CURRICULUM STRUCTURE

THIRD YEAR UG: B.E.

MECHANICAL ENGINEERING

REVISION: FRCRCE-1-24

Effective from Academic Year 2024-25
Board of Studies Approval: 9/03/2024
Academic Council Approval: 16/03/2024

Dr. DEEPAK BHOIR
Dean Academics

Dr. BHUSHAN T. PATIL
Head of Department

DR. SURENDRA RATHOD
Principal

Preamble:

Greetings and congratulations to all the education partners Fr Conceicao Rodrigues College of Engineering for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2-10/2023(AC-Policy) dated 23rd Nov 2023 conferred the autonomous status to Fr. Conceicao Rodrigues College of Engineering, Fr. Agnel Ashram, Bandstand, Bandra (West), Mumbai 400050 affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. We look towards autonomy as a great opportunity to design and implement curriculum sensitive to needs of Learner, Indian Society and Industries.

The National Education Policy (NEP), 2020 suggests that students must actively engage with the practical side of their learning as part of a holistic education to further improve their employability. ***Fr. CRCE has taken a strategic decision to implement revised assessment scheme to support more experiential learning and continuous assessment in the form of ISE-1, MSE, ISE-2 and ESE to be taken by the college. The curriculum content and credit structure is maintained same as prescribed by University of Mumbai for third year students of academic year 2024-25.***

Honours and Minor Degree Eligibility Criteria for Students:

i. Following is the eligibility criteria for students opting the Honours/ Minor Degree program:

a. Students with no backlog in semester I, II, and III

b. The CGPI (based on semester I, II, and III) of the students must be 6.75 and above

c. For direct second year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above

ii) Each eligible student can opt for maximum one Honour's or one Minor Programs at any time.

iii) However, it is optional for leaners to take Honours/Minor degree program.

iv) The Honours/ Minor degree program can be opted only during regular engineering studies

v) The student have to complete the Honours/ Minor degree program in stipulated four semesters only.

Note:

1. Technical support team for registration of Academic Bank of Credits (ABC), registration of elective/optional courses, registration of online courses, registration for degree options etc. under supervision of Dean Academics.

Society of St. Francis Xavier, Pilar's
Fr. Conceicao Rodrigues College of Engineering
Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050
(Autonomous College affiliated to University of Mumbai)

SEMESTERWISE CURRICULUM STRUCTURE

THIRD YEAR Mechanical Engineering Program:

SEM-V									
Course Code	Course Name		Contact Hours	Examination Marks					Credits
				ISE1	MSE	ISE2	ESE	Total	Total
MEC501	Mechanical Measurements and Controls	TH	3	20	30	20	30	100	3
MEC502	Thermal Engineering	TH	3	20	30	20	30	100	3
MEC503	Dynamics of Machinery	TH	3	20	30	20	30	100	3
MEC504	Finite Element Analysis	TH	3	20	30	20	30	100	3
MEDLO501X	Department Level Optional Course – 1	TH	3	20	30	20	30	100	3
MEL501	Thermal Engineering	PR	2	15	--	10	--	25	1
MEL502	Dynamics of Machinery	PR	2	20	--	30	--	50	1
MEL503	Finite Element Analysis	PR	2	20	--	30	--	50	1
MESBL501	Professional communication and ethics –II	PR	4	20	--	30	--	50	2
MEPBL501	Mini Project – 2 A	PR	4	20	--	30	--	50	2
	Total		**TH:TU:PR 15:0:14**					**725**	**22**

Department Level Optional Courses:

Department Level Optional Course – 1 (MEDLO501X)
1. Optimization Techniques
2. Design of Experiments
3. Computational Methods

SEM-VI									
Course Code	Course Name		Contact Hours	Examination Marks					Credits
				ISE1	MSE	ISE2	ESE	Total	Total
MEC 601	Machine Design	TH	4	20	30	20	30	100	4
MEC 602	Turbo Machinery	TH	3	20	30	20	30	100	3
MEC 603	Heating, Ventilation, Air conditioning and Refrigeration	TH	3	20	30	20	30	100	3
MEC 604	Automation and Artificial Intelligence	TH	3	20	30	20	30	100	3
MEDLO602X	Department Level Optional Course – 2	TH	3	20	30	20	30	100	3
MEL 601	Machine Design	PR	2	20	--	30	--	50	1
MEL602	Turbo Machinery	PR	2	10	--	15	--	25	1
MEL603	Heating, Ventilation, Air conditioning and Refrigeration	PR	2	20	--	30	--	50	1
MESBL601	Measurements and Automation	PR	4	20	--	30	--	50	2
MEPBL601	Mini Project – 2 B	PR	4	20	--	30	--	50	2
	Total		**TH:TU:PR 16:0:14**					**725**	**23**

Department Level Optional Courses:

Department Level Optional Course – 2 (MEDLO602X)
1. Press Tool Design
2. Tool Engineering
3. Metal Forming Technology

Honors Degree Offered to Mechanical Engineering Students from SEM-V to SEM-VIII:

A. Name: **Robotics**

1. SEM-V: HRBC501: Industrial Robotics
2. SEM VI: HRBC601: Mechatronics & IoT
3. SEM VII: HRBC701: Artificial Intelligence & Data Analysis
4. SEM VII: HRBSBL701: Robotics and Automation Lab
5. SEM VIII: HRBC801: Autonomous Vehicle Systems

B. Name: 3D Printing

1. SEM-V: H3DPC501: Introduction to CAD
2. SEM VI: H3DPC601: 3D Printing: Introduction & Processes
3. SEM VII: H3DPC701: Applications of 3D Printing
4. SEM VII: H3DPSBL701: Skill Based Lab– Digital Fabrication
5. SEM VIII: H3DPC801: 3D Printing in Medical Technology

C. Name: Data Science

1. SEM-V: HDSC501: Mathematics for Data Science
2. SEM VI: HDSC601: Statistical Learning for Data Science
3. SEM VII: HDSC701: Data Science for Health and Social Care
4. SEM VII: HDSSBL701: Data Science for Health and Social Care Lab
5. SEM VIII: HDSC801: Text, Web and Social Media Analytics

D. Name: **Internet of Things**

1. SEM-V: HIoTC501: IoT Sensor Technologies
2. SEM VI: HIoTC601: IoT System Design
3. SEM VII: HIoTC701: Dynamic Paradigm in IoT
4. SEM VII: HIoTSBL701: Interfacing & Programming with IoT Lab (SBL)
5. SEM VIII: HIoTC801: Industrial IoT

Minors Degree Offered to Mechanical Engineering Students from SEM-V to SEM-VIII:

A. Name Artificial Intelligence and Machine Learning

1. SEM-V: HAIMLC501: Mathematics for AI & ML
2. SEM VI: HAIMLC601: Game Theory using AI & ML
3. SEM VII: HAIMLC701: AI & ML in Healthcare
4. SEM VII: HAIMLSBL701: AI & ML in Healthcare: Lab
5. SEM VIII: HAIMLC801: Text, Web and Social Media Analytics

B. Name: Blockchain

1. SEM-V: HBCC501: Bit coin and Crypto currency
2. SEM VI: HBCC601: Blockchain Platform
3. SEM VII: HBCC701: Blockchain Development
4. SEM VII: HBCSBL701: Private Blockchain Setup Lab (SBL)
5. SEM VIII: HBCC801: DeFi (Decentralized Finance)

C. Name: Cyber Security

1. SEM-V: HCSC501: Ethical Hacking
2. SEM VI: HCSC601: Digital Forensic
3. SEM VII: HCSC701: Security Information Management
4. SEM VII: HCSSBL601: Vulnerability Assessment Penetration Testing (VAPT) Lab
5. SEM VIII: HCSC801: Application Security

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC501	Mechanical Measurements and Controls	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Handle, operate and apply the precision measuring instruments / equipment's.
	CO2	Analyze simple machined components for dimensional stability & functionality.
	CO3	Classify various types of static characteristics and types of errors occurring in the system.
	CO4	Classify and select proper measuring instrument for displacement, pressure, flow and temperature measurements.
	CO5	Design mathematical model of system/process for standard input responses and analyse error and differentiate various types of control systems and time domain specifications
	CO6	Analyse the problems associated with stability.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to Metrology, Need for inspection, Fundamental principles and definition, Standards of measurement, Errors in measurements, International standardization.	1,2,9	6
	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.	1,2,9	
2	2.1	Principles of interference, Concept of flatness, Flatness testing, Optical flats, Optical Interferometer and Laser interferometer	1,2	8
	2.2	Surface texture measurement: importance of surface conditions,	1,2,12	

		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	1,2,12	
	2.4	Gear measurement: Gear tooth comparator, Master gears, Measurement using rollers and Parkinson's Tester.	1,2,	
3	**3.1**	Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs.	3,4,5,12	6
	3.2	Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc.	3,4,5	
4	**4.1**	Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer	3,4,5,9,13	8
	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	3,4,5,13	
	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	3,4,5,13	
	4.4	Flow Measurement: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter	3,4,5,13	
	4.5	Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers	3,4,5	
5	**5.1**	Introduction to control systems, Classification of control system. Open loop and closed loop systems.	6,7,8	6
	5.2	Mathematical modelling of control systems, concept of transfer function, Block diagram algebra	6,7,8	
	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	6,7,8	
6	**6.1**	Stability analysis: Introduction to concepts of stability, The Routh criteria for stability	6,7,8	6

	6.2	Experimental determination of frequency response, Stability analysis using Root locus, Bode plot	6,7,8	
Total				**40**

Recommended 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, Oxford University 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

Course Assessment:

Theory:

ISE-1: Quiz and Assignments (20 marks)
ISE-2: Presentation on Article discussion/ latest trends (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC502	Thermal Engineering	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Analyze the three modes of heat transfer in engineering application.
	CO2	Develop mathematical models for different modes of heat transfer.
	CO3	Analyze performance parameters of different types of heat exchangers.
	CO4	Identify and analyze the Transient heat Transfer in engineering applications.
	CO5	Explain construction and working of different components of internal combustion engines.
	CO6	Evaluate engine performance and emission characteristics.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Modes of Heat Transfer:** Mechanism of conduction, Convection and radiation heat transfer and it's Governing laws.	1-9	7
	1.2	Generalized heat conduction equation in rectangular, cylindrical and spherical coordinates (only equations for cylindrical and spherical coordinates, no derivation).	1-9	
	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	1-9	
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.	1-9	6
	2.2	**Unsteady state heat transfer:** Lumped heat capacity Analysis. Applications of unsteady state heat transfer, Thermal time constant.	1-9	
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	1-9	7

		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	1-9	
	3.3	**Radiation:** Basics laws of radiation and heat exchange between two bodies.	1-9	
4	**4.1**	**Mass Transfer:** Introduction to Mass Transfer, governing equations of mass transfer. Mass transfer coefficient.	1-9	7
	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	1-9	
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.	10-14	6
	5.2	Introduction to Fuel Supply, Ignition, combustion and knocking in SI Engines. MPFI in SI Engine	10-14	
	5.3	Introduction to Fuel Injection system, Combustion and detonation in CI Engines.	10-14	
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	10-14	6
	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.	10-14	
Total				**39**

Recommended 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

Course Assessment:

Theory:

ISE-1: Quiz (10 marks) and Assignments (10 marks)
Continuous pre-defined rubrics-based evaluation
ISE-2: Quiz (10 marks) and Assignments (10 marks)
Continuous pre-defined rubrics-based evaluation
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC503	Dynamics of Machinery	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Demonstrate working Principles of different types of governors and Gyroscopic effects on the mechanical systems
	CO2	Illustrate basic of static and dynamic forces
	CO3	Determine natural frequency of element/system
	CO4	Determine vibration response of mechanical elements / systems
	CO5	Design vibration isolation system for a specific application
	CO6	Demonstrate basic concepts of balancing of forces and couples

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Governors:** Introduction to Centrifugal and Inertia governors, Study and Force analysis of Porter and Hartnell governors including Performance characteristics, Governors effort and power	3	7
	1.2	**Gyroscope:** Introduction, Gyroscopic couple and its effect on spinning bodies, naval ships during steering, pitching, rolling and their stabilization.	3	
2	2.1	Static and Dynamic force analysis of Slider crank mechanism (neglecting mass of connecting rod and crank), , Turning moment on crank shaft	3	5
	2.2	Dynamically equivalent systems to convert rigid body into two mass with and without correction couple(Case study- Connecting rod)	3	
3	3.1	**Basic 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	6
	3.2	**Free Undamped Single Degree of Freedom Vibration System:** Longitudinal, transverse, torsional vibration system, Methods for	3	

		formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's method		
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)	3	6
	4.2	**Equivalent Single Degree of Freedom Vibration System:** Conversion of multisprings, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system	3	
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)	3	8
	5.2	**Vibration Isolation and Transmissibility:** Force Transmissibility, motion transmissibility, typical isolators & mounts.	3	
	5.3	**Vibration Measuring instruments:** Principle of seismic instruments, vibrometer, accelerometer - undamped and damped, Introduction to conditioning monitoring and fault Diagnosis	3	
6	**6.1**	**Rotor Dynamics:** Critical speed of single rotor, undamped and damped	3	7
	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)	3	
Total				**39**

Recommended 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

Course Assessment:
Theory:

ISE-1: Quiz (20 marks)
ISE-2: Quiz (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC504	Finite Element Analysis	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	CAD/CAM, Engineering Mathematics - III	
Course Outcomes	CO1	Solve differential equations using weighted residual methods.
	CO2	Develop the finite element equations to model engineering problems governed by second order differential equations.
	CO3	Apply the basic finite element formulation techniques to solve engineering problems by using one dimensional elements.
	CO4	Apply the basic finite element formulation techniques to solve engineering problems by using two dimensional elements.
	CO5	Apply the basic finite element formulation techniques to find natural frequency of single degree of vibration system.
	CO6	Use commercial FEA software, to solve problems related to mechanical engineering.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM	1-3	5
	1.2	Mathematical Modelling of field problems in engineering, Governing Differential equations, primary/secondary variables, boundary conditions types-essential/natural etc.	1-3	
	1.3	Approximate solution of differential equations, Weighted residual techniques (Galerkin , Subdomain method).	1-3	
2		**FEA Procedure:(Pre-processing, Processing, Post-processing)**	1-3	8
	2.1	Discrete and Continuous Models, Weighted Residual Methods – Ritz Technique- Basic Concepts of the Finite Element Method.	1-3	
	2.2	Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom.	1-3	
	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.	1-3	
3		**One Dimensional Problems:**	1-3	10

	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	1-3	
	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)	1-3	
	3.3	Analysis of Plane trusses, Analysis of Beams	1-3	
4		**Two Dimensional Finite Element Formulations:**	1-3	5
	4.1	Introduction, three node triangular element, four node rectangular element	1-3	
	4.2	Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element	1-3	
	4.3	Convergence criterion, sources of errors	1-3	
5		**Two Dimensional Vector Variable Problems:**	1-3	6
	5.1	Equations of elasticity - Plane stress, plane strain and axi-symmetric problems	1-3	
	5.2	Jacobian matrix, stress analysis of CST.	1-3	
6		**Finite Element Formulation of Dynamics and Numerical Techniques:**	1-3	5
	6.1	Applications to free vibration problems of rod and beam, Lumped and consistent mass matrices.	1-3	
	6.2	Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation, transverse deflections and natural frequencies of beams.	1-3	
Total				**39**

Recommended 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.

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/

Course Assessment:

Theory:

ISE-1: Assignments (20 marks)

ISE-2: Article discussion based on application of FEM (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEDLO5011	Optimization Techniques	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	Engineering Mathematics-III & IV	
Course Outcomes	CO1	Identify the types of optimization problems and apply the calculus method to single variable problems.
	CO2	Formulate the problem as Linear Programming problem and analyse the sensitivity of a decision variable.
	CO3	Apply various linear and non-linear techniques for problem solving in various domain.
	CO4	Apply multi-objective decision making methods for problem in manufacturing environment and other domain.
	CO5	Apply multi criterion decision making methods for problem in manufacturing environment and other domain.
	CO6	Apply Design of Experiments method for Optimization

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	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	1-5	6
2	2.1	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.	1-5	8
3	3.1	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.	1-5	8
4	4.1	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming	6	8

		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)		
5	**5.1**	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	6	6
6	**6.1**	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)	7,8,9	8
Total				**44**

Recommended 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).
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

Course Assessment:

Theory:

ISE-1: Quiz (20 marks)
ISE-2: Software based mini project and presentation (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEDLO5012	Design of Experiments	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	Engineering Mathematics III	
Course Outcomes	CO1	Plan, design, and conduct experimental investigations efficiently and effectively
	CO2	Understand strategy in planning and conducting experiments
	CO3	Choose an appropriate experimentation scheme to evaluate a new product design or process improvement through experimentation strategy, data analysis, and interpretation of experimental results.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction, Background and Overview: A brief history of DOE-When to use DOE- Basic principles of DOE & Some typical applications. Overview of basic statistical concepts, Simple Comparative Experiments, Single Factor experiments, Randomized Blocks, Latin Square Designs and extensions. Testing of Hypothesis ('T'&'F' test), Introduction to Factorial Designs, 2^k Designs.	3,4,5,9	6
2	2.1	Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects including interaction effects and plots	3,4,5,9	6
3	3.1	Two & Three Level Fractional Factorial Design: Objective, The one-half fraction and one-quarter of the 2^k design, 2^{k-p} fractional factorial design, 3-level & Mixed-level Factorials & Fractional Factorials.	3,4,5,9	8
4	4.1	The Robust Design: Basics of robust designs, Loss Function, Taguchi designs, Orthogonal Arrays, Linear Graphs and Interaction effects, Signal to Noise Ratio, Parameter Design, Tolerance Design, Robust design example	1,2,3,9,10	8
5	5.1	Response Surface Methodology: First & second order experiments, Analysis of second-order response surfaces, Central composite designs, Plackett-Burman designs, process optimization & reliability improving experiments	6-10	6

6	**6.1**	Experiment Design According to Shainin, Multi-variate charts, components search, paired comparisons	7,9,10	6
Total				**40**

Recommended Books:

1. Statistics for Experimenters,Box, GEP, Hunter, WG, and Hunter, JS, 1978, Wiley.
2. Empirical Model-Building and Response Surfaces,Box, GEP and Draper, NR 1987, Wiley.
3. Experimental Designs, Cochran, WG and Cox, GM, 1957, Wiley.
4. The Design of Experiments, 8th Ed., Fisher, RA, 1966, Hafner.
5. Design and Analysis of Experiments (Vol I), Hinkelmann, K and Kempthorne, O, 1994, Wiley.
6. Optimal Design of Experiments,Pukelsheim, F, 1993, Wiley.
7. Statistical Principles in Experimental Design,2nd Ed., Winer, BJ, 1962, McGraw-Hill.
8. Engineering Methods for Robust Product Design: Using Taguchi Methods in Technology and Product Development, Fowlkes WY, Creveling CM, 1995, Addison-Wesley Publishing Company
9. Design and Analysis of Experiments, 5th edition, by D.C. Montgomery, John Wiley & Sons, New York, 2001
10. Total Quality Management, 4th Ed,Besterfield D.H., Carol BesterfieldM ,MaryBesterfileld Sacre, Besterfield G.H.,Urdhwareshe H, Urdhwareshe R,2015, Pearson

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/110/105/110105087/ - Design and Analysis of Experiments, IIT Kharagpur

https://nptel.ac.in/courses/111/104/111104075/ - Analysis of Variance and Design of ExperimentsI, IIT Kanpur

https://nptel.ac.in/courses/111/104/111104078/ - Analysis of Variance and Design of ExperimentsII, IIT Kanpur

Course Assessment:

Theory:

ISE-1: Quiz and Assignments (20 marks)
Continuous pre-defined rubrics-based evaluation

ISE-2: Quiz and Assignments (20 marks)
Continuous pre-defined rubrics-based evaluation

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEDLO5013	Computational Methods	3	--	--		3	--	--	3

Examination Scheme				
ISE1	MSE	ISE2	ESE	Total
20	30	20	100 (30% weightage)	100

Pre-requisite Course Codes		
Course Outcome-s	CO1	Understand and develop mathematical models of physical systems.
	CO2	Identify an appropriate mathematical formulation to linear algebraic equations.
	CO3	Build an appropriate mathematical formulation to non-linear algebraic equations.
	CO4	Evaluate and interpret the data regression, curve fitting and statistics.
	CO5	Apply the numerical techniques and numerical schemes.
	CO6	Formulate the concept of numerical methods in realistic applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Computational Methods** Motivation and applications of Computational Methods. Computation and Error Analysis: Accuracy and precision; Truncation and round-off errors (Numericals); Binary Number System; Error propagation.		6
2	2.1	**Linear Systems and Equations** Matrix representation: Cramer's rule; Gauss Elimination. Matrix Inversion: LU Decomposition; Iterative Methods; Relaxation Methods; Eigen Values and Eigen Vectors.		6
3	3.1	**Non Linear Algebraic Equations:** Bracketing methods: Bisection, Regula-Falsi. Crouts Method: LU Decomposition. Open methods: Secant, Fixed point iteration, Newton-Raphson; MultivariateNewton's method.		6
4	4.1	**Regression and Curve Fitting** Interpolation function; Cubic Splines; Multi regression analysis, polynomial regression.		8
	4.2	**Statistical methods:** Statistical representation of data, modeling and analysis of data, test of hypotheses.		

	4.3	**Fuzzy Logic:** Introduction to fuzzy logic, Fuzzy Logic Systems Architecture, Case study of Mechanical system.		
5	**5.1**	**Integration and Integral Equations** Newton Cotes Quadrature		7
	5.2	**ODEs: Initial Value Problems** Euler's methods; Predictor-corrector method (Adam's Moulton, Milne's Method)		
	5.3	**ODEs: Boundary Value Problems** Finite difference Method; Finite Element Method, Finite Volume Method		
6	**6.1**	**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.		6
Total				**39**

Recommended 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

Course Assessment:

Theory:

ISE-1: Quiz (20 marks)

ISE-2: Article discussion and presentation based on computation methods used in mechanical engineering (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEL501	Thermal Engineering	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		15		--	10	--		25	

Pre-requisite Course Codes		
Course Outcomes	CO1	Estimate thermal conductivity of engineering materials.
	CO2	Evaluate performance parameters of extended surfaces.
	CO3	Analyze heat transfer parameters in various engineering applications.
	CO4	Analyze engine performance and emission parameters at different operating conditions.

Sr. No.	Topics
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.
B)	**(any 4)**
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/Four stroke 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, Fourstroke Petrol Engine at constant speed/load along with Heat Balance Sheet (With Electrical/Rope Brake Dynamometer) (Load Test) under dual fuel mode

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1:
Part A experiments (15 Marks)
Continuous pre-defined rubrics-based evaluation

ISE-2:
Part B experiments (10 Marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEL502	Dynamics of Machinery	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Plot and analyze governor characteristics
	CO2	Analyze gyroscopic effect on laboratory model
	CO3	Estimate natural frequency of mechanical systems
	CO4	Analyze vibration response of mechanical systems
	CO5	Determine damping coefficient of a system
	CO6	Balance rotating mass

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

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1: 3 Experiments and 2 assignments (20 marks)
Continuous pre-defined rubrics-based evaluation

ISE-2: 5 Experiments and 3 assignments (30 marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEL503	Finite Element Analysis	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Select appropriate element for given problem
	CO2	Select suitable meshing and perform convergence test
	CO3	Select appropriate solver for given problem
	CO4	Interpret the result
	CO5	Apply basic aspects of FEA to solve engineering problems
	CO6	Validate FEA solution

Sr. No.	Topics
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: 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)
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.
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)

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1: 3 Experiments and course Project stage 1 evaluation (20 marks)
Continuous pre-defined rubrics-based evaluation
ISE-2: Remaining 3 Experiments and course Project stage 2 evaluation (30 marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MESBL501	Professional Communication And Ethics - II	2	--	2		--	--	2	2
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
	CO2	Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
	CO3	Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
	CO4	Deliver persuasive and professional presentations.
	CO5	Develop creative thinking and interpersonal skills required for effective professional communication.
	CO6	Apply codes of ethical conduct, personal integrity and norms of organizational behaviour

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**ADVANCED TECHNICAL WRITING :PROJECT/PROBLEM BASED LEARNING (PBL)**	[1], [2]	6
	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)		
	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 ● 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		
2		**EMPLOYMENT SKILLS**	[1], [2]	6
	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)		
		Statement of Purpose ● Importance of SOP ● Tips for Writing an Effective SOP		
		Verbal Aptitude Test ● Modelled on CAT, GRE, GMAT exams		
		Group Discussions ● Purpose of a GD ● Parameters of Evaluating a GD ● Types of GDs (Normal, Case-based & Role Plays) ● GD Etiquettes		
		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		
3	**3.1**	**BUSINESS MEETINGS** **Conducting Business Meetings** ● Types of Meetings ● Roles and Responsibilities of Chairperson, Secretary and Members ● Meeting Etiquette	[1], [2]	2
	3.2	**Documentation** ● Notice ● Agenda		

		● Minutes		
4	**4.1**	**TECHNICAL/ BUSINESS PRESENTATIONS** **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	[1], [2]	2
	4.2	**Group Presentations** ● Sharing Responsibility in a Team ● Building the contents and visuals together ● Transition Phases		
5	**5.1**	**INTERPERSONAL SKILLS** **Interpersonal Skills** ● Emotional Intelligence ● Leadership & Motivation ● Conflict Management & Negotiation ● Time Management ● Assertiveness ● Decision Making		8
	5.2	**Start-up Skills** ● Financial Literacy ● Risk Assessment ● Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)		
6	**6.1**	**CORPORATE ETHICS** **Intellectual Property Rights** ● Copyrights ● Trademarks ● Patents ● Industrial Designs ● Geographical Indications ● Integrated Circuits ● Trade Secrets (Undisclosed Information)	[1], [2]	2
	6.2	**Case Studies** ● Cases related to Business/ Corporate Ethics		

Recommended Reads

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

Course Assessment:

ISE-1 : Activities to be carried out
(1) Report/Proposal Writing (2) Movie Analysis to learn interpersonal skills (3) Reading & Understanding Statement of Purpose (4) Cover Letter and Resume - Continuous pre-defined rubrics-based evaluation for 20 marks.

ISE-2 :: Activities to be carried out
a. 1)Meeting Documentation (Notice, Agenda and Minutes) 2)Role Play/ Case Study Documentation 3) Technical Paper and GD 4) Quiz on IPR
Continuous pre-defined rubrics-based evaluation for 10 marks.
b. Report Presentation : 10 Marks
c. Group Discussion : 10 Marks

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEPBL501	Mini Project – 2A	--	--	4$		--	--	2	2
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

$ indicates work load of Learner (Not Faculty)

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Identify problems based on societal /research needs.
	CO2	Apply Knowledge and skill to solve societal problems in a group.
	CO3	Develop interpersonal skills to work as member of a group or leader.
	CO4	Draw the proper inferences from available results through theoretical/experimental/simulations.
	CO5	Analyse the impact of solutions in societal and environmental context for sustainable development.
	CO6	Use standard norms of engineering practices
	CO7	Excel in written and oral communication.
	CO8	Demonstrate capabilities of self-learning in a group, which leads to life long learning.
	CO9	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 shall 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.
- 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.

Course Assessment:

Laboratory Work: (ISE)

ISE-1: Continuous Evaluation by project guide followed by presentation at the mid semester before a panel of examiners (20 marks)
Continuous pre-defined rubrics-based evaluation

ISE-2: Continuous Evaluation by project guide followed by presentation at the mid semester before a panel of examiners (30 marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC601	Machine Design	4	--	--		4	--	--	4
		Examination Scheme							
		ISE1	MSE	ISE2	ESE	Total			
		20	30	20	100 (30% weightage)	100			

Pre-requisite Course Codes	Engineering Mechanics, Strength of Materials, Theory of Machines	
Course Outcomes	CO1	Use design data book/standard codes to standardise the designed dimensions
	CO2	Design Knuckle Joint, cotter joint and Screw Jack
	CO3	Design shaft under various conditions and couplings
	CO4	Select bearings for a given applications from the manufacturers catalogue
	CO5	Select and/or design belts and flywheel for given applications
	CO6	Design springs, clutches and brakes

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	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,	1-2	8
	1.2	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	1-2	
	1.3	Thick Cylinders: Design of thick cylinders subjected to an internal pressure using Lame's equation	1-2,12	
2	2.1	Design against static loads: Socket and Spigot Cotter joint, Knuckle joint, Bolted and welded joints under eccentric loading; Power Screw- Screw Jack.	1-2,12	8
3	3.1	Design against fluctuating loads: variables stresses, reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Endurance limitestimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria,	1-2,12	12
	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.	1-2,12	

		Couplings: Classification of coupling, Design of Flange couplings, Bush pin type flexible couplings		
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)	1-2,12	8
	4.2	Sliding Contact Bearings: Design of hydro dynamically lubricated bearings (self contained), Introduction to hydro static bearings	1-2,12	
5	**5.1**	Design and selection of Belts: Flat and V-belts with pulley construction.	1-2,12	8
	5.2	Design and selection of standard roller chains.	1-2,12	
	5.3	Design of Flywheel – Introduction, Fluctuation of energy and speed, turning moment diagram, estimating inertia of flywheel for reciprocating prime movers and machines, Weight of the flywheel, flywheel for punches, rim constructions, stresses in rims and arms, Construction of flywheel.	1-2,12	
6	**6.1**	Design of Springs: Helical compression, Tension Springs under Static and Variable loads, Leaf springs.	1-2,12	8
	6.2	Design of Clutches: Introduction, types, Basic theory of plate and cone type clutches, Design of single plate, multi-plate and with spring, lever design and thermal, wear Considerations	1-2,12	
	6.3	Design of Brakes: Design of single shoe brake	1-2,12	
Total				**52**

Recommended 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, KalaikathirAchchaga

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

Course Assessment:

Theory:

ISE-1:

Activity: Quiz 20 Marks

ISE-2:

Activity: Quiz 20 Marks

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC602	Turbo Machinery	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1	MSE	ISE2	ESE	Total			
		20	30	20	100 (30% weightage)	100			

Pre-requisite Course Codes	Applied Thermodynamics	
Course Outcomes	CO1	Define various parameters associated with steam generators and turbo machines.
	CO2	Identify various components and mountings of steam generators with their significance.
	CO3	Identify various turbo machines and explain their significance.
	CO4	Apply principles of thermodynamics and fluid mechanics to estimate various parameters like mass flow rate power, torque, efficiency, temperature, etc.
	CO5	Evaluate performance of SG and Turbo machines and apply various techniques to enhance performance.
	CO6	Evaluate various phenomena related to performance like cavitation, choking, surging.

Module No.	Unit No.	Topics	Ref.	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	4
	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.	2	4
2	2.1	**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	2	6
3	3.1	**Pumps**	2	2

		Classification of pumps, definition of pumping systems and system characteristics.		
	3.2	**3.2 Centrifugal pumps:** Construction, estimation of work done, efficiency, characteristics, determination of operating point, cavitation and NPSH, specific speed of pumps	2	4
	3.3	**Positive Displacement pumps:** 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).	2	4
4	**4.1**	**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).	1	4
5	**5.1**	**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.	1	6
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	1	5
	6.2	**Jet Propulsion Engines** Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency.	1	
Total				**39**

Recommended Books:

Text Books:-

1. Thermal Engineering, Ajoy Kumar, 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.
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 Cimbala Publisher: 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

Course Assessment:

Theory:

ISE-1: Assignments based on 50% syllabus (20 marks)
ISE-2: Assignments based on remaining 50% syllabus (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC603	Heating, Ventilation, Air Conditioning and Refrigeration	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1	MSE	ISE2	ESE	Total			
		20	30	20	100 (30% weightage)	100			

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Illustrate the fundamental principles and applications of refrigeration and air conditioning systems.
	CO2	Identify various HVAC&R components
	CO3	Evaluate performance of various refrigeration system
	CO4	Estimate cooling and heating loads for an airconditioning system.
	CO5	Select air handling unit & design air distribution system.
	CO6	Apply the knowledge of HVAC for the sustainable development of refrigeration and airconditioning systems.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Basic Knowledge:** Carnot refrigerator Carnot heat pump, Carnot coefficient of performance, Reversed Carnot cycle, and its limitation Effect of temperature and pressure on COP of the cycle	1-5	6
	1.2	**Refrigerants:** Classification, Designation, Selection of refrigerant, Physical and chemical properties of refrigerants, Secondary refrigerants	1-5	
	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-S diagram, Numerical based on simple and bootstrap air refrigeration system.	1-5	
2	2.1	**Vapour Compression 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 by using P-h chart .and refrigerant table	1-5	8
	2.2	**Vapour Absorption Refrigeration System.** Simple and practical, vapour absorption system Refrigerant-adsorbent properties, COP of ideal vapour absorption system, Domestic Electrolux refrigerator, Lithium bromide absorption system.	1-5	

	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 systems Heat pump application in an industry.	1-5	
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	1-5 and 6-10	10
	3.2	**Psychrometry of Air Conditioning Processes** Psychrometry properties, relations and processes, Adiabatic air mixing, process Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor, Apparatus dew point Numerical based on psychrometric chart and Classification of air conditioning system, relations	1-5 and 6-10	
	3.3	**Cooling Load Estimation** Introduction, Components of cooling load Different heat sources, Various load Estimation, Design of air conditioning system, Building survey and economic, aspect used in design.	1-5 and 6-10	
4	**4.1**	**Air Distribution System:** **4.1.1: Duct** Classification of ducts, duct material, pressure in ducts, Flow through duct, pressure losses in duct, Air flow through simple duct system, Equivalent diameter, Methods of duct system design **4.1.2: Air Handling Unit** Introduction Fan coil unit, Types of fans used air conditioning applications, Fan laws, Filters, supply and return grills, Sensors.	1-5 and 6-10	6
5	**5.1**	**HVACR & Components** Working of reciprocating, screw and scroll compressors, working of air cooled, and water cooled and evaporative condensers, Working of DX, Flooded, and Forced feed evaporators, Expansion devices Capillary tube, TXV, EXV, Type of insulation materials.	1-5 and 6-10	6
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.	1-5	3
Total				**39**

Recommended 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

Course Assessment:

Theory:

ISE-1: Quiz (10 marks) and Assignments (10 marks)
ISE-2: Quiz (10 marks) and Assignments (10 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEC604	Automation and Artificial Intelligence	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1	MSE	ISE2	ESE	Total			
		20	30	20	100 (30% weightage)	100			

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Demonstrate understanding of fundamentals of industrial automation and AI.
	CO2	Design & develop pneumatic / hydraulic circuits.
	CO3	Design and develop electropneumatic circuits and PLC ladder logics.
	CO4	Demonstrate understanding of robotic control systems and their applications.
	CO5	Demonstrate understanding of various AI and machine learning technologies.

Module No.	Unit No.	Topics	Ref.	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	1,20,3	4
	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	13,14	
2	2.1	**Design of Pneumatic Circuits** Design of Pneumatic sequencing circuits using Cascade method and Shift register method (up to 2 cylinders)	4,5,6	8
	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.	7,8,9	
3	3.1	**Electro-pneumatic Circuits** Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping	4,5	8
	3.2	**PLC Discrete Control Systems**	4,5	

		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.		
4	**4.1**	**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.	10,11	7
5		**(Concept and Algorithms, No programming or numericals)**		6
	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	13,14	
	5.2	**Machine Learning:** Introduction, types of machine learning: supervised, unsupervised, reinforcement learning	13,14	
	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	13,14	
6		**(Concept and Algorithms, No programming or numericals)**		6
	6.1	**Learning with regression:** Linear regression, Logistic regression	13,14	
	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	13,14	
	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	13,14	
Total				**39**

Recommended 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/

Course Assessment:

Theory:

ISE-1: Quiz (20 marks)
ISE-2: Presentation on article discussion / latest trends (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEDLO6021	Press Tool Design	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1		MSE	ISE2	ESE			Total
		20		30	20	100 (30% weightage)			100

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Demonstrate various press working operations for mass production of sheet metal parts
	CO2	Identify press tool requirements to build concepts pertaining to design of press tools
	CO3	Prepare working drawings and setup for economic production of sheet metal components
	CO4	Select suitable materials for different elements of press tools
	CO5	Illustrate the principles and blank development in bent & drawn components
	CO6	Understand safety aspects and automation in press working

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Press Working**	1-6	6
	1.1	1.1 Classification of common Press working operations, Benefits and limitations of using Press tools. Applications of pressed parts / components.	1-6	
	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.	1-6	
2		**Design Progressive die**		10
	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	1,4,5	
	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.	1,4,5	

	2.3	Centre of pressure, Different types Die sets and its selection, shut height of die, Problems based design of progressive die	1,4,5	
3		**Bending and Drawing**		8
	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	1,4,5	
	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	1,4,5	
	3.3	Defects in drawn parts	1,5	
	3.4	Basic construction and working of Bending and Drawing dies	1,4,	
4	**4.1**	**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	1,4,5	4
5	**5.1**	**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)	1,4,5	4
6	**6.1**	**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.	6	4
Total				**36**

Recommended 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

Course Assessment:

Theory:

ISE-1: Quiz (20 marks)

ISE-2: Case study presentation on press tool design (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEDLO6022	Tool Engineering	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1	MSE	ISE2	ESE				Total
		20	30	20	100 (30% weightage)				100

Pre-requisite Course Codes	Production Processes	
Course Outcomes	CO1	Calculate the values of various forces involved in the machining operations
	CO2	Design various single and multipoint cutting tools
	CO3	Analyze heat generation in machining operation and coolant operations
	CO4	Illustrate the properties of various cutting tool materials and hence select an appropriate tool material for particular machining application
	CO5	Demonstrate the inter-relationship between cutting parameters and machining performance measures like power requirement, cutting time, tool life and surface finish
	CO6	Analyze economics of machining operations

Module No.	Unit No.	Topics	Ref.	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.	1,2,3	8
	1.2	**Dynamometry:** Dynamometer requirements, force measurement, electric transducers, strain gauge lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, piezoelectric dynamometry	5,6,8	
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	1,2,3,4	5

		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		
3		**Cutting tool materials and machining induced surface integrity**	1,2,3,4	4
	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	1,2,3,4	
	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	1,2,3,4	
4		**Tool life and Machining Economics:**		6
	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	1,2,3,4	
	4.2	Components of product cost, Optimum cutting velocity for minimum cost of production and maximum production rate, problems on above topic.	1,2,3,4	
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.	1-8	5
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.	1-8	8
Total				**36**

Recommended 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

Course Assessment:

Theory:

ISE-1: Quiz (20 marks)
ISE-2: Assignment on cutting tool design and cutting force measurement (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEDLO6023	Metal Forming Technology	3	--	--		3	--	--	3
		Examination Scheme							
		ISE1	MSE	ISE2	ESE				Total
		20	30	20	100 (30% weightage)				100

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Understand the concept of different metal forming process.
	CO2	Approach metal forming processes both analytically and numerically
	CO3	Design metal forming processes
	CO4	Develop approaches and solutions to analyze metal forming processes and the associated problems and flaws.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**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 Mechanical Properties.	1-7	8
2	2.1	**Rolling:** Introduction and Classification, Types of Rolling Mills, Forces and Geometrical Relationships in Rolling, Calculation of Rolling Load, Roll Pass Design, and Defects in Rolled Products.	2-7	7
3	3.1	**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 in forging.	2-7	7
4	4.1	**Extrusion:** Introduction and Classification, Extrusion Equipment, Forces in extrusion, Analysis of Extrusion Process, Extrusion of	2-7	6

		components including Seamless Pipes and Tubes. Extrusion of pipes by cold working,		
5	**5.1**	**Drawing:** Introduction and Classification, Wire Drawing, Rod Drawing, Tube Drawing, Deep Drawing, Analysis of Wire Drawing Process and Load Calculations.	2-7	6
6	**6.1**	**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	2-7	6
Total				**40**

Recommended 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

Course Assessment:

Theory:

ISE-1: Quiz (10 marks) and Assignments (10 marks)
ISE-2: Presentation on latest trends in metal forming (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEL601	Machine Design	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes	Engineering Mechanics, Strength of Materials	
Course Outcomes	CO1	Design shaft under various conditions
	CO2	Design Knuckle Joint / cotter joint
	CO3	Design Screw Jack
	CO4	Design Flexible flange couplings/ Leaf spring
	CO5	Convert design dimensions into working/manufacturing drawing
	CO6	Use design data book/standard codes to standardise the designed dimensions.

Sr. No.	Topics
a)	**Design Exercises** (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.

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1:
One Design Exercises and Two Assignment (20 Marks)
Continuous pre-defined rubrics-based evaluation

ISE-2:
Two Design Exercise and Two Assignments (25 Marks)
Software Analysis (5 Marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEL602	Turbo Machinery	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		10		--	15	--		25	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Differentiate boiler, boiler mountings and accessories
	CO2	Conduct a trial on reciprocating compressor / centrifugal compressor.
	CO3	Conduct a trial on impulse turbine and analyze its performance
	CO4	Conduct a trail on reaction turbine and analyze its performance
	CO5	Conduct a trial on Centrifugal pump and analyze its performance
	CO6	Conduct a trial on Reciprocating pump and analyze its performance
	CO7	Conduct a trial on gear pump

Sr. No.	Topics
A)	**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)
B)	**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

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1: Group A 3 experiments (10 marks)
Continuous pre-defined rubrics-based evaluation
ISE-2: Group A 4 experiments and Group B experiments (15 marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEL603	Heating, Ventilation, Air Conditioning and Refrigeration	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Aware of the roles and ethics of HVAC &R engineers in related industries.
	CO2	Present the impact of professional engineering solutions in societal and environmental contexts.
	CO3	Evaluate performance of HVAC &R systems
	CO4	Develop awareness of the engineering and technological aspects in the HVAC &R industries.
	CO5	Communicate effectively through the preparation of report and practical presentation.
	CO6	Analyse of HVAC&R in various application

Sr. No.	Topics
A)	**List of Experiments**
1	Study and performance on simple vapour compression test rig .
2	Study and performance of heat pump test rig .
3	Trial on Vapour absorption refrigeration test rig.
4	Perform humidification and dehumdification 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 water cooler 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
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

	Industrial visit on any HVAC &R plant

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1: Experiments (20 marks)
Continuous pre-defined rubrics-based evaluation
ISE-2: case study presentation (10 marks)
Industrial Visit Report and discussion (20 marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MESBL601	Measurements and Automation	--	--	4		--	--	2	2
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Apply inspection gauge to check or measure surface parameters.
	CO2	Measure surface parameters using precision measurement tools and equipment.
	CO3	Measure different mechanical parameters by using sensors.
	CO4	Analyse the response of a control systems.
	CO5	Demonstrate use of automated controls using pneumatic and hydraulic systems.
	CO6	Implement program on PLC system and demonstrate its application

Sr. No.	Topics
A)	**Metrology (minimum 3)**
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
B)	**Mechanical Measurement (minimum 3)**
1	Experiments on measurement of displacement by sensors like LVDT, Potentiometers etc. lab view
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
C)	**Automation (minimum 3)**
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	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	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).

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

Course Assessment:

Laboratory Work: (ISE)

ISE-1: Part A (20 marks)
Continuous pre-defined rubrics-based evaluation
ISE-2: Part B (15 marks)
Part C (15 marks)
Continuous pre-defined rubrics-based evaluation

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MEPBL601	Mini Project - 2B	--	--	4$		--	--	2	2
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

$ indicates work load of Learner (Not Faculty)

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Identify problems based on societal /research needs.
	CO2	Apply Knowledge and skill to solve societal problems in a group.
	CO3	Develop interpersonal skills to work as member of a group or leader.
	CO4	Draw the proper inferences from available results through theoretical/experimental/simulations.
	CO5	Analyse the impact of solutions in societal and environmental context for sustainable development.
	CO6	Use standard norms of engineering practices
	CO7	Excel in written and oral communication.
	CO8	Demonstrate capabilities of self-learning in a group, which leads to life long learning.
	CO9	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 shall 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.
- 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.

Course Assessment:

Laboratory Work: (ISE)

ISE-1: Continuous Evaluation by project guide followed by presentation at the mid semester before a panel of examiners (20 marks)

ISE-2: Continuous Evaluation by project guide followed by presentation at the mid semester before a panel of examiners (30 marks)