AC-
Item No.-

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Mechanical Engineering

Third Year with Effect from AY 2021-22

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year B.E. in Mechanical Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ **/ U.G./** ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ **/ Semester** (Strike out which is not applicable)
8	Status	~~New~~ **/ Revised** (Strike out which is not applicable)
9	To be implemented from Academic Year	**2021-2022**

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Date

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

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 Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty 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. 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. 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.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 171, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

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Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' Scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the Institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preface

When the entire world is discussing about 'Industry 4.0', we are at the crossroads. There are so many expectations from the graduating engineers, who shall be the major contributors to ecosystem for development of the Nation. Engineering education in India, in general, is being revamped so as to impart the theoretical knowledge along with industrial exposure. It is our attempt, when we are introducing a new curriculum; to bridge the industry-academia gap. To enable this, we have introduced components such as skill-based laboratories and project-based learning. We trust that this will allow the learner to apply knowledge gained in previous and current semesters to solve problems for gaining better understanding. What once were pure mechanical systems have now been transformed into multidisciplinary systems of mechatronics, electronics and computer science. Interdisciplinary knowledge is gaining importance as we are moving towards automated world as technology advances. Keeping this in mind the curriculum has been designed in a way so that learner shall be acquainted with many Interdisciplinary subjects.

Engineers develop new technological solutions. During the engineering design process, the responsibilities of the engineer may include defining problems, conducting and narrowing research, analyzing criteria, finding and analyzing solutions, and making decisions. The Program Educational Objectives for Undergraduate Program were finalized in a brain storming session, which was attended by several faculty members and Industry experts. The Program Educational Objectives proposed for the undergraduate program in Mechanical Engineering are listed below:

1. To prepare the stake holder to exhibit leadership qualities with demonstrable attributes in lifelong learning to contribute to the societal needs.
2. To make ready the stake holder to pursue higher education for professional development
3. To help the stake holder to acquire the analytical and technical skills, knowledge, analytical ability attitude and behavior through the program
4. To prepare the stakeholders with a sound foundation in the mathematical, scientific and engineering fundamentals
5. To motivate the learner in the art of self-learning and to use modern tools for solving real life problems and also inculcate a professional and ethical attitude and good leadership qualities
6. To prepare the stake holder to able to Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

We trust this revised version of syllabus come up to the expectations of all stakeholders.We trust this revised version of syllabus come up to the expectations of all stakeholders. We wish to place on record our sincere thanks and appreciations to the various contributors from the academia and industry for their most learned inputs in framing this syllabus.

Board of Studies in Mechanical Engineering

Dr. Vivek K. Sunnapwar : Chairman
Dr. S. M. Khot : Member
Dr. V. M. Phalle : Member
Dr. Siddappa S.Bhusnoor : Member
Dr. S.S. Pawar : Member
Dr. Sanjay U. Bokade : Member
Dr. Dhanraj Tambuskar : Member

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Program Structure for Third Year Engineering
Semester V &VI
UNIVERSITY OF MUMBAI
(With Effect from 2021-2022)

Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC501	Mechanical Measurements and Controls	3	--	3	--	3
MEC502	Thermal Engineering	3	--	3	--	3
MEC503	Dynamics of Machinery	3	--	3	--	3
MEC504	Finite Element Analysis	3	--	3	--	3
MEDLO501X	Department Level Optional Course – 1	3	--	3	--	3
MEL501	Thermal Engineering	--	2	--	1	1
MEL502	Dynamics of Machinery	--	2	--	1	1
MEL503	Finite Element Analysis	--	2	--	1	1
MESBL501	Professional Communication and Ethics –II	--	2*+2	--	2	2
MEPBL501	Mini Project – 2 A	--	4$	--	2	2
Total		**15**	**14**	**15**	**07**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/ Oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
MEC501	Mechanical Measurements and Controls	20	20	20	80	3	--	--	100
MEC502	Thermal Engineering	20	20	20	80	3	--	--	100
MEC503	Dynamics of Machinery	20	20	20	80	3	--	--	100
MEC504	Finite Element Analysis	20	20	20	80	3	--	--	100
MEDLO501X	Department Level Optional Course – 1	20	20	20	80	3	--	--	100
MEL501	Thermal Engineering	--	--	--	--	--	25	--	25
MEL502	Dynamics of Machinery	--	--	--	--	--	25	25	50
MEL503	Finite Element Analysis	--	--	--	--	--	25	25	50
MESBL501	Professional Communication and Ethics - II	--	--	--	--	--	25	25	50
MEPBL501	Mini Project – 2 A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**125**	**100**	**725**

* Theory class to be conducted for full class, $ indicates work load of Learner (Not Faculty), for Mini Project;

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SBL – Skill Based Laboratory
PBL – Project Based Learning

Department Level Optional Course – 1

Course Code	**Department Level Optional Course – 1**
MEDLO5011	Optimization Techniques
MEDLO5012	Statistical Techniques
MEDLO5013	Computational Methods

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Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract/Tut.	Theory	Pract.	Total
MEC601	Machine Design	4	--	4	--	4
MEC602	Turbo Machinery	3	--	3		3
MEC603	Heating, Ventilation, Air conditioning and Refrigeration	3	--	3	--	3
MEC604	Automation and Artificial Intelligence	3	--	3	--	3
MEDLO602X	Department Level Optional Course – 2	3	--	3	--	3
MEL601	Machine Design	--	2	--	1	1
MEL602	Turbo Machinery	--	2	--	1	1
MEL603	Heating, Ventilation, Air conditioning and Refrigeration	--	2	--	1	1
MESBL601	Measurements and Automation	--	4	--	2	2
MEPBL601	Mini Project – 2 B	--	4$	--	2	2
Total		**16**	**14**	**16**	**07**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/ Oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
MEC601	Machine Design	20	20	20	80	3	--	--	100
MEC602	Turbo Machinery	20	20	20	80	3	--	--	100
MEC603	Heating, Ventilation, Air conditioning and Refrigeration	20	20	20	80	3	--	--	100
MEC604	Automation and Artificial Intelligence	20	20	20	80	3	--	--	100
MEDLO602 X	Department Level Optional Course – 2	20	20	20	80	3	--	--	100
MEL601	Machine Design	--	--	--	--	--	25	25	50
MEL602	Turbo Machinery	--	--	--	--	--	25	--	25
MEL603	Heating, Ventilation, Air conditioning and Refrigeration	--	--	--	--	--	25	25	50
MESBL601	Measurements and Automation	--	--	--	--	--	25	25	50
MEPBL601	Mini Project – 2 B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**125**	**100**	**725**

$ indicates work load of Learner (Not Faculty), for Mini Project;

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SBL – Skill Based Laboratory;
PBL – Project Based Learning

Department Level Optional Course – 2

Course Code	Department Level Optional Course – 2
MEDLO6021	Press Tool Design
MEDLO6022	Tool Engineering
MEDLO6023	Metal Forming Technology

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Course Code	Course Name	Credits
MEC501	**Mechanical Measurements and Controls**	**03**

Objectives:

1. To study the principles of precision measuring instruments & their significance.
2. To familiarize with the handling & use of precision measuring instruments/ equipment's.
3. To impart knowledge of architecture of the measurement system.
4. To deliver working principle of mechanical measurement system.
5. To study concept of mathematical modelling of the control system.
6. To acquaint with control system under different time domain.

Outcomes: Learner will be able to…

1. Handle, operate and apply the precision measuring instruments / equipment's.
2. Analyze simple machined components for dimensional stability & functionality.
3. Classify various types of static characteristics and types of errors occurring in the system.
4. Classify and select proper measuring instrument for displacement, pressure, flow and temperature measurements.
5. Design mathematical model of system/process for standard input responses and analyse error and differentiate various types of control systems and time domain specifications
6. Analyse the problems associated with stability.

Module	Details	Hrs.
1	**1.1** Introduction to Metrology, Need for inspection, Fundamental principles and definition, Standards of measurement, Errors in measurements, International standardization. **1.2** Limits, fits and tolerances of interchangeable manufacture, Elements of interchangeable system, Hole based and shaft based systems, Tolerance grades, Types of fits, General requirements of Go & No go gauging, Taylor's principle, Design of Go & No go gauges.	**06**
2	**2.1** Principles of interference, Concept of flatness, Flatness testing, Optical flats, Optical Interferometer and Laser interferometer. **2.2** Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters - Ra, Ry, Rz, RMS value etc., Surface roughness measuring instruments. **2.3** Screw Thread measurement: Two wire and three wire methods, Floating carriage micrometer. **2.4** Gear measurement: Gear tooth comparator, Master gears, Measurement using rollers and Parkinson's Tester.	**08**
3	**3.1** Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs. **3.2** Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc.	**06**
4	**4.1** Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper	**08**

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	Transducer **4.2** 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 **4.3** Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement: Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges **4.4** Flow Measurement: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter **4.5** Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers	
5	**5.1** Introduction to control systems, Classification of control system. Open loop and closed loop systems. **5.2** Mathematical modelling of control systems, concept of transfer function, Block diagram algebra **5.3** 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	**6.1** Stability analysis: Introduction to concepts of stability, The Routh criteria for stability **6.2** Experimental determination of frequency response, Stability analysis using Root locus, Bode plot	**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:

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**

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Text/Reference Books:

1. Engineering. Metrology, I.C. GUPTA, Dhanpat Rai Publications.
2. Engineering. Metrology, R. K. Jain, Khanna Publisher.
3. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
4. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
5. Instrumentation & Mechanical Measurements, A. K. Thayal
6. Control System Engineering by Nagrath I.J. and Gopal M, Wiley EasternLtd.
7. Modem Control engineering: by K. Ogata, Prentice Hall
8. Control systems by Dhanesh Manik, Cengage Learning
9. Engineering Metrology and Measurements by N V Raghavendra and L Krishnamurthy, OxfordUniversity Press.
10. Instrumentation and Control System, W. Bolton, Elsevier
11. Experimental Methods for Engineers by J P Holman, McGraw Hills Int. Edition
12. Engineering Experimentation by EO Doebelin, McGraw Hills Int. Edition
13. Mechanical Measurements by S P Venkateshan, John Wiley & Sons

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/103/112103261/ - Principles of Mechanical Measurement, IIT Guwahati
https://nptel.ac.in/courses/112/107/112107242/ - Mechanical Measurement System, IIT Roorkee
https://nptel.ac.in/courses/112/106/112106138/ - Mechanical Measurements and Metrology, IIT Madras

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Course Code	Course Name	Credits
MEC502	**Thermal Engineering**	**03**

Objectives

1. To study the heat transfer concepts applicable for steady state and transient conditions.
2. To study mathematical modeling and design concepts of heat exchangers.
3. To familiarize with the working of S.I. and C.I. engines and their performance.

Outcomes: Learner will be able to…

1. Analyze the three modes of heat transfer in engineering application.
2. Develop mathematical models for different modes of heat transfer.
3. Analyze performance parameters of different types of heat exchangers.
4. Identify and analyze the Transient heat Transfer in engineering applications.
5. Explain construction and working of different components of internal combustion engines.
6. Evaluate engine performance and emission characteristics.

Module	Details	Hrs
1	1.1. **Modes of Heat Transfer**: Mechanism of conduction, Convection and radiation heat transfer and it's Governing laws. 1.2. Generalized heat conduction equation in rectangular, cylindrical and spherical coordinates (only equations for cylindrical and spherical coordinates, no derivation). 1.3. Steady state heat conduction through plane wall, composite wall, cylinder, composite cylinder, sphere and composite sphere. Thermal contact resistance. Critical radius of insulation in cylinder and sphere.	**07**
2	2.1 **Heat transfer from Extended Surfaces**: Types of extended surfaces and its significance. Governing differential equation for fin (Finite, Infinite, and Insulated tips) and its solution. Fin efficiency and effectiveness. Analysis of Thermometric well. 2.2 **Unsteady state heat transfer:** Lumped heat capacity Analysis. Applications of unsteady state heat transfer, Thermal time constant.	**06**
3	3.1 **Convection:** Free and Forced convection. **External Flow**: Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent flow over a flat plate. **Internal Flow:** Velocity Boundary layer and Thermal Boundary layer, Laminar and Turbulent flow in tubes. General thermal analysis: Constant heat flux and constant surface temperature. 3.2 **Boiling and Condensation**: Introduction to Different boiling regimes, Film condensation, Drop wise Condensation. 3.3 **Radiation:** Basics laws of radiation and heat exchange between two bodies.	**07**

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4	4.1 **Mass Transfer**: Introduction to Mass Transfer, governing equations of mass transfer. Mass transfer coefficient. 4.2 **Heat Exchangers:** Types of heat exchangers, Overall heat transfer coefficient, LMTD, Effectiveness, Effectiveness – Number of Transfer Unit (ε- NTU) method, Correction factor for multi pass (up to 2 passes on shell and tube side) and cross flow heat exchanger.	**07**
5	5.1 Introduction to I.C. Engines and its Classification. Working of Four stroke and Two-stroke engines, Valve Timing Diagram. Fuel air cycles, Actual cycle. 5.2 Introduction to Fuel Supply, Ignition, combustion and knocking in SI Engines. MPFI in SI Engine. 5.3 Introduction to Fuel Injection system, Combustion and detonation in CI Engines.	**06**
6	6.1 **Engine Testing and Performance**: Measurement of various performance parameters, Performance characteristic of SI and CI Engine, Effect of load and speed on performance parameters, Heat balance sheet. 6.2 **Engine Emission and Control:** Sources of Engine Emissions, Constituents of S.I. and C.I. Engine exhaust and their effects on environment and health. Study of emission (Euro & Bharat stage) norms, Control methods for S.I and C I engine emissions.	**06**

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 content (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 20marks**
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 module3)
4. Only Four questions need to be solved.

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Text/Reference Books:

1. Fundamentals of Heat and Mass Transfer by F.P. Incropera and D P deWitt, Wiley India 3rd Edition.
2. Introduction to thermodynamics and Heat transfer by YunusACengel 2ndEdition, McGraw Hill.
3. Fundamentals of Heat and Mass Transfer, M. Thirumaleshwar, Pearson Education India, 2009.
4. Introduction to Heat Transfer, Som S. K ,PHI Publication.
5. Heat Transfer by P S Ghoshdastidar, 2nd Edition, Oxford University Press.
6. Heat and Mass Transfer, by R Rudramoorthy and L Malaysamy, 2nd Edition, PEARSON.
7. Heat Transfer by J P Holman, Mcgraw Hill.
8. Heat Transfer by S P Sukhatme, University Press.
9. Heat and Mass Transfer by PK Nag, TMH.
10. Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education.
11. Internal Combustion Engines, Shyam Agrawal, New Age International
12. Internal Combustion Engine, Mathur and Sharma
13. Internal Combustion Engines, Mohanty, Standard Book House
14. Internal Combustion Engine, Gills and Smith
15. Internal Combustion Engines Fundamentals, John B. Heywood , TMH
16. Internal Combustion Engines, Gupta H N, 2nd ed, PHI
17. Internal Combustion Engine, V Ganesan, TMH
18. Introduction to Internal Combustion Engines, Richard Stone, Palgrave Publication, 4th Edition
19. Internal Combustion Engine, S.L. Beohar
20. Internal Combustion Engine, P.M Heldt.
21. Internal Combustion Engine, E.F. Oberi.
22. Internal Combustion Engine by Domkundwar

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/101/112101097/ - Heat and Mass Transfer, IIT Bombay
https://nptel.ac.in/courses/112/105/112105248/ - Heat Exchangers: Fundamentals and Design Analysis, IIT Kharagpur
https://nptel.ac.in/courses/112/104/112104033/ - Engine Combustion, IIT Kanpur
https://nptel.ac.in/courses/112/103/112103262/ - IC Engines and Gas Turbines, IIT Guwahati

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Course Code	Course Name	Credits
MEC503	**Dynamics of Machinery**	**03**

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 familiarize with basics of mechanical vibrations
4. To study the balancing of mechanical systems

Outcomes: Learner willbe 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

Module	Details	Hrs.
1.	**Governors and Gyroscopes:** **1.1 Governors:** Introduction to Centrifugal and Inertia governors, Study and Force analysis of Porter and Hartnell governors including Performance characteristics, Governors effortand power. **1.2 Gyroscope:** Introduction, Gyroscopic couple and its effect on spinning bodies, naval shipsduring steering, pitching, rolling and their stabilization.	**07**
2.	**2.1** Static and Dynamic force analysis of Slider crank mechanism (neglecting mass of connecting rod and crank), , Turning moment on crank shaft **2.2** Dynamically equivalent systems to convert rigid body into two mass with and without correction couple(Case study- Connecting rod)	**05**
3.	**3.1Basic Concepts of Vibration:** Vibration and oscillation, causes and effects of vibrations, Importance of study of vibrations, Vibration parameters - springs, mass, damper, 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	**06**
4.	**4.1 Free Damped Single Degree of Freedom Vibration System:**Introduction to different methods of damping, Study and analysis of **1)** Viscous damped system (under damped, critically damped, over damped; Logarithmic decrement) **2)**Coulomb's damping (Combined Viscous and Coulomb damping excluded) **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,	**06**
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)	**08**

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	5.2 Vibration Isolation and Transmissibility: Force Transmissibility, motion transmissibility, typical isolators & mounts. **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(up to four rotors), balancing of reciprocating masses in In-line engines(up to four cylinders) , Introduction to V-engines (excluding other radial engines)	**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). Duration of each test shall be one hour.

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

Text/Reference Books:

1. Theory of Machines Thomas Bevan CSB Publishers & Distributors
2. Theory of Machines by Jagdishlal Metropolitan Book New Delhi, Company, Daryaganj, Delhi
3. Theory of Machines by S.S.Ratan Tata McGraw Hill , New Delhi
4. Theory of Machines by P.L.Bellaney Khanna publication, NewDelhi
5. Theory of Machines and Mechanisms by John J Uicker, Gordon R Pennock and Joseph E Shigley, Oxford University Press
7. Theory of Vibration with Applications, by W. Thomson, 2nd edition, Pearson Education
8. Mechanical Vibrations by S.S.Rao, fourth edition, Pearson Education
9. Mechanical Vibraitons by G.K.Grover
10. Fundamentals of Mechanical Vibration by S.Graham Kelly, Tata McGraw Hll
11. Principles of Vibration by Benson H Tongue, 2nd Edition, Oxford University Press
12. Vibration Analysis by P. Srineevasan, TMH
13. Mechanical Vibrations- Schaum's outline series, William W.Seto, McGraw Hill
14. Theory and Practice of Mechanical Vibrations by J S Rao and K Gupta, New Age International
15. Elements of Vibration Analysis by Leonard Meirovitch, McGrav- Hill, New York

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/101/112101096/ - Dynamics of Machines, IIT Bombay
https://nptel.ac.in/courses/112/107/112107212/ - Introduction to Mechanical Vibration, IIT Roorkee

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Course Code	Course Name	Credits
MEC504	**Finite Element Analysis**	**03**

Prerequisite:

Knowledge of:

- Differential equations (Formulation and solution, Types-Ordinary, Partial, Order and degree of the DE and the boundary conditions)
- Matrix algebra (Matrix operations, gauss elimination method to get inverse the inverse of matrix)
- Basics of the core field (Governing laws, relationship between the various variables and constants –like in structural field stress-strain,Thermal field-temp, heat transfer rate etc

Objectives:

1. To understand the concepts of FEA and its applicability to different engineering field problems.
2. To understand the representation of the physical model into an equivalent FEA model and steps to solve it.
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.

Module	Details	Hrs
1	**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 Differential equations, primary/secondary variables, boundary conditions-types-essential/natural etc. 1.3Approximate solution of differential equations, Weighted residual techniques (Galerkin , Subdomain method).	**05**
2	**FEA Procedure:(Pre-processing, Processing, Post-processing)** 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. 2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', assembly concepts to develop system equation.	**08**

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3	**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	**10**
4	**Two Dimensional Finite Element Formulations:** 4.1 Introduction, three node triangular element, four node rectangular element 4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element. 4.3 Convergence criterion, sources of errors	**05**
5	**Two Dimensional Vector Variable Problems:** 5.1 Equations of elasticity - Plane stress, plane strain and axi-symmetric problems 5.2 Jacobian matrix, stress analysis of CST.	**06**
6	**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.	**05**

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**

Text/Reference Books:

1. Textbook of Finite Element Analysis by Seshu P, Prentice Hall of India
2. Finite Element Method by J N Reddy, 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 S. S. Rao, Butter Worth Heinemann
8. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.

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Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/104/112104193/
https://nptel.ac.in/courses/105/106/105106051/
https://nptel.ac.in/courses/112/104/112104115/
https://nptel.ac.in/courses/112/103/112103295/
https://nptel.ac.in/courses/112/106/112106135/
https://nptel.ac.in/courses/112/106/112106130/
https://nptel.ac.in/courses/105/105/105105041/
https://nptel.ac.in/courses/112/104/112104116/

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Course Code	Course Name	Credits
MEDLO5011	**Optimization Techniques**	**03**

Objectives:

1. To Understand the need and origin of the optimization methods.
2. To understand various linear, nonlinear and other optimization techniques.
3. To understand various multi criterion and multi-objective decision making methods.
4. To understand recent tools in optimization

Outcomes: Learner will be able to…

1. Identify the types of optimization problems and apply the calculus method to single variable problems.
2. Formulate the problem as Linear Programming problem and analyse the sensitivity of a decision variable.
3. Apply various linear and non-linear techniques for problem solving in various domain.
4. Apply multi-objective decision making methods for problem in manufacturing environment and other domain.
5. Apply multi criterion decision making methods for problem in manufacturing environment and other domain.
6. Apply Design of Experiments method for Optimization

Module	Details	Hours
1	Basic Concepts: Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Classification of Optimization Problems. Classical Optimization Techniques: Single variable optimization	**06**
2	Linear Programming Problem: Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis and applications of LP Transportation and Assignment Models.	**08**
3	Integer Programming Model: Gomory's cutting plane method, Branch & Bound Technique. Non L.P. Model: Lagrangian method & Kuhn tucker Method, Newton's method. Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	**08**

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4	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. Introduction to Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, genetic algorithms, simulated annealing and Techniques based on Neural network & Fuzziness **(Only concepts)**	**08**
5	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method TOPSIS Method PROMETHEE	**06**
6	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2^k design, The general 2^{k-p} fractional factorial design Application of related software (Minitab, Design Expert or MATLAB)	**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**.

Text/Reference Books:

1. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
3. Pablo Pedregal, "Introduction to Optimization", Springer
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6. R V Rao, “Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making” (Springer Publication).

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7. Ritter, H., Martinetz, T., &Schulten, K., Addison,"Neural Computation and Self-Organizing Maps"-Wesley Publishing Company
8. Douglas C.Montgomery,"Design and analysis of experiments"(John Wiley & Sons Inc.)
9. Saravanan R,"Manufacturing Optimization through Intelligent Techniques", Taylor & Francis (CRC Press)-2006.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/101/112101298/ - Optimization from Fundamentals, IIT Bombay

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Course Code	Course Name	Credits
MEDLO5012	**Statistical Techniques**	**03**

Objectives:

1. To acquaint the learners with the basic concepts of Statistical Techniques.
2. To develop understanding of sampling theory.
3. To study methods for curve fitting and regression.
4. To learn statistical decision theory.

Outcomes: Upon successful completion of this course, Learner will be able to…

1. Apply the concepts of statistical distributions in engineering applications
2. Use sampling theory for a given data set
3. Fit curve for a given data set
4. Demonstrate the understanding of correlation and regression analysis
5. Perform analysis of variance from the available experimental data.
6. Demonstrate the understanding of Statistical Decision making and Hypothesis testing

Module	Content	No. of Hours
1	**Statistical Distributions:** Random Variable and Probability Distribution. Binomial, Poisson, Normal, Exponential, Hypergeometric, Uniform distributions	**05**
2	**Sampling Theory:** Meaning and Objectives of Sampling. Types of Sampling, Methods of drawing random samples. Sampling Distributions, Standard Error and Probable Error	**08**
3	**Curve Fitting and Methods of Least Squares:** Relationship between Variables, Curve Fitting, Equations of Approximating Curves, The Method of Least Squares, The Least Squares Line, Non-linear Relationships, The Least Squares Parabola,	**08**
4.	**Correlation and Regression:** Types of Correlation. Linear Correlation, Measures of Correlation, Standard Error of Estimate, Karl Pearson's and Rank Correlation coefficient. Simple linear regression: Least Squares Method.	**08**
5	**Analysis of Variance (ANOVA):** The Purpose of Analysis of Variance, One-Way Classification, Total Variation, Variation Within Treatments and Variation Between Treatments. The F Test for the Null Hypothesis of Equal Means, Two-Way Classification, Analysis of Variance for Two-Factor Experiments	**05**
6	**Statistical Decision Theory:** Statistical Decisions, Statistical Hypotheses, Tests of Hypotheses and Significance, or Decision Rules, Type I and Type II Errors, Level of Significance, Tests Involving Normal Distributions, Two-tailed and One-tailed Tests, Special Tests. Confidence Interval, Z test and Chi Square Test for Goodness of fit.	**05**

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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**.

Text/Reference Books:

1. Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley and Sons Inc
2. Murray R. Spiegel, "Probability and Statistics", Schaum's Outline Series, McGraw-Hill Book Company
3. Kothari, C.R.,1985, "Research Methodology-Methods and Techniques", Wiley Publications
4. N. G. Das, "Statistical Methods", Vol – I & II, Tata McGraw Hill.

NPTEL

https://nptel.ac.in/courses/112104211 – Statistical Methods for Scientists and Engineers, IIT Kharagpur

https://onlinecourses.nptel.ac.in/noc21_ma74/preview – Probability and Statistics, IIT Kharagpur

https://onlinecourses.nptel.ac.in/noc20_ma19/preview – Statistical Inference, IIT Delhi

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Course Code	Course Name	Credits
MEDLO5013	**Computational Methods**	**03**

Objectives:

1. Introduction to analytical and numerical techniques.
2. Application of mathematical modelling to mechanical systems.
3. Learn the significance of statistical techniques and data interpolation.

Outcomes: Learner will be able to…

1. Understand and develop mathematical models of physical systems.
2. Identify an appropriate mathematical formulation to linear algebraic equations.
3. Build an appropriate mathematical formulation to non-linear algebraic equations.
4. Evaluate and interpret the data regression, curve fitting and statistics.
5. Apply the numerical techniques and numerical schemes.
6. Formulate the concept of numerical methods in realistic applications.

Module	Details	Hrs
1	**Introduction to Computational Methods** Motivation and applications of Computational Methods. Computation and Error Analysis:Accuracy and precision; Truncation andround-off errors (Numericals); Binary Number System; Error propagation.	06
2	**Linear Systems and Equations** Matrix representation: Cramer's rule; Gauss Elimination. Matrix Inversion: LUDecomposition; Iterative Methods;Relaxation Methods; Eigen Values and Eigen Vectors.	06
3	**Non Linear Algebraic Equations:** Bracketing methods: Bisection, Regula-Falsi. Crouts Method: LU Decomposition. Open methods: Secant, Fixed pointiteration, Newton-Raphson; MultivariateNewton's method.	06
4	**Regression and Curve Fitting** Interpolation function; Cubic Splines; Multi regression analysis, polynomial regression. **Statistical methods:** Statistical representation of data, modeling and analysis of data, test of hypotheses. **Fuzzy Logic:** Introduction to fuzzy logic, Fuzzy Logic Systems Architecture, Case study of Mechanical system.	08
5	**Integration and Integral Equations** Newton Cotes Quadrature **ODEs: Initial Value Problems** Euler's methods; Predictor-corrector method (Adam's Moulton, Milne's Method) **ODEs: Boundary Value Problems** Finite difference Method; Finite Element Method, Finite Volume Method	07

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6	**Application of Numerical Methods** Predict vibration response of components to intricate profile generated by different machine tools, Design next generation Formula One cars to working at the cutting edge of robotics, Predict behaviour of flows to estimation of heat transfer in complex scenarios; Crank Nicolson method – Solution of 1-D Wave equation.	**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:
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
4. part (b) will be from any module other than module 3)
5. Only **Four questions need to be solved**.

Text/Reference Books:

1. S. P. Venkateshan& Prasanna Swaminathan, "Computational Methods in Engineering", Ane Books Pvt. Ltd., 1st Edition, (2014) ISBN: 978-0-12-416702-5.
2. Steven C. Chapra& Raymond P.Canale, "Numerical Methods for Engineers", Mc-Graw Hill Education, 8TH Edition, (2020), ISBN: 1260571386
3. Joe D Hoffman, "Numerical Methods for Engineers and Scientists", Second Edition, Marcel Dekker (2001) ISBN: 0-8247-0443-6.
4. M.K. Jain, S.R. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 7th Edition, New Age International Publishers, 2019.
5. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, Fifth Edition, 2012.
6. Rajesh Kumar Gupta, Numerical Methods – Fundamentals and Applications, Cambridge University Press, First Edition, 2019.
7. Gupta and Santosh K., "Numerical Methods for Engineers", 4th Edition, New Age International Publishers, 2019, ISBN: 9789387788794
8. FerzigerJ.and M. Peric, "Computational Methods for Fluid Dynamics" 3rd Edition, Springer, (2001) ISBN: 9783540420743.
9. Versteeg H., and W. Malalasekra,"An Introduction to Computational Fluid Dynamics: The Finite Volume Method" 2nd Edition, PHI(2007) ISBN: 9780131274983.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/127/106/127106019/ - Numerical Methods for Engineers, IIT Madras
https://nptel.ac.in/courses/111/107/111107105/ - Numerical Methods, IIT Roorkee
https://nptel.ac.in/courses/111/106/111106101/ - Numerical Analysis, IIT Madras
https://nptel.ac.in/courses/111/107/111107107/ - Numerical Methods: Finite Difference Approach, IIT Roorkee

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Course Code	Course Name	Credits
MEL501	**Thermal Engineering**	**01**

Objectives:

1. To familiarize the concept of various modes of heat transfer through experimental approaches.
2. To make conversant of concept of heat transfer mechanisms in various engineering applications.
3. To acquaint with the various methods for measurement of engine performance and emission parameters.

Outcomes: Learner will be able to…

1. Estimate thermal conductivity of engineering materials.
2. Evaluate performance parameters of extended surfaces.
3. Analyze heat transfer parameters in various engineering applications.
4. Analyze engine performance and emission parameters at different operating conditions.

List of Experiments

Group A (any five)

1. Measurement of thermal conductivity of metal rod/ liquids/insulating powder.
2. Measurement of thermal conductivity of composite wall.
3. Performance analysis of extended surfaces under free and force convection.
4. Measurement of heat transfer coefficient for flow over flat surface in free/forced convection.
5. Measurement of heat transfer coefficient for flow through tubes in free/forced convection.
6. Verification of Stefan Boltzmann Law.
7. Measurement of emissivity of Grey surface.
8. Determination of time constant of different materials under unsteady state heat transfer.
9. Estimation of overall heat transfer coefficient and effectiveness of heat exchanger.

Group B (Any four)

1. Study of performance and emissions characteristics of a Single Cylinder, Four-Stroke, Petrol Start, Kerosene Engine at constant speed (Load Test).
2. Study of performance and emissions characteristics of a Single Cylinder, Four- stroke Diesel Engine at constant speed (With Electrical/ Rope Brake Dynamometer) (Load Test) along with Heat Balance Sheet.
3. Study of performance and emissions characteristics of a Single Cylinder/Multi Cylinder, Two/Fourstroke petrol Engine at constant Speed/Load.
4. Study of performance and emissions characteristics of a Single Cylinder/ Multi Cylinder, Two/Four stroke petrol Engine at constant Speed along with heat balance sheet.
5. Determination of frictional power and mechanical efficiency of the Multi-cylinder Petrol Engine by Morse test.
6. Study of performance and emissions characteristics of a Single Cylinder, Four- stroke Diesel Engine at constant speed along with Heat Balance Sheet (With Electrical/ Rope Brake Dynamometer) (Load Test) using alternative fuels.
7. Study of performance and emissions characteristics of a Single Cylinder/Multi Cylinder, Four-stroke Petrol Engine at constant speed/load along with Heat Balance Sheet (With Electrical/ Rope Brake Dynamometer) (Load Test) under dual fuel mode.

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Assessment:

Term Work

Term work shall consist of the experiments as mentioned in group A and group B.

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

1. Laboratory work (Experiments): 20 marks
2. Attendance: 05 marks

Virtual Lab

https://mfts-iitg.vlabs.ac.in/ - Fluid and Thermal Sciences Lab, IIT Guwahati
https://vlab.amrita.edu/index.php?sub=1&brch=194 - Heat & Thermodynamics Virtual Lab, Amrita Vishwa Vidyapeetham
http://vlabs.iitkgp.ernet.in/rtvlas/# - Virtual Lab on Automotive Systems

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Course Code	Course Name	Credits
MEL502	**Dynamics of Machinery**	**01**

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 analyze governor characteristics
2. Analyze gyroscopic effect on laboratory model
3. Estimate natural frequency of mechanical systems
4. Analyze 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)**

b) **Assignment:**

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

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.

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Virtual Labs

https://dom-nitk.vlabs.ac.in/List%20of%20experiments.html – Dynamics of Machine Lab, NITK, Surathkal

http://mdmv-nitk.vlabs.ac.in/# - Machine Dynamics and Mechanical Vibrations Lab, NITK, Surathkal

https://mv-iitg.vlabs.ac.in/ - Virtual Labs for Mechanical Vibrations, IIT Guwahati

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Course Code	Course Name	Credits
MEL503	**Finite Element Analysis**	**01**

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 open source application programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs (Minimum 6) 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
7. Any one problem for analysis of Beams.

While performing the analysis the students should understand the concepts of selection of element type, meshing and convergence of solution.(using approach of refining mesh and or order of the element)

b. Course Project: (Any one task out of the following proposed list)

A group of not more than four students, shall do

1) 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.
2) Develop the program to verify the results obtained by manual calculations for simple 1D/2D problems using Python, MATLAB programming platform etc.
3) Simulate a problem and validate the results with experimental results (the test rigs from Strength of material /Heat transfer/Dynamics of machine/fluid lab etc may be used for obtaining the experimental results)

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

Part a:10 marks.

Part b:10 marks.

Attendance: 05 Marks.

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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

Evaluation of practical examination to be done based on the experiment performed andthe output of the experiments during practical examination.

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

Text/Reference Books:

1. Programming the Finite Element Method, I M Smith,D V Griffiths and Margetts WILEY Publications.
2. The Finite Element Method: Theory, Implementation, and Applications, Larson, Mats G., Bengzon, Fredrik,Springer
3. Introduction to Finite Element Analysis and Design by N. H. Kim, B. V. Sankar, and A. V. Kumar by Wiley publication
4. Finite Element analysis using ANSYS by PaletiSrinivas,Krishna Chaitanya, Rajesh Kumar Detti, PHI Publication.
5. Finite Element Analysis Theory and Application With ANSYS by Saeed Moaveni, Pearson Publication.
6. Introduction to Finite Element Analysis Using MATLAB and Abaqus By Amar Khennane, CRC Press publication

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Course Code	Course Name	Credits
MESBL501	**Professional Communication And Ethics - II**	**02**

Objectives:
Learners should be able to:

1. Discern and develop an effective style of writing important technical/business documents.
2. Investigate possible resources and plan a successful job campaign.
3. Understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4. Develop creative and impactful presentation skills.
5. Analyse personal traits, interests, values, aptitudes and skills.
6. Understand the importance of integrity and develop a personal code of ethics.

Outcomes: Learners will be able to…

1. Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2. Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3. Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4. Deliver persuasive and professional presentations.
5. Develop creative thinking and interpersonal skills required for effective professional communication.
6. Apply codes of ethical conduct, personal integrity and norms of organizational behaviour.

MODULE	DETAILS	HOURS
MODULE 1 - ADVANCED TECHNICAL WRITING :PROJECT/PROBLEM BASED LEARNING (PBL)		
1.1. Purpose and Classification of Reports	**Classification on the basis of:** • Subject Matter (Technology, Accounting, Finance, Marketing, etc.) • Time Interval (Periodic, One-time, Special) • Function (Informational, Analytical, etc.) • Physical Factors (Memorandum, Letter, Short & Long)	**06**
1.2. Parts of a Long Formal Report	• Prefatory Parts (Front Matter) • Report Proper (Main Body) • Appended Parts (Back Matter)	
1.3. Language and Style of Reports	• Tense, Person & Voice of Reports • Numbering Style of Chapters, Sections, Figures, Tables and Equations	

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	• Referencing Styles in APA & MLA Format • Proofreading through Plagiarism Checkers	
1.4. Definition, Purpose & Types of Proposals	• Solicited (in conformance with RFP) & Unsolicited Proposals • Types (Short and Long proposals)	
1.5. Parts of a Proposal	• Elements • Scope and Limitations • Conclusion	
1.6. Technical Paper Writing	• Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) • Language and Formatting • Referencing in IEEE Format	
MODULE 2 - EMPLOYMENT SKILLS		
2.1. Cover Letter & Resume	• Parts and Content of a Cover Letter • Difference between Bio-data, Resume & CV • Essential Parts of a Resume • Types of Resume (Chronological, Functional & Combination)	**06**
2.2 Statement of Purpose	• Importance of SOP • Tips for Writing an Effective SOP	
2.3 Verbal Aptitude Test	• Modelled on CAT, GRE, GMAT exams	
2.4. Group Discussions	• Purpose of a GD • Parameters of Evaluating a GD • Types of GDs (Normal, Case-based & Role Plays) • GD Etiquettes	
2.5. Personal Interviews	• Planning and Preparation • Types of Questions • Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) • Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
MODULE 3 - BUSINESS MEETINGS		
3.1. Conducting Business Meetings	• Types of Meetings • Roles and Responsibilities of Chairperson, Secretary and Members • Meeting Etiquette	**02**

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3.2. Documentation	• Notice • Agenda • Minutes	
MODULE 4 -TECHNICAL/ BUSINESS PRESENTATIONS		
4.1. Effective Presentation Strategies	• Defining Purpose • Analysing Audience, Location and Event • Gathering, Selecting &Arranging Material • Structuring a Presentation • Making Effective Slides • Types of Presentations Aids • Closing a Presentation • Platform Skills	**02**
4.2 Group Presentations	• Sharing Responsibility in a Team • Building the contents and visuals together • Transition Phases	
MODULE 5 - INTERPERSONAL SKILLS		
5.1. Interpersonal Skills	• Emotional Intelligence • Leadership & Motivation • Conflict Management & Negotiation • Time Management • Assertiveness • Decision Making	**08**
5.2 Start-up Skills	• Financial Literacy • Risk Assessment • Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	
MODULE 6 - CORPORATE ETHICS		
6.1. Intellectual Property Rights	• Copyrights • Trademarks • Patents • Industrial Designs • Geographical Indications • Integrated Circuits • Trade Secrets (Undisclosed Information)	**02**
6.2. Case Studies	• Cases related to Business/ Corporate Ethics	

List of Assignments for Termwork
(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal

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3. Meeting Documentation
4. Writing a Technical Paper/ Analysing a Published Technical Paper
5. Writing a SOP
7. IPR
8. Interpersonal Skills
9. Aptitude test (Verbal Ability)

Note:

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3. There will be an end–semester presentation based on the book report.

Guidelines for Internal Assessment

Term Work	25 Marks
Assignments	10 Marks
Attendance	05 Marks
Presentation slides	05 Marks
Book Report (hard copy)	05 Marks
Internal Oral -	25 Marks

Oral Examination will be based on a GD & the Project/Book Report presentation.

Group Discussion	10 Marks
Project presentation (Individual Presentation)	10 Marks
Group Dynamics	05 Marks

Suggested Reading

1. Arms, V. M. (2005). Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021). Business communication today. Upper Saddle River, NJ: Pearson.
3. Butterfield, J. (2017). Verbal communication: Soft skills for a digital workplace. Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).Personal development for life and work. Mason. South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). Organizational Behaviour. Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
8. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Virtual Labs

https://ve-iitg.vlabs.ac.in/- Virtual English and Communication Virtual Lab, IIT Guwahati
http://vlabs.iitb.ac.in/vlabs-dev/labs/communication/- Professional Communication Virtual Lab, IIT Bombay

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Course code	Course Name	Credits
MEPBL501	**Mini Project - 2A**	**02**

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.

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- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solution.

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Assessment criteria of Mini Project

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

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Course Code	Course Name	Credits
MEC601	**Machine Design**	**04**

Objectives:

1. To study basic principles of machine design
2. To familiarize with use of design data books & various codes of practice
3. To acquaint with functional and strength design principles of important machine elements
4. To familiarize selection of standard elements such as rolling element bearings, belts etc.
5. To make conversant with preparation of working drawings based on designs

Outcomes: Upon successful completion of this course, the learner will be able to

1. Use design data book/standard codes to standardise the designed dimensions
2. Design Knuckle Joint, cotter joint and Screw Jack
3. Design shaft under various conditions and couplings
4. Select bearings for a given applications from the manufacturers catalogue.
5. Select and/or design belts and flywheel for given applications
6. Design springs, clutches and brakes

Module	Details	Hrs
1	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 Thick Cylinders: Design of thick cylinders subjected to an internal pressure using Lame's equation	**08**
2	Design against static loads: Socket and Spigot Cotter joint, Knuckle joint, Bolted and welded joints under eccentric loading; Power Screw- Screw Jack.	**08**
3	3.1 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. 3.2 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	**12**
4	4.1 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) 4.2 Sliding Contact Bearings: Design of hydro dynamically lubricated bearings (self-contained), Introduction to hydro static bearings,	**08**
5	5.1 Design and selection of Belts: Flat and V-belts with pulley construction. 5.2 Design and selection of standard roller chains. 5.3 Design of Flywheel – Introduction, Fluctuation of energy and speed, turning moment	**08**

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	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.	
6	6.1 Design of Springs: Helical compression, Tension Springs under Static and Variable loads, Leaf springs. 6.2 Design of Clutches: Introduction, types, Basic theory of plate and cone type clutches, Design of single plate, multi-plate andwith spring, lever design andthermal, 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 (approximately40% 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 lecturehours 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 thenpart (b) will be from any module other than module 3)
4. Only Four questions need to be solved

Text/Reference Books:

1. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
3. Machine Design -An Integrated Approach - Robert L. Norton, Pearson Education
4. Machine Design by Pandya & Shah, Charotar Publishing
5. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
6. Machine Design by Reshetov, Mir Publication
7. Machine Design by Black Adams, McGraw Hill
8. Fundamentals of Machine Elements by Hawrock, Jacobson McGraw Hill
9. Machine Design by R.C.Patel, Pandya, Sikh, Vol-I & II C. Jamnadas& Co
10. Design of Machine Elements by V.M.Faires
11. Design of Machine Elements by Spotts
12. Recommended Data Books – Design Data: Data Book of Engineers by PSG College, KalaikathirAchchagam

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/105/112105124/ - Design of Machine Elements, IIT Kharagpur
https://nptel.ac.in/courses/112/106/112106137/ - Machine Design-II, IIT Madras

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Course Code	Course Name	Credits
MEC602	**Turbo Machinery**	**03**

Objectives

1. To apply principles of thermodynamics and fluid mechanics to turbomachines.
2. To learn the design and significance of various components of the turbomachine.
3. To estimate various parameters related to turbo machines using the governing equations.
4. To evaluate the performance of turbo machines.

Outcomes: Learner will be able to…

1. Define various parameters associated with steam generators and turbo machines.
2. Identify various components and mountings of steam generators with their significance.
3. Identify various turbo machines and explain their significance.
4. Apply principles of thermodynamics and fluid mechanics to estimate various parameters like mass flow rate power, torque, efficiency, temperature, etc.
5. Evaluate performance of SG and Turbo machines and apply various techniques to enhance performance.
6. Evaluate various phenomena related to performance like cavitation, choking, surging.

Module	Details	Hrs
1	**1.1 Steam Generators-** Layout of Thermal Power Plant, Classification of boiler, Difference between Fire tube and Water tube boiler with examples, Low pressure and high pressure boilers, once through boiler, important features of HP boilers, Mountings and accessories, Equivalent evaporation of boilers, Boiler performance, Boiler efficiency. **1.2 Introduction to turbo machines:** 1.2.1 Review of Thermodynamic principles, compressible gas flow relations, estimation of non-dimensional performance parameters for incompressible flow, specific speed. 1.2.2 Basic Euler's theory of turbo machines and it application to pumps, turbines and compressors.	**04** **04**
2	**HydraulicTurbines:** Basic theory, classification of turbines, theory of impulse and reaction turbines, estimation of work done, efficiency, characteristics of turbines, concept of draft tube and its types	**06**
3	**Pumps** **3.1** Classification of pumps, definition of pumping systems and system characteristics. **3.2 Centrifugal pumps:** Construction, estimation of work done, efficiency, characteristics, determination of operating point, cavitation and NPSH, specific speed of pumps **3.3 Positive Displacement pumps-**	**02** **04** **04**

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	Types and applications, general feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram (no numerical on reciprocating pump). Use of air vessel (only application no numerical).	
4	**Air compressor-** Introduction and general classification of reciprocating compressor-positive displacement, Multi Staging of reciprocating compressor (no derivation, numerical on single stage and two stage compressor). Centrifugal compressor, surging and choking of compressor (No numerical on centrifugal compressor).	**04**
5	**Steam Turbine**- Basic of steam turbine, Classification, compounding of turbine, Impulse turbine –velocity diagram, Condition for max efficiency Reaction turbine, Numerical on Simple Impulse turbine (De-Laval turbine) of single stage only. Degree of reaction, Parson's turbine, Condition for maximum efficiency, Numerical on Parson's turbine only.	**06**
6	**6.1 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 **6.2 Jet Propulsion Engines** Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency.	**05**

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**

Text Books:-

1. Thermal Engineering, AjoyKumar,G. N Sah,Narosa Publishing House,New Delhi
2. Fluid Mechanics and Machinery; CSP Ojha, R. Berndtsson, Oxford University.
3. Fluid Mechanics and Fluid Machines by Gautam Biswas, S K Som, Suman Chakraborty - Tata McGraw-Hill Education Pvt. Ltd.
4. Turbines, Compressors and Fans by S.M. Yahya, McGraw-Hill Education Pvt. Ltd.

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5. Turbomachinery Design and Theory by Aijaz and Gorla
6. Fluid Mechanics, thermodynamics of turbomachinery- S.L.Dixon,
7. Amsterdam; Boston: Elsevier-Butterworth-Heinemann

Reference Books:-

1. R.K.Rajput; Engineering Fluid Mechanics; S. Chand publications.
2. Dr. Mody& Seth; Hydraulics and Fluid Mechanics; Standard book house
3. S. Ramamrutham, Hydraulic, Fluid Mechanics & Fluid Machines, Dhanpat Rai publishing company.
4. Strecter, Fluid Mechanics, Tata McGraw Hill.
5. Thermal Engineering, R K. Rajput, Laxmi Publication
6. Fluid Mechanics: Fundamentals and application; Yunus A Cengel and John M CimbalaPublisher: Special India

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/106/112106303/ - Introduction to Turbomachines, IIT Madras
https://nptel.ac.in/courses/112/106/112106200/ - Fluid Dynamics and Turbomachines, IIT Madras

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Course Code	Course Name	Credits
MEC603	**Heating,Ventilation,Air Conditioning and Refrigeration**	03

Objectives:

1. Learning the fundamental principles and different methods of refrigeration and air conditioning
2. Study of various refrigeration cycles and evaluate performance of each cycle.
3. Study of components of refrigeration and air-conditioning systems along with the applications.

Outcomes: Learner will be able to…

1. Illustrate the fundamental principles and applications of refrigeration and air conditioning systems.
2. Identify various HVAC&R components
3. .Evaluate performance of various refrigeration system
4. E stimate cooling and heating loads for an airconditioning system.
5. Select air handling unit & design air distribution system
6. Apply the knowledge of HVAC for the sustainable developmentof refrigeration and .airconditioning systems

Module	Details	Hrs
1.	**1.1 BasicKnowledge:**CarnotrefrigeratorCarnot h ,eat pumpCarnot,coefficient of performance,Reversed Carnot cycle,and its limitaionEffect of temperature and pressure on COP of the cycle **1.2 Refrigerants:** Classification,Designation,Selection of refrigerant,Physical and chemical pproperties of rrefrigerants ,Secondaryrrefrigerants **1.3 Air Refrigeration System:** Bell Coleman cycle, Necessity of air cooling, Factors considered for the selection of air refrigeration system, Types of air refrigeration system with schematic and T-Sdiagram, Numerical based on simple and bootstrap air refrigeration system.	**06**
2.	**2.1 VapourCompression Refrigeration System:** Simple system on P-h and T-s diagrams, analysis of the simple cycle, factors affecting the performance of the cycle, actual cycle, Numerical based on standard vapour compression system byusing P-h chart .and refrigerant table **2.2 Vapour Absorption Refrigeration System.** Simple and practical,vapour absorption systemRefrigerant-adsorbent properties, COP of ideal vapour absorption system, DomesticElectroluxrefrigerator, Lithiumbromideabsorption system. **2.3** :**Heat Pump** performance,Primary energy ratio,Energy efficiency Introduction,Coefficient of ratio,Heating season performance factor,Seasonal energy efficiency ,ratio,Classification of heat pump,Vapour compression heat pump systemsHeat pump application in an industry.	**08**

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3.	**3.1 Thermal ComfortConditions:** Selection of inside design conditions, thermal comfort, heat balance equation for a human being, factors affecting thermal comfort, Effective temperature, comfort chart and factors governing effective temperature, selection of outside design conditions **3.2 Psychrometry:of Air Conditioning Processes** Psychrometry properties,relations and processes ,Adiabatic air mixing ,processPsychrometric chart,,RSHF,GSHF,ERSHF,Bypass factor ,Apparatus dew pointNumericalbased on psychrometric chart and .Classification of air conditioning system,relations **3.3 :Cooling Load Estimation** ,Introduction,Components of cooling loadDifferent heat sourcesV,arious load Estimation,Design of air conditioning systemBuilding survey and economic , aspect used in design.	**10**
4.	**4.1 Air DistributionSystem:** **4.1.1 :Duct** Classification of ducts,duct material, pressure in ductsFlow through duct, pressure losses in ductA,ir flow through simple duct systemE,quivalent diameter,Methods of duct system design: **4.1.2 :Air Handling Unit** ,oductionIntrFan coil unit, Types of fans used air conditioning applications, Fan lawsF,ilters,supply and return grills,Sensors.	**06**
5.	**5.1 HVACR& C:omponents** Working of reciprocating, screw and scroll compressors, working of air cooled, and water cooled andevaporative condensers. Working of DX, Flooded, and Forced feed evaporators, Expansion devices Capillary tube, TXV, EXV, Type of insulation materials.	**06**
6.	**6.1 Application of HVAC&R** Ice plant, Food storage plants, dairy and food processing plants, freeze drying, A/c in textile, Printing pharmaceutical industry and Hospitals ,Cold chain Technology, Transport air conditioning,Solar refrigeration.	**03**

Assessment:

- **Internal Assessment for 20 marks:**
  Consisting**Two Compulsory Class Tests**
  First test based onapproximately 40% of contentsand second test based onapproximately %40but excluding contents covered in Test I
- **End Semester Examination:**

1. Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.
2. Question paper will comprise of total **six questions**, **each carrying 20 marks**
3. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
4. **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)
5. Only **Four questions need to be solved**

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Text/Reference Books:-

1. Refrigeration and Air Conditioning by C.P.Arora, McGraw Hill education (India) (P) limited, New Delhi
2. Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
3. Refrigeration and Air Conditioning by Manohar Prasad, New age international (P) limited, New Delhi
4. Refrigeration and Air Conditioning by S.C.Arora and S.Domkundwar, Dhanpatrai and sons, Delhi
5. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
6. ISHRAE Air Conditioning Handbook
7. ISHRAE Refrigeration Handbook
8. ASHRAE Handbook of Fundamentals
9. ASHRAE Handbook of Equipment
10. ASHARE Handbook of System
11. Open Source Software/learning website

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/107/112107208/ - Refrigeration and Air Conditioning, IIT Roorkee
https://nptel.ac.in/courses/112/105/112105128/ - Refrigeration and Air Conditioning, IIT Kharagpur

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Course Code	Course Name	Credits
MEC604	**Automation and Artificial Intelligence**	**03**

Objectives:

1. To understand the need and justification of automation.
2. To study design of pneumatic and hydraulic circuits.
3. To study and understand electropneumatic circuits and PLC Design
4. To familiarize with robotic systems in automated manufacturing processes.
5. To study and understand AI and machine learning technologies for automation.

Outcomes: Learner will be able to…

1. Demonstrate understanding of fundamentals of industrial automation and AI.
2. Design & develop pneumatic / hydraulic circuits.
3. Design and develop electropneumatic circuits and PLC ladder logics.
4. Demonstrate understanding of robotic control systems and their applications.
5. Demonstrate understanding of various AI and machine learning technologies.

Module	Details	Hrs
1	**1.1 Introduction to Automation** Definition and fundamentals of automation, Elements of Automated system, Automation principles and strategies, Levels of automation, types of automation, Advanced automation functions **1.2 Introduction to Artificial Intelligence** Introduction, Historical development, Intelligent Systems, Types of Intelligent Agents, Components of AI, Foundations of AI, Scope of AI, Current trends in AI, Relevance to Mechanical Engineering	**04**
2	**2.1 Design of Pneumatic Circuits** Design of Pneumatic sequencing circuits using Cascade method and Shift register method (up to 2 cylinders) **2.2 Design of Hydraulic Circuits** Basic Hydraulic Circuits: Meter in, meter out and Bleed off circuits; Intensifier circuits, Regenerative Circuit, Counter balance valve circuit and sequencing circuits.	**08**
3	**3.1 Electro-pneumatic Circuits** Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping; **3.2 PLC Discrete Control Systems** Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.	**08**
4	**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, Nex-gen robots.	**07**

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5	**(Concept and Algorithms, No programming or numericals)** **5.1 Problem Solving:** Tree and Graph Search, Uninformed v/s informed search, uninformed methods: depth first search, breadth first search, Informed search: heuristic search, Best first search, branch and bound **5.2 Machine Learning:** Introduction, types of machine learning: supervised, unsupervised, reinforcement learning **5.3 Learning with Decision Trees:** Introduction to Decision Trees, Classification and Regression Trees, K means clustering algorithm, K nearest neighbours algorithm, hierarchical clustering, Concept of ensemble methods: bagging, boosting, random forests	**06**
6	**(Concept and Algorithms, No programming or numericals)** **6.1 Learning with regression:** Linear regression, Logistic regression **6.2 Artificial Neural Networks** Concept of ANN, Basic Models of Artificial Neural Networks Important Terminologies of ANNs McCulloch-Pitts Neuron, NN architecture, perceptron, delta learning rule, backpropagation algorithm, Gradient Descent algorithm, feed forward networks, activation functions **6.3 Introduction to AI Technologies in the realm of Automation** Concept of Natural Language Processing, Machine Vision, Deep learning, Expert systems, Genetic Algorithms, Industry 4.0	**06**

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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**

Text/Reference Books:

1. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press
2. Mechatronics System Design , Shetty and Kolk, Cengage Learning, India Edition
3. Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson eduaction
4. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education
5. Pneumatic Circuits and Low Cost Automation by Fawcett JR
6. Electromechanical Design Handbook , Walsh, McGraw-Hill
7. Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne
8. Industrial Hydraulics: Pippenger

9. Vickers Manual on Hydraulics
10. Hydraulic Valves and Controls: Pippenger
11. Fundamentals of pneumatics: Festo series
12. Mechatronics, NitaigourMahalik, Tata McGraw-Hill
13. Mechatronics, HMT
14. M.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education,New Delhi
15. M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey, "Industrial Robotics Technology programming and Applications", McGraw-Hill,
16. Yoram Korean, "Robotics for engineers", McGrew Hill Co
17. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.
18. Frank Petruzella," Programmable Logic Controllers", McGraw-Hill Education; 4 edition
19. Artificial Intelligence: A Modern Approach by Peter and Norvig ISBN-0-13103805-2,
20. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair ISBN-978-0-07008770-5, TMH,
21. Artificial Intelligence by Saroj KausikISBN:- 978-81-315-1099-5, Cengage Learning
22. Artificial Intelligence and Intelligent Systems by Padhy, Oxforfd University Press,
23. Artificial Intelligence & Machine Learning by Vinod Chandra .S.S. Anand Harindran. S. (PHI)
24. A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/103/112103174/

https://nptel.ac.in/courses/112/103/112103293/

https://nptel.ac.in/courses/112/102/112102011/

https://nptel.ac.in/courses/112/101/112101098/

https://nptel.ac.in/courses/112/103/112103280/

https://nptel.ac.in/courses/106/106/106106139/

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Course Code	Course Name	Credit
MEDLO6021	**Press Tool Design**	**03**

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. understand safety aspects and automation in press working

Module	Details	Hrs
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. 1.2 Theory of Shearing in Press Working. Optimum Cutting clearance & its effect on tolerances of pressed components. Press working terminology, Functions of different elements of a press tool. material handling equipment, Methods of feeding the strip/coil material.	**6**
2	**Design Progressive die** 2.1 Calculations for Economic Strip Layout, Calculations of Cutting force and Stripping force, recommending minimum tonnage of a press, Methods of reducing cutting loads on press tools 2.2 Design aspects of Press tool elements viz. Punches & methods of mounting punches, types of Die block, Stripper, Pilot, stock guides, stock stops, Selection and arrangement of Hardware used in Press tools. Selection of steels and its hardness for different elements of Press tools. 2.3 Centre of pressure, Different types Die sets and its selection, shut height of die, Problems based design of progressive die	**10**
3	**Bending and Drawing-** 3.1 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, roller bending, bending force problems on bend length calculation and bending force, 3.2 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, problems on drawing 3.3 Defects in drawn parts 3.4 Basic construction and working of Bending and Drawing dies	**8**

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4	**Miscellaneous Dies-** Basic construction & working of Shaving dies, Trimming dies, Compound dies, Combination dies, Coining dies, Embossing dies, Simple Progressive & Compound Progressive dies, drop through and inverted die, curling die, transfer die	**4**
5	**Selection of Presses and its setting** Classification of presses, Selection of Press and Press setting, calculation of shut press shut height and die shut height, Overloading of presses (load, energy considerations)	**4**
6	**Introduction to Automation & Safety in Press shop** Types of CNC Press, Types of CNC press controller, Basic hydraulic and pneumatic circuit used in press for stock feeding and ram movement, different types sensors used for hand protection, stock feeding etc., other safety equipment like break, clutch, face shield etc.	**4**

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.

Text/Reference Books

1. Die Design Fundamentals by J. R. Paquin, Industrial Press
2. Techniques of Press Working Sheet Metal by D F Eary and E A Reed
3. Press Tools Design and Construction by P H Joshi, S Chand Publishing
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

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/105/112105233/ - Metal Cutting and Machine Tools, IIT Kharagpur

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Course Code	Course Name	Credit
MEDLO6022	**Tool Engineering**	**03**

Objectives :

1. To familiarize with the basic concepts of machining science like mechanics of machining, tool wear, tool life, surface roughness and tool materials.
2. To familiarize 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. Analyze 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. Analyze economics of machining operations

Module	Details	Hrs
1	1.1 **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 & modified model for orthogonal cutting, problems on above topic. 1.2 **Dynamometry:** Dynamometer requirements, force measurement, electric transducers, strain gauge lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, piezoelectric dynamometry	**08**
2	2.1 **Temperatures in metal cutting and cutting fluids**: Heat generation in metal cutting, heat transfer in a moving material, temperature distribution in metal cutting, 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 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, dry cutting and minimum quantity lubrication, cryogenic cooling, cutting fluid maintenance and environmental considerations, disposal of cutting fluids	**05**
3	**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, Techniques for manufacturing 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,	**04**

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4	**Tool life and Machining Economics**: 4.1 Definition, tool wear, criteria for tool failure, effect of cutting parameters and tool geometry on tool life, Taylor's tool life equation, machinability of material, factors affecting machinability, 4.2 Components of product cost, Optimum cutting velocity for minimum cost of production and maximum production rate, problems on above topic.	**06**
5	**Design of single point cutting tools**: Different systems of tool nomenclature like MRS and ORS, Constructional features of solid tool, tipped tools, mechanically held regrindable 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, Tool design for EDM and USM.	**05**
6	**Design of multi point cutting tools**: Introduction to various form tools, Broach nomenclature, design steps for circular pull type, key way and spline broaches, Design of face and peripheral milling cutters, Drill, Reamer and Tap design using standard procedure.	**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.

Text/Reference Books

1. Fundamentals of Metal Machining and Machine Tools, Third Edition by Winston A. Knight, Geoffrey Boothroyd, CRC press Taylor and Francis group
2. Metal Cutting Principles by Milton Clayton Shaw,2nd Edition, Oxford University Press
3. Cutting Tools by P H Joshi, A H Wheeler Publishing Co Ltd
4. ASM Handbook, Vol. 16: Machining by Joseph R. Davis,9th Edition, ASM International
5. Fundamentals of Metal Cutting and Machine Tools by B. L. Juneja, G. S. Sekhon and Nitin Seth,2nd Edition, New Age International
6. Metal Cutting Theory and Cutting Tool Design, by V. Arshinov and G. Alekseev, Mir publishers, Moscow
7. Typical Examples and Problems in Metal Cutting and Tool Design, by N. Nefedov and K. Osipov, Mir publishers, Moscow
8. Production Technology – HMT handbook

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/105/112105233/ - Metal Cutting and Machine Tools, IIT Kharagpur

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Course Code	Course Name	Credits
MEDLO6023	**Metal FormingTechnology**	**03**

Objectives:

1. To conversant with the basic knowledge on fundamentals of metal formingprocesses
2. To study various metal formingprocesses
3. Understanding plastic deformation and technical analysis of forming processes

Outcomes: Learner will be able to…

1. Understand the concept of different metal formingprocess.
2. Approach metal forming processes both analytically andnumerically
3. Design metal formingprocesses
4. Develop approaches and solutions to analyze metal forming processes and the associated problems andflaws.

Module	Details	Hrs
1.	**Introduction to Metal Forming:** Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, effects of temperature, strain rate, microstructure and friction in metal forming-yield criteria and their significance, Classification of Metal Forming Processes, Advantages and Limitations, Stress strain relations in elastic and plastic deformation, concept of flow stresses, deformation mechanisms, Hot and Cold Working Processes and Its Effect on MechanicalProperties.	**08**
2.	**Rolling:** Introduction and Classification, Types of Rolling Mills, Forces andGeometrical Relationships in Rolling, Calculation of Rolling Load, Roll Pass Design, and Defects in Rolled Products.	**07**
3.	**Forging:** Introduction and Classification, operation and principle of Forging Processes and Equipment, Methods of forging, Open and Close Die Forging Processes, Defects, Structure and Properties of Forged Products. Force Analysis inforging	**07**
4.	**Extrusion:** Introduction and Classification, Extrusion Equipment, Forces inextrusion, Analysis of Extrusion Process, Extrusion of components including Seamless Pipes and Tubes. Extrusion of pipes by cold working,	**06**
5.	**Drawing:** Introduction and Classification, Wire Drawing, Rod Drawing, Tube Drawing, Deep Drawing, Analysis of Wire Drawing Process and Load Calculations.	**06**
6.	**Sheet Metal Forming:** Principle, process parameters, equipment and application of the following processes: spinning, stretch forming, plate, V and edge bending, Curling, Ironing, Roll Bending, Metal Spinning. Press brake forming, explosive forming, Hydro forming, electro hydraulic forming, and magnetic pulse forming.High Velocity forming of metals and High energy Rate forming	**06**

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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.

Text/Reference Books: -

1. Lin D Balint M Pietrzyk, Microstructure Evolution in Metal Forming Processes 1st Edition
2. Amitabha Ghosh and Asok Kumar Mallick, Manufacturing Science, Affiliated East-West Press
3. Christian Brecher and Ozdemir , Advances in Production Technology, Springer Publications
4. P.C.Sharma , A Text Book on Production Engineering, S.Chand Publications
5. P. N. Rao, "Manufacturing Technology", Tata McGraw Hill
6. Aviter, "Fundamental of Metal Working", McGraw Hill Publisher
7. Dieter, "Mechanical Metallurgy"

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/107/112107250/ - Principles of Metal Forming Technology, IIT Roorkee

https://nptel.ac.in/courses/112/106/112106153/ - Forming, IIT Madras

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Course Code	Course Name	Credits
MEL601	**Machine Design**	**01**

Objectives:

1. To study the basic of modelling software, part design and assembly making.
2. To familiarize with use of design data books & various codes of practice.
3. Based on design calculation preparation of working drawings of actual design model.

Outcomes: Learner will be able to…

1. Design shaft under various conditions
2. Design Knuckle Joint / cotter joint
3. Design Screw Jack
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:

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) Couplings
3) Screw Jack
4) Leaf springs

Software Analysis of any one component from the above list

b) Assignments:
Design exercises in the form of design calculations with sketches and/ or drawings on following machine elements.
1) Bolted and welded joints
2) Bearings.
3) Shaft design (solid and hollow shaft)
4) Flywheel and Belts.

The distribution of marks for term work shall be as follows:
Assignments, Exercises& Drawing sheets: 15 Marks
Course Project: 05 Marks (Minimum five components)
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.

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Text/Reference Books

1. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
3. Machine Design -An Integrated Approach - Robert L. Norton, Pearson Education
4. Machine Design by Pandya & Shah, Charotar Publishing
5. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
6. Recommended Data Books - PSG
7. Machine Design by Reshetov, Mir Publication
8. Machine Design by Black Adams, McGraw Hill
9. Fundamentals of Machine Elements by Hawrock, Jacobson McGraw Hill
10. Machine Design by R.C.Patel, Pandya, Sikh, Vol-I & II C. Jamnadas& Co
11. Design of Machine Elements by V.M.Faires
12. Design of Machine Elements by Spotts.

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Course Code	Course Name	Credits
MEL602	**Turbo Machinery**	**01**

Objectives

1. To familiarize with boilers, boiler mountings and accessories using models/cut sections.
2. To familiarize with hydraulic energy conversion devices.
3. To familiarize with thermal energy conversion devices.

Outcomes: Learner will be able to…

1. Differentiate boiler, boiler mountings and accessories
2. Conduct a trial on reciprocating compressor / centrifugal compressor.
3. Conduct a trial on impulse turbine and analyze its performance
4. Conduct a trail on reaction turbine and analyze its performance
5. Conduct a trial on Centrifugal pump and analyze its performance
6. Conduct a trial on Reciprocating pump and analyze its performance
7. Conduct a trial on gear pump

List of Experiments

Group-A (conduct any 7 including S.N.10)

1. Demonstration / e-learning of Boiler, Boiler mountings and accessories
2. Impact of jet
3. Trial on Impulse turbine (Pelton Wheel Turbine)
4. Trial on Reaction turbine (Francis Turbine)
5. Trial on Reaction turbine (Kaplan Turbine)
6. Trial on centrifugal pump (Single stage/Multistage)
7. Trial on reciprocating pump.
8. Trial on reciprocating / centrifugal air compressor
9. Trial on gear pump
10. Industrial visit to a power plant (compulsory)

Group –B (conduct any 3)

1. Measurement of Hydrostatic Pressures
2. Verification of Archimedes' Principle
3. Calibration of Venturimeter/ Orifice meter/Nozzle/ Pitot tube
4. Determination the friction factor in Pipes
5. Determination of major and minor losses in Pipe systems
6. Verification of Bernoulli's Equation
7. Calculation of Lift and Drag over an aerofoil

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Assessment:

Term Work

Term work shall consist of all the experiments from the list, 3 assignments containing numerical based on Centrifugal Pump, Reciprocating Pump and centrifugal compressor 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

Virtual Labs

http://fm-nitk.vlabs.ac.in/# - Fluid Mechanics Lab, NITK Surathkal

https://fmc-nitk.vlabs.ac.in/fluid-machinery/ - Fluid Machinery Lab, NITK Surathkal

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Course Code	Course Name	Credits
MEL603	**Heating, Ventilation, Air Conditioning and Refrigeration**	01

Objectives:

1. To study working and operating principle of vapour Compression and vapour absorption system.
2. To study Controls and Components of refrigeration and Airconditioning system.
3. To design air conditioning systems using cooling load calculation.

Outcomes: Learner will be able to…

1. **Aware** of the roles and ethics of HVAC &R engineers in related industries.
2. **Present** the impact of professional engineering solutions in societal and environmental contexts.
3. performance of HVAC &R systems **Evaluate**
4. **Develop** awareness of the engineering and technological aspects in the HVAC &R industries.
5. **Communicate** effectively through the preparation ofreport and practical presentation**.**
6. **Analyse** design aspectsof HVAC&R invarious.application

A -Part

List of Experiments

1. Study and performance on simple vapour compressiontest rig .
2. Study and performance of .heat pump test rig
3. Trial on Vapour absorbtion refrigerationtest rig.
4. Perform humidification anddehumdification air conditioning process on air .conditioning test rig
5. Study and performance of cooling tower based on the cooling load and approach to wet bulb temperature.
6. Study and performance of refrigeration cycle on Ice plant.
7. Performance analysis on watercooler system .
8. Cooling capacityanalysis of the desertcooler.
9. Steady state Simulation of VCR system with developed code or any analytical software.
10. Calculate cooling load of a confined space.

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Part -B

/Case studies through Seminar Poster presentation on

1. Chiller unit
2. Building Management system(Introduction)
3. Effect on Ozone depletion andGlobal warming,
4. Alternative Refrigerants.
5. Refrigerant Different Protocols used in
6. Variable refrigerant flow technology & its smart control

Term Work

Term work shall consist of

1. Minimumsix experiments
2. Industrial visit on any HVAC &R plant
3. Case study report

Distribution:of Term work marks as follow

1. Experiments : 10 marks
2. Case study :5 marks
3. Industrial Visit Report : 5 Marks
4. Attendance (Theory + Practical) : 5 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. .Evaluation of oral examination to be done based on the entire syllabus
6. Students work along with evaluation report to be preserved till the next examination

Virtual Labs

http://vlabs.iitb.ac.in/vlabs-dev/labs/mit_bootcamp/refigeration/index.php - Refrigeration and Air Conditioning Virtual Lab, IIT Bombay

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Course Code	Course Name	Credits
MESBL601	**Measurements and Automation**	**02**

Objectives:

1. To study fundamentals of inspection methods and systems.
2. To study working of mechanical measurement system.
3. To familiarise with different types of control systems.
4. To study different hydraulic and pneumatic systems.
5. To study various design principles of robotics through kinematic analysis, workspace analysis and trajectory planning.

Outcomes: Learner will be able to…

1. Apply inspection gauge to check or measure surface parameters.
2. Measure surface parameters using precision measurement tools and equipment.
3. Measure different mechanical parameters by using sensors.
4. Analyse the response of a control systems.
5. Demonstrate use of automated controls using pneumatic and hydraulic systems.
6. Implement program on PLC system and demonstrate its application

The laboratory experiments should be based on the following:

Group A (Metrology):
1. Experiments on linear and angular measurement using Vernier calliper, micrometer and Bevel protractor.
2. Experiments on surface measurement by using Surface roughness tester.
3. Experiments on measurement of gear parameters using Gear tooth Vernier calliper / Parkinson gear tester.
4. Experiments on screw thread measurement using screw thread micrometer, Floating carriage micrometer / bench micrometer.
5. Experiments on linear / angular measurements of screw / gear /single point tool using Optical profile projector or Tool maker's microscope.
6. Experiment using Mechanical / Pneumatic type Comparator.
7. Experiments on flatness measurement by Autocollimator / Interferometry method

Group B (Mechanical Measurement):
1. Experiments on measurement of displacement by sensors like LVDT, Potentiometers etc.
2. Experiments on measurement of pressure by gauges or sensors like vacuum Gauges, pressure gauge, piezoelectric sensors, strain gauge sensors etc.
3. Experiments on measurement of vibration by accelerometers or NI.
4. Experiments on feedback control systems and servomechanisms
5. Experiment on frequency response system identification / transient state response of a control system.
6. Experiment on design of PID controller for a system or simulate and tune a PID controller using lab view.

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Group C (Automation):

1. Experiment on trainer kit (Any one)

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

or

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

2. Experiment on simulation using software like Festo, AutoSim etc.

a) Simulation of basic pneumatic and electro-pneumatic circuits.

or

b) Simulation of hydraulic and electro-hydraulic circuits.

3. Experiments on Ladder programming

a) Experiments on Ladder programming on PLC for simple ON OFF control, timers, counter, two motor system, simple control applications with logic/ timers/counters.

or

b) Experiments on Ladder programming for Mechatronics system (e.g. bottle filling plant, control of electro-pneumatic or electro-hydraulic systems).

4. Experiments on Robotics

a) Demonstration and study of functions of components of robotics arm.

or

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

Term Work

Term work shall consist of minimum Nine Experiments. Three from each group mentioned above. There will be no theoretical assignment for the lab course. The distribution of marks for term work shall be as follows:

Laboratory work (Experiments) : 20 marks

Attendance: : 05 marks

End Semester Practical/Oral Examination:

1. Pair of Internal and External Examiner should conduct practical and viva 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/viva examination shall be as follows:

Practical performance: 15 marks

Oral: 10 marks

4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination.
5. Students work along with evaluation report to be preserved till the next examination.

Virtual Labs

http://ial-coep.vlabs.ac.in/ - Industrial Automation Laboratory, COEP

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Course code	Course Name	Credits
MEPBL601	**Mini Project - 2B**	**02**

Objectives:

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.

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- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

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Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

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