analysis of velocity of mechanism by Relative method – 3 to 5 problems</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>3</td>
<td>Analysis of Velocity &amp; Acceleration of mechanism by Relative method – 3 to 5 problems</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>4</td>
<td>Motion analysis and plotting of displacement–time, velocity-time and acceleration-time, jerk-time and layout of cam profiles - 2 to 3 problems</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>5</td>
<td>Mini project on design and fabrication of any one mechanism for a group of maximum 4 students</td>
<td>6 Hrs</td>
</tr>
</tbody>
</table>

b) Assignments: Minimum two problems on each of the following topics:
   i) Brakes
   ii) Chains and belts
   iii) Gear and gear trains

Distribution of marks for Term Work shall be as follows:
Laboratory work : 15 marks.
Assignments : 05 Marks
Attendance : 05 marks.
Course Code | Course/Subject Name | Credits
--- | --- | ---
MEL405 | Machine Shop Practice – II* | 2

**Objectives:**
1. To familiarise with basic machining processes.
2. To Acquaint to various machining operations and machine protocols

**Outcomes:** Learner should be able to ….
1. Operate lathe machine,
2. Perform shaping operations
3. Perform finishing operations on grinding machine
4. Perform milling operations.
5. Perform precision turning
6. Perform drilling and threading operations.

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>One composite job consisting minimum four parts employing operations on lathe like precision turning screw cutting, boring etc. This job shall involve use of shaping, milling and grinding operations</td>
<td>48</td>
</tr>
</tbody>
</table>

**Term Work:**
1. Composite job mentioned above
2. Complete Work-Shop Book giving details of drawing of the job and time sheet

The distribution of marks for Term work shall be as follows:
- Job Work with complete workshop book …… 40 marks
- Attendance …… 10 marks

**End Semester Practical Examination:**
Pair of Internal and External Examiner should conduct practical/viva based on contents. Practical examination will be held for 4 hours.
Job shall consist of minimum four operations such as precision turning, boring, screw cutting, drilling, milling, shaping, grinding etc.
Objectives
1. To familiarize with the working of S.I. and C.I. engines and its important systems
2. To acquaint with the various methods for measurement of engine performance
3. To provide insight into the harmful effects of engine pollutants and its control
4. To familiarise with the latest technological developments in engine technology

Outcomes: Learner will be able to…
1. Demonstrate the working of different systems and processes of S.I. engines
2. Demonstrate the working of different systems and processes of C.I. engines
3. Illustrate the working of lubrication, cooling and supercharging systems.
4. Analyse engine performance
5. Illustrate emission norms and emission control
6. Comprehend the different technological advances in engines and alternate fuels

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction</strong></td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>Classification of I.C. Engines; Parts of I.C. Engine and their materials, Cycle of operation in Four stroke and Two-stroke IC engines and their comparative study; Fuel air cycles and their analysis, Actual working cycle, Valve Timing Diagram. LHR Engines, Homogeneous charge compression Ignition, Rotary engine-Six stroke engine concept</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td><strong>S.I. Engines</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Fuel Supply System:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spark ignition Engine mixture requirements, Fuel-Air ratio, Simple carburettor and auxiliary circuits (excluding mathematical analysis of carburettors) Injection systems: Single-point and Multipoint injection, Gasoline Direct Injection</td>
<td></td>
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<tr>
<td></td>
<td><strong>Ignition System:</strong></td>
<td></td>
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<tr>
<td></td>
<td>Battery Ignition System, Magneto Ignition System, Functions and working of ignition coil, spark plug, contact breaker point, Requirements and working of Ignition advance mechanisms; mechanical and vacuum, Electronic Ignition Systems; Capacitor Discharge Ignition System, Transistorized Coil Assisted Ignition System, Transistor Ignition system with contactless breaker</td>
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<td></td>
<td><strong>Combustion:</strong></td>
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<tr>
<td></td>
<td>Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure-Crank angle diagram, Abnormal combustion, Auto ignition, Detonation and Knocking, Factors affecting combustion and detonation, Types of combustion chambers</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td><strong>Compression Ignition Engines</strong></td>
<td>10</td>
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<td></td>
<td><strong>Fuel Injection Systems:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air injection systems, Airless/solid injection systems, Common rail, individual pump, distributor and unit systems. Injection pumps, Fuel injector, Types of nozzle, Electronically controlled unit fuel injection system</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Combustion:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Combustion phenomenon in C I engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td><strong>Engine lubrication:</strong></td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems</td>
<td></td>
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<td></td>
<td><strong>Engine Cooling:</strong></td>
<td></td>
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<tr>
<td></td>
<td>Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling</td>
<td></td>
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<tr>
<td></td>
<td><strong>Supercharging/Turbo-charging:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Objectives, Limitations, Methods and Types, Different arrangements of turbochargers and superchargers</td>
<td></td>
</tr>
</tbody>
</table>
Engine Testing and Performance

Engine Exhaust Emission and its control
Constituents of exhaust emission at its harmful effect on environment and human health, Formation of NOx, HC, CO and particulate emissions, Methods of controlling emissions; Catalytic convertors, particulate traps, Exhaust Gas Recirculation, EURO and BHARAT norms.

Alternative Fuels

Basics of Electronic Engine Controls:
Electronic Control module (ECM), Inputs required and output signals from ECM, Sensors: Throttle Position, Inlet Air Temperature, Coolant Temperature, Crankshaft Position, Camshaft Position, Mass Air flow and Exhaust Gas Oxygen sensors, their construction and importance in ECM. Electronic Spark control, Air Management system, Idle speed control

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of content and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the syllabus.

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2. Question 1 will be compulsory and should cover maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References:
1. Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education.
2. Internal Combustion Engines, Shyam Agrawal, New Age International
3. Internal Combustion Engine, Mathur and Sharma
4. Internal Combustion Engines, Mohanty, Standard Book House
5. Internal Combustion Engine, Gills and Smith
6. Internal Combustion Engines Fundamentals, John B. Heywood, TMH
7. Internal Combustion Engines, Gupta H N, 2nd ed, PHI
8. Internal Combustion Engine, V Ganesan, TMH
10. Internal Combustion Engine, S.L. Beohar
12. Internal Combustion Engines, V.L. Maleeve
14. Internal Combustion Engine by Domkundwar
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course/Subject Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEC502</td>
<td>Mechanical Measurement and Control*</td>
<td>4</td>
</tr>
</tbody>
</table>

**Objectives**
1. To impart knowledge of architecture of the measurement system
2. To deliver working principle of mechanical measurement system
3. To study concept of mathematical modelling of the control system
4. To acquaint with control system under different time domain

**Outcomes:** Learner will be able to...
1. Classify various types of static characteristics and types of errors occurring in the system.
2. Classify and select proper measuring instrument for linear and angular displacement
3. Classify and select proper measuring instrument for pressure and temperature measurement
4. Design mathematical model of system/process for standard input responses
5. Analyse error and differentiate various types of control systems and time domain specifications
6. Analyse the problems associated with stability

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
</tr>
</thead>
</table>
| 01     | 1.1 Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs.  
1.2 Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc.  
1.3 Errors in measurement: Types of errors, Effect of component errors, Probable errors. | 08 |
| 02     | 2.1 Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer  
2.2 Strain Measurement: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors  
2.3 Measurement of Angular Velocity: Tachometers, Tachogenerators, Digital tachometers and Stroboscopic Methods.  
2.4 Acceleration Measurement: theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers | 08 |
3.2 Flow Measurement: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter  
3.3 Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers  
3.4 Sensitivity analysis of sensor-influence of component variation  
3.5 Signal conditioning: Amplifier, Conversion, Filtering, Impedance Buffering, Modulation / Demodulation, Linearization, Grounding and Isolation | 08 |
| 04     | 4.1 Introduction to control systems, Classification of control system. Open loop and closed loop systems.  
4.2 Mathematical modelling of control systems, concept of transfer function, Block diagram algebra | 06 |
<p>| 05     | 5.1 Transient and steady state analysis of first and second order system. Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp and parabolic inputs | 06 |</p>
<table>
<thead>
<tr>
<th>06</th>
<th>Stability analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Introduction to concepts of stability, The Routh criteria for stability</td>
<td></td>
</tr>
<tr>
<td>6.2 Experimental determination of frequency response, Stability analysis using Root locus, Bode plot and Nyquist Plots</td>
<td></td>
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<tr>
<td>6.3 State space modeling</td>
<td></td>
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<tr>
<td>6.4 Process control systems, ON-OFF control, P-I-D Control</td>
<td></td>
</tr>
</tbody>
</table>

**Assessment:**

**Internal Assessment for 20 marks:**

Consisting Two Compulsory Class Tests

First test based on approximately 40% of content and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**

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3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

**References**

3. Instrumentation & Mechanical Measurements, A K Thayal
5. Modern Control engineering: by KOgata, Prentice Hall
6. Control systems by DhaneshManik, Cengage Learning
8. Instrumentation and Control System, W. Bolton, Elsevier
11. Mechanical Measurements by S P Venkateshan, Ane books, India
Objectives
1. To Study basic heat transfer concepts applicable for steady state and transient conditions
2. To Study mathematical modelling and designing concepts of heat exchangers

Outcomes: Learner will be able to…
1. Identify the three modes of heat transfer (conduction, convection and radiation).
2. Illustrate basic modes of heat transfer
3. Develop mathematical model for each mode of heat transfer
4. Develop mathematical model for transient heat transfer
5. Demonstrate and explain mechanism of boiling and condensation
6. Analyse different heat exchangers and quantify their performance

<table>
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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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<tbody>
<tr>
<td>01</td>
<td><strong>Basic concepts of heat transfer:</strong> Define heat transfer and its importance in engineering applications, Difference between heat transfer and Thermodynamics, Physical Mechanism of modes of heat transfer, Governing laws of heat transfer, Conduction mode: Thermal conductivity, Thermal diffusivity, Convection mode: Free and Forced convection, Heat transfer Coefficient, Radiation mode: Emissivity, transmissivity, reflectivity, absorptivity, Black body, Grey body, Opaque body, Steady and unsteady heat transfer, One dimensional, two dimensional and three dimensional heat transfer, Thermal resistance concept in heat transfer, Thermal contact resistance</td>
<td>04</td>
</tr>
<tr>
<td>02</td>
<td><strong>Conduction:</strong> Assumptions in heat conduction, Generalized heat conduction equation in rectangular, cylindrical coordinates, Initial and boundary conditions, Steady state heat conduction through plane wall, Composite wall, cylinder, composite cylinder wall, sphere, Internal Heat generation concept, Heat conduction with heat generation in plane wall, solid cylinder and solid sphere, Critical radius of insulation in cylinder and sphere</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Heat transfer from Extended Surface:</strong> Types of extended surface and its significance, Governing differential equation for fin and its solution, Fin performance: Fin effectiveness and Fin efficiency, Thermo Well <strong>Unsteady state heat transfer:</strong> Applications of unsteady state heat transfer, Lumped system Analysis, Criteria for lumped system analysis: characteristic length, Biot Number, Thermal time constant and Response of a thermocouple, Heisler Charts <strong>Numerical methods in heat transfer:</strong> Significance of numerical methods in heat transfer, Finite difference formulation of differential equations, One-dimensional heat conduction</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td><strong>Convection:</strong> Determination of heat transfer coefficient, Dimensional Analysis, Dimensionless numbers in free and forced convection and their significance <strong>External Flow:</strong> Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent flow over a flat plate, Flow across cylinder and sphere, Flow across bank of tubes <strong>Internal Flow:</strong> Velocity Boundary layer and Thermal Boundary layer, Laminar and Turbulent flow in tubes, General thermal analysis: Constant heat flux and constant surface temperature</td>
<td>10</td>
</tr>
<tr>
<td>05</td>
<td><strong>Radiation:</strong> Basic laws of radiation, Black body radiation, Planck’s law, Kirchoff’s law, Wein displacement law, Lambert cosine law, Radiation intensity, Radiation heat exchange between black bodies, Shape factor algebra, Radiation heat exchange between nonblack bodies, Electrical network approach for radiation heat exchange: Radiosity and irradiation, Radiation shield</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>Boiling and Condensation:</strong> Boiling heat transfer, Pool boiling: different regimes and pool boiling curve, Flow boiling: Different Regimes and Boiling curve, Condensation heat transfer, Film condensation, Dropwise Condensation <strong>Heat Exchangers:</strong> Types of heat exchangers, Overall heat transfer coefficient, Fouling factor, Analysis of heat exchangers, LMTD, Effectiveness – NTU method, Correction factor, Effectiveness of heat exchangers <strong>Heat Pipe:</strong> Introduction and application</td>
<td>10</td>
</tr>
</tbody>
</table>
Assessment:

Internal Assessment for 20 marks:

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First test based on approximately 40% of content and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

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2. **Question 1** will be **compulsory** and should **cover maximum contents of the syllabus**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

2. Fundamentals of Heat and Mass Transfer by F P Incropera and D P deWitt, Wiley India
5. Heat Transfer by J P Holman, Mcgraw Hill
7. Heat and Mass Transfer by PK Nag, TMH
8. Heat and Mass Transfer by Mahesh Rathod, Laxmi Publications
9. Heat and Mass Transfer by R K Rajput, S Chand and company
Course Code    Course/Subject Name    Credits
MEC504    Dynamics of Machinery*    4

Objectives:
1. To acquaint with working principles and applications of Governors / Gyroscope
2. To study static and dynamic force analysis in the mechanisms
3. To familiarise with basics of mechanical vibrations
4. To study the balancing of mechanical systems

Outcomes: Learner will be able to…
1. Demonstrate working Principles of different types of governors and Gyroscopic effects on the mechanical systems
2. Illustrate basic of static and dynamic forces
3. Determine natural frequency of element/system
4. Determine vibration response of mechanical elements / systems
5. Design vibration isolation system for a specific application
6. Demonstrate basic concepts of balancing of forces and couples

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 1 | **Governors and Gyroscopes:**  
1.1 **Governors:** Introduction to Centrifugal and Inertia governors, Force analysis of governors- Porter and Hartnell governors, Performance characteristics of governors, Governors effort and power  
1.2 **Gyroscope:** Introduction, Gyroscopic couple and its effect on spinning bodies, naval ships during steering, pitching, rolling and their stabilization. Effect of gyroscopic and centrifugal couples, permissible speeds on curve paths, gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft. | 09 |
| 2 | 2.1 **Static and Dynamic force analysis,** in slider crank mechanism (neglecting mass of connecting rod and crank), Engine force analysis, Turning moment on crank shaft  
2.2 **Dynamically equivalent systems,** to convert rigid body in to two mass with and without correction couple | 06 |
| 3 | 3.1 **Basic Concepts of Vibration:**  
Vibration and oscillation, causes and effects of vibrations, Vibration parameters - springs, mass, damper, damper models, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis  
3.2 **Free Undamped Single Degree of Freedom Vibration System:**  
Longitudinal, transverse, torsional, vibration system, methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's method | 08 |
| 4 | 4.1 **Free Damped Single Degree of Freedom Vibration System:**  
Viscous damped system - under damped, critically damped, over damped; Logarithmic decrement; Coulomb's damping  
4.2 **Equivalent Single Degree of Freedom Vibration System:**  
Conversion of multi-springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system, Introduction to free multi-degree of freedom vibration systems | 07 |
| 5 | 5.1 **Forced Single Degree of Freedom Vibratory System:**  
Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper)  
5.2 **Vibration Isolation and Transmissibility:**  
Force Transmissibility, motion transmissibility, typical isolators & mounts. | 10 |
5.3 Vibration Measuring instruments: Principle of seismic instruments, vibrometer, accelerometer - undamped and damped, Introduction to conditioning monitoring and fault diagnosis

6

6.1 Rotor Dynamics:
Critical speed of single rotor, undamped and damped
6.2 Balancing: Static and Dynamic balancing of multi rotor system, balancing of reciprocating masses in In-line engines, V-engines (excluding other radial engines)

Assessment:
Internal Assessment for 20 marks:
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4. Only Four questions need to be solved

References:
1. Theory of Machines Thomas Bevan CSB Publishers & Distributors
2. Theory of Machines by Jagdishlal Metropolitan Book New Delhi, Company, Daryaganj, Delhi
4. Theory of Machines by P.L.Bellaney Khanna publication, New Delhi
8. Mechanical Vibrations by G.K.Grover
11. Vibration Analysis by P. Srinivasan, TMH
Objectives:
1. To acquaint with various press working operations for mass production of sheet metal components
2. To familiarise with sheet metal working techniques for design of press tools
3. To inculcate knowledge about scrap minimization, safety aspects and automation in press working

Outcomes: Learner will be able to….
1. Demonstrate various press working operations for mass production of sheet metal parts
2. Identify press tool requirements to build concepts pertaining to design of press tools
3. Prepare working drawings and setup for economic production of sheet metal components
4. Select suitable materials for different elements of press tools
5. Illustrate the principles and blank development in bent & drawn components
6. Elaborate failure mechanisms of pressed components, safety aspects and automation in press working

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
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</thead>
</table>
| 1      | Introduction to Press Working –
1.1 Classification of common Press working operations, Benefits and limitations of using Press tools. Applications of pressed parts/components.
|        |          | 08    |
| 2      | Design and Calculations of Piercing & Blanking Die–
2.1 Calculations for Economic Strip Layout, Calculations of Cutting force and Stripping force, Recommending minimum tonnage of a press. Centre of Pressure (its importance and calculation)
2.2 Design aspects of Press tool elements viz. Punches & methods of retaining punches, Die block, Stripper, Pilot, etc. Methods of reducing cutting loads on press tools
2.3 Different types Die sets and its selection |
|        |          | 14    |
| 3      | 3.1 Selection of Material & Hardware –Selection and arrangement of Hardware used in Press tools. Selection of steels and its hardness for different elements of Press tools. |
|        |          | 03    |
| 4      | Bending and Drawing-
4.1 Theory of Bending, Spring back and measures to control it, Calculations for Blank development of Simple Bent components, Minimum bend radius, Types of Bending dies
4.2 Theory of Drawing, Metal flow in Drawing & forming operations; reduction ratio and redrawing limits, draw clearance, drawing and blank holding forces for cylindrical draws only. Blank development of Cup
4.3 Defects in drawn as well as bent parts, Presses selection for drawing/forming operations
4.4 Basic construction and working of Bending and Drawing dies |
|        |          | 12    |
| 5      | 5.1 Miscellaneous Dies-
Basic construction & working of Shaving dies, Trimming dies, Compound dies, Combination dies, Coining dies, Embossing dies, Simple Progressive & Compound Progressive dies |
|        |          | 05    |
| 6      | Selection of Presses and its setting –
6.1 Selection of Press and Press setting for Shearing, Bending, Progressive and Drawing dies, Equipment for Sheet metal operations (Basics only), Overloading of presses (load, energy considerations)
6.2 Introduction to Automation & Safety in Press shop |
|        |          | 06    |
Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
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3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References

2. Techniques of Press Working Sheet Metal by D F Eary and E A Reed
4. Tool Design by C. Donaldson and V C Goold, TMH
5. Production Engineering by P. C. Sharma, S Chand Publishing
6. Metal working ASM Handbook
Objectives
1. To familiarise with the basic concepts of machining science like mechanics of machining, tool wear, tool life and surface roughness.
2. To familiarise with various single and multipoint cutting tools designing processes
3. To study the economics of machining process

Outcomes: Learner will be able to…
1. Calculate the values of various forces involved in the machining operations
2. Design various single and multipoint cutting tools
3. Analyse heat generation in machining operation and coolant operations
4. Illustrate the properties of various cutting tool materials and hence select an appropriate tool material for particular machining application
5. Demonstrate the inter-relationship between cutting parameters and machining performance measures like power requirement, cutting time, tool life and surface finish
6. Analyse economics of machining operations

<table>
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<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
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<tbody>
<tr>
<td>01</td>
<td>Metal Cutting Theory: Orthogonal and oblique cutting, various types of chips, Mechanics of orthogonal steady state metal cutting, shear plane and shear plane angle, Merchant’s force circle, stresses, shear strain, velocity relations, rate of strain, energy considerations, Concept of specific power consumption in machining, Ernst and Merchant’s model&amp; modified model for orthogonal cutting, Lee and Shaffer model, Analytical modelling of machining operations, mechanistic modelling of machining, slip line field analysis, finite element analysis, modelling of material properties</td>
<td>10</td>
</tr>
<tr>
<td>02</td>
<td>Dynamometry: Dynamometer requirements, force measurement, electric transducers, strain gage lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, surface grinding dynamometer, piezoelectric dynamometry</td>
<td>06</td>
</tr>
<tr>
<td>03</td>
<td>Temperatures in metal cutting and cutting fluids: Heat generation in metal cutting, heat transfer in a moving material, temperature distribution in metal cutting, temperature in primary deformation zone, temperature in secondary deformation zone, effect of cutting speed on temperature, prediction of temperature distribution in machining, measurement of cutting temperature, work-tool thermocouple, direct thermocouple measurement, radiation methods, hardness and microstructure changes in steel tools Cutting fluid types, the action of coolants, the action of lubricants, characteristics of an efficient lubricant in metal cutting, application methods of cutting fluid, cutting fluid maintenance and environmental considerations, disposal of cutting fluids, dry cutting and minimum quantity lubrication, cryogenic cooling</td>
<td>06</td>
</tr>
<tr>
<td>03</td>
<td>Cutting tool materials and machining induced surface integrity 3.1 Properties of cutting tool materials, Major tool material types, Plain carbon steel, high speed steel, cast alloys, cemented tungsten carbide, titanium carbides, ceramic and cermet tools, synthetic diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), coated tools 3.2 Measurement and specification of surface finish, primary cutting edge finish, fracture roughness, BUE formation and its influence on finish, secondary cutting edge finish,</td>
<td>06</td>
</tr>
</tbody>
</table>
geometrical contribution to roughness, edge finishing, residual stress and micro hardness

04 4.1 Tool life and machining economics:  
Definition, flank wear and crater wear, criteria for tool failure, effect of cutting parameters and tool geometry on tool life, Taylor’s tool life equation, Experimental methods to find Taylor exponents, Components of product cost, Optimum cutting velocity for minimum cost of production and maximum production rate

05 5.1 Design of single point cutting tools:  
Different systems of tool nomenclature like MRS, ORS and NRS, Interrelationship among different systems of nomenclature for tool angles, Constructional features of solid tool, tipped tools, mechanically held regrind able insert type tools and throw away tip type tools, Design of shanks, cutting tip and chip breakers for HSS and Carbide tools, ISO coding system for tipped tools and tool holders

06 6.1 Design of multi point cutting tools:  
Various types such as flat form tool, tangential form tool, circular form tool, constructional details and fields of application, Profile design of flat and circular form tools, Broach nomenclature, design steps for circular pull type, key way and spline broaches, Design of face and peripheral milling cutters

Assessment:

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3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References
7. Typical Examples and Problems in Metal Cutting and Tool Design, by N. Nefedov and K. Osipov, Mir publishers, Moscow
Course Code | Course/Subject Name | Credits
---|---|---
MEDLO5013 | Design of Jigs and Fixtures | 4

**Objectives**

1. To acquaint with the concepts of planning and writing sequence of operations
2. To acquaint basics of identification and selection of location and clamping points on work-piece
3. To familiarise design principles in designing simple productive and cost effective jigs and fixtures

**Outcomes:** Learner will be able to…

1. Write methodically, the sequence of operations of simple work-piece
2. Identify and select locating and clamping points on work-piece
3. Demonstrate construction of drill jig
4. Illustrate construction of milling fixture
5. Identify appropriate combination of tools, jigs and fixture, suitable for a particular machining operation
6. Design assembly of jigs and fixtures on simple work-piece

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>1.1 Introduction to Tool Design</strong>&lt;br&gt;Production Tooling’s Jigs, Fixtures and their difference, their requirement(accuracy, machinability, quantity modifications so as to assist production, Interchange ability, Simplicity, Swarf disposal, Handling, Ease of operation, Skill reduction, Cost reduction), Analysis for Operation planning, sequencing of operations.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Basic Construction of Jig &amp; Fixture</strong>&lt;br&gt;<strong>1.1 Location &amp; Locating Devices</strong>&lt;br&gt;Locating principles: Degrees of freedom, Redundant location, Fool-proofing, nesting, Locators: locators that control work piece on flat surfaces, location of cylindrical surfaces, conical locators, centralizers.&lt;br&gt;<strong>1.2 Clamping &amp; clamping Devices</strong>&lt;br&gt;Requirement of clamping system, Position of clamps, Types of clamps, Clamping devices; examples of typical clamps(multiple clamping and equalizing devices, quick acting clamping mechanisms such as link, toggle, cam, eccentric, pneumatic, hydraulic and electric devices), Component distortion under clamping and cutting forces, Material used for different clamping devices of jigs/fixture and recommended hardness</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td><strong>3.1 Construction of Drill Jig</strong>&lt;br&gt;Introduction, Selection of location, supporting and clamping faces /points, cutting tools and means of guiding and supporting Jigs, various types of Jig Bushes, Commonly used drill jigs, Case Study on Design of Drill Jig</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td><strong>4.1 Construction of Milling fixture</strong>&lt;br&gt;Introduction, Selection of location, supporting and clamping faces /points choice, tool setting block and Tennon’s, Case Study on Design of Milling Fixture</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>5.1 Introduction to Commonly used Fixtures</strong>&lt;br&gt;Turning Fixture (Chucks, collets, Mandrels) Grinding Fixture, Broaching Fixture, and Welding Fixture</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>6.1 Indexing Jig &amp; Fixture</strong>&lt;br&gt;Introduction, Application of indexing, Essential features of an indexing jig /fixture, Indexing Devices</td>
<td>04</td>
</tr>
</tbody>
</table>
**Assessment:**

**Internal Assessment for 20 marks:**
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

**References**

3. Jigs and Fixture, P. H. Joshi, TMH
4. Tool design, C. Donaldson, George H. Lecain, V.C. Goold, TMH
6. Jigs and Fixture, ASTME
7. Non- Standards Calming Devices, Hiran E. Grant TMH, New Delhi
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEL 501</td>
<td>Internal Combustion Engines Lab</td>
<td>01</td>
</tr>
</tbody>
</table>

**Objectives:**
1. To familiarise concept of thermal conductivity, heat transfer coefficient through experiments
2. To familiarise experimental verification of the concepts of heat transfer

**Outcomes:** Learner will be able to…
1. Dismantle engine assembly
2. Overhaul and Assemble engine components
3. Perform load test/speed test on engine setup
4. Calculate performance of multi cylinder engine
5. Analyse engine performance and draw heat balance sheet
6. Perform exhaust gas analysis

**Part A: Dismantle, overhaul and assemble the following**
1. 2 Stroke/ 4 Stroke Engines
2. Carburettor
3. Ignition system
4. Fuel injection system

**Part B: Performing experiments on engine test rigs**
1. Morse Test on petrol engine
2. Speed Test on petrol or/and diesel engine
3. Load Test on diesel engine (engines)
4. Heat Balance test on diesel or petrol engines
5. Experimental determination of Air fuel ratio and volumetric efficiency of the engine
6. Exhaust Gas/Smoke analysis of S.I./ C.I. engines
7. Effect of Supercharging on Performance Characteristics of an engine

**Term Work**
Term work shall consist of minimum 6 exercises, from the list, out of which minimum 4 must be actual experiments from Part B and 1 case study/report (in group of not more than 3 students) on latest trends/developments in IC Engines.

The distribution of marks for term work shall be as follows:
1. Laboratory work (Exercises) : 15 marks
2. Case study: 05 marks
3. Attendance: 05 marks

**End Semester Practical/Oral Examination:**
1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Distribution of marks for practical/viva examination shall be as follows:
   - Practical performance 15 marks
   - Oral 10 marks
3. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination
4. Students work along with evaluation report to be preserved till the next examination
Course Code | Course/Subject Name | Credits
--- | --- | ---
MEL 502 | Mechanical Measurement and Control | 1

**Objectives**
1. To study calibration of different measuring instruments
2. To study working of mechanical measurement system
3. To familiarise with different types of control systems

**Outcomes:** Learner will be able to…
1. Calibrate displacement sensors
2. Calibrate pressure and vacuum gauges
3. Measure torque using strain gauges
4. Identify system/process characteristics for standard input responses
5. Identify various types of control systems and time domain specifications
6. Analyse the problems associated with stability

**List of Experiments**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calibration of Displacement sensors like LVDT, Potentiometers etc.</td>
</tr>
<tr>
<td>2</td>
<td>Calibration of Pressure Gauges</td>
</tr>
<tr>
<td>3</td>
<td>Calibration of Vacuum Gauges</td>
</tr>
<tr>
<td>4</td>
<td>Torque measurement using strain gauges</td>
</tr>
<tr>
<td>5</td>
<td>Calibration of tachometers</td>
</tr>
<tr>
<td>6</td>
<td>Vibration Measurement &amp; Calibration of Accelerometers.</td>
</tr>
<tr>
<td>7</td>
<td>Experiments on feedback control systems and servomechanisms</td>
</tr>
<tr>
<td>8</td>
<td>System Identification of any one of the sensor</td>
</tr>
<tr>
<td>9</td>
<td>Experiment on frequency response system identification</td>
</tr>
<tr>
<td>10</td>
<td>Experiment on transient state response of a control system.</td>
</tr>
<tr>
<td>11</td>
<td>Experiment on design of PID controller for a system.</td>
</tr>
</tbody>
</table>

(a) Design based experiments shall be encouraged using standard National Instrument/ texas instrument/ dSPACEGmbH/ Arduino or any other platform). **Learners (in a group) may be encouraged for Project Based Learning. Appropriate weightage may be given in term work assessment**

**Term Work**

Term work shall consist of minimum 8experiments (04 from the measurement group and 4 from the control group).

The distribution of marks for term work shall be as follows:
- Laboratory work (Experiments) : **15 marks**
- Design based experiment: **05 marks**
- Attendance: **05 marks**

**End Semester Practical/Oral Examination:**
1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Distribution of marks for practical/viva examination shall be as follows:
   - Practical performance 15 marks
   - Oral 10 marks
3. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination
4. Students work along with evaluation report to be preserved till the next examination

University of Mumbai,  B. E. (Mechanical Engineering),  Rev 2016 56
Subject | Code | Subject Name | Credits
---|---|---|---
MEL 503 | Heat Transfer Lab | 01

**Objectives:**
1. To familiarise concept of thermal conductivity, heat transfer coefficient through experiments
2. To familiarise experimental verification of the concepts of heat transfer

**Outcomes:** Learner will be able to…
1. Estimate thermal conductivity of metals/non metals/liquids
2. Compute heat transfer coefficient in natural as well forced convection
3. Measure emissivity of grey body
4. Quantify fin effectiveness/efficiency
5. Analyse heat exchanger performance
6. Demonstrate energy balance for heat exchanger

The laboratory experiments should be based on the following:

<table>
<thead>
<tr>
<th>Expt.No</th>
<th>Name of Experiments</th>
</tr>
</thead>
</table>
| 1 | **Conduction: (Any Two)**
1. Measurement of thermal conductivity of metal rod
2. Measurement of thermal conductivity of insulating material
3. Measurement of thermal conductivity of liquid
4. Determination of contact resistance
5. Effect of area on heat transfer |
| 2 | **Convection: (Any One)**
1. Measurement of heat transfer coefficient in natural convection
2. Measurement of heat transfer coefficient in forced convection
3. Comparison of heat transfer coefficient of free and forced convection |
| 3 | **Radiation: (Any One)**
1. Verification of Stefan Boltzmann Law
2. Measurement of Emissivity of Grey surface |
| 4 | **Transient Conduction:**
1. Unsteady state heat transfer in cylinder/rod/wall |
| 5 | **Fins: (Any One)**
1. Determination of fin efficiency and fin effectiveness
2. Comparison of fin performance of Various type of fins |
| 6 | **Boiling and Condensation: (Any One)**
1. Measurement of heat transfer coefficient in boiling process of water.
| 7 | **Heat Exchangers: (Any One)**
1. Estimation of overall heat transfer coefficient and effectiveness of double pipe heat exchanger (parallel flow and Counter flow arrangement)
2. Estimation of overall heat transfer coefficient and effectiveness of shell and tube heat exchanger (parallel flow and Counter flow arrangement)
3. Estimation of overall heat transfer coefficient and effectiveness of plate type heat exchanger. |

**Assignments:** Assignment consisting of at least 3 numerical on each of the following topics
1. Steady state conduction
2. Fins and unsteady state conduction
3. Convection and dimensional analysis

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4. Radiation
5. Heat Exchangers

Note: Preferably, the assignments shall be based on live problems. **Project Based Learning may be incorporated by judiciously reducing number of assignments.**

**Assessment:**

Term work Mark distribution will be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory work</td>
<td>15</td>
</tr>
<tr>
<td>Assignments</td>
<td>05</td>
</tr>
<tr>
<td>Attendance</td>
<td>05</td>
</tr>
</tbody>
</table>

**End Semester Practical/oral Examination:**

1. Pair of Internal and External Examiner should conduct practical/viva based on contents Distribution of marks for practical/viva examination shall be as follows:
<table>
<thead>
<tr>
<th>Component</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical performance</td>
<td>15</td>
</tr>
<tr>
<td>Oral</td>
<td>10</td>
</tr>
</tbody>
</table>

2. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination

3. Students work along with evaluation report to be preserved till the next examination
Objectives:
1. To acquaint with working principles and applications of gyroscope and governors
2. To acquaint with the principles of vibration measuring instruments
3. To study balancing of mechanical systems

Outcomes: Learner will be able to…
1. Plot and analyse governor characteristics
2. Analyse gyroscopic effect on laboratory model
3. Estimate natural frequency of mechanical systems
4. Analyse vibration response of mechanical systems
5. Determine damping coefficient of a system
6. Balance rotating mass

Term Work: (Comprises part a and b)
a) List of Experiments: (Minimum Eight)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Title of Experiment</th>
<th>Laboratory Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Experiments on Governors- Porter Governor, Hartnell Governor</td>
<td>2 hrs</td>
</tr>
<tr>
<td>2</td>
<td>Experiments on Gyroscope</td>
<td>2 hrs</td>
</tr>
<tr>
<td>3</td>
<td>Determine natural frequency of compound pendulum, equivalent simple pendulum system.</td>
<td>2 Hrs.</td>
</tr>
<tr>
<td>4</td>
<td>Determine natural frequency for longitudinal vibrations of helical springs, and springs in series and parallel</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>5</td>
<td>Determine natural frequency and nodal points for single rotor and two-rotor vibratory system</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>6</td>
<td>Experiment on whirling of shaft</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>7</td>
<td>Determination of damping coefficient of any system/media</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>8</td>
<td>Experimental balancing of single and multi-rotor system</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>9</td>
<td>Measurement of vibration response of a system</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>10</td>
<td>Vibration analysis of mechanical system using MATLAB/SCILAB/GNU Octave</td>
<td>2 Hrs</td>
</tr>
</tbody>
</table>

b) Assignment: Minimum two problems on each of the following topics:
1. Governors and Gyroscope
2. Static and dynamic force analysis
3. Vibration, isolation and control
4. Vibration measuring instruments
5. Rotor dynamics

Project Based Learning may be incorporated by judiciously reducing number of assignments

Term Work
The distribution of marks for term work shall be as follows:
- Laboratory work : 15 marks.
- Assignments : 05 marks.
- Attendance : 05 Marks.
Objectives:
1. To study conventional machining operations
2. To familiarise with CNC machining operation
3. To acquaint with Non Traditional machining operations

Outcomes: Learner will be able to…
1. Estimate machining time for simple and taper turning operations on lathe
2. Estimate machining time for threading/knurling operations on lathe
3. Estimate machining time for various machining operations on shaper
4. Perform NC, CNC and DNC machining operations
5. Write CNC program for different operations
6. Identify machining parameters for various Non Traditional machining operations

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to machining operations</td>
</tr>
<tr>
<td>2</td>
<td>Introduction to lathe machine (other than plain turning operation) and shaping machine</td>
</tr>
<tr>
<td>3</td>
<td>Machining and machining time estimation for taper turning</td>
</tr>
<tr>
<td>4</td>
<td>Machining and machining time estimation for thread cutting</td>
</tr>
<tr>
<td>5</td>
<td>Machining and machining time estimation for internal thread cutting</td>
</tr>
<tr>
<td>6</td>
<td>Machining and machining time estimation for knurling</td>
</tr>
<tr>
<td>7</td>
<td>Machining and machining time estimation for eccentric turning</td>
</tr>
<tr>
<td>8</td>
<td>Machining of hexagon and square in shaping machine</td>
</tr>
<tr>
<td>9</td>
<td>NC, CNC, DNC machining operations</td>
</tr>
<tr>
<td>10</td>
<td>CNC programming for Turning and Drilling operations</td>
</tr>
<tr>
<td>11</td>
<td>Different Non Traditional machining operations with process parameters</td>
</tr>
</tbody>
</table>

Term Work:
All the assignments mentioned above with relevant sketches.

Distribution of marks for Term work shall be as follows:

All the above listed assignments: 20 marks
Attendance: 05 marks
Subject Code | Subject Name | Credits
--- | --- | ---
MEL506 | Business Communication & Ethics | 02

Objectives:
1. To inculcate professional and ethical attitude at the workplace
2. To enhance effective communication and interpersonal skills
3. To build multidisciplinary approach towards all life tasks
4. To hone analytical and logical skills for problem-solving

Outcomes: Learner will be able to…
1. Design a technical document using precise language, suitable vocabulary and apt style.
2. Develop the life skills/interpersonal skills to progress professionally by building stronger relationships.
3. Demonstrate awareness of contemporary issues knowledge of professional and ethical responsibilities.
4. Apply the traits of a suitable candidate for a job/higher education, upon being trained in the techniques of holding a group discussion, facing interviews and writing resume/SOP.
5. Deliver formal presentations effectively implementing the verbal and non-verbal skills

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong></td>
<td>Report Writing</td>
<td>05</td>
</tr>
<tr>
<td>1.1</td>
<td>Objectives of Report Writing</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Language and Style in a report</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Types: Informative and Interpretative (Analytical, Survey and Feasibility) and Formats of reports (Memo, Letter, Short and Long Report)</td>
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</tr>
<tr>
<td><strong>02</strong></td>
<td>Technical Writing</td>
<td>03</td>
</tr>
<tr>
<td>2.1</td>
<td>Technical Paper Writing (IEEE Format)</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>Proposal Writing</td>
<td></td>
</tr>
<tr>
<td><strong>03</strong></td>
<td>Introduction to Interpersonal Skills</td>
<td>09</td>
</tr>
<tr>
<td>3.1</td>
<td>Emotional Intelligence</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Leadership and Motivation</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>Team Building</td>
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<tr>
<td>3.4</td>
<td>Assertiveness</td>
<td></td>
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<tr>
<td>3.5</td>
<td>Conflict Resolution and Negotiation Skills</td>
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</tr>
<tr>
<td>3.6</td>
<td>Time Management</td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Decision Making</td>
<td></td>
</tr>
<tr>
<td><strong>04</strong></td>
<td>Meetings and Documentation</td>
<td>02</td>
</tr>
<tr>
<td>4.1</td>
<td>Strategies for conducting effective meetings</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>Notice, Agenda and Minutes of a meeting</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Business meeting etiquettes</td>
<td></td>
</tr>
<tr>
<td><strong>05</strong></td>
<td>Introduction to Corporate Ethics</td>
<td>02</td>
</tr>
<tr>
<td>5.1</td>
<td>Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc.)</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Introduction to Intellectual Property Rights</td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td>Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response and making ethical decisions)</td>
<td></td>
</tr>
<tr>
<td><strong>06</strong></td>
<td>Employment Skills</td>
<td>07</td>
</tr>
<tr>
<td>6.1</td>
<td>Group Discussion</td>
<td></td>
</tr>
</tbody>
</table>
Assessment:

List of Assignments
1. Report Writing (Theory)
2. Technical Proposal
4. Interpersonal Skills (Group activities and Role plays)
5. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
6. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
7. Corporate ethics (Case studies, Role plays)
8. Writing Resume and Statement of Purpose

Term Work
Term work shall consist of all assignments from the list.
The distribution of marks for term work shall be as follows:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book Report</td>
<td>10</td>
</tr>
<tr>
<td>Assignments</td>
<td>10</td>
</tr>
<tr>
<td>Project Report Presentation</td>
<td>15</td>
</tr>
<tr>
<td>Group Discussion</td>
<td>10</td>
</tr>
<tr>
<td>Attendance</td>
<td>05</td>
</tr>
</tbody>
</table>

References:
1. Fred Luthans, “Organizational Behavior”, Mc Graw Hill,
3. R.Subramaniam, “Professional Ethics” Oxford University Press
5. Raman and Sharma, Fundamentals of Technical Communication, Oxford University Press
9. Raman Sharma, Communication Skills, Oxford University Press
13. Dr. K. Alex ,“Soft Skills”, S Chand and Company
15. https://grad.ucla.edu/asis/agep/advopstem.pdf
Course Code       Course/Subject Name       Credits
MEC 601            Metrology and Quality Engineering       4

Objectives:
1. To acquaint with measuring equipment used for linear and angular measurements.
2. To familiarize with different classes of measuring instruments and scope of measurement in industry and research.
3. To acquaint with operations of precision measurement, instrument/equipment for measurement.
4. To inculcate the fundamentals of quality concepts and statistics in metrology.

Outcomes: Learner will be able to…
1. Demonstrate inspection methods and different gauges.
2. Illustrate working principle of measuring instruments and calibration methodology.
3. Illustrate basic concepts and statistical methods in quality control.
4. Demonstrate characteristics of screw threads, gear profile, and tool profile.
5. Illustrate the different sampling techniques in quality control.
6. Illustrate different nondestructive techniques used for quality evaluation.

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 <strong>Introduction to Metrology:</strong>&lt;br&gt;Fundamental Definitions, Types of Standards, Precision and Accuracy, Measurement Errors, linear measurements by Vernier calliper, micrometer, slip gauges, Angular Measurement: Universal bevel protractor, clinometers, sine bar, angle gauges, case studies on Industrial and Research Applications and Scope</td>
<td>06</td>
</tr>
<tr>
<td>1</td>
<td>1.2 <strong>Introduction to Nano-Metrology</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.3 <strong>Design of Gauges:</strong>&lt;br&gt;Limits, Fits, Tolerances, Types of Gauges, Taylor’s Principle of Limit Gauges, IS 919 for design of gauges</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>1.4 <strong>Comparators:</strong>&lt;br&gt;Definition, Classification, Working principle of Mechanical, Opto-mechanical, Pneumatic and Electrical/Electronic comparators with advantages, limitations and uses</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.5 <strong>Surface Texture measurement:</strong>&lt;br&gt;Surface roughness, Waviness, Roughness Parameter Ra, Rz, RMS etc., working of Tomlinson surface meter, Taly-surf surface roughness tester, Surface roughness symbols</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.6 <strong>Flatness Test measurement by Interference principle:</strong>&lt;br&gt;Concept of Flatness, Interferometer principle for measurement, Optical Flats – study of Surface textures under monochromatic light source, fingertip test technique</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3.1 <strong>Screw Thread Measurement:</strong>&lt;br&gt;Screw threads Terminology, screw thread errors, Effective diameter measurement of screw thread by Floating Carriage micrometer</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>3.2 <strong>Gear Measurement:</strong>&lt;br&gt;Gear Terminology, Gear errors, Measurement by Parkinson Gear tester and Gear tooth Vernier Calliper</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3.3 <strong>Special Measuring Instruments:</strong>&lt;br&gt;Measurement by Tool Maker’s Microscope, Optical Profile Projector, CMM and Autocollimator</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.1 Quality Engineering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Introduction to Quality, Classification of Quality Tools, Quality of Design, Quality of Conformance, Compromise between Quality and Cost, Introduction to Six Sigma</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.2 SQC &amp; SQC tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Statistics in Quality control, Variables and Attributes data, Process Capability, Control charts for variables and for attribute data($\bar{X}$ and R-Chart, p-chart np-chart, c-chart, U-chart), Applications of SQC in engineering – case studies</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5.1 Sampling Techniques</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advantages of Sampling Inspection, operating characteristic (OC) curve. Choosing OC curve for appropriate sampling plan, acceptance sampling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2 Role of computers in metrology</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5.1 Non-destructive Testing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Visual, Dye Penetrant, Magnetic Particle, X ray Radiography, Ultrasonic Testing, Eddy Current testing methods.</td>
<td></td>
</tr>
</tbody>
</table>

**Assessment:**

**Internal Assessment for 20 marks:**

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

**References**

1. Engineering Metrology, K.J. Hume, Kalyani Publications
2. Mechanical Measurements and Metrology by RK Jain, Khanna Publishers
6. Engineering Metrology and Measurements, Bentley, Pearson Education
8. Statistical Quality Control by R C Gupta, Khanna Publishers
10. Statistical Quality Control by M Mahajan, Dhanpat Rai and Sons
Course Code | Course Name | Credits
---|---|---
MEC602 | MACHINE DESIGN – I* | 4

**Objective:**
1. To study basic principles of machine design
2. To acquaint with the concepts of design based on strength & rigidity
3. To familiarize with use of design data books & various codes of practice
4. To make conversant with preparation of working drawings based on designs

**Outcomes:** Learner will be able to…
1. Demonstrate understanding of various design considerations
2. Illustrate basic principles of machine design
3. Design machine elements for static as well as dynamic loading
4. Design machine elements on the basis of strength/ rigidity concepts
5. Use design data books in designing various components
6. Acquire skill in preparing production drawings pertaining to various designs

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Material properties and their uses in design, Manufacturing consideration in design, Design consideration of casting and forging, Basic principle of Machine Design, Modes of failures, Factor of safety, Design stresses, Theories of failures (Selection in the process of designing), Standards, I.S. Codes, Preferred Series and Numbers</td>
<td>06</td>
</tr>
<tr>
<td>2</td>
<td>Curved Beams: Assumptions made in the analysis of curved beams, Design of curved beams: Bending stresses in curved beams, such as crane hook, C-frame, etc. Thick Cylinders: Design of thick cylinders subjected to an internal pressure using Lame’s equation</td>
<td>06</td>
</tr>
<tr>
<td>3</td>
<td>Design against static loads: Cotter joint, Knuckle joint, Turn buckle, Bolted and welded joints under eccentric loading; Power Screw – screw presses, C-clamps along with the Frame, Screw Jack</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Design against fluctuating loads: variables stresses, reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Endurance limit- estimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria, Fatigue design under combined stresses</td>
<td>06</td>
</tr>
<tr>
<td>5</td>
<td>Design of Shaft: power transmitting, power distribution shafts, Module (excluding crank shaft) under static and fatigue criteria Keys: Types of Keys and their selection based on shafting condition Couplings: Classification of coupling, Design of Flange couplings, Bush pin type flexible couplings</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>Design of Springs: Helical compression, Tension Springs under Static and Variable loads, Leaf springs</td>
<td>07</td>
</tr>
</tbody>
</table>

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

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2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **four questions need to be solved**

References:

2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
5. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
6. Recommended Data Books - PSG
7. Machine Design by Reshetov, Mir Publication
11. Design of Machine Elements by V.M.Faires
12. Design of Machine Elements by Spotts
Objectives:
1. To familiarise with concepts of FEM
2. To study the applicability of FEM to engineering problems
3. To acquaint with application of numerical techniques for solving problems

Outcomes: Learner will be able to…
1. Solve differential equations using weighted residual methods
2. Develop the finite element equations to model engineering problems governed by second order differential equations
3. Apply the basic finite element formulation techniques to solve engineering problems by using one dimensional elements
4. Apply the basic finite element formulation techniques to solve engineering problems by using two dimensional elements
5. Apply the basic finite element formulation techniques to find natural frequency of single degree of vibration system
6. Use commercial FEA software, to solve problems related to mechanical engineering

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
</tr>
</thead>
</table>
| 01     | **Introduction:**
|        | 1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM
|        | 1.2 Mathematical Modelling of field problems in engineering, Governing equations, Differential equations in different fields
|        | 1.3 Approximate solution of differential equations, Weighted residual techniques, Boundary value problems |
| 02     | **FEA Procedure:**
|        | 2.1 Discrete and Continuous Models, Weighted Residual Methods - Ritz Technique- Basic Concepts of the, Finite Element Method
|        | 2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, boundary conditions.
|        | 2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', transformation and assembly concepts |
| 03     | **One Dimensional Problems:**
|        | 3.1 One dimensional second order equations - discretization-element types - linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors
|        | 3.2 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer and fluid flow (stepped and taper bars, fluid network, spring-Cart Systems)
|        | 3.3 Analysis of Plane trusses, Analysis of Beams
|        | 3.4 Solution of one dimensional structural and thermal problems using FE Software, Selection of suitable element type, modelling, meshing, boundary condition, convergence of solution, result analysis, case studies |
| 04     | **Two Dimensional Finite Element Formulations:**
|        | 4.1 Introduction, three node triangular element, four node rectangular element, four node quadrilateral element
|        | 4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange’s methods for deriving shape functions for triangular and quadrilateral element
|        | 4.3 Sub parametric, Isoparametric, super parametric elements, Compatibility, Patch test, Convergence criterion, sources of errors |
Two Dimensional Vector Variable Problems:
5.1 Equations of elasticity - Plane stress, plane strain and axisymmetric problems
5.2 Jacobian matrix, stress analysis of CST and four node Quadratic element

Finite Element Formulation of Dynamics and Numerical Techniques:
6.1 Applications to free vibration problems of rod and beam, Lumped and consistent mass matrices
6.2 Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation, transverse deflections and natural frequencies of beams

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
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2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References:
2. Finite Element Method by JNReddy, TMH
3. 'Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu,Pearson Education
4. Finite Element Methods by R Dhanraj and K Prabhakaran Nair, Oxford University Press
5. A first course in Finite Element Method by Logan D L, Thomson Asia PvtLtd
6. 'Concepts and Applications of Finite Element Analysis by Cook R D, Malkus D S, Plesha ME, John-Wiley Sons
7. The Finite Element Method in Engineering by SSRao, Butter WorthHeinemann
8. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.
Objectives
1. To study working and operating principles of Air Refrigeration, Vapour Compression and Vapour Absorption system
2. To study components of refrigeration and air conditioning systems
3. To study controls and applications of refrigeration and air conditioning

Outcomes: Learner will be able to…
1. Demonstrate fundamental principles of refrigeration and air conditioning
2. Identify and locate various important components of the refrigeration and air conditioning system
3. Illustrate various refrigeration and air conditioning processes using psychometric chart
4. Design Air Conditioning system using cooling load calculations.
5. Estimate air conditioning system parameters
6. Demonstrate understanding of duct design concepts

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Refrigeration:</strong> Methods of refrigeration, First and Second Law applied to refrigerating machines, Carnot refrigerator, Carnot heat pump, unit of refrigeration, Co-efficient of Performance, Energy Efficiency Ratio (EER), and BEE star rating Air refrigeration systems: Bell Coleman cycle, applications. Aircraft air refrigeration systems: Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, Reduced ambient, Regenerative air cooling system, Comparison of these systems based on DART rating.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Vapour Compression Refrigeration System:</strong> Simple vapour compression cycle, Effect of liquid sub cooling &amp; superheating, effect of evaporator and condenser pressures, methods of subcooling, use of P-h charts, Actual VCR cycle, Use of P-h Charts, Comparison between air-cooled and water-cooled condenser based air conditioning systems, Types of condensers, evaporators, expansion devices and Compressors. <strong>Cooling tower:</strong> Types of cooling towers, tower approach, tower range, tower efficiency, tower losses, tower maintenance. <strong>Refrigerants:</strong> Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties, Secondary refrigerants, ODP and GWP, Montreal protocol and India’s commitment, Recent substitutes for refrigerants.</td>
<td>12</td>
</tr>
<tr>
<td>03</td>
<td><strong>Other Refrigeration Systems:</strong> Vapour Absorption Refrigeration, Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Single and double effect, Electrolux refrigeration system. <strong>Non-Conventional Refrigeration Systems:</strong> Thermoelectric Refrigeration, Thermo-acoustic Refrigeration, Vortex Tube Refrigeration.</td>
<td>06</td>
</tr>
<tr>
<td>04</td>
<td><strong>Psychrometry:</strong> Need for air conditioning, Principle of psychrometry, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, summer and Winter Air conditioning.</td>
<td>05</td>
</tr>
</tbody>
</table>
**Duct Design** Friction chart for circular ducts, Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal pressure drop methods of duct design, Factors considered in air distribution system, Air distribution systems for cooling and heating

**Controls and Applications:**
Controls – LP/HP cutoff, Thermostats, Humidistats, Interlocking control, Electronic Controllers
Applications Refrigeration & A/C Ice plant – food storage plants – dairy and food processing plants, Food preservation, Freeze Drying, A/c in textile, printing, pharmaceutical industry and Hospitals, liquefaction of LNG, Liquefaction of gases (cryogenics), Deep sea water air-conditioning

**Assessment:**

**Internal Assessment for 20 marks:**
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
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3. Remaining questions will be **mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

**References**

1. Refrigeration and air-conditioning – C P Arora, TMH
3. Refrigeration and air-conditioning – W F Stoeker and J W Jones, TMH
4. Modern Air-conditioning practice – C P Arora, TMH
5. Refrigeration and air-conditioning- Manohar Prasad, New Age Int (P) Ltd
6. Basic Refrigeration and air-conditioning- P.Ananthanarayana, TMH
7. ASHRAE Handbook of Fundamentals
8. ASHRAE Handbook of Systems
9. ASHRAE Handbook of Equipment
10. ISHRAE Air Conditioning Handbook
11. ISHRAE Refrigeration Handbook
Objectives
1. To study key elements of Mechatronics system and its integration
2. To familiarise concepts of sensors characterization and its interfacing with microcontrollers
3. To acquaint with concepts of actuators and its interfacing with microcontrollers
4. To study continuous control logics i.e. P, PI, PD and PID
5. To study discrete control logics in PLC systems and its industrial applications

Outcomes: Learner will be able to…
1. Identify the suitable sensor and actuator for a mechatronics system
2. Select suitable logic controls
3. Analyse continuous control logics for standard input conditions
4. Develop ladder logic programming
5. Design hydraulic/pneumatic circuits
6. Design a mechatronic system

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<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Introduction of Mechatronics and its block diagram representation</strong>&lt;br&gt;Key elements of mechatronics, Applications of Mechatronics domestic, industrial etc. Representation of mechatronic system in block diagram and concept of transfer function for each element of mechatronic system, Reduction methods and its numerical treatment for represented block diagram</td>
<td>08</td>
</tr>
<tr>
<td>2</td>
<td><strong>Selection of Sensors &amp; Actuators</strong>&lt;br&gt;Sensors: Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics.&lt;br&gt;Actuators: Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety etc.&lt;br&gt;Principle and selection of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC</td>
<td>08</td>
</tr>
<tr>
<td>3</td>
<td><strong>Data Acquisition, Signal Conditioning &amp; Microcontroller System Theory:</strong>&lt;br&gt;Concept of Bit accuracy/width and Sampling speed, sampling theorem, aliasing, Nyquist criteria, ADC (Analog to Digital Convertor) Successive approximation method and sample and hold circuitry, DAC (Digital to Analog Convertor) R-2R circuit and DAC resolution&lt;br&gt;Signal Filters: Low pass, High Pass and Band Pass with circuit diagrams for simple cases</td>
<td>08</td>
</tr>
<tr>
<td>4</td>
<td><strong>Pneumatics and hydraulics:</strong>&lt;br&gt;Hydraulic and pneumatic devices: Different types of valves, Actuators and auxiliary elements in Pneumatics and hydraulics, their applications and use of their ISO symbols, Synthesis and design of circuits (up to 2 cylinders)–pneumatic, electro- pneumatics and hydraulics, electro-hydraulics</td>
<td>08</td>
</tr>
<tr>
<td>5</td>
<td><strong>Control System</strong>&lt;br&gt;Control system design and analysis by Root Locus Method, Control system Design by Frequency response method, stability margin, Nyquist diagram, Bode diagram P, I and D control actions, P, PI, PD and PID control systems, Transient response:- Percentage overshoot, Rise time, Delay time, Steady state error, PID tuning (manual), Zigler Method</td>
<td>08</td>
</tr>
<tr>
<td>6</td>
<td><strong>Discrete Control System PLC (Programming Logic Control)Theory:</strong>&lt;br&gt;Introduction to PLC, Architecture, Ladder Logic programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming</td>
<td>08</td>
</tr>
</tbody>
</table>
Assessment:

Internal Assessment for 20 marks:
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

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3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References

1. Mechatronics, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc
5. Mechatronics, Neculescu, Pearson education
6. Mechatronics - Electromechanics and Control Mechanics , Mill Springer-Verlag
10. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education
11. Pneumatic Circuits and Low Cost Automation by Fawcett JR
12. The Art of Electronics, Horowitz and Hill Cambridge, University Press
19. Mechatronics, A. Smaili, F. Mrad, OXFORD Higher Education.
21. Industrial Hydraulics: Pippenger
22. Vickers Manual on Hydraulics
24. Pneumatic Applications: Deppert Warner & Stoll Kurt
25. Mechanization by Pneumatic Control: Vol. 1 & 2 Deppert Warner & Stoll kurt
26. Hydraulics and Pneumatics for Production: Stewart
27. Hydraulic Valves and Controls: Pippenger
28. Fundamentals of pneumatics: Festo series
31. Mechatronics, HMT
33. Design with Microprocessors for Mechanical Engineers, StifflerMcGraw-Hill
**Objectives:**
1. To study the basics of robotics and its control
2. To study various design principles of robotics through kinematic analysis, workspace analysis, and trajectory planning
3. To study applications of robots in industrial inspection and material handling
4. To study the role of a robot as a humanoid

**Outcomes:** Learner will be able to…
1. Demonstrate the basic functioning of a robot
2. Identify various components of robots
3. Carry out kinematic analysis, workspace analysis, and trajectory planning for a robot
4. Identify suitable sensors/actuators for robot
5. Select an appropriate robot for given industrial inspection and material handling systems.
6. Illustrate various aspects of a robot as a humanoid

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction</strong>&lt;br&gt;Definition of robot, Evolution of robots, Laws of robots, International Robotic Standards, Types of robots, Selection of robots, Robot Classifications, Degrees of freedom, Robot configuration, Accuracy and repeatability, Specification of a robot, Robot feedback controls: Point to point control and Continuous path control, Control system for robot joint, Adaptive control, Actuators and sensors, Drives and transmission systems, End effectors, Applications of robots</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Kinematics of Robots</strong>&lt;br&gt;<em>Direct:</em> Link coordinates D-H Representation, The ARM equation, Direct kinematic analysis for Four axis, SCARA Robot and three, five, and six axis Articulated Robots.&lt;br&gt;<em>Inverse:</em> The inverse kinematics problem, General properties of solutions, Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis Articulated robot.&lt;br&gt;<strong>Mobile Robot Kinematics</strong>&lt;br&gt;Introduction, Kinematic models and constraints, Representing robot position, Forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints, Mobile robot maneuverability, Degree of mobility, Degree of steerability, Mobile robot workspace, Degree of freedom, Holonomic robots, Path and trajectory considerations, Motion control, Open loop control, Feedback control.</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td><strong>Workspace Analysis and Trajectory Planning</strong>&lt;br&gt;Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - Continuous path motion, Interpolated motion, Straight line motion and Cartesian space technique in trajectory planning.</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td><strong>Sensors &amp; Actuators</strong>&lt;br&gt;Sensors: Selection of sensors (Displacement, temperature, acceleration ,force/pressure) based on static and dynamic characterstics, Interfacing: Concept of interfacing, bit accuracy and sampling speed, amplifying electronics, and microcontroller&lt;br&gt;Actuators: Principle and selection of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC</td>
<td>08</td>
</tr>
</tbody>
</table>
Robots for Inspection and Material Handling
Robotic vision systems, Image representation, Object recognition and categorization, Depth measurement, Image data compression, Visual inspection, Software considerations
Concepts of material handling, Principles and considerations in material handling systems design, Conventional material handling systems - Industrial trucks, Monorails, Rail guided vehicles, Conveyor systems, Cranes and Hoists, Advanced material handling systems, Automated guided vehicle systems, Automated storage and retrieval systems, Bar code technology, Radio frequency identification technology

Humanoids
Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, and sound, Vision, Tactile Sensing, Models of emotion and motivation, Performance, Interaction, Safety and robustness, Applications, Case studies

Assessment:

Internal Assessment for 20 marks:
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
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3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References

10. J.Hirchhorn, “Kinematics and Dynamics of Machinery”, McGrew Hill Book Company

University of Mumbai, B. E. (Mechanical Engineering), Rev 2016
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEDLO6023</td>
<td>Industrial Automation</td>
<td>4</td>
</tr>
</tbody>
</table>

**Objectives:**

1. To study the need for the automation, its advantages and limitations
2. To study the basic functional elements of automation
3. To familiarise with the levels of automation and strategies of automation
4. To acquaint with control of mechanical operations involving pneumatic, electric, hydraulic and electronic systems

**Outcomes:** Learner will be able to...

1. Demonstrate basics of industrial automation
2. Identify various types of automation
3. Demonstrate use of automated controls using pneumatic and hydraulic systems.
4. Illustrate the control systems in automated system.
5. Demonstrate applicability of PLC in process industry
6. Design electro-pneumatic circuits

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Automation:</strong> Definition and fundamentals of automation, reasons for Automating, basic elements of an automated system: Power, Program and control system <strong>Advanced automation functions:</strong> safety, maintenance &amp; repair diagnosis, error detection and recovery <strong>Levels of automation</strong> <strong>Automation principles and strategies:</strong> USA principle, ten strategies of automation and production system, automation migration strategy</td>
<td>06</td>
</tr>
<tr>
<td>02</td>
<td><strong>Mechanization and Automation:</strong> Mechanization and automation, product cycle, hard Vs flexible automation, Capital-intensive Vs low cost automation Types of systems—mechanical, electrical, hydraulic, pneumatic and hybrid systems Automation using CAMS, Geneva mechanisms, gears etc. Assembly line Automation: automated assembly systems, transfer systems, vibratory bowl feeders, non-vibratory feeders, part orienting, feed track, part placing &amp; part escapement systems Introduction to Material storage/handling and transport systems, and its automation using AS/RS, AGVS and conveyors etc.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Pneumatics and hydraulics:</strong> Hydraulic and pneumatic devices-Different types of valves, Actuators and auxiliary elements in Pneumatics &amp; hydraulics, their applications and use of their ISO symbols Synthesis and design of circuits (up to 3 cylinders)—pneumatic, electro pneumatics and hydraulics Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping</td>
<td>14</td>
</tr>
<tr>
<td>04</td>
<td>Sensors &amp; Actuators Sensors: Selection of sensors (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics Interfacing: Concept of interfacing, bit accuracy and sampling speed, amplifying electronics, and microcontroller Actuators: Principle and selection of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC</td>
<td>06</td>
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<tr>
<td>05</td>
<td><strong>Industrial control systems:</strong></td>
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<tr>
<td></td>
<td>Process industries versus discrete manufacturing industries, Continuous verses discrete control, Computer process control, Forms of computer process control</td>
<td></td>
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<tr>
<td></td>
<td>Discrete control using PLC- discrete process control, Programmable logic controller, its architecture, ladder diggs, Ladder Logic</td>
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<tr>
<td></td>
<td>Programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming</td>
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</tr>
</tbody>
</table>

| 06 | **Robots and their applications:** |
|    | Introduction to robots, Types, Classifications, Selection of robots, Robot Degrees of freedom, Robot configuration, Accuracy and repeatability, Specification of a robot, Robot feedback controls: Point to point control and Continuous path control, Control system for robot joint, Adaptive control, Drives and transmission systems, End effectors, Industrial robot applications of robots |

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1 will be compulsory and should cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

**Reference Books:**
4. Yoram Korean, “Robotics for engineers”, McGrew Hill Co
7. Industrial Hydraulics: Pippenger
10. Fundamentals of pneumatics: Festo series
Course Code | Course/Subject Name | Credits
--- | --- | ---
MEL601 | Metrology and Quality Engineering | 1

**Objectives:**

1. To familiarise with working of gauges
2. To acquaint with gear parameter measurement
3. To acquaint with operations of precision measurement, instrument/equipment for measurement
4. To inculcate the fundamentals of quality concepts and statistics in metrology

**Outcomes:** Learner will be able to...

1. Measure linear and angular dimensions
2. Measure surface roughness
3. Measure various parameters of gear tooth profile
4. Use optical profile projector for measurement
5. Use various instruments for measurement of screw threads
6. Measure flatness by Autocollimator / Interferometry method

Six Experiments need to be performed on the below mentioned topics:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vernier Calliper, Micrometer and Bevel Protractor for linear and angular measurement</td>
</tr>
<tr>
<td>2</td>
<td>Surface measurement by Surface roughness tester</td>
</tr>
<tr>
<td>3</td>
<td>Gear measurement – Gear tooth Vernier calliper / Parkinson gear tester</td>
</tr>
<tr>
<td>4</td>
<td>Screw Thread Measurement – screw thread Micrometer, Floating carriage micrometer / bench micrometer</td>
</tr>
<tr>
<td>5</td>
<td>Optical profile projector for miniature linear / angular measurements of screw / gear or components</td>
</tr>
<tr>
<td>6</td>
<td>Tool maker’s microscope for linear / angular measurement of single point tools</td>
</tr>
<tr>
<td>7</td>
<td>Comparator – Mechanical / Pneumatic type</td>
</tr>
<tr>
<td>8</td>
<td>Flatness measurement by Autocollimator / Interferometry method</td>
</tr>
<tr>
<td>9</td>
<td>QC charts for 50 sample readings of OD / ID of specimen and printouts</td>
</tr>
</tbody>
</table>

**Term-Work**

Consists of minimum six experiments from the above list and presented with Aim, Apparatus/equipment’s, and Introduction, Working principle, Diagram, method, observation table, Analysis, Results and conclusion/inferences.

Also, minimum 5 assignments to help smooth conducting of laboratory exercises and one case study relevant to contents

**Project Based Learning may be incorporated by judiciously reducing number of assignments**

Distribution of marks for term work shall be as follows:

- Laboratory work: 15 marks
- Assignments: 05 marks
- Attendance: 05 marks

**End Semester Practical/Oral examination**

1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Distribution of marks for practical/viva examination shall be as follows:
   a) Practical performance …… 15 marks
   b) Oral ……. 10 marks
3. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
4. Students work along with evaluation report to be preserved till the next examination
Course Code | Course Name | Credits
------------|------------|-----
MEL602      | Machine Design –I * | 1

Objectives:
1. To study the basic design principles
2. To familiarize with use of design data books & various codes of practice
3. To make conversant with preparation of working drawings based on designs

Outcomes: Learner will be able to…
1. Design shaft under various conditions
2. Design Knuckle Joint / cotter joint
3. Design Screw Jack/C-clamp along with frame
4. Design Flexible flange couplings/ Leaf spring
5. Convert design dimensions into working/manufacturing drawing
6. Use design data book/standard codes to standardise the designed dimensions

Term Work: (Comprises a & b)

a) Term work - Shall consist of (minimum 3) design exercises from the list which may include computer aided drawing on A3 size sheets.
   1) Knuckle Joint / cotter joint
   2) Screw Jack
   3) Flexible flange couplings
   4) Leaf springs
   5) C-clamps along with the Frame

b) Assignment: Design exercises in the form of design calculations with sketches and/ or drawings on following machine elements.
   1) Bolted and welded joints
   2) Combined stresses problem using theory of failure.
   3) Shaft design (solid and hollow shaft)
   4) Design against fluctuating loads (finite and infinite life)

The distribution of marks for term work shall be as follows:
- Part - a : 15 marks.
- Part--b : 05 marks.
- Attendance: 05 Marks.
**Course Code** | **Course Name** | **Credits**
---|---|---
MEL603 | Finite Element Analysis | 1

**Objectives:**
1. To familiarise FEA concept for practical implementation
2. To acquaint with FEA application software

**Outcomes:** Learner will be able to…
1. Select appropriate element for given problem
2. Select suitable meshing and perform convergence test
3. Select appropriate solver for given problem
4. Interpret the result
5. Apply basic aspects of FEA to solve engineering problems
6. Validate FEA solution

**Term Work:** (Comprises a and b)

a) **List of Experiments:** Students should use the commercial software or programmes form the text-books or self-developed programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs should be included in the Journal. The proposed list is given below:

1. Any two problems using bar element
2. Any two problems using truss element
3. Any two problems using CST element
4. Any two problem using axisymmetric element
5. Any one problem of free vibration analysis using bar element
6. Any one problem on steady state heat conduction

While performing the analysis the students should understand the concepts of selection of element type, meshing and convergence of solution.

b) **Course Project:**
A group of not more than four students, shall do Finite Element Analysis of any mechanical engineering element/system, which involves element selection, assigning properties, meshing, assigning loads, and boundary conditions, analysis and result interpretation.

The distribution of marks for term work shall be as follows:
- Part a: 15 marks.
- Part b: 05 marks.
- Attendance: 05 Marks.

**End Semester Practical/Oral examination**
1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Duration of practical examination is 2 hour
3. Distribution of marks for practical/viva examination shall be as follows:
   - a) Practical performance …… **15** marks
   - b) Oral …… .......................... **10** marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination
Course Code | Course/Subject Name | Credits
---|---|---
MEL604 | Refrigeration and Air Conditioning TW/Practical | 1

Objectives
1. To study operating principles of Vapour Compression system
2. To study components of refrigeration and air conditioning systems
3. To study controls and applications of refrigeration and air conditioning

Outcomes: Learner will be able to…
1. Demonstrate fundamental principles of refrigeration and air conditioning
2. Identify and locate various important components of the refrigeration and air conditioning system
3. Represent various refrigeration and air conditioning processes using psychometric chart
4. Operate and maintain refrigeration system
5. Operate and maintain air conditioning system
6. Simulate VCRS

Part A: List of Experiments
Trial on window air conditioner or Air Conditioning Test Rig
Trial on water cooler/Refrigeration Test Rig
Trial on Ice Plant
Trial on cooling tower

Part B: Demonstrations/Reports/Assignments/Simulations
Demonstration of domestic refrigerator along with wiring diagram
Demonstration of leak detection, evacuation and charging of refrigerant
Report on different protocols to regulate global warming
Visit report of Refrigeration establishment like Cold storage plant or ice plant or air-conditioning plant
Assignment on humidification and dehumidification, heating and cooling, mixing of two air streams
Steady state Simulation of VCR system with developed code or any analytical software

Term work
Term work shall consists of minimum Three Laboratory Experiments, at least one demonstration exercise, Industrial Visit Report, at least one assignment consisting of numerical based on Refrigeration and Air Conditioning and one simulation exercise on VCR

The distribution of marks for term work shall be as follows:
Part a: 15 marks.
Part b: 05 marks.
Attendance: 05 Marks.

End Semester Practical/Oral examination:
1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Practical examination (in a group of not more than 5 students) duration is 2 hours
3. Distribution of marks for practical/viva examination shall be as follows:
   a. Practical performance …..15 marks
   b. Oral ….. …………………10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination
Objectives
1. To study sensors and actuators
2. To study control systems
3. To study automation

Outcomes: Learner will be able to…
1. Demonstrate implementation of interfacing sensors and actuators using microcontrollers
2. Demonstrate of interfacing various utilities with microcontrollers
3. Demonstrate discrete control system using PLC microcontroller
4. Design and develop a control system for specific use
5. Implement program to PLC system and demonstrate its application
6. Develop pneumatic circuits for a specific system

The laboratory experiments should be based on the following

**Group 1: Sensors & Actuators**
1. Theoretical & Experimental Implementation of Interfacing of Sensors using microcontroller and determination of sensor characteristics such as Static Characteristics (Sensitivity, Accuracy, Range, Resolution etc.), Dynamic Characteristics (Transient Response and Frequency Response)
2. Measurement and Calibration of Load / Force (*It is suggested to determine all characteristics of sensor mentioned in previous experiments*)
3. Measurement, Calibration and Comparison of Temperature Sensors (Thermocouple, RTD and Thermistor) (*It is suggested to determine all characteristics of sensor mentioned in previous experiments*)
4. Interfacing of Stepper Motor with microcontroller and its programming for Rotational or XY table (*It is suggested to program to vary the position of rotary or XY table and compare the positioning accuracy using standard calibrated angular or linear sensor*)
5. Interfacing of DC Motor with microcontroller and its programming for characterization of DC motor setup ( *It is suggested to program to vary the speed of DC motor and determine its load-speed characteristics *)
6. Interfacing of Water Heater with microcontroller and its programming for determination of its transient and steady state characteristics (*It is suggested to program to vary the input current to heater and determine its transient and steady state characteristics*)
**Group 2: Control Systems**

1. Experimental demonstration of Discrete control system using PLC microcontroller using standard PLC demo setup (Bottle filling Machine, Traffic Light Signal, Water heater and its stirring System etc.). *(here it is suggested to carry out ladder programing and demonstrate its operation)*

2. System Identification of Spring Mass Damper System for step input & harmonic input and determination of poles and zeros of system. *(Spring Mass Damper setup with all required position sensors mounted is to be characterized for step input, it is suggested to determine transfer function (i.e. input output relation) of the setup and plotting its transient and frequency response (Bode plot))*

3. Design & Experimental Implementation of PID control strategy for Spring Mass Damper Setup to control precisely position of mass. *(it is suggested to conduct experimental study on effect of variation of controller parameters on its transient characteristics also to study the changes in poles and zeros of system).*

4. Design & Experimental Implementation of PID control strategy for DC motor speed control under varying loading conditions and effect of variation of load is to be studied.

5. Design & Experimental implementation of PID control strategy for Real Time Temperature Control of furnace *(it is suggested to conduct experimental study on effect of variation of controller parameters on its transient characteristics also to study the changes in poles and zeros of system).*

6. Modeling and design of control system for quarter car suspension model using any suitable modeling and analysis software.

**Group 3: Automation**

1. Real time Logic implementation for traffic Control demo setup and it is necessary to carry out ladder programming and implement program to PLC system and demonstrate its operations

2. IOT: Real time interfacing of sensors (temperature, humidity, position, level etc.) and actuator (stepper motor, dc motor, servo motor etc.) with microcontroller and Ethernet shield and controlling the actuator and monitoring of sensor output remotely using internet.

3. Robotics: Real Time demonstration of line following robot using standard robotic kit

4. Demonstration and study of functions of components of robotics arm.

5. Visualization of DH parameters in Roboanalyzer. *(Roboanalyzer is free software developed by IIT Delhi, available on www.roboanalyzer.com)*

6. Designing sequential operation for two cylinders using electro-hydraulic circuits

7. Designing sequential operation for two cylinders using electro-pneumatic circuits

8. Development of pneumatic circuits to understand pneumatic components and their working
**Term work**

Term work shall consists of minimum Nine Experiments, Three from each group mentioned above.

The distribution of marks for term work shall be as follows:

- Laboratory Work: 20 marks.
- Attendance: 05 Marks.

**End Semester Practical/Oral examination:**

1. Pair of Internal and External Examiner should conduct practical/oral based on contents.
2. Practical examination (in a group of not more than 4 students) duration is 2 hours.
3. Distribution of marks for practical/Oral examination shall be as follows:
   - a. Practical performance ……15 marks
   - b. Oral ……. 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination.
Objective:

1. To acquaint with functional and strength design principles of important machine elements
2. To familiarise selection of standard elements such as rolling element bearings, belts etc.

Outcomes: Learner will be able to...

1. Select appropriate gears for power transmission on the basis of given load and speed
2. Design gears based on the given conditions.
3. Select bearings for a given applications from the manufacturers catalogue.
4. Select and/or design belts and flywheel for given applications
5. Design cam and follower mechanisms.
6. Design clutches and brakes

Module | Details | Hrs.
--- | --- | ---
01 | Design of Gears:  
1.1 Gears: Design of spur, helical, bevel and worm gears with strength, wear and thermal considerations  
1.2 Gear Box: Two stage Gear box with fixed ratio consisting of spur, helical and bevel gear pairs: gear box housing layout and housing design | 14
02 | 2.1 Rolling Contact Bearings: Types of bearing and designation, selection of rolling contact bearings based on constant / variable load & speed conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, self-aligning bearing and thrust bearing) | 05
03 | 1.1 Sliding Contact Bearings: Design of hydro dynamically lubricated bearings (self-contained), Introduction to hydro static bearings, Types and selection of Mechanical seals | 05
04 | 4.1 Design of Cams and Followers: Design of Cam and Roller follower mechanisms with spring and shaft | 06
05 | 5.1 Design and selection of Belts: Flat and V-belts with pulley construction  
5.2 Design of Flywheel – Introduction, Fluctuation of energy and speed, turning moment diagram, estimating inertia of flywheel for reciprocating prime movers and machines, Weight of the flywheel, flywheel for punches, rim constructions, stresses in rims and arms, Construction of flywheel  
5.3 Design and selection of standard roller chains | 10
06 | 6.1 Design of Clutches: Introduction, types, Basic theory of plate and cone type clutches, Design of single plate, multi-plate and cone clutches, with spring, lever design and thermal, wear considerations.  
6.2 Design of Brakes: Design of single shoe brake | 08

Assessment:

Internal Assessment for 20 marks:  
Consisting Two Compulsory Class Tests  
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References:

2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
5. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
6. Recommended Data Books - PSG
7. Machine Design by Reshetov, Mir Publication
11. Design of Machine Elements by V.M.Faires
12. Design of Machine Elements by Spotts
Course Code | Course/Subject Name | Credits
-------------|---------------------|-------
MEC702       | CAD/CAM/CAE         | 04    

Objectives
1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.
3. To develop New API for CAD

Outcomes: Learner will be able to…
1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects & store and manage data.
3. CAM Toolpath Creation and NC-G code output.
4. Use rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Computer Graphics and Techniques for Geometric Modeling</strong>&lt;br&gt;Computer Graphics: Two dimensional computer graphics, vector generation, the windowing transformation, Three dimensional Computer graphics, viewing transformation, Homogeneous coordinates, Perspective projection, Hidden line removal &amp; hidden surface removal algorithm, light &amp; shade ray tracing. The parametric representation of geometry, Bezier curves, Cubic Spline curve, B-Spline curve, parametric representation of line, circle, ellipse &amp; parabola. Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Feature recognition, Design by feature.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Transformation, Manipulation &amp; Data Storage</strong>&lt;br&gt;2D &amp; 3D Transformations (Translation, Rotation, &amp; Scaling &amp; Magnification), Concatenations, Matrix representation, Problems &amp; object oriented programming on Transformations. Object transformation, mirror transformation, Artificial Intelligence in Design &amp; Manufacturing, Representation of Knowledge, and Knowledge base Engineering.&lt;br&gt;<strong>Application Programming Interface (API)</strong>&lt;br&gt;Concept of customizing applications by writing programs, Fusion Object Model, Creating Scripts and Add-Ins, Document and assembly structure, Attributes, Creating Programs for Assemblies, Joint, B-Rep &amp; Geometry.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Design to Manufacturing (CAM)</strong>&lt;br&gt;2D Machining Strategies, 3D Machining Strategies, Fixture Component Terminology, Work Coordinate System Terminology, Create setups, Apply 2D operations, Facing, 2D adaptive clearing, 2D contour. Chamfer milling, Bore ,Tool simulation and stock material removal , Produce setup sheets , Product NC code via post processing.</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td><strong>Computer Aided Engineering (CAE)</strong>&lt;br&gt;Fundamentals of computer aided engineering, CAE includes mass property calculations, kinematic analysis and animation (movement, visualization, simulation and FEA). Case study based on modeling and analysis of structural, thermal/fluid, and dynamic (vibration analysis) system. Parameter optimization.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Computer Integrated Manufacturing &amp; Technology Driven Practices</strong>&lt;br&gt;Introduction, Evolution, Objectives, CIM Hardware and Software, CIM Benefits, Nature and role of the elements of CIM, Identifying CIM needs, Data base requirements of CIM, Role of CAD/CAM in CIM, Obstacles to Computer Integrated Manufacturing, Concept of the future CIM systems, Socio -techno- economic aspects of CIM.</td>
<td>08</td>
</tr>
</tbody>
</table>
Rapid Prototyping and Tooling

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References:
4. “CAD/CAM Principles, Practice and Manufacturing Management” by Chris McMahon, Jimmie Browne, Pearson Education
5. “CAD/CAM/CIM” by P. Radhakrishan, S. Subramanyan, V. Raju, New Age International Publishers
8. David L. Goetsch, Fundamental of CIM technology ,Delmar publication


18. “Rapid Prototyping” Chee Kai ChuaWorld Scientific Publishing


### Course Code: MEC703  
### Course/Subject Name: Production Planning and Control  
### Credits: 4

#### Objectives:
1. To provide an exposure to Production Planning & Control (PPC) and its significance in Manufacturing Industries
2. To give insight into the ongoing & futuristic trends in the control of inventory
3. To appraise about need and benefits of planning functions related to products and processes
4. To give exposure to production scheduling and sequencing so as to optimise resources

#### Outcomes: Learner will be able to…
1. Illustrate production planning functions and manage manufacturing functions in a better way
2. Develop competency in scheduling and sequencing of manufacturing operations
3. Forecast the demand of the product and prepare an aggregate plan
4. Develop the skills of Inventory Management and cost effectiveness
5. Create a logical approach to Line Balancing in various production systems
6. Implement techniques of manufacturing planning and control

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1      | Concepts of PPC:  
          1.1. Manufacturing systems- components and types, need for PPC, functions of PPC, relationship of PPC with other functions  
          1.2. Factors influencing PPC in the organization, manufacturing methods- projects & jobbing products, batch, mass / flow production, continuous / process production.  
          1.3. Organization of PPC- status of PPC department, internal structure, degree of centralization, PPC as an integrated approach  
          1.4. Prerequisites of PPC – data pertaining to design, equipment, raw materials, tooling, performance standards, labour and operating systems | 06 |
| 2      | Forecasting, Aggregate planning, Capacity planning  
          2.1. Forecasting: Need for forecasting, role of forecasting in PPC, forecasting methods of qualitative type like judgment techniques. Forecasting methods of quantitative types like time series analysis, least square method, moving average method, exponential smoothing method. Forecasting Errors and Forecasting Bias  
          2.2. Aggregate planning : Concept of aggregate planning, decision rules, strategies and methods  
          2.3. Capacity Planning: Measurement of capacity, Measures of capacity, Factors influencing effective capacity, short range, medium range and long range capacity planning, Rough cut capacity planning. | 08 |
| 3      | Inventory Control:  
          3.1. Basic concepts of inventory, Types of inventory, purpose of holding stock and influence of demand on inventory, Costs associated with Inventory management.  
          3.2. Inventory Models: Deterministic models - instantaneous stock replenishment model, Production model, planned shortages and price discount model, Probabilistic models-fixed quantity system(Q-system) and Fixed period system (p-system)  
          3.3. Selective Inventory Control techniques - ABC analysis, HML analysis and VED analysis | 08 |
| 4      | Process Planning and Line Balancing  
          4.1 Process planning: Prerequisite information requirement, steps in process planning, process planning in different situations, documents in process planning, machine / process selection & Computer Aided Process Planning  
          4.2 Line Balancing: objectives, constraints, terminology in assembly line, heuristic methods like Kilbridge-Wester, Largest Candidate rule, Rank positional weight | 08 |
| 5      | Production Scheduling and Sequencing  
          5.1 Scheduling: Inputs for scheduling, loading and scheduling devices, factors influencing scheduling, scheduling techniques, use of Gantt Charts and basic scheduling problems. | 10 |
Project scheduling by using elements of network analysis – PERT & CPM, cost analysis & crashing, resource leveling

5.2 Sequencing: Product sequencing, dispatching, progress report & expediting and control. Johnson’s Rule for optimal sequence of N jobs on 2 machine. Process n Jobs on 3 Machines (n/3 problem) and Jackson Algorithm. Processing of 2 Jobs on m Machine (2/m) problem

MRP, MRP II, ERP

6.1. Material Requirement planning(MRP) and Manufacturing Resource Planning (MRP-II) - general concepts, types of demands, Inputs to MRP, MRP objectives, outputs of MRP, Estimation of planned order releases. Benefits and Limitations of MRP II

6.2. Enterprise Resource Planning (ERP): Evolution, features, purpose of modeling an enterprise, information mapping, generic model of ERP, Modules in ERP, Methodology of implementation, critical success factors of ERP, Case studies of success and failure of ERP implementations, ERP packages

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References

1. Production Planning and Control – Samuel Eilon.
2. Production Planning and Control – L C Jamb
3. Production Planning and Control, W. Bolton-Longman Scientific & Technical
4. Production Systems- Planning, Analysis& Control, James. L. Riggs-John Wiley &Sons
7. Production and Operations Management, S.N.Chary- TMH publishing company
Objectives:
1. To study basic concepts of vibration analysis
2. To acquaint with the principles of vibration measuring instruments
3. To acquaint with the practices of monitoring health conditions of the systems

Outcomes: Learner will be able to…
1. Develop mathematical model to represent dynamic system.
2. Estimate natural frequency of mechanical element / system.
3. Analyse vibratory response of mechanical element / system.
4. Estimate the parameters of vibration isolation system and
5. Control the vibrations to the acceptable level using basic vibration principles
6. Handle the vibration measuring instruments

Module | Details | Hrs.
--- | --- | ---
1 | **1.1 Basic Concepts of Vibration:** Introduction, classification, terminology, modelling vibration analysis  
**1.2 Free Undamped Single Degree of Freedom Vibration System:** Longitudinal, transverse, torsional, vibration system, methods for formulation of differential equations by D’Alembert’s Principle, Newton, Energy, Lagrangian and Rayleigh's method | 08
2 | **Multi Degree of Freedom System:**  
**2.1 Undamped free vibration:** Free vibration equation of motion, Influence coefficients (stiffness and flexibility), Reciprocity theorem, Generalized Coordinates, and Coordinate Coupling, Lagrangian equations, Rayleigh and Dunkerley method, two rotor and geared systems  
**2.2 Eigen Values and Eigen vectors:** for translatory and torsional two d.o.f. systems, Matrix method, Holzer’s method (translatory and torsional unbranched systems) | 10
3 | **Free Damped Single Degree of Freedom Vibration System:** Types of dampers, Viscous damped system- translatory and rotary systems, Coulomb's damping- final rest position of body in coulomb damping, motion with negative damping factor. | 06
4 | **4.1 Forced Single Degree of Freedom Vibratory System:** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation  
**4.2 Vibration Isolation and Control:** Conventional Methods: By mass /Inertia, stiffness, damping (vibration isolation principles ) Force Transmissibility, motion transmissibility, typical isolators & mounts. Introduction to Semi-Active and Active Vibration control. | 10
5 | **5.1 Vibration Measuring Instruments:** Principle of seismic instruments, vibrometer, accelerometer- undamped, damped  
**5.2 Introduction to Conditioning Monitoring and Fault Diagnosis:** Introduction to conditioning monitoring and fault diagnosis, Condition & Vibration Monitoring Techniques, Condition / vibration monitoring data collection. Signature analysis | 07
6 | **Non-Linear Vibration:** Basics of Non-linear vibration, systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase –plane technique, Duffing’s equation, Jump phenomenon, Limit Cycle, Perturbation method. | 07

Assessment:

Internal Assessment for 20 marks:  
Consisting **Two Compulsory Class Tests**  
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture
hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1 will be compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then
   part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

References:
1. Mechanical Vibrations by S.S.Rao, fourth edition, Pearson Education
2. Mechanical Vibrations by G. K. Grover
7. Mechanical Vibrations by Den, Chambil, Hinckle
15. Vibrations by Balakumar Balachandran, Edward Magrab, Cengagae Learning
### Objectives:
1. To impart the understanding of important mechanical systems of an automobile
2. To provide insight into the electrical systems of an automobile
3. To familiarize with the latest technological developments in automotive technology

### Outcomes:
Learner will be able to...
1. Illustrate the types and working of clutch and transmission system.
2. Demonstrate the working of different types of final drives, steering gears and braking systems
3. Illustrate the constructional features of wheels, tyres and suspension systems
4. Demonstrate the understanding of types of storage, charging and starting systems
5. Identify the type of body and chassis of an automobile
6. Comprehend the different technological advances in automobile

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clutch : Requirements of Clutches, Types of Clutches; Single Plate, Multi-plate, Wet Clutch, Semi-centrifugal, Centrifugal. Clutch materials. Clutch operating mechanisms; Mechanical, Electric, Hydraulic and Vacuum. Free Pedal Play. Transmission: Necessity of gear box. Sliding mesh, Constant mesh, and Synchronmesh Gear selector mechanisms. Overdrives and hydrodynamic torque converter, Trouble shooting and remedies. Propeller Shaft and Axle: Propeller shafts and universal joints: Types and construction, Different types of universal joints and constant velocity joints Types of live axles; semi, three quarter and full floating axles Types of Front Stub Axles; Elliot, Reverse Elliot, Lamoine and Reverse Lamoine</td>
<td>09</td>
</tr>
<tr>
<td>3</td>
<td>Suspension System Objects of suspension, Basic requirements, Sprung and un-sprung mass, Types of Independent and rigid axle suspension. Air suspension and its features. Pitching, rolling and bouncing. Shock absorbers and its types Wheels and Tyres: Requirements of wheels and tyres. Types of wheels, types of tyres and types of carcass</td>
<td>07</td>
</tr>
<tr>
<td>4</td>
<td>Automotive Electrical System : Storage System: Lead-Acid Battery; construction, working, ratings, types of charging methods, Alkaline, ZEBRA, Sodium Sulphur and Swing batteries Charging System:</td>
<td>06</td>
</tr>
</tbody>
</table>
Alternator: Principle of operation, Construction, Working. Rectification from AC to DC

**Starting system:**
Requirements, Various torque terms used, Starter motor drives; Bendix, Rubber compression, Compression Spring, Overrunning Clutch.
Starter motor solenoids and switches

**Body Engineering:**
Importance of Body design, Materials for body construction-Styling forms-Coach and bus body style, layouts of passenger cars, Bus and truck bodies.
Chassis types and structure types: Open, Semi integral and integral bus structure
Frames: functions and types of frames, Loads on frames, Load distribution of structure, Location of power plant

**Recent trends in Automobiles:**
**Intelligent Vehicle Systems:**
Cruise Control, Adaptive Cruise Control (ACC), Electronic Stability Program (ESP), Electronic Brake Distribution (EBD), Traction Control System (TCS). Integrated Starter Alternator (ISA)

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**Assessment:**

**Internal Assessment for 20 marks:**

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**End Semester Examination:**

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4. Only **Four questions need to be solved**

**Reference Books:**

1. Automobile Engineering, Kirpal Singh, Vol I & II, Standard publishers Distributors, Delhi
2. The Automobile by Harbans Singh Reyat
3. The Automobile Engineering by T.R. Banga and Nathu Singh
4. Automotive Engineering Fundamentals by Richard Stone, Jeffrey K. Ball, SAE International
5. Vehicle body engineering by J Powlowski
10. Automotive Mechanics by Joseph Heitner
11. Automobile Electrical and Electronics by Tom Denton
12. Automotive Electrical Equipment by P. L. Kohli
13. Computerised Engine Control by Dick H. King
Objectives
1. To study of Different types of Pumps, Compressors & Fans
2. To familiarise design aspects of Pumps, Compressors & Fans

Outcomes: Learner will be able to…
1. Select suitable Pump
2. Design a reciprocating pump and analyse its performance
3. Design a centrifugal pump and analyse its performance
4. Demonstrate basic principles of fans and blowers
5. Design fan/blower and analyse its performance
6. Design a compressor and analyse its performance

<table>
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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Fluid Machinery:</strong> Introduction to pumps, Introduction to blowers and compressors, Basic equations of energy transfer between fluid and rotor, Performance characteristics, Dimensionless parameters, Specific speed, stage velocity triangles, work and efficiency.</td>
<td>04</td>
</tr>
<tr>
<td>02</td>
<td><strong>Reciprocating Pumps and Centrifugal Pumps:</strong> Introduction: Types, Component and Working of Reciprocating pump and Centrifugal Pumps, Discharge, Work done and power required to drive for single acting and double acting, Coefficient of discharge, slip, Effect of acceleration of piston on velocity and pressure, indicator diagram, Air Vessel, Operating characteristics.</td>
<td>06</td>
</tr>
<tr>
<td>03</td>
<td><strong>Design &amp; Analysis of Pumps:</strong> Design procedure and design optimization of Pumps, selection of pumps, Thermal design- Selection of materials for high temperature and corrosive fluids, Hydraulic design- Selection of impeller and casing dimension using industrial manuals</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td><strong>Introduction to Fans, Blowers and Compressors:</strong> Classification of blowers, Basics of stationary and moving air, Eulers characteristics, velocity triangles and operating pressure conditions, Equations for blowers, Losses and hydraulic efficiency, flow through impeller casing, inlet nozzle, Volute, diffusers, leakage, mechanical losses, surge and stall, Applications of blowers and fans <strong>Compressors:</strong> Basic theory, classification and application, Working with enthalpy-entropy diagram</td>
<td>06</td>
</tr>
<tr>
<td>05</td>
<td><strong>Design and Analysis of Fans and Blowers:</strong> Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, Design procedure for selection and optimization of Blowers. Stage pressure rise, stage parameters and design parameters, Design of impeller and casing dimension in aerodynamic design</td>
<td>06</td>
</tr>
<tr>
<td>06</td>
<td><strong>Design &amp; Analysis of Compressors:</strong> Construction and approximate calculation of centrifugal compressors, impeller flow losses, slip factor, diffuser analysis, performance curves of centrifugal compressors, Basic design features of axial flow compressors; velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, work done factor, simple stage of axial flow compressors</td>
<td>06</td>
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4. Only **Four questions need to be solved**.

Reference Books:

1. Principles of Turbo machinery by Shepherd, D.G., Macmillan
2. Centrifugal Pump Design by John Tuzson, John Wiley
4. Centrifugal pumps and blowers by Austin H. Chruch, John Wiley and Sons
5. Centrifugal Pumps Design and Applications by Val S.Labanoff and Robert Ross, Jaico P House
7. Pumps by G.K.Sahu, New age international
11. Steam and Gas Turbine by R. Yadav, Central Publishing House, Allahabad
Objectives:
1. To study basic principles of Computational Fluid Dynamics
2. To study grid generation and discretization methods

Outcomes: Learner will be able to…
1. Demonstrate methodology to work with CFD
2. Illustrate principles of grid generation and discretization methods
3. Identify and apply specific boundary conditions relevant to specific application
4. Decide solution parameters relevant to specific application
5. Analyze the results and draw the appropriate inferences
6. Demonstrate basic principles of FVM

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<tr>
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<tr>
<td>01</td>
<td><strong>Introduction:</strong> What is CFD, Scope and Application of CFD, Methods of Predictions like Experimental and theoretical, Working of Commercial CFD Software, Solution methodology-Preprocessing, Solver, Post processing.</td>
<td>04</td>
</tr>
<tr>
<td>04</td>
<td><strong>Heat Conduction, Convection and Diffusion:</strong> Steady One-dimensional Conduction, Unsteady One-dimensional Conduction, Two and Three-dimensional Situations, Over relaxation and Under relaxation, Steady One-dimensional and Two Dimensional Convection-Diffusion, Unsteady One-dimensional Convection.</td>
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</tr>
<tr>
<td>06</td>
<td><strong>Finite Volume Methods:</strong> FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems, FVM solutions to convection-diffusion problems - one and two dimensional, steady and unsteady; Advection schemes; Pressure velocity coupling</td>
<td></td>
</tr>
</tbody>
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4. Only **Four questions need to be solved**.

References:

3. Introduction to Computational Fluid Dynamics, Niyogi P. ,Laha M.K., Chakrabarty S.K., Pearson Education, India
10. Anderson, J.D. Computational Fluid Dynamics, McGraw Hill
### Course Code | Course Name | Credits
--- | --- | ---
ILO 7011 | Product Life Cycle Management | 03

#### Objectives:
1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

#### Outcomes:
Learner will be able to…
1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
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</thead>
</table>
| 01 | **Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications  
**PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM | 10 |
| 03 | **Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation | 05 |
| 04 | **Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies | 05 |
| 05 | **Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life | 05 |

06

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4. Only Four questions need to be solved.

REFERENCES:

## Objectives:
1. To familiarize the students with various aspects of probability theory
2. To acquaint the students with reliability and its concepts
3. To introduce the students to methods of estimating the system reliability of simple and complex systems
4. To understand the various aspects of Maintainability, Availability and FMEA procedure

## Outcomes:
Learner will be able to…
1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

<table>
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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Probability theory:</strong> Probability: Standard definitions and concepts; Conditional Probability, Baye’s Theorem. <strong>Probability Distributions:</strong> Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. <strong>Measures of Dispersion:</strong> Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Reliability Concepts:</strong> Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. <strong>Failure Data Analysis:</strong> Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. <strong>Reliability Hazard Models:</strong> Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>System Reliability:</strong> System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td><strong>Reliability Improvement:</strong> Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Maintainability and Availability:</strong> System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td><strong>Failure Mode, Effects and Criticality Analysis:</strong> Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, FailIt tree analysis and Event tree Analysis</td>
<td>05</td>
</tr>
</tbody>
</table>

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REFERENCES:

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<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ILO 7013</td>
<td>Management Information System</td>
<td>03</td>
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</table>

**Objectives:**
1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today’s business and define various technology architectures on which information systems are built.
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage.
4. Identify the basic steps in systems development.

**Outcomes:** Learner will be able to…
1. Explain how information systems Transform Business.
2. Identify the impact information systems have on an organization.
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making.
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses.

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<th>Module</th>
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<tr>
<td>01</td>
<td>Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS</td>
<td>4</td>
</tr>
<tr>
<td>02</td>
<td>Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results</td>
<td>7</td>
</tr>
<tr>
<td>03</td>
<td>Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls</td>
<td>7</td>
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<tr>
<td>05</td>
<td>Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.</td>
<td>6</td>
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</table>

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4. Only Four questions need to be solved.

REFERENCES:

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
Objectives:
1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to…
1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

<table>
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<tr>
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<td>Introduction</td>
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<td>1.1 Strategy of Experimentation</td>
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<td>1.2 Typical Applications of Experimental Design</td>
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<td>1.3 Guidelines for Designing Experiments</td>
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<td>1.4 Response Surface Methodology</td>
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<tr>
<td>02</td>
<td>Fitting Regression Models</td>
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<td>2.1 Linear Regression Models</td>
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<td>2.2 Estimation of the Parameters in Linear Regression Models</td>
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<td>2.3 Hypothesis Testing in Multiple Regression</td>
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<td>2.4 Confidence Intervals in Multiple Regression</td>
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<td>2.5 Prediction of new response observation</td>
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<td>2.6 Regression model diagnostics</td>
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<td>2.7 Testing for lack of fit</td>
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<td>03</td>
<td>Two-Level Factorial Designs</td>
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<tr>
<td></td>
<td>3.1 The $2^2$ Design</td>
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<td>3.2 The $2^3$ Design</td>
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<td>3.3 The General $2^k$ Design</td>
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<td>3.4 A Single Replicate of the $2^k$ Design</td>
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<td>3.5 The Addition of Center Points to the $2^k$ Design,</td>
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<td>3.6 Blocking in the $2^k$ Factorial Design</td>
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<td>3.7 Split-Plot Designs</td>
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<td>04</td>
<td>Two-Level Fractional Factorial Designs</td>
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<td>4.1 The One-Half Fraction of the $2^k$ Design</td>
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<td>4.2 The One-Quarter Fraction of the $2^k$ Design</td>
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<td></td>
<td>4.3 The General $2^{k-p}$ Fractional Factorial Design</td>
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<td>4.4 Resolution III Designs</td>
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<td>4.5 Resolution IV and V Designs</td>
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<td>4.6 Fractional Factorial Split-Plot Designs</td>
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<td>05</td>
<td>Response Surface Methods and Designs</td>
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<tr>
<td></td>
<td>5.1 Introduction to Response Surface Methodology</td>
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<td>5.2 The Method of Steepest Ascent</td>
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<td>5.3 Analysis of a Second-Order Response Surface</td>
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<td></td>
<td>5.4 Experimental Designs for Fitting Response Surfaces</td>
<td></td>
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REFERENCES:

5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T. Voss
**Course Code**: ILO 7015  
**Course Name**: Operations Research  
**Credits**: 03

### Objectives:
1. Formulate a real-world problem as a mathematical programming model.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Use mathematical software to solve the proposed models.

### Outcomes:
Learner will be able to…
1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model’s optimal solution as the data change.
3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
4. Understand the applications of integer programming and a queuing model and compute important performance measures.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 01     | **Introduction to Operations Research**: Introduction, Structure of the Mathematical Model, Limitations of Operations Research  
**Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis  
**Assignment Problem**: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem  
**Integer Programming Problem**: Introduction, Types of Integer Programming Problems, Gomory’s cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms. | 14 |
| 02     | **Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population | 05 |
| 03     | **Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation | 05 |
| 04     | **Dynamic programming**: Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems. | 05 |
05 **Game Theory.** Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.

06 **Inventory Models:** Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model.

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1 will be compulsory and should cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved.**

**REFERENCES:**

5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons
Objectives:
1. To understand and identify different types of cybercrime and cyber law
2. To recognize Indian IT Act 2008 and its latest amendments
3. To learn various types of security standards compliances

Outcomes: Learner will be able to…
1. Understand the concept of cybercrime and its effect on outside world
2. Interpret and apply IT law in various legal issues
3. Distinguish different aspects of cyber law
4. Apply Information Security Standards compliance during software design and development

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Cybercrime:</strong> Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.</td>
<td>4</td>
</tr>
<tr>
<td>03</td>
<td><strong>Tools and Methods Used in Cyberline</strong> Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)</td>
<td>6</td>
</tr>
<tr>
<td>05</td>
<td><strong>Indian IT Act.</strong> Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments</td>
<td>6</td>
</tr>
<tr>
<td>06</td>
<td><strong>Information Security Standard compliances</strong> SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.</td>
<td>6</td>
</tr>
</tbody>
</table>

Assessment:

**Internal Assessment for 20 marks:**
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. Question 1 will be **compulsory** and should **cover maximum contents of the curriculum**
3. Remaining questions will be **mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538
 course Code: ILO 7017  
Course Name: Disaster Management and Mitigation Measures  
Credits: 03

Objectives:

1. To understand physics and various types of disaster occurring around the world
2. To identify extent and damaging capacity of a disaster
3. To study and understand the means of losses and methods to overcome /minimize it.
4. To understand role of individual and various organization during and after disaster
5. To understand application of GIS in the field of disaster management
6. To understand the emergency government response structures before, during and after disaster

Outcomes: Learner will be able to…

1. Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
2. Plan of national importance structures based upon the previous history.
3. Get acquainted with government policies, acts and various organizational structure associated with an emergency.
4. Get to know the simple do’s and don’ts in such extreme events and act accordingly.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.1 Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.</td>
<td>03</td>
</tr>
<tr>
<td>02</td>
<td>Natural Disaster and Manmade disasters:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1 Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion</td>
<td>09</td>
</tr>
<tr>
<td></td>
<td>2.2 Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Disaster Management, Policy and Administration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1 Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management.</td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>3.2 Policy and administration: Importance and principles of disaster management policies, command and coordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Institutional Framework for Disaster Management in India:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.1 Importance of public awareness, Preparation and execution of emergency management program. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations.</td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Financing Relief Measures:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.1 Ways to raise finance for relief expenditure, role of government agencies and NGO’s in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO’s and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams.</td>
<td>09</td>
</tr>
</tbody>
</table>
5.2 International relief aid agencies and their role in extreme events.

**Preventive and Mitigation Measures:**
6.1 Pre-disaster, during disaster and post-disaster measures in some events in general
6.2 Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication
6.3 Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans.
6.4 Do’s and don’ts in case of disasters and effective implementation of relief aids.

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

**REFERENCES:**

5. ‘Disaster management & rehabilitation’ by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6. ‘Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications. (Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)
Objectives:

1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management.
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to...

1. To identify and describe present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities.
5. To analyze the data collected during performance evaluation and recommend energy saving measures.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td><strong>Energy Audit Principles:</strong> Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring &amp; targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Energy Management and Energy Conservation in Electrical System:</strong> Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. <strong>Energy efficiency measures in lighting system, Lighting control:</strong> Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td><strong>Energy Management and Energy Conservation in Thermal Systems:</strong> Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.</td>
<td>10</td>
</tr>
</tbody>
</table>
### Assessment:

**Internal Assessment for 20 marks:**
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**End Semester Examination:**
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4. Only **Four questions need to be solved**.

### REFERENCES:

1. Handbook of Electrical Installation Practice, Geoffry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
8. www.energymanagertraining.com
9. www.bee-india.nic.in
Objectives:

1. To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural Development
2. To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
3. An exploration of human values, which go into making a ‘good’ human being, a ‘good’ professional, a ‘good’ society and a ‘good life’ in the context of work life and the personal life of modern Indian professionals
4. To understand the Nature and Type of Human Values relevant to Planning Institutions

Outcomes: Learner will be able to…

1. Apply knowledge for Rural Development.
2. Apply knowledge for Management Issues.
3. Apply knowledge for Initiatives and Strategies
4. Develop acumen for higher education and research.
5. Master the art of working in group of different nature.
6. Develop confidence to take up rural project activities independently

<table>
<thead>
<tr>
<th>Module</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.</td>
<td>08</td>
</tr>
<tr>
<td>2</td>
<td>Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people’s participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.</td>
<td>04</td>
</tr>
<tr>
<td>3</td>
<td>Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.</td>
<td>06</td>
</tr>
<tr>
<td>4</td>
<td>Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.</td>
<td>04</td>
</tr>
<tr>
<td>5</td>
<td>Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education</td>
<td>04</td>
</tr>
</tbody>
</table>
Assessment:

Internal Assessment for 20 marks:
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
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3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

Reference
1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
Objectives:
1. To familiarise applications of strength design principles for various machine elements
2. To make conversant with preparation of working drawings

Outcomes: Learner will be able to…
1. Design gears based on the given conditions
2. Design gearbox for a given application
3. Design cam & followers for a given condition
4. Design clutches for a given application
5. Design brakes for given condition
6. Select bearings for a given applications from the manufacturers catalogue

Term Work: (Comprises a and b)

a) 1. **Term work** - Shall consist of design and detailed assembly drawing of minimum two design problems form the mentioned list (computer aided drawing on **A3 size sheets**):
   1. Design of Gears and gear box
   2. Design of cam and followers
   3. Design of clutches
   4. Design of brakes

2. **Course Project**: Students in a group of two to four will be able to design and prepare working drawings of any system having minimum 5 to 6 components by applying the knowledge gained during the course.

b) **Assignment**: Each assignment containing at least 2- numerical based on following topics. These design exercises should be in the form of design calculations with sketches and/ or drawings.
   1. Rolling contact bearings
   2. Sliding contact bearing
   3. Design of belt, chain and flywheel

The distribution of marks for term work shall be as follows:
- Exercises & Drawing sheets: 15 Marks
- Course Project: 05 Marks
- Attendance: 05 Marks

End Semester Practical/Oral examination:
1. Each student will be given a small task of design, based on syllabus, which will be assessed by pair of examiners during the oral examination.
2. Distribution of marks for practical-oral examination shall be as follows:
   - Design Task: 15 marks
   - Oral: 10 marks
3. Evaluation of practical/oral examination to be done based on the performance of design task.
4. Students work along with evaluation report to be preserved till the next examination
Objectives
1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.
3. To develop New API for CAD

Outcomes: Learner will be able to...
1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects as well as store and manage data.
3. Create CAM Toolpath and prepare NC- G code
4. Apply rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

List of Exercises
1. Programming for transformations,
2. API on Creating As built joints, Slider Joint Motion
3. Get the physical Properties API
4. Get the circle and arc data from the edge
5. Sketch spline through points creation : API
6. Solid modeling using any 3D modeling software
7. Part programming and part fabrication on CNC trainer (Turning / Milling)
8. Geometrical optimization of any mechanical component using computer aided engineering concepts. (Shape optimization)
9. Development of physical 3D mechanical structure using any one of the rapid prototyping processes.

Term Work
Term work shall consist of
a. Any four exercises from 1 to 6 of above list
b. Part programming and part fabrication on CNC trainer
c. A course project in a group of not more than four students based on 8 and 9 of above list

The distribution of marks for term work shall be as follows:
- Exercises : 15 Marks
- Course Project : 05 Marks
- Attendance : 05 Marks

Assessment:

End Semester Practical/Oral Examination:
1. Each student will be given a small task of design based on syllabus, which will be assessed by pair of examiners during the oral examination.
2. Distribution of marks for practical-oral examination shall be as follows:
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4. Students work along with evaluation report to be preserved till the next examination
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<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEL703</td>
<td>Production Planning and Control</td>
<td>01</td>
</tr>
</tbody>
</table>

**Objectives:**
1. To provide an exposure related to Production Planning & Control (PPC)
2. To give exposure to production scheduling and sequencing

**Outcomes:** Learner will be able to…
1. Prepare a process sheet
2. Prepare a Gantt Chart
3. Forecast the demand of the product and prepare an aggregate plan.
4. Perform ABC analysis of a given problem
5. Develop the skills of Inventory Management and cost effectiveness.
6. Create a logical approach to Line Balancing for various production systems.

**Term Work**
The Term work shall comprise of the following:
At least six laboratory exercises/assignments comprising questions/problems

<table>
<thead>
<tr>
<th>Sr No</th>
<th>List of Laboratory Exercises (Any Six)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparation of a Process sheet of a simple turned/milled component</td>
</tr>
<tr>
<td>2</td>
<td>Numerical example on Johnson’s Algorithm</td>
</tr>
<tr>
<td>3</td>
<td>An example on network crashing</td>
</tr>
<tr>
<td>4</td>
<td>Preparation of a Gantt Chart</td>
</tr>
<tr>
<td>5</td>
<td>A real life example on ABC analysis</td>
</tr>
<tr>
<td>6</td>
<td>An example on MRP for planned released orders</td>
</tr>
<tr>
<td>7</td>
<td>An example on line balancing</td>
</tr>
<tr>
<td>8</td>
<td>Preparation of organization charts with functional relationship for any SME</td>
</tr>
</tbody>
</table>

**Project Based Learning may be incorporated by judiciously reducing number of laboratory exercises**

The distribution of marks for term work shall be as follows:
- Lab work/assignments/exercise : 20 marks
- Attendance : 05 marks

**Practical/Oral examination**
1. Each student will be given a small task based on laboratory exercises, which will be assessed by pair of examiners during the oral examination.
2. Distribution of marks for practical-oral examination shall be as follows:
   - Exercise: 15 marks
   - Oral: 10 marks
3. Evaluation of practical/oral examination to be done based on the performance of design task
4. Students work along with evaluation report to be preserved till the next examination
Objectives:
1. To familiarise with the concept of system and methodology of system design
2. To study system design of various systems such as snatch block, belt conveyors, engine system, pumps and machine tool gearbox

Outcomes: Learner will be able to…
1. Apply the concept of system design.
2. Design material handling systems such as hoisting mechanism of EOT crane,
3. Design belt conveyor systems
4. Design engine components such as cylinder, piston, connecting rod and crankshaft
5. Design pumps for the given applications
6. Prepare layout of machine tool gear box and select number of teeth on each gear

Module | Details | Hrs.
---|---|---
01 | Methodology & Morphology of design, Optimum design, system concepts in design. | 04
02 | Design of Hoisting mechanism: Design of Snatch Block Assembly including Rope Selection, Sheave, Hook, Bearing for hook, cross piece, Axle for sheave and shackle plate, Design of rope drum, selection motor with transmission system. | 10
03 | Design of belt Conveyors- Power requirement, selection of belt, design of tension take up unit, idler pulley | 06
04 | Engine Design (Petrol and Diesel): Design of cylinder, Piston with pin and rings, connecting rod & crank shaft with bearings | 10
05 | Design of Pump: 
5.1 Design of main components of gear pump. 
1. Motor selection 
2. Gear design 
3. Shaft design and bearing selection 
4. Casing and bolt design 
5. Suction and delivery pipe 
5.2 Design of main components of Centrifugal Pump: 
1. Motor selection 
2. Suction and Delivery pipe 
3. Design of Impeller, Impeller shaft 
4. Design of Volute Casing | 10
06 | Design of Gear Box: 
Design of gear boxes for machine tool applications(Maximum three stages and twelve speeds), Requirements of gear box, determination of variable speed range, graphical representation of speeds, structure diagram, ray diagram, selection of optimum ray diagram, estimation of numbers of teeth on gears, deviation diagram, layout of gear box. | 08

Assessment:
Internal Assessment for 20 marks:
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. **Only Four questions need to be solved.**

Use of standard design data books like PSG Data Book, Machine Design Data Book- design of engine parts by Khandare S.S and Kale A.V. are permitted at the examination and shall be supplied by the college.

References:
3. Mechanical design analysis by M F Spotts, Prentice Hall Inc
4. Design of Machine Elements, Bhandari VB, TMH
7. I S: 2825 Code for unfired pressure vessels
8. Mechanical Design Synthesis with Optimisation Applications by Johnson R C, Von Nostrand-Reynold Pub
11. Machine tool design by NK Mehta, TMH
13. Material Handling Equipment by Rudenko, M.I.R. publishers, Moscow
15. Material Handling Equipments by N. Rudenko, Peace Publication
16. Material Handling Equipments by Alexandrov, Mir Publication
17. Machine Design by Reshetov, Mir Publication
19. Design of Machine Elements by V. M. Faires
20. Pumps: Theory, Design and Applications by G K Sahu, New Age International
22. Design Data Book- Design of engine parts by Khandare S.S & Kale A.V
Course Code: MEC802
Course/Subject Name: Industrial Engineering and Management
Credits: 04

Objectives
1. To familiarise with concept of integration of various resources and the significance of optimizing them in manufacturing and allied Industries
2. To acquaint with various productivity enhancement techniques

Outcomes: Learner will be able to...
1. Illustrate the need for optimization of resources and its significance
2. Develop ability in integrating knowledge of design along with other aspects of value addition in the conceptualization and manufacturing stage of various products.
3. Demonstrate the concept of value analysis and its relevance.
4. Manage and implement different concepts involved in method study and understanding of work content in different situations.
5. Describe different aspects of work system design and facilities design pertinent to manufacturing industries.
6. Illustrate concepts of Agile manufacturing, Lean manufacturing and Flexible manufacturing

<table>
<thead>
<tr>
<th>Modules</th>
<th>Detailed contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction to Industrial Engineering: History and contribution, Industrial engineering approach, techniques of industrial engineering, objectives of industrial engineering, system approach to industrial engineering, definition and concept of productivity, productivity measurements, factors influencing productivity and productivity improvement techniques.</td>
<td>06</td>
</tr>
<tr>
<td>02</td>
<td>Value Engineering and Value Analysis: Distinction between value engineering &amp; value analysis and their Significance. Steps in value engineering &amp; analysis and Check lists.</td>
<td>05</td>
</tr>
<tr>
<td>03</td>
<td>Work study: Method study, micro-motion study and principles of motion economy, Work measurement: time study, work sampling, standard data, PMTS; MOST</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td>Work system design: Introduction to ergonomics and its scope in relation to work. Outline of discipline of anatomy, physiology and psychology, with respect to ergonomics building blocks such as anthropometry and biomechanics Job evaluation, merit rating, incentive schemes, wage administration and business process reengineering</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td>Facility Design: Facility location factors and evaluation of alternate locations; types of plant layout and their evaluation; computer aided layout design techniques; assembly line balancing; materials handling systems Concepts of Group Technology and cellular manufacturing</td>
<td>09</td>
</tr>
</tbody>
</table>

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

University of Mumbai, B. E. (Mechanical Engineering), Rev 2016 123
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture
hours mentioned in the curriculum.
1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then
   part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References

2. Ergonomics at Work, Murrell
3. Plant Layout and Material Handling, James M. Apple, John Wiley & Sons
4. Facility Layout and Location – An Analytical Approach, Richard L. Francis & John A. White,
   Prentice Hall
5. Production Planning and Control, Samuel Elion
6. Production and Operations Management, Joseph G. Monks
7. Quality planning and analysis, J M Juran, FM Gryana, TMH
8. Total Quality Management, D. H. Bester Field et al. prentice hall
9. TQM in new product manufacturing, HG Menon; TMH
10. Industrial Engineering and Management by Dr Ravi Shankar
### Course Code: MEC803  
**Course Name:** Power Engineering  
**Credits:** 4

#### Objectives
1. To study boilers, boiler mountings and accessories  
2. To study utilization of thermal and hydraulic energy  
3. To study gas turbine and its applications

#### Outcomes: Learner will be able to…
1. Compute heat interactions in combustion of reactive mixtures  
2. Differentiate boilers, boiler mountings and accessories  
3. Calculate boiler efficiency and assess boiler performance  
4. Demonstrate working cycles of gas turbines  
5. Draw velocity triangles of impulse/reaction turbines and calculate performance parameters/efficiency  
6. Demonstrate basic working of pumps

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 01     | **Combustion of Reactive Mixtures**  
Combustion reactions, Stoichiometric A/F ratio, Actual A/F ratio, Heat of combustion, Enthalpy of formation, First law of reactive system, Adiabatic flame temperature. | 04   |
| 02     | **Steam Generators**  
Fire tube and Water tube boiler, Low pressure and high pressure boilers, once through boiler, examples, and important features of HP boilers, Mountings and accessories, Equivalent evaporation of boilers, Boiler performance, Boiler efficiency  
**Steam Turbine:** Basic of steam turbine, Classification, compounding of turbine, Impulse turbine – velocity diagram, Condition for max efficiency  
Reaction turbine - velocity diagram, degree of reaction, Parson's turbine, Condition for maximum efficiency | 12   |
| 03     | **Gas Turbines**  
Applications of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat, and regeneration, Effect of operating variable on thermal efficiency and work ratio | 05   |
| 04     | **Jet Propulsion Engines**  
Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency, Afterburner, Introduction to Turbojet, Turbofan, Ram jet, Turboprop and Rocket engine | 05   |
| 05     | **Impact of Jets:** Impact of jet on flat and curved plates  
**Water Turbines:** Types of hydro turbines - impulse and reaction, definition of various turbine parameters like gross head, discharge, work done, input power, output power, efficiencies etc., Eulers' equation applied to a turbine, turbine velocities and velocity triangles, expression for work done.  
**Impulse Turbine:** Components of Pelton turbine, definition of design parameters like speed ratio, jet ratio, and estimation of various parameters like head, discharge, and efficiency etc., determination of number of buckets.  
**Reaction Turbines:** Types of reaction turbines - inward and outward flow, radial mixed and axial; elements of the turbine, estimation of various parameters | 12   |
| 06     | **Pumps**  
Classification of pumps - positive displacement and non - positive displacement  
Positive Displacement pumps: Types and applications, general features of rotary pumps, general feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram, use of air vessel.  
**Centrifugal Pumps** | 10   |

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Rev 2016
Types - radial flow, mixed flow and axial flow, Priming of pumps, components of the pump, Euler's equation and velocity triangles, correction factors for the head, design constant e.g., head constant, flow constant etc., self-priming pumps, series and parallel operation of pumps, system curve for branch network, determination of operating point, Cavitation in pumps, Determination of available and required NPSH

Assessment:

Internal Assessment for 20 marks:
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End Semester Examination:
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3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. Thermal Engineering, R K. Rajput, Laxmi Publication
2. Thermal Engineering, Kothandraman, Domkundwar, Khajuria, Arora, Dhanpatrai & Sons
3. Steam and gas turbine, R Yadav.
5. Fluid Mechanics and Hydraulic Machinery, Modi and Seth, Standard Book House
6. Hydraulic Machinery, Jagdish Lal
7. Hydraulic Machines, R K Rajput, S.Chand Publication
Objectives
1. Study basic working principles of different power plants
2. Study power plant economics

Outcomes: Learner will be able to…
1. Comprehend various equipment/systems utilized in power plants
2. Demonstrate site selection methodology, construction and operation of Hydro Electric Power Plants
3. Discuss working, site selection, advantages, disadvantages of steam power plants
4. Discuss operation of Combined Cycle Power Plants
5. Discuss types of reactors, waste disposal issues in nuclear power plants
6. Illustrate power plant economics

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
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<tbody>
<tr>
<td>01</td>
<td>Introduction: Energy resources and their availability, types of power plants, selection of the plants, review of basic thermodynamic cycles used in power plants</td>
<td>06</td>
</tr>
<tr>
<td>02</td>
<td>Hydro Electric Power Plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plants design, construction and operation of different components of hydro-electric power plants, site selection, comparison with other types of power plants</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td>Steam Power Plants: Flow sheet and working of modern-thermal power plants, super critical pressure steam stations, site selection, coal storage, preparation, coal handling systems, feeding and burning of pulverized fuel, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td>Combined Cycles: Constant pressure gas turbine power plants, Arrangements of combined plants (steam &amp; gas turbine power plants), re-powering systems with gas production from coal, using PFBC systems, with organic fluids, parameters affecting thermodynamic efficiency of combined cycles, Problems</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td>Nuclear Power Plants: Principles of nuclear energy, basic nuclear reactions, nuclear reactors-PWR, BWR, CANDU, Sodium graphite, fast breeder, homogeneous; gas cooled, Advantages and limitations, nuclear power station, waste disposal.</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td>Power Plant Economics: Load curve, different terms and definitions, cost of electrical energy, tariffs methods of electrical energy, performance &amp; operating characteristics of power plants- incremental rate theory, input-output curves, efficiency, heat rate, economic load sharing, Problems.</td>
<td>08</td>
</tr>
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</table>

Assessment:

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4. Only **Four questions need to be solved**

References

1. Power Plant Engineering, A K Raja, Amit Praksh Shrivastava, Manish Dwivedi, New Age International Publishers
6. A Course in Power Plant Engineering, Arora, Domkundwar, DhanpatRai & Co
7. Power Plant Engineering, P.C. Sharma, S.K. Kataria & Sons
8. Power Plant Engineering, G.R. Nagpal, Khanna Publishers
9. Power station Engineering and Economy by Bernhardt G.A. Skrotzki and William A. Vopat, TMH
10. Power Plant Engineering, Manoj Kumar Gupta, PHI Learning
11. Nuclear Power Plant Engineering, James Rust, Haralson Publishing Company
**Objectives**

1. To familiarise with importance of Rapid Prototyping in Product Development.
2. To acquaint with the Synergic Integration Technologies

**Outcomes:** Learner will be able to…

1. Select the feasible RP process
2. Select the feasible RP material
3. Gauge and Hybridize the ever-evolving Protoyping Technologies
4. Contribute towards the Product Development at the respective domain in the industry
5. Apply RP to build working prototypes
6. Demonstrate basics of virtual reality

<table>
<thead>
<tr>
<th>Module</th>
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<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>04</td>
<td>Rapid Tooling: Need for metallic tooling, approaches, RP Processes for Tooling, Silicon Rubber Molding, Epoxy Tooling, Spray Metal Tooling, Cast Kirksite Tooling, 3D KelTool, QuickCast.</td>
<td>05</td>
</tr>
<tr>
<td>05</td>
<td>Materials for Rapid Prototyping Systems: Nature of material, types of material; polymers, metals, ceramics and composites, liquid based materials; photo polymer development, solid based materials; powder based materials.</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td>Reverse Engineering: Introduction to Digitizing Methods; contact type and non-contact type, brief introduction to the types of medical imaging. Virtual reality: Definition, features of VR, Technologies used in VR, Introduction to Augmented reality.</td>
<td>04</td>
</tr>
</tbody>
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4. Only Four questions need to be solved

References:

1. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
3. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley
4. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley
6. Rapid Manufacturing by Pham D T and Dimov S S, Springer Verlog
Objectives:
1. To study working principles of various renewable energy sources and their utilities.
2. To study economics of harnessing energy from renewable energy sources

Outcomes: Learner will be able to…
1. Demonstrate need of different renewable energy sources
2. Discuss importance of renewable energy sources
3. Discuss various renewable energy sources in Indian context
4. Calculate and analyse utilization of solar and wind energy
5. Illustrate design of biogas plant
6. Demonstrate basics of hydrogen energy

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<tr>
<td>01</td>
<td><strong>Introduction to Energy Sources</strong>: Renewable and non-renewable energy sources, Need for Renewable Energy Sources, Energy Consumption as a measure of Nation's development; Strategy for meeting the future energy requirements, Global and National scenarios, Prospects of renewable energy sources, Present status and current installations, Introduction to Hybrid Energy Systems.</td>
<td>07</td>
</tr>
<tr>
<td>02</td>
<td><strong>Solar Energy</strong>: Merits and demerits, Solar radiation - beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solar radiation, local solar time, derived solar angles, sunrise, sunset and day length, Methods of Solar Radiation estimation. <strong>Solar Energy collection devices and Classification</strong>: Flat plate collectors, concentrating collectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating &amp; cooling of buildings, Solar Photovoltaic systems &amp; applications.</td>
<td>12</td>
</tr>
<tr>
<td>03</td>
<td><strong>Wind Energy</strong>: Principle of wind energy conversion; Basic components of wind energy conversion systems; wind mill components, various types and their constructional features; design considerations of horizontal and vertical axis wind machines: analysis of Aerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations.</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td><strong>Energy from Biomass</strong>: Biomass conversion technologies, Biogas generation plants, classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas.</td>
<td>06</td>
</tr>
<tr>
<td>05</td>
<td><strong>Geothermal Energy</strong>: Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India. <strong>Energy from the ocean</strong>: Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India. Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy.</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>Hydrogen Energy</strong>: Methods of Hydrogen production, Hydrogen Storage, Fuel Cells and Types of Fuel Cells.</td>
<td>05</td>
</tr>
</tbody>
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4. Only Four questions need to be solved

Reference Books:

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
5. Wind Power Technology, Joshua Earnest, PHI Learning, 2014
12. Magneto Hydrodynamics by Kuliovsky and Lyubimov, Addison
Objectives:
1. To familiarise principles of energy management and concept of energy management in utility systems
2. To study energy economics and auditing
3. To study electrical energy management, cogeneration and waste heat recovery.

Outcomes: Learner will be able to…
1. Demonstrate general aspects of energy management
2. Summarize and explain need for energy management, economics and auditing
3. Illustrate basics of energy economics and financial analysis techniques
4. Describe importance of thermal and electrical utilitie’s maintenance
5. Assess potential and summarise benefits of waste heat recovery and cogeneration
6. Illustrate waste heat recovery and cogeneration methods

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>General Aspects of Energy Management</strong>: Introduction to utility systems (Types)\n\nCurrent energy scenario: India and World, Current energy consumption pattern in global and Indian industry, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy and environment, Need of Renewable and energy efficiency, Energy Conservation Act</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Energy Auditing</strong>: Need of Energy Audit, Types of energy audit, Components of energy audit, Energy audit methodology, Instruments, equipment used in energy audit, Analysis and recommendations of energy audit - examples for different applications, Energy audit reporting, Energy audit software, Material &amp; Energy Balance</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Energy Economics</strong>: Costing of Utilities - Determination of cost of steam, natural gas, compressed air and electricity.\n\nFinancial Analysis Techniques - Simple payback, Time value of money, Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis</td>
<td>09</td>
</tr>
<tr>
<td>04</td>
<td><strong>Energy Efficiency in Thermal Utilities</strong>: Energy performance assessment and efficiency improvement of Boilers, Furnaces, Heat exchangers, Fans and blowers, pumps, Compressors and HVAC systems. Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Electrical Energy Management and Lighting</strong>: Distribution and transformer losses.\n\nElectrical motors - types, efficiency and selection. Speed control, Energy efficient motors.\n\nElectricity Act 2003.\n\n<strong>Lighting</strong> - Lamp types and their features, recommended illumination levels, lighting system energy efficiency.</td>
<td>07</td>
</tr>
<tr>
<td>06</td>
<td><strong>Cogeneration and Waste Heat Recovery</strong>: Cogeneration- Need, applications, advantages, classification, the cogeneration design process.\n\nWaste heat recovery- Classification and application, Potential for waste-heat recovery in Industry, Commercial WHR devices, saving potential. CDM projects and carbon credit calculations</td>
<td>08</td>
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4. Only Four questions need to be solved.

References:

1. Energy engineering and management, Amlan Chakrabarti, PHI Learning, New Delhi 2012
5. Energy Performance assessment for equipment and Utility Systems Vol. 1 to 4, Bureau of Energy Efficiency, Govt. of India
11. www.enrgymanagertraining.com
12. www.bee-india.nic.in
<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Project Management Foundation: Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical &amp; atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI)</td>
<td>5</td>
</tr>
<tr>
<td>02</td>
<td>Initiating Projects: How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development &amp; growth (forming, storming, norming &amp; performing), team dynamics</td>
<td>6</td>
</tr>
<tr>
<td>03</td>
<td>Project Planning and Scheduling: Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).</td>
<td>8</td>
</tr>
<tr>
<td>05</td>
<td>5.1 Executing Projects: Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings 5.2 Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit 5.3 Project Contracting Project procurement management, contracting and outsourcing,</td>
<td>8</td>
</tr>
<tr>
<td>06</td>
<td>6.1 Project Leadership and Ethics: Introduction to project leadership, ethics in projects, Multicultural and virtual projects 6.2 Closing the Project:</td>
<td>6</td>
</tr>
</tbody>
</table>

Objectives:
1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes: Learner will be able to…
1. Apply selection criteria and select an appropriate project from different options.
2. Write work breakdown structure for a project and develop a schedule based on it.
3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
4. Use Earned value technique and determine & predict status of the project.
5. Capture lessons learned during project phases and document them for future reference.
Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.

**Assessment:**

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4. Only Four questions need to be solved

**REFERENCES:**

1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India
3. Project Management, Gido Clements, Cengage Learning
4. Project Management, Gopalan, Wiley India
### Objectives:
1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

### Outcomes: Learner will be able to…
1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
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</table>
| 01     | **Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System.  
          **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.  
          **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market  
          **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges | 06 |
| 02     | **Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.  
          **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting. | 06 |
| 03     | **Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.  
          **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis. | 09 |
| 04     | **Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR)  
          **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity’s Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities. | 10 |
| 05     | **Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. | 05 |
**Capital Structure:** Factors Affecting an Entity’s Capital Structure; Overview of Capital Structure Theories and Approaches—Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure

**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity’s Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon’s Approach, Walter’s Approach, and Modigliani-Miller Approach

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<tr>
<th>Course Code</th>
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<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILO8023</td>
<td>Entrepreneurship Development and Management</td>
<td>03</td>
</tr>
</tbody>
</table>

**Objectives:**
1. To acquaint with entrepreneurship and management of business
2. Understand Indian environment for entrepreneurship
3. Idea of EDP, MSME

**Outcomes:** Learner will be able to…
1. Understand the concept of business plan and ownerships
2. Interpret key regulations and legal aspects of entrepreneurship in India
3. Understand government policies for entrepreneurs

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Overview Of Entrepreneurship:</strong> Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship</td>
<td>04</td>
</tr>
<tr>
<td>02</td>
<td><strong>Business Plans And Importance Of Capital To Entrepreneurship:</strong> Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur <strong>Entrepreneurship And Business Development:</strong> Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations</td>
<td>09</td>
</tr>
<tr>
<td>03</td>
<td>Women’s Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td><strong>Indian Environment for Entrepreneurship:</strong> key regulations and legal aspects, MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Effective Management of Business:</strong> Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>Achieving Success In The Small Business:</strong> Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business</td>
<td>05</td>
</tr>
</tbody>
</table>

**Assessment:**

**Internal Assessment for 20 marks:**
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

University of Mumbai,  B. E. (Mechanical Engineering),  Rev 2016
End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
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3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved.**

REFERENCES:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmsme.gov.in
13. www.msmetraining.gov.in
**Objectives:**
1. To introduce the students with basic concepts, techniques and practices of the human resource management
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today’s organizations
3. To familiarize the students about the latest developments, trends & different aspects of HRM
4. To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers

**Outcomes:** Learner will be able to…
1. Understand the concepts, aspects, techniques and practices of the human resource management.
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today’s emerging organizational perspective.
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

<table>
<thead>
<tr>
<th>Module</th>
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<th>Hrs</th>
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</thead>
</table>
| 01     | **Introduction to HR**  
  • Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions  
  • Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues | 5 |
| 02     | **Organizational Behaviour (OB)**  
  • Introduction to OB Origin, Nature and Scope of Organizational Behaviour, Relevance to Organizational Effectiveness and Contemporary issues  
  • Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness  
  • Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behaviour  
  • Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor);  
  • Group Behaviour and Group Dynamics: Work groups formal and informal groups and stages of group development, Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team.  
  • Case study | 7 |
| 03     | **Organizational Structure &Design**  
  • Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress.  
  • Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership.  
  • Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies. | 6 |
| 04     | **Human resource Planning** | 5 |
• Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale
• Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning
• Training & Development: Identification of Training Needs, Training Methods

05 Emerging Trends in HR
• Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation in HR.
• Cross Cultural Leadership and Decision Making; Cross Cultural Communication and diversity at work, Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation

06 HR & MIS: Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries
Strategic HRM: Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals
Labor Laws & Industrial Relations: Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

REFERENCES:
### Objectives:
1. To understand professional ethics in business
2. To recognized corporate social responsibility

### Outcomes: Learner will be able to…
1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

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<tr>
<th>Module</th>
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<tbody>
<tr>
<td>01</td>
<td><strong>Professional Ethics and Business</strong>: The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business</td>
<td>04</td>
</tr>
<tr>
<td>02</td>
<td><strong>Professional Ethics in the Marketplace</strong>: Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy <strong>Professional Ethics and the Environment</strong>: Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Professional Ethics of Consumer Protection</strong>: Markets and Consumer Protection; Contract View of Business Firm’s Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy <strong>Professional Ethics of Job Discrimination</strong>: Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.</td>
<td>06</td>
</tr>
<tr>
<td>04</td>
<td><strong>Introduction to Corporate Social Responsibility</strong>: Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India</td>
<td>05</td>
</tr>
<tr>
<td>05</td>
<td><strong>Corporate Social Responsibility</strong>: Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>Corporate Social Responsibility in Globalizing India</strong>: Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.</td>
<td>08</td>
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4. Only **Four questions need to be solved**.

REFERENCES:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
### Objectives:
1. To understand Research and Research Process
2. To acquaint students with identifying problems for research and develop research strategies
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

### Outcomes:
Learner will be able to…
1. Prepare a preliminary research design for projects in their subject matter areas
2. Accurately collect, analyze and report data
3. Present complex data or situations clearly
4. Review and analyze research findings

<table>
<thead>
<tr>
<th>Module</th>
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</table>
| 01     | Introduction and Basic Research Concepts  
1.1 Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology  
1.2 Need of Research in Business and Social Sciences  
1.3 Objectives of Research  
1.4 Issues and Problems in Research  
1.5 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical | 09 |
| 02     | Types of Research  
2.1 Basic Research  
2.2 Applied Research  
2.3 Descriptive Research  
2.4 Analytical Research  
2.5 Empirical Research  
2.6 Qualitative and Quantitative Approaches | 07 |
| 03     | Research Design and Sample Design  
3.1 Research Design – Meaning, Types and Significance  
3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors | 07 |
| 04     | Research Methodology  
4.1 Meaning of Research Methodology  
4.2 Stages in Scientific Research Process:  
a. Identification and Selection of Research Problem  
b. Formulation of Research Problem  
c. Review of Literature  
d. Formulation of Hypothesis  
e. Formulation of research Design  
f. Sample Design  
g. Data Collection  
h. Data Analysis  
i. Hypothesis testing and Interpretation of Data  
j. Preparation of Research Report | 08 |
| 05     | Formulating Research Problem  
5.1 Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis | 04 |
| 06     | Outcome of Research  
6.1 Preparation of the report on conclusion reached | 04 |
Assessment:

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<tr>
<td>01</td>
<td><strong>Introduction to Intellectual Property Rights (IPR):</strong> Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc.</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td><strong>Importance of IPR in Modern Global Economic Environment:</strong> Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td><strong>Enforcement of Intellectual Property Rights:</strong> Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td><strong>Indian Scenario of IPR:</strong> Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td><strong>Emerging Issues in IPR:</strong> Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td><strong>Basics of Patents:</strong> Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent</td>
<td>07</td>
</tr>
<tr>
<td>05</td>
<td><strong>Patent Rules:</strong> Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)</td>
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</tr>
<tr>
<td></td>
<td><strong>Patent databases:</strong> Important websites, Searching international databases</td>
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<tbody>
<tr>
<td>ILO 8028</td>
<td>Digital Business Management</td>
<td>03</td>
</tr>
</tbody>
</table>

**Objectives:**
1. To familiarize with digital business concept
2. To acquaint with E-commerce
3. To give insights into E-business and its strategies

**Outcomes:** The learner will be able to …..
1. Identify drivers of digital business
2. Illustrate various approaches and techniques for E-business and management
3. Prepare E-business plan

<table>
<thead>
<tr>
<th>Module</th>
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<th>Hours</th>
</tr>
</thead>
</table>
| 1      | **Introduction to Digital Business**- Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts  
Drivers of digital business- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services)  
Opportunities and Challenges in Digital Business, | 09    |
| 2      | **Overview of E-Commerce**  
E-Commerce- Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement  
Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing  
EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC | 06    |
| 3      | **Digital Business Support services**- ERP as e –business backbone, knowledge  
Tope Apps, Information and referral system  
Application Development: Building Digital business Applications and Infrastructure | 06    |
| 4      | **Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business  
| 6      | **Materializing e-business: From Idea to Realization**-Business plan preparation  
Case Studies and presentations | 08    |
Assessment:

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End Semester Examination:
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4. Only Four questions need to be solved.

References:

2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
6. Trend and Challenges in Digital Business Innovation, VinocenzoMorabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
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<tbody>
<tr>
<td>ILO8029</td>
<td>Environmental Management</td>
<td>03</td>
</tr>
</tbody>
</table>

**Objectives:**
1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

**Outcomes:** Learner will be able to…
1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

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<tbody>
<tr>
<td>01</td>
<td>Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario</td>
<td>10</td>
</tr>
<tr>
<td>02</td>
<td>Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.</td>
<td>06</td>
</tr>
<tr>
<td>03</td>
<td>Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td>Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility</td>
<td>10</td>
</tr>
<tr>
<td>05</td>
<td>Total Quality Environmental Management, ISO-14000, EMS certification.</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td>General overview of major legislations like Environment Protection Act, Air (P &amp; CP) Act, Water (P &amp; CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.</td>
<td>03</td>
</tr>
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**Assessment:**

**Internal Assessment for 20 marks:**
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First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

**End Semester Examination:**
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4. Only **Four questions need to be solved**.
REFERENCES:

2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Macmillan India, 2000
Objectives:

1. To familiarise with the concept of system and methodology of system design
2. To study system design of various systems such as snatch block, belt conveyors, engine system, pumps and machine tool gearbox
3. To familiarise with the standard codes of professional practices in designing the various systems

Outcomes: Learner will be able to…

1. Apply the concept of system design.
2. Design of hoisting mechanism of EOT crane,
3. Design belt conveyor systems
4. Design pumps for the given applications
5. Design engine components such as cylinder, piston, connecting rod and crankshaft
6. Design of machine tool gearbox

Term Work: Comprises a & b

a) Term work - Shall consist of

1. Design and detailed assembly drawing (computer aided drawing on A3 size sheets) of minimum two design problems, from the following:
   i) Design of hoisting mechanisms
   ii) Design of belt conveyors
   iii) Design of pumps

2. Course Project: Students in a group of two to four should be able to apply and integrate the knowledge gained during the course. Design and preparation of working drawings of any system having minimum 5 to 6 components is expected.

b) Assignment: Exercises on following topics in the form of design calculations with sketches and/or drawings.

   1. Engine design
   2. Design of gearbox

The distribution of marks for term work shall be as follows:

- Exercises and Drawing sheets : 10 marks.
- Assignments : 05 marks
- Course Project : 05 marks.
- Attendance : 05 Marks.

Assessment:

End Semester Practical/Oral examination:

1. Each student will be given a small task of design based on syllabus, which will be assessed by pair of examiners during the oral examination.
2. Distribution of marks for practical-oral examination shall be as follows:
   Design Task: 15 marks
   Oral: 10 marks
3. Evaluation of practical/oral examination to be done based on the performance of design task
4. Students work along with evaluation report to be preserved till the next examination
Objectives
1. To familiarise with boilers, boiler mountings and accessories using models/cut sections
2. To familiarise with hydraulic energy conversion devices

Outcomes: Learner will be able to…
1. Differentiate boilers
2. Differentiate boiler mountings and accessories
3. Conduct a trial on impulse turbine and analyse its performance
4. Conduct a trial on reaction turbine and analyse its performance
5. Conduct a trial on Centrifugal pump and analyse its performance
6. Conduct a trial on Reciprocating pump and analyse its performance

List of Experiments
1. Demonstration of Boilers
2. Demonstration of Boiler mountings and accessories
3. Trial on Impulse turbine
5. Trial on Reaction turbine
6. Trial on centrifugal pump (Single stage/Multistage)
7. Trial on reciprocating pump
8. Visit to Thermal Power Plant/Hydroelectric Power Plant/Gas Turbine Power Plant

Assessment:

Term Work
Term work shall consist of all the experiments from the list, 3 assignments containing numerical based on maximum contents of the syllabus and a visit report
The distribution of marks for term work shall be as follows:
   Laboratory work (Experiments): 10 marks
   Assignments: 05 marks
   Visit report: 05 Marks
   Attendance: 05 marks

End Semester Practical/Oral Examination:
1. Students in a group (4 to 6) have to perform trial either on Impulse turbine, Reaction turbine, Centrifugal Pump or Reciprocating Pump and the same will be assessed by pair of examiners during the oral examination.
2. Distribution of marks for practical-oral examination shall be as follows:
   Trial: 15 marks
   Oral: 10 marks
3. Evaluation of practical/oral examination to be done based on the performance
4. Students work along with evaluation report to be preserved till the next examination
Course Code | Course Name | Credits
---|---|---
MEP701/MEP801 | Project (I and II) | 03 + 06

**Objectives:**
1. To acquaint with the process of undertaking literature survey/industrial visit and identifying the problem
2. To familiarize the process of problem solving in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

**Outcomes:** Learner will be able to…
1. Do literature survey/industrial visit and identify the problem
2. Apply basic engineering fundamental in the domain of practical applications
3. Cultivate the habit of working in a team
4. Attempt a problem solution in a right approach
5. Correlate the theoretical and experimental/simulations results and draw the proper inferences
6. Prepare report as per the standard guidelines.

**Guidelines for Project**
Students should do literature survey/visit industry/analyse current trends and identify the problem for Project and finalize in consultation with Guide/Supervisor
Students should use multiple literatures and understand the problem.
Students should attempt solution to the problem by experimental/simulation methods.
The solution to be validated with proper justification and report to be compiled in standard format.

**Guidelines for Assessment of Project I**
Project I should be assessed based on following points
1. Quality of problem selected
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization
4. Clarity of objective and scope
5. Breadth and depth of literature survey

Project I should be assessed through a presentation by the student project group to a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

**Guidelines for Assessment of Project II**
Project II should be assessed based on following points
1. Quality of problem selected
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization / Industrial trends
4. Clarity of objective and scope
5. Quality of work attempted
6. Validation of results
7. Quality of Written and Oral Presentation

Project Report has to be prepared strictly as per University of Mumbai report writing guidelines. Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiner approved by the University of Mumbai

Students should be motivated to publish a paper in Conferences/students competitions based on the work