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’s 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 (PEO’s) and give freedom to affiliated Institutes to add few (PEO’s). 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
### Semester V

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Teaching Scheme (Contact Hours)</th>
<th>Credits Assigned</th>
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<td>Pract</td>
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<tr>
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<td>Internal Combustion Engines*</td>
<td>04</td>
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<tr>
<td>MEC502</td>
<td>Mechanical Measurements and Control*</td>
<td>04</td>
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<td>Heat Transfer*</td>
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<td>Business Communication and Ethics</td>
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<td>MEDLO5011</td>
<td>Press Tool Design</td>
</tr>
<tr>
<td>MEDLO5012</td>
<td>Machining Sciences and Tool Design</td>
</tr>
<tr>
<td>MEDLO5013</td>
<td>Design of Jigs and Fixtures</td>
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### 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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<tbody>
<tr>
<td>01</td>
<td><strong>Introduction</strong> 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>06</td>
</tr>
</tbody>
</table>
| 02     | **S.I. Engines**

  * **Fuel Supply System:**
    - 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
  
  **Ignition System:**
    - 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
  
  **Combustion:**
    - 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 |

| 03     | **Compression Ignition Engines**

  * **Fuel Injection Systems:** 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
  
  **Combustion:**
    - 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 |

| 04     | **Engine lubrication:** Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems
  
  **Engine Cooling:** Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling
  
  **Supercharging/Turbo-charging:** Objectives, Limitations, Methods and Types, Different arrangements of turbochargers and superchargers | 06   |
### 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.

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. 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. Maleeeve
14. Internal Combustion Engine by Domkundwar
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

Module | Contents | Hours
--- | --- | ---
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
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
6. Stability analysis
   6.1 Introduction to concepts of stability, The Routh criteria for stability
   6.2 Experimental determination of frequency response, Stability analysis using Root locus, Bode plot and Nyquist Plots
   6.3 State space modeling
   6.4 Process control systems, ON-OFF control, P-I-D Control

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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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>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<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 **Numerical methods in heat transfer:**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>
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<tr>
<td>05</td>
<td><strong>Radiation:</strong> Basic laws of radiation, Black body radiation, Planck’s law, Kirchhoff’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>
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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

Reference Books:
2. Fundamentals of Heat and Mass Transfer by FPIncropera 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
<table>
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<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
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| 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

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<tr>
<th>6</th>
<th>6.1 Rotor Dynamics:</th>
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<tr>
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<td>Critical speed of single rotor, undamped and damped</td>
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<tr>
<th>6</th>
<th>6.2 Balancing:</th>
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<tr>
<td></td>
<td>Static and Dynamic balancing of multi rotor system, balancing of reciprocating masses in In-line engines, V-engines (excluding other radial engines)</td>
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</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:**
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 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, NewDelhi
8. Mechanical Vibrations by G.K.Grover
11. Vibration Analysis by P. Srinivasaas, 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
**Assessment:**

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**End Semester Examination:**
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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. 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
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<tbody>
<tr>
<td>01</td>
<td><strong>Metal Cutting Theory:</strong>&lt;br&gt;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>1.1</td>
<td><strong>Dynamometry:</strong>&lt;br&gt;Dynamometer requirements, force measurement, electric transducers, strain gage lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, surface grinding dynamometer, piezoelectric dynamometry</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td><strong>Temperatures in metal cutting and cutting fluids:</strong>&lt;br&gt;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&lt;br&gt;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>02</td>
<td><strong>Cutting tool materials and machining induced surface integrity</strong>&lt;br&gt;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&lt;br&gt;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>
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<tr>
<td>03</td>
<td></td>
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</tbody>
</table>
geometrical contribution to roughness, edge finishing, residual stress and microhardness

| 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:

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

7. Typical Examples and Problems in Metal Cutting and Tool Design, by N. Nefedov and K. Osipov, Mir publishers, Moscow
### Course Code: MEDLO5013
### Course/Subject Name: Design of Jigs and Fixtures
### Credits: 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>
</table>
| 01     | 1.1 Introduction to Tool Design  
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. | 08 |
| 02     | Basic Construction of Jig & Fixture  
1.1 Location & Locating Devices  
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.  
1.2 Clamping & clamping Devices  
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 | 10 |
| 03     | 3.1 Construction of Drill Jig  
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 | 10 |
| 04     | 4.1 Construction of Milling fixture  
Introduction, Selection of location, supporting and clamping faces/points choice, tool setting block and Tennon’s, Case Study on Design of Milling Fixture | 08 |
| 05     | 5.1 Introduction to Commonly used Fixtures  
Turning Fixture (Chucks, collets, Mandrels) Grinding Fixture, Broaching Fixture, and Welding Fixture | 08 |
| 06     | 6.1 Indexing Jig & Fixture  
Introduction, Application of indexing, Essential features of an indexing jig /fixture, Indexing Devices | 04 |
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
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 8 experiments (04 from the measurement group and 04 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
<table>
<thead>
<tr>
<th>Expt.No</th>
<th>Name of Experiments</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><strong>Convection: (Any One)</strong>&lt;br&gt;1. Measurement of heat transfer coefficient in natural convection&lt;br&gt;2. Measurement of heat transfer coefficient in forced convection&lt;br&gt;3. Comparison of heat transfer coefficient of free and forced convection</td>
<td>2Hrs</td>
</tr>
<tr>
<td>4</td>
<td><strong>Transient Conduction:</strong>&lt;br&gt;1. Unsteady state heat transfer in cylinder/rod/wall</td>
<td>2Hrs</td>
</tr>
<tr>
<td>5</td>
<td><strong>Fins: (Any One)</strong>&lt;br&gt;1. Determination of fin efficiency and fin effectiveness&lt;br&gt;2. Comparison of fin performance of Various type of fins</td>
<td>2Hrs</td>
</tr>
<tr>
<td>6</td>
<td><strong>Boiling and Condensation: (Any One)</strong>&lt;br&gt;1. Measurement of heat transfer coefficient in boiling process of water.&lt;br&gt;2. Measurement of heat transfer coefficient in condensation of saturated steam.</td>
<td>2Hrs</td>
</tr>
<tr>
<td>7</td>
<td><strong>Heat Exchangers: (Any One)</strong>&lt;br&gt;1. Estimation of overall heat transfer coefficient and effectiveness of double pipe heat exchanger (parallel flow and Counter flow arrangement)&lt;br&gt;2. Estimation of overall heat transfer coefficient and effectiveness of shell and tube heat exchanger (parallel flow and Counter flow arrangement)&lt;br&gt;3. Estimation of overall heat transfer coefficient and effectiveness of plate type heat exchanger.</td>
<td>2Hrs</td>
</tr>
</tbody>
</table>

**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
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:**

- 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 Distribution of marks for practical/viva examination shall be as follows:
   - Practical performance 15 marks
   - Oral 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 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.
Course Code | Course/Subject Name | Credits
---|---|---
MEL 505 | Manufacturing Sciences Lab | 1

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>
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<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**
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>01</td>
<td>Report Writing</td>
<td></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>
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<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>
<td>02</td>
<td>Technical Writing</td>
<td></td>
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<tr>
<td>2.1</td>
<td>Technical Paper Writing (IEEE Format)</td>
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<tr>
<td>2.2</td>
<td>Proposal Writing</td>
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<tr>
<td>03</td>
<td>Introduction to Interpersonal Skills</td>
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<tr>
<td>3.1</td>
<td>Emotional Intelligence</td>
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<td>3.2</td>
<td>Leadership and Motivation</td>
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<td>3.3</td>
<td>Team Building</td>
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<td>3.4</td>
<td>Assertiveness</td>
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<tr>
<td>3.5</td>
<td>Conflict Resolution and Negotiation Skills</td>
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<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>04</td>
<td>Meetings and Documentation</td>
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<tr>
<td>4.1</td>
<td>Strategies for conducting effective meetings</td>
<td></td>
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<tr>
<td>4.2</td>
<td>Notice, Agenda and Minutes of a meeting</td>
<td></td>
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<tr>
<td>4.3</td>
<td>Business meeting etiquettes</td>
<td></td>
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<tr>
<td>05</td>
<td>Introduction to Corporate Ethics</td>
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<tr>
<td>5.1</td>
<td>Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc.)</td>
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<tr>
<td>5.2</td>
<td>Introduction to Intellectual Property Rights</td>
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<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>
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<tr>
<td>06</td>
<td>Employment Skills</td>
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<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 marks</td>
</tr>
<tr>
<td>Assignments</td>
<td>10 marks</td>
</tr>
<tr>
<td>Project Report Presentation</td>
<td>15 marks</td>
</tr>
<tr>
<td>Group Discussion</td>
<td>10 marks</td>
</tr>
<tr>
<td>Attendance</td>
<td>05 marks</td>
</tr>
</tbody>
</table>

References:
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