AC –
Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1 , 4, 5		
Name of the Programme – B.E. (Mechanical Engineering)		
Faculty of Engineering		
Board of Studies in Mechanical Engineering		
U.G. Third Year Programme	**Exit Degree**	**B.Sc. Tech. Engineering-Mechanical Engineering.**
Semester		**V & VI**
From the Academic Year		**2026-27**

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:**_____	**B.E. (Mechanical Engineering)**
2	**Exit Degree**	**B.Sc. Tech. Engineering- Mechanical Engineering.**
3	**Scheme of Examination** **R:** _____	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	**Standards of Passing** **R:** _____	**40%**
5	**Credit Structure** **R:** _____	**Attached herewith**
6	**Semesters**	**Sem. V & VI**
7	**Program Academic Level**	**5.5**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2026-27**

Sd/-	**Sd/-**	**Sd/-**
Dr. S. M. Khot	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS-Chairman-Mechanical Engineering	**Associate Dean**	**Dean**
Faculty of Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The third-year engineering course is a core training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, multidisciplinary minor, and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program and skills required for the Mechanical Engineering Branch of engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends in technology. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Mechanical Engineering in Engineering for open electives and multidisciplinary minor courses in the third and fourth semesters. Essentially, to give a glimpse of trends in the industry under vocational and enhanced skill practices, the pool is offered to nurture and develop creative skills in contemporary industrial practices. Criteria met in the structure is the opportunity for learners to choose the course of their interest in all disciplines.

Program Core Course Cover Mechanical Engineering core courses. Also, OE and MDM where a pool of subjects are given for selection. Considering the present scenario, diverse choices need to be made available to fulfill the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. Ability enhancement can be achieved in Undergraduate training by giving an objective viewpoint to the learning process and transitioning a learner from a rote learner to a creative professional. for the purpose Design Thinking is introduced in the First Semester to orient a journey learner to become a skilled professional. Considering the NEP-2020 structure of award of Certificate & Diploma at multiple exit-point pools of Vocational skills is arranged for giving exposure to the current Industry practices.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught, which will enhance the learner's learning process. NEP 2020 grading system enables a much-required shift in focus from teacher-centric to continuous-based learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation, which will enhance the quality of education. Credit assignment for courses is based on a 15-week teaching-learning process for NEP 2020, however, the content of courses is to be taught in 12-13 weeks, and the remaining 2-3 weeks are to be utilized for revision, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the second-year syllabus must not be heavily loaded to the learner and it is of utmost importance that the learner entering into the third year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a learner to get accustomed to the new environment of a college and to create a bond between the teacher and the learner. The present curriculum will be implemented for the Third Year of Engineering from the academic year 2026-27. Subsequently, this system will be carried forward for Final Year Engineering in the academic year 2027-28.

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B.Sc. Tech. Engineering- Mechanical Engineering.

Credit Structure (Sem. V & VI)

	R: _____C								
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC ,IKS**	**OJT, FP, CEP, CC, RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.0	V	PCC501:3 PCC502:3 PCC503:3 PCL501:1 PCL502:1 PCL503:1	PEC501:3 PEL501:1	MDC:3 MDL:1	OE:2	--	IKS:2	--	24	B.Sc. Tech. Engineering - 48
	R:_____D									
	VI	PCC601:3 PCC602:3 PCL601:1 PCL602:1	PEC601:3 PEC602:3 PEL601:1 PEL602:1	MDC: 3 MDL:1	--	VSEC: 2	AEC:2	--	24	
	Cum Cr.	20	12	8	2	2	2+2	--	48	

Exit option: Award of BSc. Tech Engineering with 138 credits and additional 4 credits core **one** theory subject with 3 credits and **one** lab with 1 credit from one final year from where they want to take Exit degree. Along with theory and practical course student must compulsory do internship for **one month or 160 hours** which internship is equal to 4 credits.

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

THIRD YEAR MECHANICAL ENGINEERING SCHEME

SEM. - V

Program Structure for Third Year of Mechanical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER V

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total Credits
2405111	Fluid Mechanics and Machinery	3	-	-	3	-	-	3
2405112	Measurements and Control	3	-	-	3	-	-	3
2405113	CAD/CAM & CAE	3	-	-	3	-	-	3
2405114X	PEC-1	3	-	-	3	-	-	3
@MDC501	Multidisciplinary Minor	3	--	--	3	--	--	3
2405115	Fluid Mechanics and Machinery lab	--	2	--	--	1	-	1
2405116	Measurements and Control lab	--	2	--	--	1	-	1
2405117	CAD/CAM/CAE Lab	--	2	--	--	1	-	1
2405118X	PEL-1 Lab	--	2	--	--	1	-	1
@MDL501	Multidisciplinary Minor (Lab)	--	2	--	--	1	--	1
#OECL501	To be taken from the bucket provided by the university	2	--	--	2	--	--	2
2405511	Indian Knowledge System-II	--	2*+2	--	--	2	--	2
	Total	**17**	**14**	**0**	**17**	**7**	**0**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

- Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Institute shall offer a course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

@Institute shall offer a course for MDM from other Engineering Branch.

Course Code	Course Description
24051141	PEC-1 - Dynamics of Machinery
24051142	PEC-1 - Vibration Analysis & Control
24051143	PEC-1 - Machinery Diagnostics

Course Code	Lab Description
24051181	PEL-1 Vibration and Machinery Diagnostics Laboratory

Course Code	Course Description	Examination Scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2405111	Fluid Mechanics and Machinery	20	20	40	60	2	--	--	100
2405112	Measurements and Control	20	20	40	60	2	--	--	100
2405113	CAD/CAM & CAE	20	20	40	60	2	--	--	100
2405114X	PEC-1	20	20	40	60	2	--	--	100
@MDC501	Multidisciplinary Minor	20	20	40	60	2	--	--	100
2405115	Fluid Mechanics and Machinery lab	--	--	--	--	--	25	--	25
2405116	Measurements and Control lab	--	--	--	--	--	25	25	50
2405117	CAD/CAM/CAE Lab	--	--	--	--	--	25	25	50
2405118X	PEL-1 Lab	--	--	--	--	--	25	25	50
@MDL501	Multidisciplinary Minor (Lab)	--	--	--	--	--	25	25	50
#OECL501	To be taken from the bucket provided by the university	--	--	--	--	--	50	--	50
2405511	Indian Knowledge System-II	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**100**	**825**

Program Structure for Third Year of Mechanical Engineering
UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER VI

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total Credits
2406111	Machine Design	3	--	--	3	--	--	3
2406112	Thermal Engineering	3	--	--	3	--	--	3
2406113X	PEC-2	3	--	--	3	--	--	3
2406114X	PEC-3	3	--	--	3	--	--	3
@MDC601	Multidisciplinary Minor	3	--	--	3	--	--	3
2406411	Mini Project - II	--	4	--	--	2	--	2
2406511	Professional Skills	--	2*+2	--	--	2	--	2
2406115	Machine Design lab	--	2	--	--	1	--	1
2406116	Thermal Engineering lab	--	2	--	--	1	--	1
2406117X	PEL-2 Lab	--	2	--	--	1	--	1
2406118X	PEL-3 Lab	--	2	--	--	1	--	1
@MDL601	Multidisciplinary Minor Lab	--	2	--	--	1	--	1
Total		**15**	**18**	**00**	**15**	**09**	**00**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

- Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

@Institute shall offer a course for MDM from other Engineering Branch.

Course Code	**Course Description (**PEC-2)
24061131	PEC-2 - Refrigeration & Air-Conditioning
24061132	PEC-2 - Heating, Ventilation, Air-Conditioning & Refrigeration
24061133	PEC-2 - Cryogenics

Course Code	**Course Description (**PEC-3)
24061141	PEC-3 - Robotics
24061142	PEC-3 - Internet of Things (IoT)
24061143	PEC-3 - Industrial Automation
24061144	PEC-3 - Unmanned Aerial Vehicles

Course Code	**Lab Description (**PEL-2)
24061171	PEL-2 - Heating, Ventilation, Air-Conditioning & Refrigeration Lab

Course Code	**Lab Description (**PEL-3)
24061181	PEL-3 Robotics Lab
24061182	PEL-3 Internet of Things (IoT) Lab
24061183	PEL-3 Industrial Automation Lab
24061184	PEL-3 Unmanned Aerial Vehicles Lab

Course Code	Course Description	Examination Scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2406111	Machine Design	20	20	40	60	2	--	--	100
2406112	Thermal Engineering	20	20	40	60	2	--	--	100
2406113X	PEC-2	20	20	40	60	2	--	--	100
2406114X	PEC-3	20	20	40	60	2	--	--	100
@MDC601	Multidisciplinary Minor	20	20	40	60	2	--	--	100
2406411	Mini Project - II	--	--	--	--	--	50	--	50
2406511	Professional Skills	--	--	--	--	--	25	--	25
2406115	Machine Design lab	--	--	--	--	--	25	25	50
2406116	Thermal Engineering lab	--	--	--	--	--	25	25	50
2406117X	PEL-2 Lab	--	--	--	--	--	25	25	50
2406118X	PEL-3 Lab	--	--	--	--	--	25	25	50
@MDL601	Multidisciplinary Minor Lab	--	--	--	--	--	25	25	50
Total		**100**	**100**	**200**	**300**	**10**	**200**	**125**	**825**

VERTICAL – 1

MAJOR

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*2405111	Fluid Mechanics and Machinery	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs.)			
		Test 1	Test 2	Total					
*2405111	Fluid Mechanics and Machinery	20	20	40	60	2	-	-	100

***This course is common with Mechanical Engineering Automobile, Automobile Engineering**

Rationale:

The course on Fluid Mechanics and Machinery provides fundamental knowledge of fluid behaviour and its applications in engineering systems. It enables students to understand and analyse fluid properties, flow behaviour, and the performance of hydraulic machines, such as pumps and turbines.

Aligned with the NEP 2020 guidelines, the syllabus emphasises conceptual clarity, analytical thinking, and practical application. It prepares students to evaluate and design fluid systems, thereby building competence for industry, higher studies, and research in mechanical and allied engineering domains.

Course Objectives:

1. To study the properties of fluid and hydrostatic forces on various surfaces.
2. To study fluid kinematics and fluid dynamics.
3. To study laminar viscous force and flow through Pipes.
4. To analyse the behavior and control of boundary layers in fluid flow, and study the impact of free jets on surfaces.
5. To understand the construction, working principles, and performance characteristics of turbines, and to study the significance of draft tubes.
6. To understand the construction and working principles of pumps, and to study their performance characteristics.

Course Outcomes: Learner will be able to…

1. Understand the fundamental properties and behaviors of fluids, and explain the principles of fluid statics
2. Analyse the motion of fluids using fundamental principles of kinematics and dynamics, and apply Bernoulli's and momentum equations to evaluate flow parameters and performance of flow-measuring devices.
3. Apply the principles of laminar and turbulent flow to analyse viscous fluid motion through pipes.
4. Analyse fluid flow phenomena using dimensional analysis, interpret boundary layer behaviors and their control, and examine the impact of free jets on surfaces.
5. Apply the principles of fluid mechanics to explain the construction and working of impulse and reaction turbines, and analyse their performance characteristics with respect to draft tubes and specific speed.
6. Apply the principles of fluid mechanics to explain the classification, working of centrifugal and reciprocating pumps, and analyse their performance characteristics with respect to multi-stage operation, cavitation, and the use of air vessels.

Prerequisite:

Knowledge of Engineering Mechanics, Engineering Physics, and Basic Thermodynamics — including concepts of pressure, force, energy, and properties of fluids.

Detailed Syllabus:

Sr. No.	Module	Detailed Content	Hrs.	CO Mapping
I	Properties of Fluid & Fluid Statics	1.1Properties of Fluid: Significance of Fluid Mechanics, Properties of Fluid, Newton's Law of Viscosity, Types of Fluids. 1.2Fluid Statics: Pascal's Law, Hydrostatic Law,Hydrostatic Forces on Surfaces (Horizontal, Vertical, Inclined & Curved).	5	CO1
II	Fluid Kinematics & Fluid Dynamics	2.1 Fluid Kinematics: Description of Fluid Motion, Types of Fluid Flow, Types of Flow Lines, Continuity Equation in Cartesian Co-ordinates, Acceleration of Fluid Particle, Velocity Potential Function & Stream Function. 2.2 Fluid Dynamics: Importance of Reynolds Transport Theorem and its derivation (no numerical), Forces acting on Fluid in Motion, Euler's equation in Cartesian Coordinate, Bernoulli's equation by integration of Euler's Equation, Practical application of Bernoulli's equation (Venturimeter, Orificemeter, Pitot Tube & Rotameter), Impulse Momentum Equation and its application to determine the resultant fore acting on Pipe bends.	7	CO2

III	Laminar Flow & Flow through Pipes	3.1 Laminar Flow: Introduction to Reynolds Number, Reynolds Experiment, Physical Significance of Navier-Stokes Equation of Motion (no derivation), Flow of Viscous Fluid in Circular Pipe (Hagen Poiseuille Flow), Flow of Viscous Fluid between Two Parallel Plates (Couette Flow and Plane Poiseuille Flow. 3.2 Flow through Pipes: Loss of Energy in Pipes (Major and Minor), Hydraulic Gradient & Total Energy Lines, Pipes in Series & Parallel, Equivalent Pipe.	7	CO3
IV	Boundary Layer Theory &Impacts of Free Jets	4.1 Boundary Layer Theory: Boundary Layer Definitions and Characteristics, Boundary Layer Thickness, Displacement Thickness, Momentum Thickness and Energy Thickness, Boundary Layer Separation & Methods to control Separation. 4.2 Impacts of Free Jets: Introduction, Force exerted by the jet on the stationary and the moving plate. 4.3 Hydraulic Machines: Hydraulic Press, Crane, Ram, Coupling, Torque Converter. *Self Study: Introduction and Methods of Dimensional Analysis (Rayleigh's Method & Buckingham's π-Method)	6	CO4
V	Hydraulic Turbines	Hydraulic Turbines: Introduction, Classification of Hydraulic Turbines, Construction, Working, Work Done and Efficiencies of Impulse and Reaction Turbines, Draft Tube (no numerical), Specific Speed, Unit Quantities, Performance Characteristics of Hydraulic Turbine.	7	CO5
VI	Hydraulic Pumps	Hydraulic Pumps: 6.1 Centrifugal Pump: Classification of Centrifugal Pumps, Construction and Working of Centrifugal Pump, Minimum Speed for Starting a Centrifugal Pump, Losses and Efficiencies of Centrifugal Pumps, Multi-stage Centrifugal Pumps, Specific Speed, Net Positive Suction Head (NPSH), Cavitation and Priming in Centrifugal Pump. 6.2 Reciprocating Pump: Classification of Reciprocating Pumps, Working of Single-acting and Double-acting Reciprocating Pumps, Discharge, Work done and Power required for Reciprocating Pump, Effect of Acceleration of Piston on Velocity and Pressure in the Suction and Delivery Pipes, Indicator Diagram (no numerical), Air vessel (no numerical)	7	CO6

***Self Study Note:** No questions to be asked in theory examination however the question can be asked in assignment.

Text Books:

1. R. K. Rajput – Fluid Mechanics and Hydraulic Machines, S. Chand & Company Ltd.
2. Bansal, R.K. – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications (P) Ltd.
3. Jagdish Lal – Hydraulic Machines Including Fluidics, Metropolitan Book Co. Pvt. Ltd.
4. K. L. Kumar – Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd, 1st Edition and Reprint 2016.
5. Dr P.N. Modi and Dr S.M. Seth – Hydraulics and Fluid Mechanics, including Hydraulic Machines, Standard Book House, Delhi.
6. D.S. Kumar – Fluid Mechanics and Fluid Power Engineering, Kataria & Sons.

References:

1. R.S. Khurmi – A Textbook of Hydraulics, Fluid Mechanics and Hydraulic Machines S. Chand & Company Ltd.
2. Yunus A. Çengel & John M. Cimbala, Fluid Mechanics: Fundamentals and Applications, McGraw-Hill Education.
3. Frank M. White, Fluid Mechanics, McGraw-Hill Education.
4. Sadhu Singh – Fluid Machinery and Hydraulic Machines, Khanna Publishers, New Delhi.
5. S. K. Ukarande – Fluid Mechanics and Hydraulics, Ane Books Pvt. Ltd., Revised and Updated 1st Edition, 2026.
6. Bruce R. Munson, Donald F. Young, and Theodore H. Okiishi – Fundamentals of Fluid Mechanics, Wiley India.
7. Victor L. Streeter, E. Benjamin Wylie, and Keith W. Bedford – Fluid Mechanics, McGraw-Hill Education.
8. J. F. Douglas, J. M. Gasiorek, and J. A. Swaffield – Fluid Mechanics, Pearson Education.
9. A. K. Jain – Fluid Mechanics including Hydraulic Machines, Khanna Publishers.
10. R. P. Saini – Fluid Mechanics & Fluid Machines, (IIT Roorkee publication).
11. Saiful Islam – Hydraulics and Hydraulic Machines, V.E.I. India.

Online References:

1. Fluid Mechanics by **Prof. S.K. Som**, IIT Kharagpur
   https://nptel.ac.in/courses/112105183
2. Hydraulic Machines by **Prof. Subhash C. Mishra**, IIT Guwahati
   https://nptel.ac.in/courses/112103174
3. Fluid Machines by **Prof. Suman Chakraborty**, IIT Kharagpur
   https://onlinecourses.nptel.ac.in/noc21_me75
4. Fluid Mechanics by **Prof. T. I. Eldho**, IIT Bombay
   https://nptel.ac.in/courses/105101082?utm
5. Introduction to Fluid Mechanics for Mechanical Engineers by Prof. **P.M.V. Subbarao**
   https://web.iitd.ac.in/~pmvs/course_MCL106.php
6. Fluid Mechanics for Engineers
   https://swayam.gov.in
7. Fluid Mechanics (2.25) – MIT
   https://ocw.mit.edu/courses/mechanical-engineering/2-25-advanced-fluid-mechanics-fall-2013/

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2405112	Measurements and Control	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2405112	Measurements and Control	20	20	40	60	2	--	--	100

Rationale :

Imparting fundamental knowledge of metrology, instrumentation, and control systems essential for mechanical engineering applications, to enables students to measure, analyze, and control various physical parameters with accuracy and reliability, as well as build a foundation for understanding automation, quality control, and system performance, preparing students for careers in manufacturing, process industries, and modern engineering systems.

Course Objectives:

1. To understand the fundamental concepts of metrology, standards of measurement, and the principles of limits, fits, tolerances, and gauging.
2. To study methods of precision measurement using interferometry, surface roughness testing, and measurement of threads and gears for assessing component accuracy.
3. To understand the structure of measurement systems, their elements, and to analyze their static and dynamic characteristics affecting measurement accuracy.
4. To learn about mechanical and process variable measurements including displacement, strain, pressure, flow, and temperature.
5. To gain knowledge of control system fundamentals, develop mathematical models, and analyze system response in time domain for first and second order systems.
6. To understand and apply various stability analysis and frequency response techniques such as Routh, Root Locus, and Bode plots for evaluating system performance.

Course Outcomes:

1. Explain fundamentals of metrology, standards, limits, fits, and gauges.
2. Analyze measurement of surface, thread, and gear parameters using interferometric and precision tools.
3. Describe measurement systems and evaluate their static and dynamic behavior.
4. Measure various mechanical and process variables using suitable sensors and transducers.
5. Model and analyze control systems for dynamic and steady-state performance.
6. Evaluate control system stability and frequency response using classical techniques.

Prerequisite:

1. Basic knowledge of Engineering Physics – units, measurement errors, and optical principles.
2. Fundamentals of Electrical and Electronics Engineering – circuits, bridge networks, and signal behavior.
3. Basic concepts of Thermodynamics and Fluid Mechanics – pressure, temperature, and flow fundamentals.
4. Mathematical background – differential equations and Laplace transforms for system modeling.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Fundamentals of Metrology and Limits, Fits, and Gauge	1.1 Introduction to Metrology, Need for inspection, Coordinate measurement machine, Fundamental principles and definition, Standards of measurement, Errors in measure-ments, International standardization. 1.2 Limits, fits and tolerances of interchangeable manufacture, Elements of interchangeable system, Hole based and shaft based systems, Tolerance grades, Types of fits, General requirements of Go & No go gauging, Taylor's principle, Design of Go & No go gauges.	06	CO1

II	Interferometry, Surface, Thread, and Gear Measurement	2.1 Principles of interference, Concept of flatness, Flatness testing, Optical flats, Optical Interferometer and Laser interferometer. 2.2 Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters - Ra, Ry, Rz, RMS value etc., Surface roughness measuring instruments. Form measurement machine. 2.3 Screw Thread measurement: Two wire and three wire methods, Floating carriage micrometer, Profile projector. 2.4 Gear measurement: Gear tooth comparator, Master gears, Measurement using rollers and Parkinson's Tester.	08	CO2
III	Fundamentals and Characteristics of Measurement Systems	3.1 Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs. 3.2 Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc. 3.3 Dynamic characteristics: speed of response, fidelity, lag etc.	05	CO3
IV	Measurement of Mechanical and Process Variables	4.1 Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Nozzle Flapper Transducer. 4.2 Strain Measurement: Theory of Strain Gauges, gauge factor, temperature Compensation 4.3 Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows 4.4 Flow Measurement: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter.	08	CO4

		4.5 Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples *****Self Study topics: Strain measurement: Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors, Pressure measurement: High Pressure Measurements, Bridge man gauge, Vacuum measurement: Vacuum gauges viz. McLeod gauge, Thermal conductivity gauges. Temperature measurement: Pyrometers.		
V	Basics of Control Systems and System Modelling	5.1 Introduction to control systems, Classification of control system. Open loop and closed loop systems. 5.2 Mathematical modelling of control systems, concept of transfer function, Block diagram algebra. 5.3 Transient and steady state analysis of first and second order system. Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp and parabolic inputs	06	CO5
VI	Stability and Frequency Response Analysis	6.1 Stability analysis: Introduction to concepts of stability, The Routh criteria for stability. 6.2 Experimental determination of frequency response, Stability analysis using Root locus, Bode plot.	06	CO6

***Self Study Topics Note:** No questions to be asked in theory examination however the question can be asked in assignment.

Text Books:

1. Engineering. Metrology, I.C. GUPTA, Dhanpat Rai Publications.
2. Engineering. Metrology, R. K. Jain, Khanna Publisher.
3. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
4. Control System Engineering by Nagrath I.J. and Gopal M, Wiley EasternLtd. **5.** Modem Control engineering: by K. Ogata, Prentice Hall

References:

1. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
2. Engineering Metrology and Measurements by N V Raghavendra and L Krishnamurthy, Oxford University Press.
3. Mechanical Measurements by S P Venkateshan, John Wiley & Sons
4. Instrumentation & Mechanical Measurements, A. K. Thayal
5. Control systems by Dhanesh Manik, Cengage Learning
6. Instrumentation and Control System, W. Bolton, Elsevier
7. Experimental Methods for Engineers by J P Holman, McGraw Hills Int. Edition
8. Engineering Experimentation by EO Doebelin, McGraw Hills Int. Edition

Links for online NPTEL/SWAYAM courses:

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

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2405113	CAD/CAM & CAE	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2405113	CAD/CAM & CAE	20	20	40	60	2	--	--	100

Rationale:

CAD/CAM/CAE plays a crucial role in engineering product development by enabling accurate digital modeling, modification, simulation, digital prototyping and analysis of complex components. Understanding geometric modeling principles, transformation techniques, assembly strategies, reverse engineering workflows, and data exchange formats for various types of performance investigations equips learners to participate effectively in modern learnings.

Course Objectives:

1. To familiarize with basic concepts of generation of graphic entity
2. To familiarize with basics concepts of modifications in the graphical entity
3. To study the reverse engineering method of obtaining a CAD model.
4. To study programming aspects of subtractive manufacturing process.
5. To familiarize with basic process of additive manufacturing.
6. To familiarize with various types analysis can be carried out by FEA.

Course Outcomes: The students will be able to …

1. Identify suitable computer graphics techniques for 3D modelling.
2. Transform, manipulate objects & store and manage data.
3. Demonstrate conceptual understanding of reverse engineering and biomedical model reconstruction.
4. Create the CAM toolpath for specific given operations.
5. Build and create data for 3D printing of any given object using rapid prototyping
6. Apply the appropriate type of analysis for the mechanical system design.

Prerequisite: Mathematics, Conceptual design process, basics of Manufacturing, basic analysis & simulation

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to CAD and Generation of Graphics Element	Role of CAD in product lifecycle. Functions of the graphics package. Industry oriented CAD workflows. Benefits of CAD. Geometric & Parametric Modeling Fundamentals; Parametric representation of curves: Synthetic Curves - Bezier curves, Hermite Curves. Surface representation. Solid Modeling: Constructive solid geometry, Boundary Representation, Feature based modeling.	7	CO1
II	Transformation function	Homogeneous Coordinate system, Matrix representation, Concatenations, 2D and 3D Geometric transformation (Translation, Reflection, Scaling, Rotation)	6	CO2
III	CAD with Reverse Engineering & CAD Data Integration	Reverse engineering; Introduction- Noncontact & Contact type. CAD model from Point cloud data operations, its process. CAD model from medical images (DICOM files) its process and usefulness with Computed tomography (CT) & Magnetic resonance Imaging (MRI). CAD data integration and exchanges with graphics standards includes IGES, STEP, DXF,DMIS, STL.	6	CO3
IV	Subtractive Manufacturing	Introduction to CNC Machines, CNC Hardware, Coordinate system, Part Programming Methods, Manual Part Programming for machining operations like milling and turning including Canned Cycles.	6	CO4
V	Additive Manufacturing	Introduction, Classification & Applications of AM Processes. RP wheel, RP tooling. Working principle, application, advantages & disadvantages of FDM, SLA, SLS, LOM.	6	CO5
VI	CAE- Introduction & types of Analysis	Methods to solve engineering problems- analytical, numerical, experimental, their merits and comparison, discretization into smaller elements and effect of size/ shape on accuracy, importance of meshing, boundary conditions. Types of analysis in CAE: static (linear/ nonlinear) , dynamic, buckling, thermal, fatigue, crash NVH and CFD, review of normal, shear, torsion, stress-strain; types of forces and moments, tri-axial stresses, moment of inertia, how to do meshing, 1-2-3-d elements and length of elements.	8	CO6

Text Books:

1. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
2. CNC Programming for Machining, Kaushik Kumar, Chikes Ranjan, J. Paulo Davim, Springer Publication.
3. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
4. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
5. Chandrupatla T. R. and Belegunda A. D., "Introduction to finite elements in engineering", Prentice Hall of India
6. Practical Finite Element Analysis, Nitin S. Gokhale, Finite to Infinite Publication, 2008.

References:

1. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
2. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
3. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
4. Seshu P., ―Text book of Finite Element Analysis‖, PHI Learning Private Ltd. New Delhi, 2010
5. Shrikhande, M. Finite Element Method and Computational Structural Dynamics, PHI Learning Pvt. Ltd., New Delhi, 2014. ISBN: 978-81-203-4995-7.
6. Edney, R. C. Computer aided engineering for mechanical engineers. New York : Prentice Hall ; 1991

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.swayam2.ac.in/nou22_me08/preview
2.	https://nptel.ac.in/courses/112102102
3.	https://nptel.ac.in/courses/112102101

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*24051141	PEC-1 - Dynamics of Machinery	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
*24051141	PEC-1 - Dynamics of Machinery	20	20	40	60	2	--	--	100

***This course is common with Mechanical and Automation Engineering.**

Rationale:

Dynamics of Machinery develops understanding of vibrations, damping, force analysis, and balancing in mechanical systems. It enables students to analyze dynamic behavior of mechanisms and rotors, integrating theoretical mechanics with practical design for efficient, balanced, and reliable machine operation in industrial and automotive applications.

Course Objectives:

1. To familiarize with mechanical vibration fundamentals and free undamped systems.
2. To study free damped vibrations and equivalent vibratory systems.
3. To acquaint with forced vibrations, isolation, vibration measurements and sensors.
4. To familiarize with multi degree of freedom system.
5. To study static and dynamic force analysis in the mechanisms.
6. To study balancing of mechanical systems.

Course Outcomes: Learner will be able to…..

1) Estimate natural frequency of mechanical element/system.
2) Analyze vibratory response of mechanical element/system.
3) Estimate the parameters of vibration isolation system.
4) Estimate natural frequency of two or more than two degree of freedom system.
5) Illustrate basic of static and dynamic forces.
6) Demonstrate basic concepts of balancing of forces and couples.

Prerequisite:

Knowledge of Engineering Mechanics, Theory of Machines, Strength of Materials, Engineering Mathematics and Physics of Oscillations, including concepts of inertia, torque, and energy transfer in rotating and reciprocating systems.

(Note: There will be no questions from the prerequisite in the theory examination)

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Mechanical Vibration Fundamentals and Free Undamped Systems	1.1 Mechanical Vibration Fundamentals: Definition of Vibration, Natural Frequency, Resonance, Causes and effects of vibrations, Importance of vibration analysis in mechanical systems, Applications of vibration monitoring. 1.2 Basic Elements of Vibrating Systems: Springs, mass, damper, Vibrating motions, Degree of freedom, Static equilibrium position, Types of vibration. 1.3 Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional vibratory systems, Conversion of Physical Systems into Spring, Mass, Damper Model, Concept of mathematical modelling of mechanical systems, Need of mathematical modelling, Idealization of real mechanical systems, Equivalent spring mass representation, Lumped parameter systems, Methods for formulation of differential equations - Newton, Energy, Lagrangian and Rayleigh's method.	06	CO1
II	Free Damped Vibrations and Equivalent Systems	2.1 Free Damped Single Degree of Freedom Vibration System: Introduction to different methods of damping, Study and analysis of viscous damped system (under, critical and overdamped), Coulomb's damping (Combined Viscous and Coulomb damping excluded). 2.2 Equivalent Single Degree of Freedom Vibration System: Conversion of multi springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system. Examples of mechanical systems modelled as spring mass damper systems. (Vehicle Suspension System, Machine Mounted on Flexible Foundation, Rotor-Bearing System, Washing machine drum suspension, Elevator)	06	CO2

III	Forced Vibrations, Isolation, Measurements and Instrumentation	3.1 Forced Single Degree of Freedom Vibratory System: Analysis of linear and torsional systems subjected to harmonic force excitation and motion excitation (excluding elastic damper). 3.2 Vibration Isolation and Transmissibility: Force Transmissibility, motion transmissibility, typical isolators & mounts. 3.3 Vibration Measuring Instruments: Need for vibration measurement, Measurement Parameters used in vibration analysis, Units of vibration measurement, Time domain and frequency domain representation. Spectral Amplitude Scaling: RMS, Peak, Peak-to-Peak and Peak Particle Velocity, Selection criteria. Principle of seismic instruments, vibrometer, accelerometer - undamped and damped. 3.4 Vibration Measuring Sensors: Concept of sensors and transducers, Role of sensors in condition monitoring and fault detection, Sensor output signals and signal conditioning. Types of Vibration Sensors - Displacement, Velocity, acceleration, proximity & MEMS-Based sensors. Sensor Selection Criteria - Measurement range, Frequency range, Sensitivity, Accuracy and resolution, Environmental conditions, Mounting requirements, Cost and reliability.	08	CO3
IV	Free Undamped Multi Degree of Freedom Vibration System	4.1 Free Undamped Multi Degree of Freedom Vibration System: Eigen values and Eigen vectors for linear system and torsional two degrees of freedom; 4.2 Holzer method: Linear and torsional unbranched system.	06	CO4
V	Static and Dynamic force analysis of Mechanisms	5.1. Static and Dynamic force analysis of Slider crank mechanism (neglecting mass of connecting rod and crank). Turning moment on crank shaft. 5.2 Dynamically equivalent systems to convert rigid body into two mass with and without correction couple (Case study- Connecting rod)	06	CO5
VI	Rotor Dynamics and Balancing	6.1 Rotor Dynamics: Critical speed of single rotor, undamped and damped. 6.2 Balancing: Static and Dynamic balancing of multi rotor system (up to four rotors), balancing of reciprocating masses in In-line engines (up to four cylinders). Introduction to V-engines (excluding other radial engines)	07	CO6

Text Books:

1. Doebelin's Measurement Systems, by Ernest O Doebelin and Dhanesh N Manik, 6th Edition, McGraw Hill Education.
2. Theory of Vibration with Applications, by W. Thomson, 2nd Edition, Pearson Education.
3. G. K. Grover, "Mechanical Vibrations", 5th Edition 2009, Nem Chand and Bros.
4. Balakumar Balachandran and Edward B. Magrab, "Vibrations", 2nd Edition, Cengage Learning.
5. Fundamentals of Mechanical Vibration by S. Graham Kelly, Tata McGraw Hill.
6. Principles of Vibration Control – Asok Kumar Mallik, Affiliated East-West Press Pvt. Ltd.
7. A. K. Mallik and A. Chatterjee, "Principles of Active and Passive Vibration Control", East-West- Press 2014.
8. Andre Preumont, "Vibration Control of Active Structures", Springer 2018.
9. S. S. Rao, "Mechanical Vibrations", 5th Edition 2004, Pearson Publications.
10. Clarence de Silva, "Vibration: Fundamentals and Practice",1st Edition 2000, CRC Press

References:

1. A. K. Mallik and A. Chatterjee, "Principles of Active and Passive Vibration Control", East-West- Press 2014.
2. Andre Preumont, "Vibration Control of Active Structures", Springer 2018.
3. S. S. Rao, "Mechanical Vibrations", 5th Edition 2004, Pearson Publications.
4. Clarence de Silva, "Vibration: Fundamentals and Practice",1st Edition 2000, CRC Press

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/112101096 - Dynamics of Machines, IIT Bombay
2.	https://nptel.ac.in/courses/112107212 - Introduction to Mechanical Vibration, IIT Roorke
3.	https://nptel.ac.in/courses/112103024 - Theory & Practice of Rotor Dynamics, IIT Guwahati

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24051142	PEC-1 - Vibration Analysis and Control	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24051142	PEC-1 - Vibration Analysis and Control	20	20	40	60	2	--	--	100

Rationale :

In present scenario, use of various dynamic systems in day to day life is increasing rapidly. Utilization of such dynamic systems leads to vibrations, which in turn raises a crucial need for vibration analysis and control. In some cases, these vibrations like musical instruments, vibrators etc. are useful however these are undesirable in many engineering systems as it leads to fatigue failure, noise, severe damage, loss of machining accuracies of workpieces due to vibrations in machine tools, loss of comfort in automobiles etc. This course will make students aware of principles behind vibration analysis and control and the strategies used for achieving safety, reliability, accuracy and efficient operation of dynamic systems with practical examples.

Course Objectives:

1. To familiarize with mechanical vibration fundamentals and free undamped systems.
2. To study free damped vibrations and equivalent vibratory systems.
3. To acquaint with forced vibrations, isolation, vibration measurements and sensors.
4. To familiarize with vibration absorbers and vibration control methods.
5. To study semi-active vibration control methods and applications.
6. To study active vibration control methods and applications.

Course Outcomes: Learner will be able to…..

1) Estimate natural frequency of mechanical element/system.
2) Analyze vibratory response of mechanical element/system.
3) Estimate the parameters of vibration isolation system.
4) Apply concepts of absorbers for vibration control of mechanical systems.
5) Understand semi-active vibration control methods and applications.
6) Understand active vibration control methods and applications.

Prerequisite:

Knowledge of Engineering Mechanics, Theory of Machines, Strength of Materials, Engineering Mathematics and Physics of Oscillations, including concepts of inertia, torque, and energy transfer in rotating and reciprocating systems.

(Note: There will be no questions from the prerequisite in the theory examination)

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Mechanical Vibration Fundamentals and Free Undamped Systems	1.1 Mechanical Vibration Fundamentals: Definition of Vibration, Natural Frequency, Resonance, Causes and effects of vibrations, Importance of vibration analysis in mechanical systems, Applications of vibration monitoring. 1.2 Basic Elements of Vibrating Systems: Springs, mass, damper, Vibrating motions, Degree of freedom, Static equilibrium position, Types of vibration. 1.3 Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional vibratory systems, Conversion of Physical Systems into Spring, Mass, Damper Model, Concept of mathematical modelling of mechanical systems, Need of mathematical modelling, Idealization of real mechanical systems, Equivalent spring mass representation, Lumped parameter systems, Methods for formulation of differential equations - Newton, Energy, Lagrangian and Rayleigh's method.	06	CO1

II	Free Damped Vibrations and Equivalent Systems	2.1 Free Damped Single Degree of Freedom Vibration System: Introduction to different methods of damping, Study and analysis of 1) Viscous damped system (under, critical and overdamped 2) Coulomb's damping (Combined Viscous and Coulomb damping excluded). 2.2 Equivalent Single Degree of Freedom Vibration System: Conversion of multi springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system. Examples of mechanical systems modelled as spring mass damper systems. (Vehicle Suspension System, Machine Mounted on Flexible Foundation, Rotor-Bearing System, Washing machine drum suspension, Elevator)	06	CO2
III	Forced Vibrations, Isolation, Measurements and Instrumentation	3.1 Forced Single Degree of Freedom Vibratory System: Analysis of linear and torsional systems subjected to harmonic force excitation and motion excitation (excluding elastic damper). 3.2 Vibration Isolation and Transmissibility: Force Transmissibility, motion transmissibility, typical isolators & mounts. 3.3. Vibration Measuring Instruments: Need for vibration measurement, Measurement Parameters used in vibration analysis, Units of vibration measurement, Time domain and frequency domain representation. Spectral Amplitude Scaling: RMS, Peak, Peak-to-Peak and Peak Particle Velocity, Selection criteria. Principle of seismic instruments, vibrometer, accelerometer - undamped and damped. 3.3.Vibration Measuring Sensors: Concept of sensors and transducers, Role of sensors in condition monitoring and fault detection, Sensor output signals and signal conditioning, Types of Vibration Sensors - Displacement, Velocity, acceleration, proximity & MEMS-Based sensors, Sensor Selection Criteria - Measurement range, Frequency range, Sensitivity, Accuracy and resolution, Environmental conditions, Mounting requirements, Cost and reliability.	08	CO3
IV	Introduction to Vibration Analysis and Control	4.1 Introduction: Methods of vibration control, vibration reduction at source, factors affecting vibration level, isolation of the source, dynamic properties and selection of materials for vibration control.	08	CO4

		4.2 Vibration Analysis and Control using Absorbers: Dynamic vibration neutralizers, self-tuned pendulum neutralizer, gyroscopic vibration absorbers, impact absorbers, absorbers attached to continuous systems (Numerical can be asked on this module)		
V	Semi-active Vibration Control	5.1 Semi-active Vibration Control: Introduction, Magneto-rheological fluids, MR models and devices, semi-active suspension, semi-active tuned vibration absorbers, semi-active isolation.	05	CO5
VI	Active Vibration Control	6.1 Active Vibration Control: Classification and modeling, actuators and sensors for active vibration control, Active vibration absorption and damping, classical control, optimal control, piezoelectric transducers for active vibration control, Active tuned vibration absorber, active mass damper, Active single-axis base isolation, Active force isolation system, Isolator based on piezoelectric stack actuator, Active control of vehicle suspensions	06	CO6

Text / Books:

1) Doebelin's Measurement Systems, by Ernest O Doebelin and Dhanesh N Manik, 6th Edition, McGraw Hill Education.
2) Theory of Vibration with Applications, by W. Thomson, 2nd Edition, Pearson Education.
3) G. K. Grover, "Mechanical Vibrations", 5th Edition 2009, Nem Chand and Bros.
4) Balakumar Balachandran and Edward B. Magrab, "Vibrations", 2nd Edition, Cengage Learning.
5) Fundamentals of Mechanical Vibration by S. Graham Kelly, Tata McGraw Hill.
6) Principles of Vibration Control – Asok Kumar Mallik, Affiliated East-West Press Pvt. Ltd.

References:

1) A. K. Mallik and A. Chatterjee, "Principles of Active and Passive Vibration Control", East-West- Press 2014.
2) Andre Preumont, "Vibration Control of Active Structures", Springer 2018.
3) S. S. Rao, "Mechanical Vibrations", 5th Edition 2004, Pearson Publications.
4) Clarence de Silva, "Vibration: Fundamentals and Practice",1st Edition 2000, CRC Press

Online References:

Sr. No.	Website Name
1	https://nptel.ac.in/courses/112/107/112107212/ - Introduction to Mechanical Vibration, IIT Roorkee
2	https://nptel.ac.in/courses/112104211 - Principles of Vibration Control, IIT Kanpur
3	https://nptel.ac.in/courses/112107088 - Vibration control, IIT Roorkee

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24051143	PEC-1 - Machinery Diagnostics	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24051143	PEC-1 - Machinery Diagnostics	20	20	40	60	2	--	--	100

Rationale:

Machinery Diagnostics is studied to help students understand how machines vibrate, why faults occur, and how to detect these issues early using fundamental vibration principles. By learning system modeling, damping behavior, and vibration response, students gain the ability to diagnose problems accurately, prevent failures, and improve the reliability and safety of industrial machinery.

Course Objectives:

1. To familiarize with mechanical vibration fundamentals and free undamped systems.
2. To study free damped vibrations and equivalent vibratory systems.
3. To acquaint with forced vibrations, isolation, vibration measurements and sensors.
4. To understand vibration signal analysis for condition monitoring.
5. To understand vibration analysis for identifying common mechanical faults in rotating machinery.
6. To learn advanced fault diagnosis methods for machine components using vibration analysis.

Course Outcomes: Learner will be able to…

1. Estimate natural frequency of mechanical element/system.
2. Analyze vibratory response of mechanical element/system.
3. Estimate the parameters of vibration isolation system.
4. Acquire and interpret vibration data using FFT for machine health assessment.
5. Detect and analyze unbalance, misalignment, and looseness using vibration signal analysis.
6. Evaluate faults in bearings, gearboxes, pumps, and fans using vibration signal analysis.

Prerequisite:

Knowledge of Engineering Mechanics, Theory of Machines, Strength of Materials, Engineering Mathematics, and Physics of Oscillations, including concepts of inertia, torque, and energy transfer in rotating and reciprocating systems.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Mechanical Vibration Fundamentals and Free Undamped Systems	1.1 Mechanical Vibration Fundamentals: Definition of Vibration, Natural Frequency, Resonance, Causes and effects of vibrations, Importance of vibration analysis in mechanical systems, Applications of vibration monitoring. 1.2 Basic Elements of Vibrating Systems: Springs, mass, damper, Vibrating motions, Degree of freedom, Static equilibrium position, Types of vibration. 1.3 Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional vibratory systems, Conversion of Physical Systems into Spring, Mass, Damper Model, Concept of mathematical modelling of mechanical systems, Need of mathematical modelling, Idealization of real mechanical systems, Equivalent spring mass representation, Lumped parameter systems, Methods for formulation of differential equations - Newton, Energy, Lagrangian and Rayleigh's method.	06	CO1
II	Free Damped Vibrations and Equivalent Systems	2.1 Free Damped Single Degree of Freedom Vibration System: Introduction to different methods of damping, Study and analysis of viscous damped system (under, critical and overdamped), Coulomb's damping (Combined Viscous and Coulomb damping excluded).	06	CO2

		2.2 Equivalent Single Degree of Freedom Vibration System: Conversion of multi springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system. Examples of mechanical systems modelled as spring mass damper systems. (Vehicle Suspension System, Machine Mounted on Flexible Foundation, Rotor-Bearing System, Washing machine drum suspension, Elevator).		
III	Forced Vibrations, Isolation, Measurements and Instrumentation	3.1 Forced Single Degree of Freedom Vibratory System: Analysis of linear and torsional systems subjected to harmonic force excitation and motion excitation (excluding elastic damper). 3.2 Vibration Isolation and Transmissibility: Force Transmissibility, motion transmissibility, typical isolators & mounts. 3.3 Vibration Measuring Instruments: Need for vibration measurement, Measurement Parameters used in vibration analysis, Units of vibration measurement, Time domain and frequency domain representation. Spectral Amplitude Scaling: RMS, Peak, Peak-to-Peak and Peak Particle Velocity, Selection criteria. Principle of seismic instruments, vibrometer, accelerometer - undamped and damped. 3.4 Vibration Measuring Sensors: Concept of sensors and transducers, Role of sensors in condition monitoring and fault detection, Sensor output signals and signal conditioning. Types of Vibration Sensors - Displacement, Velocity, acceleration, proximity & MEMS-Based sensors. Sensor Selection Criteria - Measurement range, Frequency range, Sensitivity, Accuracy and resolution, Environmental conditions, Mounting requirements, Cost and reliability.	08	CO3
IV	Condition Monitoring Techniques and Vibration Signal Processing	4.1 Introduction to Condition Monitoring Techniques: Overview of condition monitoring and maintenance principles. Spectral amplitude scaling, time and frequency domain, phase and orbit analysis, and vibration signal interpretation. Goals, steps, and benefits of vibration based condition monitoring and fault prognosis. 4.2 Data Acquisition & Signal Processing: Classification and analysis of signals, Fast Fourier Transform (FFT), and essentials of data acquisition systems — plot formats, frequency span, resolution, averaging, windowing, spectrum scaling, and signal conditioning.	07	CO4

V	Machinery Fault Diagnosis-I	Time and Frequency domain analysis to identify unbalance, bent shaft, Misalignment, Soft foot conditions, Mechanical looseness, Case studies based on applications like sugar mill and turbine.@	06	CO5
VI	Machinery Fault Diagnosis-II	Rolling element bearing and Journal Bearing fault diagnosis, Faults related to Gearbox, vane defects in pumps, Fault in Fans and Blowers, Case studies based on applications like sugar mill and turbine.@	06	CO6

@Note: Aspects to be covered in Case Studies: Selection of sensors, direction of measurement, selection of plot type, Data validation and Identification of Faults

Text Books:

1. Theory of Vibration with Applications, by W. Thomson, 2nd edition, Pearson Education
2. Mechanical Vibrations by S.S.Rao, fourth edition, Pearson Education
3. Mechanical Vibraitons by G.K.Grover
4. Fundamentals of Mechanical Vibration by S.Graham Kelly, Tata McGraw Hill
5. Principles of Vibration by Benson H Tongue, 2nd Edition, Oxford University Press
6. Vibration Analysis by P. Srineevasan, TMH
7. Mechanical Vibrations- Schaum's outline series, William W.Seto, McGraw Hill
8. Theory and Practice of Mechanical Vibrations by J S Rao and K Gupta, New Age International
9. Elements of Vibration Analysis by Leonard Meirovitch, McGrav- Hill, New York

References:

1. R.B. Randall, “Vibration-based Condition Monitoring”, Wiley2021, ISBN: 978-1-119-47755-6
2. A.R. Mohanty, “Machine Condition Monitoring: Principles and Practices”, CRC Press 2017, ISBN:9781138748255
3. R.A. Collacott, “Mechanical Fault Diagnosis and Condition Monitoring”,1st Edition, Chapman and Hall, ISBN: 978-94-009-5723-7
4. J.S. Rao, “Vibratory Condition Monitoring of Machine”, Narosa Publishing House.

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/112/107/112107212/ - Introduction to Mechanical Vibration, IIT Roorkee
2.	Links for online NPTEL/SWAYAM courses: https://nptel.ac.in/courses/112105232 – Machinery Fault Diagnosis and Signal Processing, IIT, Kharagpur

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2405115	Fluid Mechanics and Machinery Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2405115	Fluid Mechanics and Machinery Lab	-	-	-	-	25	-	25

Course Objectives:

1. To understand and verify Archimedes' Principle by determining the buoyant force acting on a body immersed in a fluid.
2. To verify Bernoulli's theorem experimentally for steady, incompressible flow of fluid through a varying cross-section.
3. To determine the nature of flow (laminar, transitional, or turbulent) of a fluid through a pipe by using the Reynolds apparatus.
4. To study the impact of fluid jet on stationary and moving vanes of different shapes.
5. To understand the working principles, constructional details, and operating characteristics of impulse and reaction turbines.
6. To understand the construction, working principles, and applications of centrifugal and reciprocating pumps.

Course Outcome: Learner will be able to…

1. Apply the concept of buoyancy and up thrust in fluids
2. Apply Bernoulli's equation to determine total energy variation along a streamline.
3. Explain and distinguish different flow regimes by observing dye streak patterns and calculating the Reynolds number
4. Conduct an experiment to measure the force exerted by a fluid jet on various vanes
5. Explain the working principle and operation of Pelton, Francis, and Kaplan turbines
6. Conduct performance tests to determine discharge, head, power, and efficiency of pumps

List of Experiments:

Sr. No.	List of Experiments	Hrs.	LO
	Part A: Fluid Mechanics		
01	Study or Verification of Archimedes' Principle.	2	LO1
02	Verification of Bernoulli's Equation.	2	LO2
03	Calibration of Venturimeter/ Orificemeter/Nozzle meter/ Pitot tube.	2	LO2
04	Experiment on Laminar flow in pipes (Reynolds experiment).	2	LO3
05	Determination of major and minor losses in pipe systems.	2	LO3
06	To determine the force exerted by a jet of water on different types of vanes (flat, hemispherical, or curved).	2	LO4
	Part B: Hydraulic Machinery		
01	Conduct a trial on the Impulse turbine (Pelton Wheel Turbine).	2	LO5
02	Conduct a trial on the Reaction turbine (Kaplan Turbine).	2	LO5
03	Conduct a trial on the Reaction turbine (Francis Turbine).	2	LO5
04	Conduct a trial on the Centrifugal pump.	2	LO6
05	Conduct a trial on the reciprocating pump.	2	LO6

List of Assignments:

Sr. No.	List of Assignments / Tutorials	Hrs.	LO
01	Two Numerical examples on the properties of fluid and three numerical examples on hydrostatic forces.	2	LO1
02	Two Numerical examples on fluid kinematics and three numerical examples on fluid dynamics.	2	LO2
03	Three numerical examples on laminar flow and two numerical examples on flow through pipes.	2	LO3
04	Three numerical examples on boundary layer theory.	2	LO4
05	Five numerical examples on impulse and reaction turbines.	2	LO5
06	Three numerical examples on centrifugal pumps and describe the principles and working of reciprocating pumps.	2	LO6

Industrial Visit or Case Study Report.:

Sr. No.	Industrial Visit / Case Study
01	Case study on the application of Pascal's principle in hydraulic lifts and braking systems
02	Demonstration of fluid flow measuring devices at industrial instrumentation labs.
03	Analysis of pipe losses using industry data.
04	Case study on boundary layer applications in turbine blades and automobiles.
05	Practical study: Priming and performance testing in industry.

Note : An industrial visit is encouraged.

Virtual Labs:

1. http://fm-nitk.vlabs.ac.in/# – Fluid Mechanics Lab, NITK Surathkal
2. https://fmc-nitk.vlabs.ac.in/fluid-machinery/ – Fluid Machinery Lab, NITK Surathkal
3. https://me.iitp.ac.in/Virtual-Fluid-Laboratory/ – Virtual Fluid Laboratory – IIT Patna
4. https://www.necg.ac.in/virtual-lab.php?utm – Virtual Lab Portal – NECG
5. https://mfts-iitg.vlabs.ac.in/ – Fluid and Thermal Sciences Lab, IIT Guwahati

Assessment:

Term Work: Term work shall include at least **four experiments from Part A and four from Part B**, along with **all six assignments** and **case study report, and regular laboratory attendance.**

The distribution of term work marks shall be as follows:

Total 25 Marks:

Experiments	: 10 Marks
Assignments	: 05 Marks
Case Study Report	: 05 Marks
Attendance	: 05 Marks

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2405116	Measurements and Control Lab	--	2	--	--	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical / Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2405116	Measurements and Control Lab	--	--	--	--	25	25	50

Course Objectives:

1. Understand the principles and working of basic linear and angular measurement instruments.
2. Learn methods for surface texture, gear, and thread parameter measurements.
3. Apply optical and comparator-based instruments for precise dimensional inspection.
4. Study the working of sensors and transducers for measuring displacement, pressure, and vibration.
5. Understand the fundamentals of feedback, servomechanism, and system response in control systems.
6. Develop and tune PID controllers using simulation or LabVIEW to analyze control behavior.

Course Outcomes:

1. Perform accurate linear and angular measurements using precision instruments like Vernier, micrometer, and bevel protractor.
2. Conduct surface, gear, and thread measurement using specialized instruments and interpret results.
3. Evaluate component geometry using optical devices and comparators for precision inspection.
4. Measure displacement, pressure, and vibration using appropriate sensors and transducers.
5. Analyze performance of feedback control systems through transient and frequency response experiments.
6. Design and tune PID controllers through simulation or experimental setup for system performance improvement

List of Experiments

Sr No	List of Experiments	Hrs
01	Experiments on linear and angular measurement using Vernier calliper, micrometer and Bevel protractor.	2
02	Experiments on surface measurement by using Surface roughness tester.	2
03	Experiments on measurement of gear parameters using Gear tooth Vernier calliper / Parkinson gear tester.	2
04	Experiments on screw thread measurement using screw thread micrometer, Floating carriage micrometer / bench micrometer.	2
05	Experiments on linear / angular measurements of screw / gear /single point tool using Optical profile projector or Tool maker's microscope.	2
06	Experiment using Mechanical / Pneumatic type Comparator.	2
07	Experiments on flatness measurement by Autocollimator / Interferometry method	2
08	Experiments on measurement of displacement by sensors like LVDT, Potentiometers.	2
09	Experiments on measurement of pressure by gauges or sensors like vacuum Gauges, pressure gauge, piezoelectric sensors, strain gauge sensors etc.	2
10	Experiments on measurement of vibration by accelerometers or using appropriate software.	2
11	Experiments on feedback control systems and servomechanisms	2
12	Experiment on frequency response system identification / transient state response of a control system.	2
13	Experiment on design of PID controller for a system or simulate and tune a PID controller using lab view.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Fundamentals of Metrology, Limits, Fits, and Gauging	2
02	Interferometry, Surface, Thread, and Gear Measurement	2
03	Measurement Systems and Their Characteristics	2
04	Measurement of Mechanical and Process Variables	2
05	Control System Modelling and Time-Domain Analysis	2
06	Stability and Frequency Response Analysis	2

Text Books:

1. Engineering. Metrology, I.C. GUPTA, Dhanpat Rai Publications.
2. Engineering. Metrology, R. K. Jain, Khanna Publisher.
3. Control System Engineering by Nagrath I.J. and Gopal M, Wiley Eastern Ltd.

References:

1. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
2. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
3. Control systems by Dhanesh Manik, Cengage Learning

Online Resources:

Sr. No.	Website Name
1.	https://ic-coep.vlabs.ac.in/List%20of%20experiments.html
2.	https://www.ni.com/en/shop/labview/pid-theory-explained.html

Assessment :

Term Work: Term Work shall consist of at least 10 Experiments based on the above list. Also, Term work Journal must include at least 6 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2405117	CAD/CAM & CAE Lab	--	2	--	--	1	-	1

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2405117	CAD/CAM & CAE Lab	-	-	-	-	-	25	25	50

Rationale:

CAD/CAM/CAE plays a crucial role in engineering product development by enabling accurate digital modeling, modification, simulation, digital prototyping and analysis of complex components. Understanding geometric modeling principles, reverse engineering workflows, and data exchange formats for various types of FEA analysis.

Course Objectives:

1 To acquaint with basic process of 3D modeling using biomedical data.

2. To introduce with the various CAD data exchange process among the various soft tools.
3. To acquaint with basic part programing for CNC machining.
4. To familiarize with steps in 3D printing and prototype development.
5. To know the concept of discretization of continuum, Loading conditions and analyze the structure using pre-processor and postprocessor conditions.
6. To introduce fundamentals of the analysis software, its features and applications.

Course Outcomes: The students will be able to …

1. Develop 3D model using available biomedical data.
2. Develop an ability to understand the importance of data exchange files.
3. Develop and execute part programing for any given specific operation
4. Develop a 3D printed object prototype.
5. Perform the various steps involved in FEA process.
6. Predict the performance of a given problem statements

List of Experiments.

Sr No	List of Experiments
01	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available DICOM files).
02	Case study on various 3D scanning techniques for the development of 3D CAD model.
03	Part programming and part fabrication on CNC Turning trainer (Involving processes like Step turning, facing, Taper turning, threading, etc.).
04	Part programming and part fabrication on CNC Milling trainer (Involving processes like contouring, drilling, facing, pocketing etc.).
05	Development of physical 3D mechanical structure using Stereolithography Apparatus (SLA) technique on the basis of constraints, features like layer thickness, orientation of geometry, support generation, post processing etc.
06	Development of physical 3D mechanical structure using FDM technique on the basis of constraints, features like layer thickness, orientation of geometry, support generation, post processing etc.
07	Static structural analysis using bar element
08	Thermal (conduction and convection) analysis using bar element
09	Analysis of truss
10	Static analysis of plate with a hole using 2D element
11	Modal analysis using bar element
12	Demonstration of CFD analysis (students will write a report on a sample CFD analysis demonstrated by faculty).

Text Books:

1. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
2. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
3. Practical Finite Element Analysis, Nitin S. Gokhale, Finite to Infinite Publication, 2008.

References:

1. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
2. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
3. Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers.

Online Resources:

Sr. No.	Website Name
1	https://onlinecourses.nptel.ac.in/noc25_me151/preview
2	https://nptel.ac.in/courses/112105211
3	https://onlinecourses.nptel.ac.in/noc21_me115/preview
4	https://nptel.ac.in/courses/112105308
5	https://nptel.ac.in/courses/112106130

Assessment :

Term Work: Term Work shall consist of at least 10 practical's based on the above list.

Term Work Marks: 25 Marks (Total marks) = 20 Marks (Experiment) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24051181	PEL-1 - Vibration and Machinery Diagnostics Laboratory	--	2	--	--	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical / Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
24051181	PEL-1 – Vibration and Machinery Diagnostics Laboratory	--	--	--	--	25	25	50

Course Objectives:

1. To imbibe skills emphasizing basic concepts of vibration analysis through experimental study.
2. To impart technical skills to understand damping concept necessary for vibration analysis.
3. To enable students towards balancing the rotating masses necessary for vibration analysis and machinery diagnostics.
4. To impart skills to understand mechanical vibration measurements.
5. To enable students towards vibration measurement and fault diagnosis.
6. To enable students towards vibration analysis and simulation.

Course Outcomes:

1. To apply Newton's law for finding Natural frequency of dynamic systems.
2. To apply concepts of mechanical vibrations for finding damping present in the system.
3. To determine unbalance in rotating masses useful for vibration analysis and machinery diagnostics.
4. To apply experimental techniques to capture and analyze vibration signals from the dynamic systems.
5. To apply experimental technique to identify common faults in machinery using vibration signals.
6. To apply knowledge of mechanical vibrations for software based vibration analysis and simulation.

Prerequisite: Verification of Polygon law of coplanar forces, Resultant of Coplanar, non-coplanar, Concurrent force systems, Determination of support reactions of a Simply Supported Beam, torsion test, flexural test on a beam, measurement of vibration by accelerometers.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	LO Mapping
I	Natural Frequency Measurement of Dynamic Systems	Experimental study of vibration parameters - springs, mass, damper, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, Finding Natural frequency of dynamic systems, longitudinal vibrating system, torsional vibrating system.	4	LO1
II	Damping Measurement of Dynamic Systems	Introduction to different methods of damping, effects of damping, types of damping, Free vibration response of single degree of freedom system with viscous damping, logarithmic decrement method.	4	LO2
III	Balancing of Rotating Masses	Static and Dynamic balancing of rotating masses, balancing of I C Engines on the basis of primary and secondary cranks concept.	4	LO3
IV	Mechanical Vibration Measurement	Experimental study of forced vibration system subjected to force excitations.	7	LO3, LO4, LO5
V	Vibration Measurement and Fault Diagnosis	Analysis of forced vibration system subjected to dynamic loading and fault diagnosis.	3	LO5
VI	Vibration Analysis and Simulation	Vibration analysis and simulation of dynamic system subjected to external excitation.	4	LO6

List of Experiments.

Sr No	List of Experiments	Hrs
Part A		
01	Determination of natural frequency in a longitudinal vibrating system (helical springs, springs in series and parallel)	3
02	Determination of damping coefficient of any system/media.	3
03	Determination of radius of gyration of given bar using Bi-filar suspension.	2
04	Experiment on distributed parameter system as Transverse vibration of beam (Dunkerley's rule experiment)	2
05	Experimental determination of counterweight position for static and dynamic balancing of rotating masses	2
06	Measurement of vibration response of a system.	2
07	Experimental and Theoretical investigation of whirling of shaft.	2
08	Vibration based Machinery Fault Diagnosis.	2
09	Vibration analysis of mechanical system using appropriate software.	2
Part B		
10	Determine natural frequency of compound pendulum, equivalent simple pendulum system.	2
11	Determine natural frequency and nodal points for single rotor and two-rotor vibratory system.	2
12	Simulation-based vibration Analysis of Beams with Various Boundary Conditions using a computational method.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Static and dynamic force analysis (Numerical).	2
02	Eigen values and Eigen vectors for linear system, Holzer method (Numerical).	2
03	Dynamic vibration neutralizers (Numerical).	2
04	Dynamic vibration absorber and transmissibility (Numerical).	2
05	Rolling contact bearing fault diagnosis (Numerical).	2
06	Sliding contact bearing fault diagnosis (Numerical).	2

Note :

1. All Experiments mentioned in Part A and at least one experiment from Part B to be performed from the remaining and any two Assignments are mandatory

2. Industrial visit of students to an automobile service station/any other machinery maintenance workshop is encouraged.

Text / Reference Books:

1. Theory of Vibration with Applications, by W. Thomson, 2nd Edition, Pearson Education.
2. G. K. Grover, “Mechanical Vibrations”, 5th Edition 2009, Nem Chand and Bros.
3. Balakumar Balachandran and Edward B. Magrab, “Vibrations”, 2nd Edition, Cengage Learning.
4. Engineering Vibrations, Daniel J. Inman., 3rd Edition, 2009 Pearson Education.
5. Mechanical Vibrations, Singiresu S. Rao, 6th Edition, 2018 Pearson Education.

Online Resources:

Sr. No.	Website Name
1.	Introduction to Mechanical Vibration, IIT Roorkee - https://nptel.ac.in/courses/112107212
2.	Mechanical Vibrations, IIT Guwahati - https://nptel.ac.in/courses/112103111
3.	Vibration and Structural Dynamics, IIT Kharagpur - https://onlinecourses.nptel.ac.in/noc21_ae15/preview
4.	Principles of Vibration Control, IIT Kanpur - https://nptel.ac.in/courses/112104211

Assessment :

Term Work: Term Work shall consist of at least 10 practical’s based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiments) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

VERTICAL – V

IKS

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2405511	Indian Knowledge System-II	--	2*+2	-	--	2	--	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg.					
2405511	Indian Knowledge System-II	--	--	--	--	--	50	--	50

* Two hours of practical class to be conducted for full class as demo/discussion.

Rationale:

India has ancient Indian knowledge systems (IKS) that have significantly contributed to mathematics, science and engineering etc. NEP 2020 visualizes a framework where students can apply traditional knowledge with contemporary approaches to suggest sustainable solutions and innovative practices. This subject aims to integrate the IKS into present-day engineering education, research, and practice to cultivate well-rounded individuals grounded in India's great intellectual traditions

Course Objectives:

To impart necessary knowledge and skills so as to enable students to

1. Understand the premise of Indian Knowledge System (IKS) in the domain of town planning and governance
2. Appreciate the ancient technologies used in Irrigation planning and transport systems, astronomy and Vastu shastra (The science of architecture) for fulfilling basic human needs.
3. To introduce students to traditional Indian chemical engineering knowledge and chemical processes related to metallurgy, pharmaceuticals.
4. To understand traditional chemical engineering practices, rasashastra apparatus, and to compare traditional processes with modern chemical engineering processes.
5. To enable students to understand India's rich Indigenous Knowledge Systems (IKS) in metals and metal processing.
6. To introduce the early development of transmission systems in India.

Course Outcomes:

After completion of this course, learner will be able to

1. Compare the ancient knowledge in the domain of town planning, governance, and traditional principles in residential (Vastu) construction.
2. Evaluate the developments in irrigations systems, transport systems and astronomy.
3. Explain traditional Indian chemical engineering knowledge and their scientific principles.
4. Describe classical chemical processes, rasashastra apparatus, and indigenous material processing techniques and compare traditional chemical engineering processes with modern chemical engineering processes.
5. Evaluate India's indigenous metal and metal-processing heritage.
6. Analyze early Indian transmission technologies

Prerequisite: Basic concepts of Science and Technology

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Town Planning and Governance, Vastu shastra – The science of Architecture	1.1 Development of ancient text, principles, Terminologies, Indic languages, various typologies, social infrastructure- places for gathering, worship, entertainment, cremation etc. Perspective of Arthaśāstra on town planning. 1.2 Governance systems and Principles of Town Planning: Principles of land management, local and global trade routes and trade centres; the establishment and decay of urban settlements. Ancient India urbanization, layouts in terms of geometry, population, geography, and various communities. Evolution of the cities, planning principles in urban centres. interconnection between ancient knowledge of town planning and present planning practices. 1.3 Eight limbs of Vastu, Ancient literature and archaeological evidence of building and building materials, Fortification and Forts. 1.4 Structural Principles in worship places Architecture. marvelous stone architecture for eternity, Iconography Use of bricks or dressed stone based on logical principals of structural engineering.	5	CO1

II	Irrigation planning, transport systems and Astronomy	2.1 Irrigation and water management. Ancient irrigation systems, dams, reservoirs, sluices, canals, embankments, wells, water-lifting devices, etc. from a historical point of view. Irrigation systems and practices in South India 2.2 Ancient transport systems during various periods : Indus valley, Buddhist period, Mauryan period, Gupta period, etc. Shipbuilding: Indigenous shipbuilding, materials and methods-Use of local materials: teak, bamboo, coir, and lac- Construction techniques: -Innovations in hull design, masts, and rigging. 2.3 Indian Astronomy: Planetary System. Motion of the Planets; Velocity of Light; Eclipse. Astronomy. Navagrahas. Important works in Indian Astronomy. Aryabhata and Nilakantha: Contribution to Astronomical Studies	4	CO2
III	Traditional Chemical Processes and Industrial Advancements	3.1 Overview of ancient Indian scientific texts related to chemicals, Arthashastra – mining techniques and metallurgy, 3.2 Charaka Samhita – pharmaceutical preparations and fermentation, Sushruta Samhita – preparation of alkali and mineral medicines, traditional chemical operations and processes such as manual metal extraction methods and herbal extraction techniques, small-scale batch production methods, 3.3 Production of natural alkali from plant ash, comparison of traditional metallurgy with modern metallurgical processes, herbal extraction with solvent extraction and chromatography, natural alkali production with chlor-alkali industry, batch processing with continuous processing.	4	CO3
IV	Rasashastra – Ancient Indian Chemical Science and Classical Apparatus	4.1 Introduction, scope of rasashastra in traditional Indian alchemy and medicine, development of rasashastra, contributions of Nagarjuna in metallurgical and alchemical practices, role of mercury (Parada) and metals in classical medicinal formulations, 4.2 Various apparatus used in rasashastra such as Dolayantra (boiling and heating setup), Patana Yantra (distillation apparatus), Puta (system for controlled heating), Musha (crucible) used for melting and calcination, Khalva Yantra (grinding and mixing of materials), rasashastra processes	4	CO4

		such as Shodhana (purification), Marana (calcination), Jarana (roasting) and Bhavana (levigation). 4.3 Comparison of Dolayantra with modern jacketed reactors, Patana Yantra with distillation columns, Marana process with rotary kiln or muffle furnace, mercury purification methods with modern hydrometallurgical refining techniques.		
V	Indigenous Metal and Metal Processing Techniques	5.1 Early Metals in India Use of copper, bronze, gold, silver, tin, and lead in Harappan and Vedic periods. Indigenous mining, ore beneficiation, furnace designs, and smelting practices. 5.2 Landmark Indian Metallurgical Achievements Wootz Steel: crucible steelmaking, carbon control, carbide banding, global influence as Damascus steel. Zawar Zinc Distillation: world's earliest large-scale zinc production; downward distillation furnaces. Chola Bronze Metallurgy: alloy design (Cu–Sn–Pb), precision lost-wax casting for sculptures. Aranmula Metal Mirror: high-tin bronze polishing technology with mirror-grade reflectivity. Konark Temple Iron Beams & Clamps: structural iron demonstrating marine corrosion resistance. 5.3 Scientific Insights Behind Traditional Metallurgy Delhi Iron Pillar: natural formation of a passive protective layer; high-phosphorus wrought iron. Microstructure evolution through traditional forming and heat-treatment cycles. Traditional Indian blacksmiths (Lohar, Vishwakarma, Asari, Kammalar communities)	5	CO5
VI	Development of Transmission in India	6.1 Transmission in Early Indian Civilizations Indus Valley Civilization: evidence of wheel technology, carts, pottery wheels, and early bearing surfaces. Use of pulleys, levers, and inclined planes in construction and material handling. 6.2 Traditional gear and motion Conversion systems Sugarcane crushers, oil ghanis, temple clocks, and granaries	4	CO6

Textbooks:

1. Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi.
2. Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.
3. Kak, S.C. (1987). "On Astronomy in Ancient India", Indian Journal of History of Science, 22(3), pp. 205–221.
4. Bag, A.K. (1997). History of Technology in India, Vol. I, Indian National Science Academy, New Delhi.
5. Acarya, P.K. (1996). Indian Architecture, Munshiram Manoharlal Publishers, New Delhi.
6. Banerjea, P. (1916). Public Administration in Ancient India, Macmillan, London.
7. Gagan Bansal, Indian Knowledge System: Integrating Heritage with Engineering
8. Prafulla Chandra Ray, A History of Hindu Chemistry –
9. R. Balasubramaniam – Wootz Steel: An Advanced Material of the Ancient World
10. K.T.M. Hegde – Indian Archaeometallurgy
11. T.R. Anantharaman – The Rustless Wonder: The Iron Pillar of Delhi
12. AICTE – IKS Division Publications

References:

1. Kapoor Kapil, Singh Avadhesh (2021). "Indian Knowledge Systems Vol – I & II", Indian Institute of Advanced Study, Shimla, H.P.
2. Subbarayappa, B.V. and Sarma, K.V. (1985). Indian Astronomy: A Source Book, Nehru Centre, Mumbai.
3. R.T.V. Ramachandra – History of Indian Metallurgy
4. A. Ghosh - Encyclopedia of Indian Archaeology
5. Research papers on Zawar zinc distillation, Chola bronzes, and Aranmula mirror metallurgy.

Online References:

Sr. No.	Website Name
1	https://onlinecourses.swayam2.ac.in/e-learning/preview/imb23_mg54
2	https://iksindia.org
3	https://iks.iitk.ac.in

The experiential learning sessions may include:

- Field Visits to historical sites, museums.
- Arranging students' discussions with experts in various fields of IKS.
- Providing the students with online lectures by distinguished experts in the field.
- Students' participation in activities related to understand the practical aspects of Indian knowledge systems.

Traditional practices of arts, crafts, agriculture, Vastu Shastra etc.,

Herbal extraction using decoction or distillation methods.

Preparation of lime mortar (calcination, slaking, carbonation).

Natural dye extraction and mordanting process.

Herbal soap preparation through saponification.

Comparative study of batch vs continuous processing.

Sr No	**Details of Activities**
01	Project-based activities
02	Presentation
03	Case studies
04	Visit Museum/historical places and write a report
05	Flip class mode
06	Quiz with MCQ
07	Comparative Study of IKS & other scientific systems around the world
08	Group Discussions
09	Roleplay
10	Self-study activities

The faculty can choose any of these activities for continuous assessment

Assessment:

Term work Assessment for 50 marks:

- Suggested Pedagogy and assessment criteria:

1. Assignment as per the modules. 06
2. Project-based activities.
3. Presentation, Group Discussions, and Case studies.
4. Visit historical places.
5. Flip class mode/ Roleplay
6. Quiz MCQ
7. Assessment through flipped class and PowerPoint presentation along with documentation

Term Work:

Assignments	10 Marks
Presentation	20 Marks
Quiz /MCQ	15 Marks
Attendance	05 Marks

SEM. – VI

VERTICAL – 1

MAJOR

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2406111	Machine Design	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2406111	Machine Design	20	20	40	60	2	--	--	100

Rationale:

Machine Design is a core subject in Mechanical Engineering that bridges theoretical mechanics with practical application. It equips students with the analytical and creative skills required to design safe, reliable, and economical machine components. The course emphasizes design thinking, material selection, manufacturing feasibility, and adherence to standards, preparing students to handle real-world engineering problems. By integrating sustainability, ergonomics, and the use of modern design tools, students gain the competence to innovate and improve mechanical systems across industries.

Course Objectives:

1. To understand and explain the fundamental principles, in mechanical design, including ergonomics, manufacturability, and sustainability.
2. To analyze and evaluate the behavior of materials and components under fluctuating and fatigue loading conditions.
3. To apply design standards in designing various types of mechanical joints and fasteners under static and dynamic loading conditions.
4. To design and synthesize power transmission elements such as shafts, keys, and couplings, ensuring structural integrity, reliability, and compliance with safety factors.
5. To select and evaluate rolling and sliding bearings using catalog data, load-life equations, and lubrication theory for optimized performance and durability.
6. To integrate mechanical design knowledge to create efficient, cost-effective, and sustainable solutions involving belt drive, brakes and spring systems

Course Outcomes:

After successful completion of this course, students will be able to:

1. Explain and differentiate various types of machine design processes, material selection criteria, and design considerations in accordance with IS standards and safety factors.
2. Analyze fluctuating load conditions and compute fatigue life using Soderberg and Goodman design criteria to ensure design safety under varying stresses.
3. Design and evaluate cotter, knuckle, bolted, and welded joints subjected to eccentric and dynamic loading using appropriate failure theories.
4. Develop design solutions for shafts, keys, and couplings by synthesising loading conditions, material properties, and manufacturing constraints.
5. Select suitable rolling or sliding bearings from manufacturer data and evaluate their performance under static and dynamic load conditions.
6. Design brake and spring systems used in mechanical assemblies, considering stress distribution, energy storage, and functional reliability.

Prerequisite:

Engineering Mechanics , Engineering Graphics, Strength of Materials, Material Science, Theory of Machines, Engineering Mathematics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Design Fundamentals	Mechanical Engineering Design, Basic principles of Machine Design, Steps involved in design, types of design, Material properties and their uses in design, Aesthetic and Ergonomics consideration in design, Design consideration of casting and forging, Manufacturing consideration in design, Selection Criteria for factor of safety, IS Design standard, stresses & strains, static & variable loading, stress concentration, Modes of failures, theories of failure, introduction to design for sustainability. Preferred Series and Numbers.	5	CO1

II	Design against Fluctuating Loads	Variable stresses - reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Endurance limit, estimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria, Fatigue design under combined stresses	6	CO2
III	Joints & Fasteners	Design of Cotter & knuckle joints, Design of bolted joints subjected to eccentric loading, Design of welded joints under eccentric loading	7	CO3
IV	Shafts, Keys & Couplings	Design of Shaft: Power transmitting and power distribution shafts (excluding crank shaft) under static and fatigue loading, (Numerical should be either on Pulley System or Gear System, No combination of both) Keys: Types of Keys and their selection based on shafting condition. Couplings: Classification of couplings, Design of Flange couplings.	7	CO4
V	Bearings	Bearings: Types of bearing and designation Rolling Contact Bearings: selection of rolling contact bearings based on constant / variable load & speed conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, selfaligning bearing and thrust bearing) (Numerical Only on Deep Groove Ball Bearing) Sliding Contact Bearings: Design of hydro dynamically lubricated bearings (selfcontained).	7	CO5
VI	Springs, Brakes	Design of Springs: Classification and applications, design of helical compression and tension springs (only circular cross-section) under static and variable loads, Design of leaf springs. Design of Brakes: Design of single shoe brake, Disc Brake.	7	CO6

Text Books:

1. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
3. Design of Machine Elements - Sharma, Purohit. Prentice Hall India Publication
4. Machine Design by R.S.KHURMI AND J.K.GUPTA , EURASIA PUBLISHING HOUSE (PVT.) LTD.

References:

1. Design of Machine Elements by V.M.Faires
2. Machine Design by Reshetov, Mir Publication
3. Machine Design by Black Adams, McGraw Hill
4. Design Data book by P.S.G. College of Technology, Coimbatore.

Online References:

Sr. No.	Website Name
1.	Design of Machine Elements, IIT Kharagpur: https://nptel.ac.in/courses/112/105/112105124/
2.	Machine Design-II, IIT Madras: https://nptel.ac.in/courses/112/106/112106137/
3.	Design of Machine Elements, Dr. A Kumaravel, M. Kathirselvam: https://ekumbh.aicteindia.org/

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Practical	Tut.	Total
2406112	Thermal Engineering	3	--	--	3	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2406112	Thermal Engineering	20	20	40	60	2	--	--	100

Rationale:

Thermal Engineering is a fundamental subject in Mechanical Engineering that focuses on energy conversion, thermodynamics and heat transfer. The syllabus is designed in line with the UN Sustainable Development Goals. This course fosters technical competence and environmental awareness, preparing students to understand and evaluate different thermal systems to contribute sustainable development.

Course Objectives:

1. To introduce the fundamental modes and governing laws of heat transfer.
2. To develop an understanding of extended surfaces (fins).
3. To familiarize students with convective heat transfer phenomena.
4. To impart knowledge on phase change heat transfer mechanisms.
5. To introduce mass transfer and heat exchanger analysis methods.
6. To provide a comprehensive understanding of internal combustion engines and Thermal management in electric vehicles.

Course Outcomes: Learner will be able to…

1. Explain heat transfer modes and governing laws and analyze steady state heat conduction in various geometries.
2. Apply the principles of extended surfaces to evaluate fin efficiency and effectiveness, and use lumped heat capacity analysis to determine transient temperature variations in thermal systems.
3. Analyze convective heat transfer in external and internal flows, evaluate radiative heat exchange between surfaces, and Compare heat transfer mechanisms in boiling and condensation.
4. Evaluate heat exchanger performance using LMTD and NTU method and understand the application of phase change materials (PCMs) for energy-efficient system.
5. Understand combustion and performance characteristics of internal combustion engines, and evaluate engine efficiency using performance parameters and heat balance analysis.
6. Analyze engine emissions with their environmental impact, emission control technologies, and study thermal management techniques for electric vehicles.

Prerequisite:

Basic of Thermodynamics, Basic concepts of heat, temperature, and energy transfer, Thermal properties of Material. Basic familiarity with Engine components, Introduction and Classification IC Engines. Working of Four stroke and Two-stroke engines, Fuel air cycles, Actual cycle.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Mechanisms of Heat Transfer and Steady-State Heat Conduction	1.1 Mode of heat transfer, Mechanism of conduction, Convection and radiation heat transfer and its Governing laws. 1.2 Generalized heat conduction equation in rectangular coordinates (derivation and its form), cylindrical and spherical coordinates (only final equations, no derivation). 1.3. Steady state heat conduction through plane wall, composite wall, cylinder, composite cylinder, sphere and composite sphere (only final equations, no numerical), Critical radius of insulation in cylinder (Derivation and Numerical) and sphere (only final equations and no numerical).	7	CO 1

II	Extended Surfaces and Unsteady State Heat Transfer	2.1 Heat transfer from Extended Surfaces: Types of extended surfaces and its various field application. Governing differential equation for fin (Finite, Infinite, and Insulated tips) and its solution. Fin efficiency and effectiveness (Derivation and Numerical). 2.2Unsteady state heat transfer: Lumped heat capacity Analysis. Applications of unsteady state heat transfer, Thermal time constant.	6	CO 2
III	Convection, Radiation and Boiling and Condensation	3.1Convection: Free and Forced convection. External Flow: Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent flow over a flat plate. Internal Flow: Velocity Boundary layer and Thermal Boundary layer, Laminar and Turbulent flow in tubes. General thermal analysis with Constant heat flux and constant surface temperature, Significance of Nusselt number (*Nu*). 3.2Radiation: Basic governing laws of radiation and heat exchange between two bodies (Simple numerical) 3.3Boiling and Condensation: Introduction to Different boiling regimes (pool boiling curve), Film condensation, Drop wise condensation.	6	CO 3
IV	Mass Transfer and Heat Exchangers	4.1Mass Transfer: Introduction to Mass Transfer, governing equations of mass transfer. Mass transfer coefficient. 4.2Heat Exchangers: Types of heat exchangers, Overall heat transfer coefficient, LMTD, Effectiveness, Number of Transfer Unit (NTU) method (Derivation and Numerical). Application Phase Change Material in Heat Exchanger, (Self-study content: Working of heat pipe and it's applications.)	6	CO 4
V	IC Engine and Engine Performance Testing	5.1. IC Engine: Introduction to Fuel Supply and Fuel Injection system, (No numerical), stages of combustion, knocking and detonation in SI and CI Engines. Octane and Cetane numbers, (Self-study: Supercharging and turbocharging in engines and Alternative Fuels for IC Engine.)	7	CO 5

		5.2.Engine Performance Testing: Measurement of various performance parameters, Methods of friction power measurement, Heat balance sheet (Numerical). *(Self-study) : Principle of working simple carburettor Concept of Waste heat recovery from automotive system,)		
VI	Engine emissions with its control and Thermal Management in Electric Vehicles	6.1Engine Emission: SI and CI engine exhaust emissions constituents and their effects on environment and health. Study of emission norms (Euro norms and Bharat stage norms). 6.2Engine emissions control technologies: Exhaust Gas Recirculation (EGR), Diesel Oxidation Catalysts (DOC), Diesel Particulate Filters (DPF) and Selective Catalytic Reduction (SCR). 6.3Thermal Management in Electric Vehicles, Battery cooling, Concept and Application of Nano-fluids for heat transfer enhancement.	7	CO 6

***Self-study Topic Note:** No questions to be asked in theory examination however, the question can be asked in assignment.

Text Books:

1. Heat and Mass Transfer by P. K. Nag, McGraw Hill
2. J. P. Holman, Heat Transfer, 8th Edition, McGraw Hill
3. Heat and Mass Transfer, R. K. Rajput, S. Chand Publication
4. Internal Combustion Engine, V. Ganesan, McGraw Hill
5. Internal Combustion Engine, M. L. Mathur and R. P. Sharma, Dhanpat Rai Publication

References:

1. Introduction to thermodynamics and Heat transfer by Yunus A Cengel 2nd Edition, McGraw Hill.
2. Fundamentals of Heat and Mass Transfer, M. Thirumaleshwar, Pearson Education India, 2009.
3. Introduction to Heat Transfer, Som S. K., PHI Publication.
4. Heat Transfer by P. S. Ghoshdastidar, 2nd Edition, Oxford University Press.
5. Heat and Mass Transfer, by R Rudramoorthy and L Malaysamy, 2nd Edition, PEARSON.
6. Heat Transfer by S. P. Sukhatme, University Press.

7. Internal Combustion Engines, Shyam Agrawal, New Age International
8. Internal Combustion Engines, Gupta H N, PHI
9. Internal Combustion Engine, S. L. Beohar
10. Internal Combustion, R. K. Rajput, Laxmi Prakashan
11. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles – Mehrdad Ehsani et al. (CRC Press)
12. Hybrid Electric Vehicles: Principles and Applications – Chris Mi et al. (Wiley)
13. Electric Vehicle Technology Explained – James Larminie & John Lowry (Wiley)
14. Nanofluids Technology for Thermal Sciences and Engineering: Research, Development, and Applications, Mukesh Kumar Awasthi, Taylor & Francis

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/112/101/112101097 - Heat and Mass Transfer, IIT Bombay
2.	https://nptel.ac.in/courses/112/105/112105248 - Heat Exchangers: Fundamentals and Design Analysis, IIT Kharagpur
3.	https://nptel.ac.in/courses/112/104/112104033 - Engine Combustion, IIT Kanpur
4	https://nptel.ac.in/courses/112/103/112103262 - IC Engines and Gas Turbines, IIT Guwahati
5	https://nptel.ac.in/courses/108106170 - Electric and Hybrid Vehicles, IIT Madras and IIT Delhi
6	https://nptel.ac.in/courses/112103316 - Thermal Engineering: Basic And Applied IIT Guwahati
7	https://nptel.ac.in/courses/112105221 - Energy Conservation And Waste Heat Recovery IIT Kharagpur
8	https://nptel.ac.in/courses/112105318 - Microfluidics and Nanofluidics, IIT Kharagpur

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Practical	Tut.	Total
24061131	PEC-2 - Refrigeration & Air-Conditioning	3	--	--	3	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24061131	PEC-2 - Refrigeration & Air-Conditioning	20	20	40	60	2	--	--	100

Rationale:

Refrigeration & Air-Conditioning is an essential subject in Mechanical Engineering that deals with the principles of thermal comfort, air quality, and refrigeration technologies. The course integrates concepts of thermodynamics, heat transfer, and fluid mechanics to develop energy-efficient and environmentally sustainable systems. In alignment with the UN Sustainable Development Goals (SDGs) and the National Education Policy (NEP) 2020**,** this syllabus emphasizes the use of eco-friendly refrigerants**,** renewable energy-based cooling systems**,** and sustainable design practices**.** The course aims to equip students with the technical competence to analyze, design, and apply HVAC&R systems in industrial, commercial, and domestic sectors, fostering both professional excellence and environmental responsibility.

Course Objectives:

1. To understand the refrigeration principles, refrigerant impact on environment and air refrigeration system performance.
2. To understand the working principles of RAC Components and evaluated the performance of vapour compression and vapour absorption refrigeration system.
3. To learn the determinants of human thermal comfort, psychrometric principles & their application in air property analysis.
4. To estimate the cooling load for air conditioning system design.
5. To Understand the principles of duck design, pressure losses, friction factor and calculation of equivalent diameter using duct design methods.
6. To understand HVACR system controls and explore application of RAC systems including sustainable refrigeration technologies.

Course Outcomes: Learner will be able to…

1. Understand the environmental impact of refrigerants and evaluate the performance of air refrigeration systems.
2. Evaluate the performance of vapour compression and vapour absorption refrigeration systems & Understand/Explore the working of RAC components.
3. Analyze parameters influencing human thermal comfort and Evaluate psychrometric processes governing air-conditioning system performance.
4. Estimate the cooling load of air-conditioning systems by identifying various heat sources and component.
5. Calculate equivalent diameter for rectangular ducts, and apply basic methods of duct design.
6. Explore refrigeration system controls and various applications of RAC systems.

Prerequisite: Fundamentals of Thermodynamics: types of system, Temperature, Heat, Work, Carnot Cycle. VCRS construction and working.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Refrigerants and air refrigeration system	1.1 Basic Knowledge: Introduction, Carnot refrigeration cycle, Bell Coleman cycle, COP. 1.2 Refrigerants: Primary and secondary refrigerants, Properties of Refrigerant, Designation of Refrigerants, Eco-friendly refrigerants, 1.3 Air Refrigeration system. Methods of air refrigeration system, Numerical based on Simple and Bootstrap air refrigeration.	5	CO1
II	Vapor and Refrigeration system & Components	2.1 Vapor Compression Refrigeration System: Thermodynamic analysis of Simple VCRS and T-s and P-h chart, Effect of Suction and discharge pressure, Effect of sub cooling and superheating on COP and capacity. Numerical based on p-h chart 2.2 Vapor Absorption Refrigeration System: Simple and practical vapor absorption system, Domestic Electrolux refrigerator, Lithium-bromide absorption system	9	CO2

		2.3 RAC components Reciprocating, screw and scroll compressors, Air cooled and water cooled and evaporative condensers, DX, Flooded and Forced feed evaporators, Expansion devices: TXV, EXV; *Self Study: Capillary tube		
III	Thermal Comfort, Psychrometry	3.1 Thermal Comfort Conditions: Thermal comfort and its significance, Factors influencing human thermal comfort, Effective Temperature, ASHRAE Comfort chart 3.2 Psychrometry: Various Psychrometry properties, Psychrometric relations and Psychrometric processes, Psychrometric chart, Numerical based on psychrometric chart. Classification of air conditioning system	8	CO3
IV	Cooling load Estimation	4.1 Cooling Load Estimation: Introduction, Components of cooling load, Different heat sources, Design of air conditioning system (More emphasis on industry based load estimation.)	8	CO4
V	Duct Design	5.1 Duct Design: Pressure & Pressure losses in ducts, Friction factor & friction chart for circular ducts, Equivalent diameter of a circular duct for rectangular ducts, Methods of duct system design. *Self Study: Classification of ducts & duct material.	4	CO5
VI	Controls and application	6.1 Controls: LP/HP cut-off, Thermostats, Humidistats, Interlocking control, Electronic Controllers. 6.2 Application of HVAC&R: Ice plant, Food storage plants, AC in textile, Printing pharmaceutical industry and Hospitals, Cold chain Technology & Transport air conditioning. *Self Study: Defrost Controller, Solar refrigeration, Liquefaction of gases	5	CO6

***Self Study Note:** No questions to be asked in theory examination however, the question can be asked in assignment.

Text Books:

1. Refrigeration and Air Conditioning by C. P. Arora, McGraw Hill education (India) (P) limited, New Delhi
2. Refrigeration and Air Conditioning by Manohar Prasad, New age international (P) limited, New Delhi
3. Refrigeration and Air Conditioning by S. C. Arora and S. Domkundwar, Dhanpatrai and sons, Delhi
4. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
5. Textbook Of Refrigeration & Air-Conditioning by Rk Rajput (Author), Sk Kataria & Sons (Publisher)

References:

1) Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
2) Basic Refrigeration and Air conditioning by P.N. Ananthanarayana. McGraw-Hill.
3) SHRAE Air Conditioning Handbook
4) ISHRAE Refrigeration Handbook
5) ASHRAE Handbook of Fundamentals
6) ASHRAE Handbook of Equipment
7) ASHARE Handbook of System
8) Open Source Software/learning website

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/112107208 - Refrigeration and Air-Conditioning, IIT Roorkee
2.	https://nptel.ac.in/courses/112105128 - Refrigeration and Air Conditioning, IIT Kharagpur
3.	https://nptel.ac.in/courses/112105129 - Refrigeration and Air Conditioning, IIT Kharagpur
4.	International Journal of Air-Conditioning and Refrigeration
5.	https://www.ashraeindia.org/
6.	Home | ashrae.org

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Practical	Tut.	Total
24061132	PEC-2 – Heating, Ventilation, Air-Conditioning & Refrigeration	3	--	--	3	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24061132	PEC-2 - Heating, Ventilation, Air-Conditioning & Refrigeration	20	20	40	60	2	--	--	100

Rationale:

Heating, Ventilation, Air Conditioning and Refrigeration (HVAC&R) is an essential subject in Mechanical Engineering that deals with the principles of thermal comfort, air quality, and refrigeration technologies. The course integrates concepts of thermodynamics, heat transfer, and fluid mechanics to develop energy-efficient and environmentally sustainable systems. In alignment with the UN Sustainable Development Goals (SDGs)**,** this syllabus emphasizes the use of **eco**-friendly refrigerants**,** renewable energy-based cooling systems, and sustainable design practices**.** The course aims to equip students with the technical competence to analyse, design, and apply HVAC&R systems in industrial, commercial, and domestic sectors, fostering both professional excellence and environmental responsibility.

Course Objectives:

1. To Understand the refrigeration principles, refrigerant impact on environment and air refrigeration system performance.
2. To study the working and performance evaluation of vapour compression, vapour absorption, and understand heat pump cycles with performance indicators, and ratings.
3. To learn the determinants of human thermal comfort, psychrometric principles & their application in air property analysis.
4. To estimate the cooling load for air conditioning system design.
5. To design air distribution systems and understand the different AHU component.
6. Understand the working of HVACR components and applications of HVACR systems including sustainable refrigeration technologies.

Course Outcomes: Learner will be able to…

1. Evaluate the performance of air refrigeration systems.
2. Evaluate the performance of vapor compression and vapor absorption refrigeration systems.
3. Analyze parameters influencing human thermal comfort and Evaluate psychrometric processes governing air-conditioning system performance.
4. Estimate the cooling load of air-conditioning systems by identifying various heat sources and component.
5. Design air distribution systems by applying principles of duct flow.
6. Analyze the working of components and various applications of HVAC&R systems.

Prerequisite: Fundamentals of Thermodynamics: types of system, Temperature, Heat, Work, Carnot Cycle.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Refrigeration Fundamental, Refrigerants and Air Refrigeration Systems	1.1 Basic Knowledge: Carnot Refrigerator, Carnot Heat Pump and their Coefficient of Performance (COP) & limitations. Effect of Temperature and Pressure on COP of the Cycle (Self Study). 1.2 Refrigerants: Classification and Designation of Refrigerants, Desirable Properties of Refrigerants, Greenhouse Effect & Refrigerant Alternatives. 1.3 Air Refrigeration System: Bell Coleman Cycle, Necessity of Air Cooling, Factors Considered for the Selection of Air Refrigeration System, Methods of Air Refrigeration System with Schematic and T-s Diagram, Numerical Based on Simple and Bootstrap Air Refrigeration System only.	7	CO1
II	Refrigeration and Heat Pump Systems	2.1 Vapor Compression Refrigeration System: Simple & actual VCR system on P-h and T-s diagrams, Thermodynamic analysis of the simple VCR cycle., Factors affecting the performance of the cycle. Numerical based on standard VCR system by using P-h chart and properties table.	8	CO2

		2.2 Vapor Absorption Refrigeration System. Simple and Practical (Self Study) VAR System, COP of Ideal Vapor Absorption System, Refrigerant-Adsorbent Properties, Domestic Electrolux Refrigerator, Lithium-Bromide Absorption System. (No Numerical on VAR)., 2.3 Heat Pump Primary Energy Ratio, Energy Efficiency Ratio, Heating Season Performance Factor Seasonal Energy Efficiency Ratio, BEE Star Rating, Classification of Heat Pump (No Numerical on Heat Pump) *Self Study: Vapor Compression Heat Pump Systems, Heat Pump Application in an Industry.		
III	Thermal Comfort, Psychrometry and Cooling Load Estimation	3.1 Thermal Comfort Conditions: Selection of Inside Design Conditions, Thermal Comfort and its significance,Factors Affecting Thermal Comfort, Effective Temperature & Factors Governing Effective Temperature, Comfort Chart, Selection of Outside Design Conditions. 3.2 Psychrometry of Air Conditioning Processes: Psychrometry Properties and Relations Psychrometry Processes, Adiabatic Air Mixing, Process on Psychrometric Chart, RSHF, GSHF, ERSHF, Bypass Factor (Numerical Based On Psychrometric Chart Or Relations) *Self Study :Classification of Air conditioning System	10	CO3
IV	Cooling load Estimation	4.1Cooling Load Estimation: Introduction, Components of cooling load, Different heat sources, Design of air conditioning system, (More emphasis on industry based load estimation.)	6	CO4
V	Air Distribution and Handling Systems in HVAC	5.1 Air Distribution System: 5.1.1: Duct: Classification of Ducts, Duct Material (Self Study), Pressure in Ducts, Flow of Air Through Duct, Pressure Losses in Duct, Air Flow Through Simple Duct System, Equivalent Diameter, Methods of Duct System Design (Self Study), Numerical on duct sizing. 5.2: Air Handling Unit Fan Coil Unit, Types of Fans Used Air Conditioning Applications, Fan Laws Filters Supply and Return Grills, Sensors.	4	CO5

VI	HVACR Components and application	6.1.HVACR components: Reciprocating, screw and scroll compressors, Air cooled and water cooled and evaporative condensers, DX, Flooded and Forced feed evaporators, Expansion devices: Capillary tube, TXV, EXV, Type of insulation materials. *Self Study : 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, Liquefaction of gases	4	CO6

***Self Study Note:** No questions to be asked in theory examination however, the question can be asked in assignment.

Text Books:

1. Refrigeration and Air Conditioning by C. P. Arora, McGraw Hill education (India) (P) limited, New Delhi
2. Refrigeration and Air Conditioning by Manohar Prasad, New age international (P) limited, New Delhi
3. Refrigeration and Air Conditioning by S. C. Arora and S. Domkundwar, Dhanpatrai and sons, Delhi
4. Khurmi R.S. and Gupta J.K., Refrigeration and Air Conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
5. Textbook of Refrigeration & Air-Conditioning by R.K. Rajput (Author), S.K. Kataria & Sons (Publisher)

References:

1. Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
2. Basic Refrigeration and Air conditioning by P.N. Ananthanarayana. McGraw-Hill.
3. ISHRAE Air Conditioning Handbook
4. ISHRAE Refrigeration Handbook
5. ASHRAE Handbook of Fundamentals
6. ASHRAE Handbook of Equipment
7. ASHARE Handbook of System
8. Open Source Software/learning website

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/112107208 - Refrigeration and Air-Conditioning, IIT Roorkee
2.	https://nptel.ac.in/courses/112105128 - Refrigeration and Air Conditioning, IIT Kharagpur
3.	https://nptel.ac.in/courses/112105129 - Refrigeration and Air Conditioning, IIT Kharagpur
4.	International Journal of Air-Conditioning and Refrigeration
5.	https://www.ashraeindia.org/
6.	International Journal of Air-Conditioning and Refrigeration (IJACR)
7.	Home | ashrae.org

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24061133	PEC-2 - Cryogenics	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24061133	PEC-2 - Cryogenics	20	20	40	60	2	--	--	100

Rationale:

The subject Cryogenics provides students with a comprehensive understanding of low-temperature engineering, beginning with the principles & methods used in domestic, commercial Refrigeration and Air conditioning and extending to the specialized field of cryogenics. Cryogenics is an essential field that deals with the production, behaviour, and application of materials at extremely low temperatures, typically below –150°C. Incorporating this subject into the undergraduate syllabus provides students with a strong theoretical foundation and practical understanding of low-temperature phenomena that are increasingly relevant in modern technology and industry. It prepares graduates for advanced studies and research, as well as for careers in high-tech industries where cryogenic technologies play a crucial role.

Course Objectives:

1. Learning the fundamental principles and different methods of refrigeration and air refrigeration system.
2. To impart knowledge of vapour compression refrigeration systems and refrigerants.
3. To develop understanding of psychrometric processes and cooling load estimation in air conditioning.
4. To explore the applications of cryogenics in various fields and to study various gas liquefaction systems.
5. To familiarize students with cryogenic refrigeration systems, different components, accessories, controls and storage systems.
6. To impart knowledge of low-temperature and liquid level measurement systems and cryogenic insulations.

Course Outcomes:

1. Describe the fundamental principles, terminology, methods of refrigeration and air refrigeration and evaluate the performance of air refrigeration systems.
2. Understand the working of vapour compression refrigeration systems and determine its performance, to illustrate various types of refrigerants, its designation and its properties.
3. Illustrate various air conditioning processes using psychometric chart and design air conditioning system using cooling load estimation.
4. Understand the fundamental, terminologies of cryogenics and study the applications of cryogenics in various fields and describe the different gas liquefaction systems.
5. Describe various cryogenic refrigeration systems, and to understand different components, accessories, controls in refrigeration and cryogenics, storage arrangement and its safety devices for cryogenic fluids.
6. Explain the low temperature and liquid level measurement systems/methods and cryogenics insulations

Prerequisite: Knowledge of Thermodynamics, Heat Transfer.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Refrigeration	1.1 Basic Knowledge: Reversed Carnot cycle and its limitation, Coefficient of Performance, Ton of refrigeration, Methods of refrigeration. 1.2 Air refrigeration systems: Bell Coleman cycle, Need for aircraft refrigeration system, Types of air refrigeration system with schematic and T-S diagram (Simple air cooling ,Simple air evaporative, Bootstrap, Bootstrap evaporative, Reduced ambient) & Numerical based on simple air cooling and bootstrap air refrigeration system.	07	CO1
II	Vapour Compression Refrigeration System & Refrigerants	2.1 Vapour Compression Refrigeration(VCR) System: Simple Vapor Compression system cycle, P-h chart, types of VCR cycles, Numerical based on vapour compression system by using P-h chart and refrigerant table, factors affecting the performance of the cycle, actual VCR cycle 2.2 Refrigerants: Classification, Designation, Physical and chemical properties of refrigerants, Secondary refrigerants.	06	CO2

III	Psychrometry of Air Conditioning Processes & Cooling Load Estimation	3.1-Psychrometry of Air Conditioning Processes: Psychrometry properties, processes, Adiabatic air mixing process ,Psychrometric chart, Bypass factor, SHF, RSHF, GSHF, ERSHF, Apparatus dew point, numerical based on psychrometric chart. 3.2: Cooling Load Estimation: Introduction, Different heat sources, Various load Estimation, Design of air conditioning system for domestic & commercial.	06	CO3
IV	Application of Cryogenics & Low temperature properties of engineering materials & cryogenic fluids, Gas Liquefaction systems	4.1-Cryogenics & its applications-Introduction of Cryogenics, (Self Study topic- Chronology of cryogenic technology), Application of cryogenics in superconducting devices, Space Technology, Food processing, Cryogenics in Biology and Medicine, Mechanical design and Manufacturing processes, Cryogenic recycling of tires, plastics. Effect on Mechanical, thermal and magnetic properties of materials in cryogenics temperature range *Self Study topics-Liquid Helium II and its superfluidity, Properties of cryogenic fluids) 4.2- Gas Liquefaction Systems: Inversion curves and Joule–Thomson effect. Gas Liquefaction systems using Joule–Thomson cycle: System performance parameters, Thermodynamically ideal Liquefaction system, Liquefaction systems for gases other than Neon, Hydrogen & Helium (Only Theory-Simple Linde Hampson system, Precooled Linde Hampson system ,Linde dual pressure system) 4.3-Gas Liquefaction systems using Expansion engine cycles: Only Theory -Claude system, Kapitza system.	08	CO4
V	Cryogenic Refrigeration System, System components and Accessories, Controls in Refrigeration & Cryogenics, Cryogenic fluid Storage	5.1-Cryogenic Refrigeration system: Ideal Refrigeration systems. Refrigerators for temperatures above 2K:-Joule-Thomson refrigeration system, Expansion engine refrigeration system, Philips refrigerator, V-M refrigerator, Gifford-McMahon refrigerator. Refrigerators for temperatures below 2K:-Magnetic cooling, Magnetic refrigeration system. 5.2-System components and Accessories, Controls in Refrigeration & Cryogenics : System components and Accessories, Controls in Refrigeration :Types of Condensers, Evaporators, expansion devices, Working of Hermatically sealed	07	CO5

		compressor, Reciprocating, Screw compressors. Accessories-(Self study -oil separator, drier), Controls-HP-LP cut out, Thermostat Cryogenic Equipment and Components- Compressors, expanders, heat exchangers and regenerators 5.3-Cryogenic fluid storage vessel, its piping arrangements & Basic Safety devices.		
VI	Measurement systems for low temperature, Cryogenic Insulations & Liquid Level Measurement methods	6.1-Measurement systems for low temperature: Introduction, Metallic resistance thermometer, Thermocouples, Constant-volume gas thermometer, Vapour Pressure thermometer. 6.2-Cryogenic Insulations -Types & their comparison on the basis of advantages and disadvantages. 6.3-Liquid Level Measurement methods: Hydrostatic gauges, Electric resistance gauges.	05	CO6

***Self Study Note:** No questions to be asked in theory examination however, the question can be asked in assignment.

Text Book:

1. Refrigeration and Air Conditioning by C.P.Arora, McGraw Hill education (India) (P) limited, New Delhi
2. A course on Refrigeration and Air Conditioning by Arora and S.Domkundwar, Dhanpatrai and sons, Delhi
3. Khurmi R.S. and Gupta J.K., A Textbook of Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
4. Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
5. Basic Refrigeration and air-conditioning- P.Ananthanarayana, TMH
6. Stoecker & Jones, Refrigeration and Air Conditioning
7. Cryogenics Systems, R. Barron Oxford University Press
8. Cryogenic Engineering, T.M.Flynn , Marcel Dekker
9. Cryogenic: Application and progress, A.Bose and P.Sengupta, Tata McGraw Hill
10. S. Mukhopadhyay, Cryogenic Engineering Fundamentals and Applications, PHI Learning.
11. Timmerhaus & Flynn, Cryogenic Process Engineering.

References:

1. ISHRAE Air Conditioning Handbook.
2. ISHRAE Refrigeration Handbook.
3. ASHRAE Handbook of Fundamentals.
4. ASHRAE Handbook of Equipment.
5. ASHARE Handbook of System.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc25_me114/preview
2.	https://nptel.ac.in/courses/112107208
3.	https://nptel.ac.in/courses/112101004

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24061141	PEC-3 - Robotics	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24061141	PEC-3 - Robotics	20	20	40	60	2	--	--	100

Rationale :

Offering robotics as an elective course in Mechanical Engineering will empower the learners to integrate design, control and automation principles which will help for advanced careers in the fields such as - Robotics, Mechatronics, Smart manufacturing and related emerging technologies.

Course Objectives:

1. To introduce foundational concepts of robotics.
2. To develop the ability to understand robot anatomy and components.
3. To equip students with mathematical tools to model robotic manipulators through forward and inverse kinematics.
4. To foster analytical skills to derive dynamic models of robotic systems.
5. To train students in implementing control strategies at the joint level and introduce image processing techniques for integrating vision into robotic systems.
6. To encourage problem-solving through task-level planning.

Course Outcomes: Six Course outcomes

After completing the course, students will be able to:

1. Differentiate robot classes, specifications and applications.
2. Demonstrate the robots based on its anatomy and select appropriate components for a specific task
3. Formulate forward and inverse kinematic models for robotic manipulators
4. Derive dynamic equations of motion for robotic manipulators using Newton Euler and Lagrangian methods and plan the robot trajectory.
5. Implement joint-level controllers and process the image for robot vision.
6. Solve a task level problem through proper planning.

Prerequisite:

Engineering Mechanics, Matrices, CAD - Computer Graphics, Dynamics of Machinery

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Robotics	Definition, history, evolution, scope, types of robots, applications (manufacturing, defense, healthcare, service industries, etc.) Robot classification based on - drive technologies, coordinate systems (Cartesian, cylindrical, spherical, SCARA, articulated) and motion control methods. Robot specifications - Number of Axes, Capacity and Speed, Reach and Stroke, Tool Orientation, Repeatability, Precision, and Accuracy, Operating Environment.	4	CO1
II	Robot Anatomy and the Components	Mechanical structure- links, joints, frames Sensors - position, velocity, force, vision Actuators - hydraulic, pneumatic, electric End-effectors- grippers, tools	4	CO2
III	Robot Kinematics	Direct Kinematics Dot and Cross products, Coordinate Frames, Rotations (fundamental and composite). Homogeneous coordinates - Homogeneous Coordinate Frames, Translations and Rotations,Composite Homogeneous transformations, Screw Transformations. Link Coordinates - Kinematic Parameters, Normal, Sliding, and	9	CO3

		Approach Vectors.The Denavit-Hartenberg (D-H) Representation,The Arm Equation-The Arm Matrix, The Arm Equation. The Link-Coordinate Diagram and the Arm Matrix for - A Four-Axis SCARA Robot (Note: Derivations/numerical based on this to be covered) Inverse Kinematics The Inverse Kinematics Problem- General Properties of Solutions, Existence of Solutions, Uniqueness of Solutions, Contents, Tool Configuration, Tool Configuration Vector.Tool Configuration of - a Four-Axis SCARA Robot Inverse Kinematics of a Four-Axis SCARA Robot (Note: Derivations/numerical based on this to be covered)		
IV	Robot Dynamics and Trajectory Planning	Dynamics Lagrange's Equation. Kinetic and Potential Energy, Link Inertia Tensor, Link Jacobian, Manipulator Inertia Tensor, Gravity. Generalized Force - Actuators, Friction. Dynamic Model of a One-Axis Robot (Inverted Pendulum) - Lagrange Euler Formulation, Newton Euler formulations. (Note: Derivations/numerical based on this to be covered) The Pick and Place Operation - Pick and Lift Off Points, Place and Set-Down Points, Speed Variation. Continuous Path Motion Paths and Trajectories,Continuous-Path Control of a Four- Axis SCARA Robot. Straight-Line Motion. Interpolated Motion - Cubic Polynomial Paths, Linear Interpolation with Parabolic Blends.	9	CO4
V	Robot Control and Vision	Control Open-loop vs closed-loop control. PID control for joint- level motion. Advanced control strategies: adaptive, robust, and model-based control. Vision Image Representation. Template Matching. Polyhedral Objects- Edge Detection, Corner Points, Run-Length Encoding. Shape Analysis- Line Descriptors, Area Descriptors, Principal Angle, Segmentation - Thresholding, Region Labeling. Iterative Processing - Shrink and swell Operators. Structured Illumination -Light Sources, Light Patterns, Triangulation. Camera Calibration.	8	CO5

VI	Robot Task Planning	Task Level Programming. Uncertainty. Configuration Space - Translations, Rotations. Gross-Motion Planning - Generalized Voronoi Diagrams (GVD). Grasp Planning. Fine-Motion Planning. A Task Planning Problem - Source and Goal Scenes, Task Planning Sub problems, Task Planner Simulation. (Note: Task planning exercises based on this to be covered)	5	CO6

Text Books:

1. Robert J. Schilling Fundamentals of Robotics: Analysis and Control (Prentice Hall India Learning Private Limited)
2. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics: Control, Sensing, Vision, and Intelligence (McGraw-Hill Education ISE Editions)
3. John J. Craig Introduction to Robotics: Mechanics and Control (Pearson Education India)

References:

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey Industrial Robotics: Technology, Programming, and Applications (McGraw Hill Education)
2. R.K. Mittal & I.J. Nagrath Robotics and Control (McGraw Hill Education)

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24061142	PEC-3 - Internet of Things (IoT)	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24061142	PEC-3 - Internet of Things (IoT)	20	20	40	60	2	--	--	100

Rationale:

The rapid integration of smart sensing, data communication, and connected devices in modern mechanical systems has made IoT an essential skill for future engineers. This course provides foundational knowledge to understand, monitor, and optimize electromechanical and industrial systems using IoT technologies. It prepares students for emerging domains such as Industry 4.0, predictive maintenance, and smart manufacturing.

Course Objectives:

1. Introduce the fundamental concepts, architecture, and ecosystem of the Internet of Things (IoT).
2. Develop understanding of various sensors, actuators, and controllers used in IoT-based mechanical systems.
3. Explain the principles of data acquisition, signal conditioning, and interfaces for reliable data measurement.
4. Familiarize students with IoT communication models, network technologies, and standard communication protocols.
5. Provide knowledge of data flow, cloud connectivity, and visualization platforms for IoT applications.
6. Expose students to real-world IoT applications related to manufacturing, maintenance, and automation.

Course Outcomes:

1. Explain the fundamental concepts, architecture, and applications of IoT.
2. Identify and describe various sensors, actuators, and controllers used in IoT systems.
3. Interpret the concepts of data acquisition and signal conditioning required for accurate sensing.
4. Compare different IoT communication technologies and application protocols for industrial connectivity.
5. Describe the process of IoT data management and cloud integration for monitoring and analytics.
6. Discuss real-world Industrial IoT applications related to smart manufacturing and predictive maintenance.

Prerequisite: Basic knowledge of Engineering Physics, Electrical / Electronics fundamentals, and Mechanical Measurements/Instrumentation. Familiarity with the operation of sensors and general computer usage is expected.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Internet of Things (IoT)	Definition, concept, and evolution of IoT; Comparison of IoT and Machine-to-Machine (M2M); IoT architecture; IoT Ecosystem and Components; Key characteristics; IoT Applications; Challenges.	5	CO1
II	Sensors, Actuators and Controllers	Sensors: Definition; Sensor characteristics (static and dynamic characteristics); Classification and working principles; Sensors: Temperature, Humidity, Smoke/Gas, Pressure, Vibration, Displacement, and Proximity. Actuators: Definition, Classification and working principles; Based on the type of energy source (electric, hydraulic and pneumatic actuators), Based on Type of Motion (Linear actuators (Solenoid), Rotary actuators (Motors: Stepper and Servo motors)); Controllers: Role of microcontrollers in IoT; Conceptual overview of Arduino, ESP32 Node MCU, Raspberry Pi as IoT controllers (no programming).	9	CO2

III	Data Acquisition and Signal Conditioning	Data Acquisition (DAQ) system: Architecture and workflow; Analog vs. digital signals, Sampling rate, ADC resolution; Signal conditioning fundamentals: Amplification, Filtering, Isolation, and Noise reduction; Calibration and linearization of sensors.	5	CO3
IV	IoT Communication Technologies and Protocols	Communication models: Device-to-Device, Device-to-Gateway, Device-to-Cloud; Wireless Communication Technologies: Wi-Fi, Bluetooth/BLE, ZigBee, LoRaWAN, NB-IoT, RFID; Application Protocols: HTTP, MQTT (emphasize industrial usage), CoAP; OPC-UA for shop-floor and SCADA communication (overview) Interfaces (Conceptual Only): GPIO, UART, I2C, SPI.	7	CO4
V	IoT Data Management and Cloud Integration	Data flow: Sensing → Transmission → Cloud → Visualization; Data storage concepts: Local, Edge, Fog, Cloud; Visualization dashboards for real-time monitoring. Cloud computing models: IaaS, PaaS, SaaS; IoT Cloud Platforms (overview only): AWS IoT, Azure IoT Hub, Google IoT, ThingSpeak; Security in IoT Systems: Authentication, Encryption, Data integrity; Common industrial vulnerabilities and mitigation strategies.	7	CO5
VI	Industrial Applications of IoT	Introduction to Industrial IoT (IIoT); IoT-driven smart manufacturing and production systems; Condition monitoring and predictive maintenance; Energy management and optimization through IoT; Digital twins and cyber-physical production systems; Smart transportation and logistics systems; Case study: IoT-enabled shop-floor monitoring.	6	CO6

Text Books:

1. Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press.
2. Raj Kamal, Internet of Things: Architecture and Design Principles, McGraw Hill.
3. Cuno Pfister, Getting Started with the Internet of Things, O'Reilly Media.

References:

1. Adrian McEwen and Hakim Cassimally, Designing the Internet of Things, Wiley, 2013.
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley, 2011.
3. Dietmar P. F. Möller and Roland E. Haas, Guide to Computing Fundamentals in Cyber-Physical Systems, Springer, 2017.
4. Michael Miller, The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World, Pearson, 2015.
5. Sabrie Soloman, Sensors Handbook, McGraw Hill, 2010.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc22_cs53/preview - Introduction to Internet of Things
2.	https://onlinecourses.nptel.ac.in/noc20_cs69/preview - Introduction to Industry 4.0 & Industrial IoT
3.	https://onlinecourses.nptel.ac.in/noc21_ee32/preview - Sensors and Actuators
4.	https://onlinecourses.nptel.ac.in/noc23_cs54/preview - Embedded System Design (Conceptual understanding of controllers)

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Practical	Tut.	Total
24061143	PEC-3 - Industrial Automation	3	--	--	3	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
24061143	PEC-3 - Industrial Automation	20	20	40	60	2	--	--	100

Rationale:

Industrial Automation is an important subject in Mechanical Engineering that combines mechanical systems with electronics, sensors, actuators, and control technologies to make industrial operations more efficient and accurate. The course is designed in such a way that, it will help students to develop technical skills, creativity, and awareness of sustainable practices. By learning automation concepts, students are prepared to design and implement smart and intelligent systems that support modern manufacturing and sustainable industrial growth.

Course Objectives:

1. To introduce the fundamentals, principles, and strategies of industrial automation.
2. To understand different types and levels of automation used in modern industries.
3. To study sensors and actuators used for measurement and control in automation systems.
4. To design basic hydraulic, pneumatic, and electro-pneumatic control circuits.
5. To develop PLC-based control logic for automated operations.
6. To understand the basics of industrial robotics, configurations, and control systems.

Course Outcomes: Learner will be able to…

1. Explain the fundamentals, principles, and strategies of automation.
2. Identify and classify automation systems and their industrial applications.
3. Select and integrate appropriate sensors and actuators for control systems.
4. Design hydraulic and pneumatic circuits for automated systems.
5. Develop and simulate electro-pneumatic and PLC-based control logic.
6. Explain robotic configurations, control, and drive mechanisms in industrial automation.

Prerequisite: Basics of Electrical and Electronic Circuits, Fundamentals of Control Systems, Manufacturing Process Overview, Pneumatics and Hydraulics Fundamentals.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Automation	1.1.Introduction to Automation Definition and fundamentals of automation, need of automation in improving efficiency, Elements of Automated system, Levels of automation, types of automation. 1.2.Advanced automation functions Safety, maintenance & repair diagnosis, error detection and recovery. 1.3.Automation principles and strategies Ten strategies of automation and production system, automation migration strategy.	4	CO 1
II	Mechanization and Industrial Automation	2.1. Fundamentals mechanization and automation, product life cycle and role of automation, Hard vs. Flexible Automation, Capital-intensive vs. Low-cost Automation. 2.2. Types and Classification of Automation Systems, mechanical, electrical, hydraulic, pneumatic, and hybrid systems, Selection criteria for different types of automation on basis of applications. 2.3. Automation in Material Handling and Storage Systems material handling, storage, and transport systems, Automated Storage and Retrieval Systems (AS/RS), Automated Guided Vehicle Systems (AGVS), use of conveyors.	5	CO 2

III	Sensing and Actuation Elements	3.1. Sensors and Their Selection Introduction, type and classification of sensor, Displacement Sensors, Temperature Sensors, Acceleration Sensors, Force and Pressure Sensors, Sensor Selection Criteria: Based on static characteristics, dynamic characteristics,Sensor Interfacing, Integration of Sensors. 3.2. Actuators Overview, selection criteria of actuators, Hydraulic, Pneumatic and Mechano-Electrical Actuators.	5	CO 3
IV	Hydraulic and pneumatic	4.1 Hardware components for Automation: Hydraulic and pneumatic devices, Different types of valves, auxiliary elements in Pneumatics & hydraulics, their applications and use of their ISO symbols. 4.2 Design of Pneumatic Circuits: Design of Pneumatic sequencing circuits using Cascade method and Shift, register method (up to 2 cylinders) 4.3 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.	10	CO 4
V	Electro-pneumatic and Programmable Logic Controller	5.1 Electro-pneumatic Circuits Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping. 5.2 PLC Discrete Control Systems Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.	10	CO 5

VI	Intelligent Automation Systems	6.1 Introduction to AI in Industrial Automation: Definition and scope of Artificial Intelligence, conventional vs AI-based Automation, concept of natural language processing, machine learning, expert systems, neural networks and computer vision. Role of AI in industrial automation, applications of AI in process control, smart manufacturing, Genetic Algorithms, Industry 4.0 (Concept and Algorithms, No programming or numericals)	5	CO 6

Text Books:

1. M. P. Groover "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education,New Delhi
2. Joffrey Boothroyd, Peter Dewhurst and Winston A. Knight, "Product Design for manufacture and Assembly", CRC Press
3. M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey, "Industrial Robotics Technology programming and Applications", McGraw-Hill,
4. Yoram Korean, "Robotics for engineers", McGrew Hill Co
5. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.
6. Frank Petruzella," Programmable Logic Controllers", McGraw-Hill Education; 4 edition

References:

1. Industrial Hydraulics: Pippenger
2. Mechatronics - Mechanical System Interfacing , Auslander and Kempf, Prentice Hall
3. Pneumatic Circuits and Low Cost Automation: by Fawcett J.R.
4. Fundamentals of pneumatics: Festo series.

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/108105062 - Industrial Automation and Control, IIT Kharagpur
2.	https://nptel.ac.in/courses/108105063 - Industrial Automation and Control, IIT Kharagpur

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*24061144	PEC-3 - Unmanned Aerial Vehicle	3	_	-	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks					Term work	Prac / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
*24061144	PEC-3 - Unmanned Aerial Vehicle	20	20	40	60	2	--	--	100

***This course is common with Mechanical and Automation Engineering.**

Rationale:

The rapid advancement in Unmanned Aerial Vehicle (UAV) technology has revolutionized multiple sectors such as defense, agriculture, logistics, and environmental monitoring. With the introduction of the Drone Rules 2021 by the Ministry of Civil Aviation (MoCA), India has established clear frameworks for UAV design, operation, and certification. This course introduces mechanical engineering students to UAV fundamentals, aerodynamic principles, and regulatory standards, preparing them for multidisciplinary applications in emerging aerial systems.

Course Objectives:

The course aims to:

1. Introduce fundamental concepts, evolution, and classifications of UAV systems.
2. Explain national and international UAV rules, standards, and safety requirements.
3. Describe aerodynamic principles and design aspects relevant to UAV performance.
4. Identify major mechanical, electrical, electronic, and software components of UAVs.
5. Demonstrate operational procedures, mission planning, and maintenance practices.
6. Explore industrial, societal, environmental, and defence applications of UAV technologies.

Course Outcomes:
After completing the course, students will be able to:

1 Differentiate UAV types, classifications, and design categories.
2 Interpret UAV regulations, licensing requirements, and global standards.
3 Demonstrate understanding of aerodynamic forces and UAV design characteristics.
4 Explain UAV components, sensors, communication systems, and software tools.
5 Demonstrate UAV mission planning, flight operations, safety checks, and Maintenance.
6 Describe UAV applications, future technologies, and ethical considerations

Prerequisite: Basic understanding of physics, aerodynamics, electronics, communication systems, programming fundamentals, and ability to interpret technical diagrams for UAV concepts and operations.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction	Historical Development, Introduction to UAV, Types (fixed, rotary, hybrid), Classification(based on weight, Range, and Design).	5	CO1
II	UAV Regulations and Standards (India & International)	DGCA Rules (CAR, Drone Rules 2021, Digital Sky Platform, UIN, UAOP), Drone classifications by weight and use in India, Airspace management and No-Fly zones, Global UAV regulations – FAA (USA), EASA (EU), ICAO Certification and licensing requirements, Ethical, privacy, and safety aspects of UAV operation	7	CO2
III	Basics of UAV Design and Aerodynamics	Fundamental of flight mechanics: lift, drag, thrust, and weight, Basic aerodynamic principles and airflow over lifting surfaces, stages of UAV design, Airframe configurations and aerodynamic characteristics of UAVs Types of aircraft and their basic performance characteristics, Introductory aspects of airframe design and structural considerations	6	CO3

IV	UAV Components and Software Systems	Mechanical Components: Airframe types, structural materials (composites, aluminum alloys) Propulsion system: motors, propellers, ESCs, landing gears Assembly requirements, mechanical balancing, vibration control Electrical & Electronic Components: Power systems (Li-Po batteries, power management) Sensors (IMU, GPS, barometer, magnetometer, ultrasonic, lidar) Communication systems (Radio, Telemetry, Wi-Fi) On-board controllers (Pixhawk, APM, Raspberry Pi) Software and Simulation: Ground control software: Mission Planner, Q Ground Control Flight simulation tools: Gazebo, AirSim Basic programming for waypoint mission Data logging and analysis	10	CO4
V	UAV Operations and Maintenance	Pre-flight checks and calibration procedures, Flight planning and mission execution, Manual vs. autonomous operation, Safety protocols and emergency handling, Maintenance and repair procedures, Troubleshooting mechanical /electronic issues.	7	CO5
VI	UAV Applications and Future Trends	UAV Applications (Industrial, Societal & environmental and Defense) Industrial applications: agriculture, surveillance, mapping, logistics, infrastructure monitoring Societal & environmental applications: disaster management, healthcare, smart cities, wildlife tracking, Forestry, Hydromorphological study, Defense and warfare – ethical use, peacekeeping operations, security, reconnaissance and surveillance. Future scope: Swarm drones, AI integration, additive manufacturing of UAV parts.	4	CO6

Text Books:

1 Unmanned Aerial Vehicles_ An Introduction by P.K. Garg

2 Introduction to the Handbook on UAVs by K.P. Valavanis and G.J. Vachtsevanos.

3 Introduction to Unmanned Aircraft Systems - . Kurt Barnhart Douglas, Marshall Eric Shappee

4 Unmanned Aerial Vehicles: Fundamentals, Components, Mechanics, And Regulations By M. P. Stewart and S. T. Martin.

5 Drone Law and Policy: Global Development, Risks, Regulation and Insurance By Anthony A. Tarr, Julie-Anne Tarr, Maurice Thompson, Jeffrey Ellis.

6 International Regulation of Non-Military Drones By Anna Masutti, Filippo Tomasello.

7 Unmanned Aircraft System UAVs Design, Development And Deployment by Reg Austin.

8 Handbook of Unmanned Aerial Vehicles-Kimon P. Valavanis • George J. Vachtsevanos-Springer

9 Small Unmanned Aircraft Systems Guide: UAV Fundamentals, Operations, Communications & Sensors by Brent Terwilliger

References:

1 Composite Materials for Aircraft Structures, Second Edition (AIAA Education Series) by Baker, Alan; Dutton, Stuart; Kelly, Donald

2 Design of Unmanned Aerial Systems (Aerospace Series) -- Mohammad H_ Sadraey

3 https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=1749154 & https://static.pib.gov.in/writereaddata/specificdocs/documents/2022/jan/doc202212810701.pdf

Online References:

Sr.No.	Website Links
1	https://onlinecourses.nptel.ac.in/noc21_ae13/preview
2	https://onlinecourses.nptel.ac.in/noc20_ae04/preview
3	https://onlinecourses.nptel.ac.in/noc25_ae30/preview
4	https://onlinecourses.swayam2.ac.in/ntr24_ed12/preview

Assessment:

Internal Assessment (IA) for 40 marks:

● IA will consist of two compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Examination for 60 Marks:

➢ **Question paper format**

● The Question Paper will comprise a total of six questions, each carrying 15 marks. Question 1 will be compulsory and should cover the full syllabus.

● Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from module 3, then part (b) must be from any other module randomly selected from all the modules.

● A total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2406115	Machine Design lab	-	2	-	-	1	-	1

Course Code	Course Name				Examination Scheme			
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2406115	Machine Design lab	--	--	--	--	25	25	50

Couse Objectives:

The Machine Design Laboratory aims to:

1. Enable students to apply fundamental engineering principles for designing machine components subjected to static and dynamic loading.
2. Develop proficiency in modeling, assembling, and analyzing mechanical parts using CAD and FEA software.
3. Encourage design thinking, decision-making, and problem-solving based on standard design data and practices.
4. Introduce students to industrial drafting practices including GD&T, limits and fits, and preparation of manufacturing drawings.
5. Bridge the gap between theoretical design concepts and practical applications through simulation based validation.
6. Impart knowledge of design safety, failure analysis, and standardization principles relevant to mechanical design.

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

1. Design and analyze fundamental joints such as cotter, knuckle, welded, and bolted joints using CAD and FEA tools.
2. Design power transmission elements including shafts, bearings, and springs under realistic loading conditions.
3. Prepare assembly and detailed manufacturing drawings using GD&T, limits, fits, and BOM standards.
4. Validate design results using analytical and computational tools for accuracy and safety.
5. Evaluate design performance through empirical, analytical, and simulation-based methods.
6. Demonstrate understanding of fatigue, material selection, and manufacturability in real-world applications.

List of Experiments.

Sr No	List of Experiments	Hrs
	Part A (Any 5)	
01	Design of thick cylinders subjected to an internal pressure using Lame's equation.	02
02	Design of a Screw jack.	02
03	Design of Flywheel.	02
04	Design and selection of standard roller chains.	02
05	Design of Flat Belt.	02
06	Design of V- Belt.	02
	Part B (Any 3)	
07	Design Cotter joint and change the dimensions according to design values (use models developed in CAD modeling Course) and verify the results by using analysis software. (Use parametric 3D modeling Software). Use GD&T, Limits and Fits, BOM. (A3 Size Print for Drawing and Analysis Results should be submitted in A4 color printout)	02

08	Design Knuckle joint and change the dimensions according to design values (use models developed in CAD modeling Course) and verify the results by using analysis software. (Use parametric 3D modeling Software). Use GD&T, Limits and Fits, BOM. (A3 Size Print for Drawing and Analysis Results should be submitted in A4 color printout)	02
09	Prepare CAD model of Screw jack. Also prepare assembly and detailed manufacturing drawing by using any CAD software. Use GD&T, Limits and Fits, BOM. (Use values from assignment) (A3 Size Print for Drawing)	02
10	Design leaf spring. Prepare a CAD model by using 3D Parametric Modeling Software and by using Analysis software do the analysis of it. (A3 Size Print for Drawing and Analysis Results should be submitted in A4 color printout)	02
11	Design bolted joints under eccentric loading and validate the results by using analysis software. (A3 Size Print for Drawing and Analysis Results should be submitted in A4 color printout)	02

Sr No	List of Assignments / Tutorials	Hrs
01	Design against fluctuating loads. (At least 2 Numerical)	01
02	Design of Shafts. (At least 2 Numerical)	01
03	Design and select suitable bearing from design data book. (At least 2 Numerical)	01
04	Design helical Spring.	01
05	Design of Coupling.	01

Text Books:

1. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
3. Design of Machine Elements - Sharma, Purohit. Prentice Hall India Publication
4. Machine Design by R.S.KHURMI AND J.K.GUPTA , EURASIA PUBLISHING HOUSE (PVT.) LTD.

References:

1. Design of Machine Elements by V.M.Faires
2. Machine Design by Reshetov, Mir Publication
3. Machine Design by Black Adams, McGraw Hill
4. Design Data book by P.S.G. College of Technology, Coimbatore.

Online Resources:

Sr. No.	Website Name
1.	Design of Machine Elements, IIT Kharagpur: https://nptel.ac.in/courses/112/105/112105124/
2.	Machine Design-II, IIT Madras: https://nptel.ac.in/courses/112/106/112106137/
3.	Design of Machine Elements, Dr. A Kumaravel, M. Kathirselvam: https://ekumbh.aicteindia.org/

Assessment :

Term Work: Term Work shall consist of at least 8 practicals' based on the above list. Also, Term work Journal must include least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tut.	Theory	Practical	Tut.	Total
2406116	Thermal Engineering Lab	--	2	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical / Oral	Total Marks
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Total Tests				
2406116	Thermal Engineering Lab	--	--	--	--	25	25	50

Couse Objectives:

1. To determine thermal conductivity of metals, liquids, and insulating materials experimentally.
2. To analyse the performance and efficiency of extended surfaces (fins) under different convection modes.
3. To determine convective heat transfer coefficients under free and forced convection conditions.
4. To study radiative heat transfer, estimate emissivity, and evaluate heat exchanger effectiveness.
5. To perform load tests on petrol and diesel engines and prepare heat balance sheets.
6. To determine engine frictional losses, mechanical efficiency, and analyze exhaust emissions.

Couse Outcomes:

1. Measure and compare thermal conductivities of metals, liquids, and insulating materials.
2. Evaluate the performance and efficiency of extended surfaces (fins) under different convection modes.
3. Determine convective heat transfer coefficients under free and forced convection conditions and analyze related flow and temperature parameters.
4. Analyze radiative heat transfer, estimate surface emissivity, and evaluate heat exchanger effectiveness.
5. Perform load tests on petrol and diesel engines and prepare heat balance sheets to assess overall efficiency.
6. Estimate engine frictional losses, determine mechanical efficiency, and analyze exhaust emissions using standard instruments.

List of Experiments:

Sr. No.	List of Experiments	Hrs.	LO
Group-A (Heat Transfer) (At least seven experiments to be performed)			
1	Measurement of thermal conductivity of metal rod/ liquids/insulating powder.	2	1
2	Measurement of thermal conductivity of composite wall/lagged pipe.	2	1
3	Performance analysis of extended surfaces under free/force convection.	2	2
4	Determination of time constant of different materials under unsteady state heat transfer.	2	2
5	Measurement of heat transfer coefficient for flow over flat surface/ flow through tubes in free/forced convection.	2	3
6	Measurement of emissivity of grey surface.	2	4
7	Verification of Stefan Boltzmann Law.	2	4
8	Estimation of overall heat transfer coefficient and effectiveness of parallel and counter-flow heat exchanger.	2	4

Group-B (IC Engines) (At least Three experiments to be performed)			
9	Performance testing of Single/Multi Cylinder, Four- stroke Diesel Engine at constant speed (Load Test) along with Heat Balance Sheet.	2	5
10	Performance testing of Single Cylinder/Multi Cylinder, Four stroke Petrol Engine at constant Speed/Load.	2	5
11	Determination of frictional power and mechanical efficiency of the multi-cylinder petrol/diesel engine by Morse test.	2	6
12	Measurement of exhaust gas emission constituent of single/multi cylinder, four-stroke, petrol/diesel engine using exhaust gas analyser.	2	6

Sr. No.	List of Assignments / Tutorials	Hrs.
01	Conduction Numerical/Derivation	2
02	Convection Numerical/Derivation	2
03	Radiation/Heat exchanger Numerical/Derivation	2
04	IC Engine Numerical on Performance Testing	2
05	IC Engine Numerical on Heat balance sheet/Morse test	2
06	Report/Case study on Thermal Management in E-vehicle	2

Text Books:

1. Heat and Mass Transfer – R.K. Rajput Publisher: S. Chand & Company
2. Heat Transfer – J.P. Holman Publisher: McGraw Hill Education
3. Fundamentals of Engineering Heat and Mass Transfer – Frank P. Incropera & David P. DeWitt Publisher: Wiley India
4. Internal Combustion Engines – V. Ganesan Publisher: Tata McGraw Hill Education

References:

1. Heat Transfer: Principles and Applications – D.S. Kumar Publisher: S.K. Kataria & Sons
2. A Textbook of Heat and Mass Transfer – S.P. Sukhatme & J.K. Nayak Publisher: Universities Press
3. IC Engines – Mathur & Sharma Publisher: Dhanpat Rai Publications

Online Resources:

Sr. No.	Website Name
1.	https://mfts-iitg.vlabs.ac.in/ - Fluid and Thermal Sciences Lab, IIT Guwahati
2.	https://vlab.amrita.edu/index.php?sub=1&brch=194 - Heat & Thermodynamics Virtual Lab, Amrita Vishwa Vidyapeetham
3.	http://vlabs.iitkgp.ernet.in/rtvlas/# - Virtual Lab on Automotive Systems

Assessment:

Term Work: Term Work shall consist of at least 10 practical's based on the above list. Term work Journal must include 6 assignments (At least 3 questions in each assignment).

Term Work Marks:

Total 25 Marks = 15 Marks on Experiment + 5 Marks on assignments + 5 Marks on attendance.

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
24061171	PEL-2 – Heating, Ventilation, Air-Conditioning & Refrigeration Lab	--	02	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Total Tests				
24061171	PEL-2 – Heating, Ventilation, Air-Conditioning & Refrigeration Lab	--	--	--	--	25	25	25

Couse Objectives:

1. To understand the fundamental principles of vapor compression, vapor absorption, and heat pump systems.
2. To study and apply psychrometric properties and processes in analyzing air conditioning operations and assessing the efficiency of different cooling systems.
3. To determine the cooling load of a confined space by identifying and quantifying various internal and external heat sources.
4. To familiarize with the key HVAC&R components, controls, and sensors used in refrigeration & air conditioning systems.
5. To simulate and analyze the performance of vapor compression refrigeration systems using computational tools.
6. To promote awareness of modern HVAC technologies, smart control systems, and SDG practices.

Couse Outcome:

1. To analyze and evaluate the performance of vapor compression, vapor absorption, and heat pump systems using COP and cycle diagrams.
2. To analyze and apply psychrometric principles to evaluate air conditioning processes and the performance of various cooling systems.
3. To estimate the cooling load of a confined space by identifying and quantifying various internal and external heat sources.
4. To identify and explore the functions of major HVAC&R components, control devices, and sensors used in air conditioning systems.
5. To simulate and analyze the performance of vapor compression refrigeration systems using computational tools.
6. To communicate effectively the modern HVAC technologies and control systems while integrating environmental sustainability, global refrigerant protocols, and green building principles in HVAC applications.

Prerequisite: Fundamentals of Thermodynamics: types of system, Temperature, Heat, Work, Carnot Cycle, Elements of Mechanical Engg.

DETAILED SYLLABUS:

Sr. No.	Name of the Module	Detailed Content	Hours	LO Mapping
1	VCR & VAR	Basic principles of refrigeration and reverse Carnot cycle. Working Principle, Components and COP of various refrigeration system Vapour Compression Refrigeration (VCR) System Heat Pump, Vapour Absorption Refrigeration (VAR) System, Ice Plant)	8	LO1
2	Air Conditioning	Psychrometric properties of air: Psychrometric processes:, Air conditioning systems:, Working principle of Cooling Tower with the concept of Tower approach and range, cooling efficiency, Water Cooler and Desert Cooler: Construction, working, and performance analysis, Factors affecting cooling capacity and efficiency	6	LO2
3	Cooling Load	Components of Cooling Load, Types of cooling loads(Sensible and latent heat loads): External loads: solar radiation, conduction through walls, roof, and windows, Internal loads: occupants, lights, appliances, and equipment Ventilation and infiltration loads Various Load Estimation, Design of Air Conditioning System, Cooling load calculation using psychrometric data.	4	LO3

4	Components, Controls and Sensor	HVAC&R System Components: Working of reciprocating, screw and scroll compressors, working of air cooled, and water cooled and evaporative condenser, Working of DX, Flooded, and Forced feed evaporators, Expansion devices: Capillary tube, TXV, EXV. Type of insulation materials. Control Systems: Thermostats, humidistats, and pressure controls,Safety devices and relays Sensors in HVAC Systems:Temperature, humidity, pressure, and flow sensors Integration in Building Management Systems (BMS)Maintenance activities: Charging of refrigerantsLeakage detection methods (soap bubble, electronic, halide torch)	2	LO4
5	Simulation	Simulation of refrigeration systems to find the performance.Use of simulation software and virtual lab for the Performance evaluation of refrigeration system: COP and mass flow rate computation, enthalpyP-h & T-s diagram Effects of evaporator and condenser temperature on system performance Interpretation of simulation results and comparison with experimental data	2	LO5
6	Latest Technologies	Chiller Systems: vapor compression and absorption chillers, applications in HVAC Building Management Systems (BMS): introduction, functions, and automation in HVAC, Environmental Impact of Refrigeration:Ozone depletion potential (ODP) and global warming potential (GWP) Refrigeration protocols: Montreal, Kyoto, and Kigali amendments, Alternative Refrigerants: eco-friendly and low-GWP refrigerants (R134a, R290, R600a, CO_2, NH_3), Variable Refrigerant Flow (VRF) Technology: principle, components, and smart controls Sustainability in HVAC: energy-efficient systems, heat recovery, green building design, SDG-oriented activities: energy conservation, renewable integration, lifecycle cost analysis.	2	LO6

List of Experiments:

Sr. No.	List of Experiments	Hrs.	LO
1	To determine the theoretical and experimental Coefficient of Performance (COP) of Vapour Compression Test Rig	2	LO1
2	To determine the theoretical and experimental COP of a heat pump.	2	LO1
3	To study and determine the COP of Vapor Absorption Refrigeration System	2	LO1
4	Study and performance of refrigeration cycle on Ice plant.	2	LO1
5	Perform humidification and dehumidification air conditioning process on air conditioning test rig	2	LO2
6	Study and performance of cooling tower based on the cooling load and approach to wet bulb temperature.	2	LO2
7	Performance analysis on watercooler system	2	LO2
8	Cooling capacity analysis of the desert cooler.	2	LO2
9	Calculate the cooling load of a confined space or room using standard methods and psychrometric principles.	2	LO3
10	Study of various HVAC&R components	2	LO4
11	Charging and leakage detection in refrigeration and air conditioning (RAC) systems.	2	LO4
12	Steady state Simulation of VCR system with developed code or any analytical software.	2	LO5
Case studies through Seminar /Poster presentation/Activity on			
1	Chiller unit	2	LO6
2	Radiant Cooling		
3	Building Management system(BMS)		
4	Effect on Ozone depletion and Global warming,		
5	Alternative refrigerants		
6	Refrigerant protocols (Montreal, Kyoto, Kigali)		
7	Variable Refrigerant Flow (VRF) technology and smart control systems		
8	Sustainable Development Goals (SDG) based activities		
9	Green Building: Building survey and economic aspect used in design.		

Text Books:

1. Refrigeration and Air Conditioning by C. P. Arora, McGraw Hill education (India) (P) limited, New Delhi
2. Refrigeration and Air Conditioning by Manohar Prasad, New age international (P) limited, New Delhi
3. Refrigeration and Air Conditioning by S. C. Arora and S. Domkundwar, Dhanpatrai and sons, Delhi
4. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
5. Textbook Of Refrigeration & Air-Conditioning by Rk Rajput (Author), Sk Kataria & Sons (Publisher)

References:

1. Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
2. Basic Refrigeration and Air conditioning by P.N. Ananthanarayana. McGraw-Hill.
3. ISHRAE Air Conditioning Handbook
4. ISHRAE Refrigeration Handbook
5. ASHRAE Handbook of Fundamentals
6. ASHRAE Handbook of Equipment
7. ASHARE Handbook of System
8. Open Source Software/learning website

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/112107208 - Refrigeration and Air-Conditioning, IIT Roorkee
2.	https://nptel.ac.in/courses/112105128 - Refrigeration and Air Conditioning, IIT Kharagpur
3.	https://nptel.ac.in/courses/112105129 - Refrigeration and Air Conditioning, IIT Kharagpur
4.	International Journal of Air-Conditioning and Refrigeration
5.	https://www.ashraeindia.org/
6.	International Journal of Air-Conditioning and Refrigeration (IJACR)
7.	Home | ashrae.org

Virtual Labs

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

Term Work:

Term work shall consist of

1. Minimum Eight experiments to performed.

2. Industrial visit on any HVAC&R plant

3. Case study report

Distribution of Term work marks (Total 25 Marks) as follow

1. Experiments : 10 marks

2. Case study : 5 marks

3. Industrial Visit Report (HVAC plant/ Exhibition) : 5 Marks

4. Attendance (Theory + Practical) : 5 marks

End Semester Practical/Oral examination:

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

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*24061181	PEL-3 Robotics Lab	--	2	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
*24061181	PEL-3 Robotics Lab	--	--	--	--	25	25	50

***Note : Conduct the experiment related to the chosen program elective.**

Course Objectives:

1. To analyze robotic arm components, functions, and kinematic parameters.
2. To program and simulate robotic arms for pick-and-place actions.
3. To master robot software interfaces, ROS commands, and visualization tools.
4. To interface infrared, ultrasonic, and encoder sensors with microcontrollers.
5. To design and implement autonomous obstacle-avoiding and line-following mobile robots.
6. To develop advanced robot control systems using vision, voice, and gestures.

Course Outcomes :

1. Students will identify robotic arm components and analyze kinematic parameters.
2. Students will execute pick-and-place operations via programming and simulation.
3. Students will operate robot programming interfaces, ROS, and visualization platforms.
4. Students will integrate diverse sensors with microcontrollers for environment perception.
5. Students will construct functional mobile robots for navigation and line following.
6. Students will implement vision-based, voice-driven, and autonomous decision-making robotic systems.

List of Experiments.

***Note :** Conduct the experiment related to the chosen program elective.

Sr No	List of Experiments	Hrs
Robotics (Any Eight Experiments to be performed)		
1	Demonstration and study of different components of robotics arm and its functions.	02
2	Experiment on programming the robotic arm for pick & place operation and its kinematic parameter analysis.	02
3	Experiment on simulation of a pick & place robotic arm and visualization of kinematic parameters using any of the softwares like - CoppeliaSim/Webots/IsaacSim/Roboanalyzer,etc.	02
4	Study of robot programming interface (teach pendant / software)	02
5	Introduction to robot operating system : Installation and basic command execution	02
6	Robot visualization using RViz / Gazebo	02
7	Interfacing IR Senser for obstacle detection using microcontroller	02
8	Interfacing ultrasonic sensor for distance measurement	02
9	Measurement for motor speed using encoder and microcontroller	02
10	Design and implementation of line follower robot	02
11	Design and implementation of obstacle avoidance robot	02
12	Basic navigation control of mobile robot	02
13	Gesture controlled robot using sensors / camera	02
14	Voice-controlled robot using mobile or PC interfance	02
15	Object detection using open CV (basic implementation)	02
16	Autonomous robot using rule based decision making	02
17	Mini project : Design and develop a robotic system for real world application	02

Online Resources:

Sr. No.	Website Name
1.	https://mr-iitkgp.vlabs.ac.in/ - Mechanisms and Robotics

An Industrial Visit to any of the industry in the field of - Robotics is suggested. Learners shall prepare an industrial visit report and attach it to the term work file.

Assessment:

Term Work: The term work file must include reports of **minimum e**ight **experiments** related to the chosen program elective with the copies of simulation/diagrams/circuits attached.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiments) +05 marks (Industrial visit report) + 5 Marks (Attendance)

Practical& Oral Exam:
An Oral & Practical exam will be held based on the above syllabus.

1. To be conducted by pair of Internal and External Examiners.
2. Practical examination duration is two hours, based on the Term work.
3. Oral examination should also be conducted based on the theoretical concepts applied in performing the practical exam, steps followed, etc..
4. The distribution of marks for practical examination shall be as follows:
   a. Practical Exam ….15 marks
   b. Oral Exam ...……10 marks
5. Evaluation of practical examination to be done based on practical performance report submitted by the student.
6. Students work along with evaluation report to be preserved till the next examination.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*24061182	PEL-3 Internet of Things (IoT) Lab	--	2	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
*24061182	PEL-3 Internet of Things (IoT) Lab	--	--	--	--	25	25	50

***Note : Conduct the experiment related to the chosen program elective.**

Course Objectives :

1. To understand the Arduino environment and basic microcontroller programming.
2. To master digital output control using single and multiple LEDs.
3. To apply Pulse Width Modulation for variable voltage device control.
4. To interface environmental sensors including DHT11 and PIR modules.
5. To control electromechanical actuators using the SG90 servo motor.
6. To implement wireless communication and cloud-based sensor data logging.

Course Outcomes :

1. Students will install the Arduino IDE and write basic programs.
2. Students will design circuits to control single and multiple LEDs.
3. Students will generate PWM signals to alter signal duty cycles.
4. Students will acquire data from temperature and motion detection sensors.
5. Students will program and manipulate the positioning of servo motors.
6. Students will transmit sensor data wirelessly and log it onto cloud platforms.

List of Experiments.

***Note :** Conduct the experiment related to the chosen program elective.

Sr No	List of Experiments	Hrs
Internet of Things (IoT) (Any Eight experiments to be performed)		
1.	Introduction and Installation of Arduino Programming	02
2.	Simple LED Blinking using Arduino	02
3.	Multiple LED Blinking using Arduino	02
4.	Pulse Width Modulation using Arduino	02
5.	Interfacing Arduino with temperature sensor (DHT11)	02
6.	Interfacing Arduino with PIR Sensor	02
7	Interfacing Arduino with Servo Motor (SG90)	02
8	Communication with Arduino using Wireless Medium as Bluetooth Module (HC05)	02
9	Setting up and Cloud Platform and logging Sensor Data on the platform.	02

Online Resources:

Sr. No.	Website Name
1.	https://plc-coep.vlabs.ac.in/- PLC

An Industrial Visit to any of the industry in the field of - Robotics/Industrial Automation/IoT/Drone Technology is suggested. Learners shall prepare an industrial visit report and attach it to the term work file.

Assessment:

Term Work: The term work file must include reports of **minimum e**ight **experiments** related to the chosen program elective with the copies of simulation/diagrams/circuits attached.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiments) +05 marks (Industrial visit report) + 5 Marks (Attendance)

Practical& Oral Exam:
An Oral & Practical exam will be held based on the above syllabus.

1. To be conducted by pair of Internal and External Examiners.
2. Practical examination duration is two hours, based on the Term work.
3. Oral examination should also be conducted based on the theoretical concepts applied in performing the practical exam, steps followed, etc..
4. The distribution of marks for practical examination shall be as follows:
   a. Practical Exam ….15 marks
   b. Oral Exam ...……10 marks
5. Evaluation of practical examination to be done based on practical performance report submitted by the student.
6. Students work along with evaluation report to be preserved till the next examination.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*24061183	PEL-3 Industrial Automation Lab	--	2	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
*24061183	PEL-3 Industrial Automation Lab	--	--	--	--	25	25	50

***Note : Conduct the experiment related to the chosen program elective.**

Course Objectives :

1. To evaluate the characteristics of sensors, signal conditioning, and pneumatic components.
2. To analyze automated material handling and automated storage and retrieval systems.
3. To design electro-hydraulic sequencing circuits via physical kits and simulation software.
4. To construct electro-pneumatic dual-cylinder sequencing circuits using hardware and software.
5. To develop fundamental PLC ladder programs using timers, counters, and logic gates.
6. To implement advanced PLC control systems for complex automated mechatronics applications.

Course Outcomes :

1. Students will assess sensor signal conditioning and pneumatic component behaviors.
2. Students will explain the operation of automated material handling and retrieval models.
3. Students will build and simulate operational dual-cylinder electro-hydraulic sequencing systems.
4. Students will create and test physical and simulated electro-pneumatic sequencing circuits.
5. Students will program basic PLC ladder logic for industrial motor and process controls.
6. Students will execute automation programs for complex systems like bottle filling plants.

List of Experiments.

***Note :** Conduct the experiment related to the chosen program elective.

Sr No	List of Experiments	Hrs
Industrial Automation (Any Eight experiments to be performed)		
1	Study of Sensors and Signal Conditioning	02
2	Characteristics of Pneumatic Components	02
3	Study of an Automated Material Handling System / AS/RS Model	02
4	Experiment on design of electro-hydraulic circuits for sequencing two cylinders using trainer kit.	02
5	Design of Electro-Pneumatic Circuit using Solenoid Valves	02
6	Experiment on design and simulation of electro-hydraulic circuits for sequencing two cylinders using any Hydraulic software like - FluidSIM, Festo, AutoSim, etc.)	02
7	Experiment on design and simulation of electro-pneumatic circuits for sequencing two cylinders using trainer kit.	02
8	Experiment on simulation of electro-pneumatic circuits for sequencing two cylinders using any pneumatic software like (FluidSIM, Festo, AutoSim, etc.)	02
9	Experiment on Ladder programming on PLC for any simple control applications like - Simple ON OFF control, timers, counter, two motor system, simple control applications with logic/ timers/counters.	02
10	Experiments on Ladder programming for Mechatronics system (e.g. bottle filling plant, lift simulator, control of electro-pneumatic or electro-hydraulic systems).	02

Online Resources:

Sr. No.	Website Name
1.	http://ial-coep.vlabs.ac.in/ - Industrial Automation
2.	https://pc-coep.vlabs.ac.in/- Pneumatics
3.	https://plc-coep.vlabs.ac.in/- PLC

An Industrial Visit to any of the industry in the field of - Industrial Automation is suggested. Learners shall prepare an industrial visit report and attach it to the term work file.

Assessment:

Term Work: The term work file must include reports of **minimum e**ight **experiments** related to the chosen program elective with the copies of simulation/diagrams/circuits attached.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiments) +05 marks (Industrial visit report) + 5 Marks (Attendance)

Practical& Oral Exam:
An Oral & Practical exam will be held based on the above syllabus.

1. To be conducted by pair of Internal and External Examiners.
2. Practical examination duration is two hours, based on the Term work.
3. Oral examination should also be conducted based on the theoretical concepts applied in performing the practical exam, steps followed, etc..
4. The distribution of marks for practical examination shall be as follows:
   a. Practical Exam ….15 marks
   b. Oral Exam ...……10 marks
5. Evaluation of practical examination to be done based on practical performance report submitted by the student.
6. Students work along with evaluation report to be preserved till the next examination.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
*24061184	PEL-3 Unmanned Aerial Vehicles Lab	--	2	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
*24061184	PEL-3 Unmanned Aerial Vehicles Lab	--	--	--	--	25	25	50

***Note : Conduct the experiment related to the chosen program elective.**

Course Objectives :

1. To evaluate the construction, functional components, and aerodynamic classifications of various Unmanned Aerial Vehicles.
2. To integrate essential electronic components including flight controllers, speed controllers, and power modules.
3. To configure software architecture, flashing firmware, and executing sensor calibration sequences.
4. To practice manual piloting fundamentals encompassing safe take-off profiles, flight maneuvers, and landings.
5. To utilize specialized drone telemetry and payload operations for industry-specific field applications.
6. To implement loop-tuning procedures and safety protocols via simulated PID controls and flight checks.

Course Outcomes :

1. Students will classify distinct UAV configurations and explain their structural mechanics.
2. Students will assemble operational propulsion and power distribution networks on a physical drone frame.
3. Students will initialize ground control station software and calibrate basic navigational sensors.
4. Students will execute precision take-off, standard flight pathways, and controlled landing routines.
5. Students will deploy configured drones to resolve realistic target goals and telemetry tasks.
6. Students will tune PID flight stabilization loops and conduct pre-flight and post-flight safety audits.

List of Experiments.

***Note :** Conduct the experiment related to the chosen program elective.

Sr No	List of Experiments	Hrs
Unmanned Aerial Vehicles (Any Eight Experiments to be performed using either physical drone set up or Vlabs (https://drone-iitd.vlabs.ac.in)		
1	To study the construction, classification, and functional components of different types of Unmanned Aerial Vehicles	02
2	Experiment on assembling of Electrical Components of Drone	02
3	Experiment on assembling of Software Based Components of Drone	02
4	Experiment on Drone's Software Download, Installation and Calibration	02
5	Experiment on Drone's Take-off, Flight and Landing Basics	02
6	Experiment on Operation of drone for any application	02
7	PID controller tuning to stabilize a drones flight using any simulation software	02
8	To study Pre flight Checks of drone before each flight.	02
9	To study the Post flight Checks for identifying any potential issues.	02
10	To study the construction, classification, and functional components of different types of Unmanned Aerial Vehicles	02

Online Resources:

Sr. No.	Website Name
1.	https://drone-iitd.vlabs.ac.in/- Drone Technology

An Industrial Visit to any of the industry in the field of - Drone Technology is suggested. Learners shall prepare an industrial visit report and attach it to the term work file.

Assessment:

Term Work: The term work file must include reports of **minimum e**ight **experiments** related to the chosen program elective with the copies of simulation/diagrams/circuits attached.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiments) +05 marks (Industrial visit report) + 5 Marks (Attendance)

Practical& Oral Exam:
An Oral & Practical exam will be held based on the above syllabus.

1. To be conducted by pair of Internal and External Examiners.
2. Practical examination duration is two hours, based on the Term work.
3. Oral examination should also be conducted based on the theoretical concepts applied in performing the practical exam, steps followed, etc..
4. The distribution of marks for practical examination shall be as follows:
   a. Practical Exam ….15 marks
   b. Oral Exam ...……10 marks
5. Evaluation of practical examination to be done based on practical performance report submitted by the student.
6. Students work along with evaluation report to be preserved till the next examination.

VERTICAL – IV

VSEC

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2406411	Mini Project - II	-	04	-	-	2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment			End Sem. Exam	Term Work	Practical / Oral	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)				
2406411	Mini Project - II	--	--	--	--	50	--	50

Course Objectives:

1. To enable students to identify real-world problems through need-based surveys, literature review, and structured requirement analysis.
2. To develop skills in formulating clear problem statements and project objectives based on feasibility, innovation, and societal relevance.
3. To train students in designing and planning project execution using tools such as Gantt charts,
4. PERT/CPM, and structured methodologies.
5. To provide hands-on experience in developing and implementing functional prototypes or models using appropriate engineering tools and domain-specific technologies.
6. To enhance teamwork, leadership, and project management skills through collaborative group work, progress tracking, and review presentations.
7. To cultivate professional competencies in documentation, technical communication, validation, and evaluation of project outcomes with sustainability and continuous learning focus.

Course Outcomes: On successful completion of the course, the learner will be able to:

Sr. No.	Course Outcomes	Cognitive Levels of Attainment as per Bloom's Taxonomy
1	Formulate a real-world problem by conducting need-based surveys and demonstrating professional responsibility in problem selection.	L2, L3, L4
2	Implement appropriate engineering methods to develop a functional solution while collaboratively exhibiting ethical teamwork behaviour.	L2, L3, L4, L5, L6
3	Demonstrate effective leadership or collaboration by actively coordinating project tasks and responding constructively to group dynamics.	L2, L3, L4
4	Validate experimental results through analytical techniques and justify findings with disciplined technical documentation.	L2, L3, L4, L5, L6
5	Evaluate the societal and environmental impact of the developed solution while applying sustainable engineering practices.	L3, L4, L5
6	Execute project activities using standard engineering tools while exhibiting commitment towards continuous self-directed learning.	L2, L3, L4, L5, L6

Guidelines for Mini Project - II:

1. 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.
2. Interdisciplinary project is also allowed.
3. Students should do survey and identify needs, which shall be converted into problem statement for project in consultation with faculty supervisor/head of department/internal committee of faculties.
4. Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of project.
5. A logbook to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
6. Faculty supervisor may give inputs to students during project activity; however, focus shall be on self-learning.
7. Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.

8. Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
9. The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
10. With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the project.

Term Work:

1. The review/progress monitoring committee shall be constituted by head of departments of each institute. The progress of project to be evaluated on continuous basis, minimum two reviews in the semester.
2. In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Distribution of Term work marks shall be as below:			Marks
1	Marks awarded by guide/supervisor based on logbook		5
2	Marks awarded by review committee (Average of Review 1 & Review 2)		40
Project Review - 1			
1	Identification of Problem		4
2	Requirement analysis and Feasibility of the proposed work		4
3	Literature Review		4
4	Objectives of the proposed work		4
5	Methodology of the proposed work		4
	Total Marks		20
Project Review - 2			
	a	Planning of project work and team structure	4
	b	Design Methodology	4
	c	Conceptual and Technical Demonstration	4
	d	Presentation: Oral delivery, contact with audience, slides, timing	4
	e	Quality of answers	4
	Total Marks		20
	Quality of Project Report		5

Online References:

Sr. No.	URL
1	https://www.geeksforgeeks.org/project-idea-college-network/?ref=ml_lbp
2	https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/ai-project-ideas
3	https://roadmap.sh/backend/project-ideas
4	https://webflow.com/blog/website-ideas
5	https://gist.github.com/MWins/41c6fec2122dd47fdfaca31924647499
6	https://www.projectpro.io/article/artificial-intelligence-project-ideas/461
7	https://github.com/The-Cool-Coders/Project-Ideas-And-Resources
8	https://nevonprojects.com/project-ideas/software-project-ideas/
9	https://roadmap.sh/projects

VERTICAL – V

AEC

Course Code	Course Name	Teaching Scheme (Contact Hours)				Credits Assigned		
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2406511	Professional Skills	--	2*+2	--	--	2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2406511	Professional Skills	--	--	--	--	--	25	--	25

***This course is common with Mechatronics Engineering**

Rationale:

This course equips engineering students with professional communication, ethical values and soft skills essential for global industry demands. It enhances technical writing, presentation and interpersonal abilities through practical sessions, fostering confidence, teamwork and social responsibility as competent engineering professionals.

Course Objectives - Students are expected to learn to:

1. Develop effective speaking, presentation, group discussion and interview skills required for employability and professional success.
2. Analyse and evaluate AI-generated content for accuracy, bias, credibility and ethical professional use.
3. Prepare clear, concise and professional technical/business documents such as resumes, reports, SOP and formal correspondence.
4. Demonstrate managerial and collaborative skills required for conducting meetings, preparing proposals and workplace communication.
5. Apply interpersonal, critical thinking, negotiations, time management, leadership, decision-making and adaptability skills for lifelong learning and career growth.
6. Exhibit ethical values, intellectual property awareness, digital responsibility and professionalism in workplace practices.

Course Outcomes - Students will be able to:

1. Demonstrate effective speaking skills through participation in group discussions, interviews, presentations and collaborative activities.
2. Analyse and evaluate AI-generated content in terms of quality, bias, reliability and ethical use for academic and professional purposes.
3. Create professional documents such as resumes, cover letters, statements of purpose, reports and other technical/business correspondence using standard formats.
4. Organise and execute professional meetings, proposals and technical papers using appropriate workplace communication strategies and digital tools.
5. Apply and demonstrate interpersonal skills such as leadership, critical thinking, negotiation, decision-making, time management and adaptability to support career growth and lifelong learning.
6. Exhibit ethical practices, digital responsibility and awareness of intellectual property rights in professional environments.

DETAILED SYLLABUS:

Sr. No.	Name of the Module	Content	Hours	CO Mapping
1	Employability Skills: Advanced Speaking	1.1. Group Discussions (GDs) • Purpose, Evaluation parameters, GD etiquette • Types: Factual (Regular & Controversial), Abstract, Case-based (Textual & Picture-based) and Role-plays (Textual & Cue-card-based) • Online GDs and digital collaboration etiquette (Zoom, Google-Meet, MS Teams etc.) 1.2. Personal Interviews • Planning and preparation for Technical and HR interviews • Interview types: Structured, Stress, Behavioural and Case-based • Virtual interviews, AI-assisted interview simulations and post-interview reflections (Google Interview Warmup, Yoodli, Pramp etc.)	8	CO1

		1.3. Presentation Strategies • Purpose, Audience analysis, Content organisation • Slide design, Text, Infographics and AI-based presentation design (Canva, Beautiful.ai, Gamma AI etc.) • Division of roles, collaborative preparation and seamless transitions		
2	Critical AI Literacy	• Nature of AI Generated Language - Understanding AI-generated language as probabilistic output and distinguishing between Fluency and Accuracy while identifying risks such as AI Slop and Hallucination • Evaluating AI Content - Differentiating between Evidence and Assertion and applying verification strategies to assess Accuracy, Clarity and Depth • Bias, Framing and Information Silos - Understanding linguistic Bias, Framing, Information Silos and Selective Exposure that shape AI responses and limit perspective • Drafting, Editing and Prompt Engineering with AI - Using AI for Drafting and Editing through effective Prompt Engineering while maintaining originality, specificity and professional voice • Identifying Low-Quality AI Content - Identify markers of low-quality AI content, such as repetition, lack of depth, and absence of concrete detail, while applying ethical practices that distinguish Assistance from Substitution and ensure responsible AI use	4	CO2
3	Employability Skills: Advanced Technical Writing	3.1. Cover Letter & Resume • Difference between Bio-data, Resume and CV • Resume types: Chronological, Functional and Hybrid • Resume structure and content • Digital resumes, Application Tracking System (ATS) friendly formatting and LinkedIn portfolio integration 3.2. Reports • Purpose: Importance of reports in engineering and industry decision-making	8	CO3

		• Classification of Reports: Subject Matter - Technical, R&D, Operations, Finance, Marketing etc. Time Interval - Periodic, One-time, Special Function - Informational, Examinational and Analytical Reader Writer Relationship – Administrative, Professional and Independent Format – Memo, Letter, Short, Long, E-Reports, Digital Dashboards Digital and AI-aided reporting formats (Power BI, Google Data Studio, ChatGPT etc. for summaries) • Parts of a Long Formal Report Prefatory Parts: Title Fly, Title Page, Letter of Transmittal, Table of Contents, List of Illustrations, Executive Summary Report Proper (Main Body): Introduction, Intervening chapters with headings as per the topic, Result & Analysis, Summary (Informational) Or Summary & Conclusions (Examinational) Or Summary, Conclusions & Recommendations (Analytical) Appended Parts: Appendix, List of References, Glossary, Index • Language and Style of Reports Tense, person and voice appropriate to reports Numbering and labelling conventions for figures, tables, charts, equations etc. Referencing formats (APA, MLA etc.) Plagiarism checks (Turnitin, Grammarly, other AI-detectors etc.) 3.3. Statement of Purpose (SOP) • Purpose: SOPs for international internships, funding for research programs and higher education • Structure: Paragraph 1 - Hook (introducing yourself in a unique manner and demonstrating your passion for the field) Paragraph 2 - Academic Background Paragraph 3 - Research-oriented Endeavours		

		Paragraph 4 - All-round Development Paragraph 5 - Reasons for choosing the Program and Institution Paragraph 6 - Conclusion and Thank-you note		
4	Workplace Managerial Skills	**4.1.** Conducting Business Meetings • Types of Meetings: Executive Meetings - Decide Management Meetings - Implement Committee Meetings - Recommend Review Meetings - Evaluate Planning Meetings - Design the future Crisis Meetings - Resolve urgency • Roles and Responsibilities: Chair - Leads meeting, maintains order, ensures decisions Secretary - Records minutes, documents decisions, tracks actions Core Members - Discuss issues, contribute ideas, make decisions Specialists - Provide expertise, clarify issues, support decisions • Documentation: Notice, Agenda and Minutes • Meeting Platforms and AI Assistance: Virtual and hybrid meeting management, online etiquette, use of collaborative tools (Google Meet, Slack, Trello etc.) Digital documentation, e-Minutes and collaborative platforms like Notion or Microsoft OneNote **4.2.** Writing Proposals • Types: Solicited vs. Unsolicited • Format: Memo, Short and Long • Parts of a Short Proposal: Purpose of the proposal Need for the proposal (SWOT analysis) Description of the plan (budget, timeline etc.) Evidence of ability to deliver Benefits to both parties Conclusion	6	CO4

		4.3. Structuring and Formatting Technical Papers Components: Title, Author(s) & Affiliations, Abstract, Keywords/Index Terms, Introduction, Sections with different headings, Results, Discussion, Conclusion, Acknowledgement, References, Biography • Formatting and referencing (IEEE style) • Use of AI tools for grammar check, plagiarism validation and submission to international conferences		
5	21st Century Professional Skills	**5.** Interpersonal Skills • Emotional Intelligence • Critical thinking, Reflection & Self Analysis • Leadership and Motivation Strategies • Conflict Management and Negotiation • Time Management • Anger and Stress Management • Decision Making and Adaptability	6	CO5
6	Digital Ecosystems and Ethics	**6**.1. Intellectual Property Rights (IPR) • Categories: Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits and Trade Secrets • AI-generated content ownership, open-source ethics, digital rights management • Social Media Content and Legal Responsibility 6.2. Case Studies on Corporate and Engineering Ethics • Real-world ethical dilemmas • Corporate Social Responsibility (CSR) • Environmental Social Governance (ESG) • Sustainability and Green Engineering • AI Ethics in Design and Automation	4	CO6

ASSESSMENTS :

List of Compulsory Assignments for Term Work:

Module 1: GD documentation with Topic, Type and Highlights in 5 bullet points

Module 2: Assignment on Prompt Engineering

Module 3: A - Cover Letter, Resume and B - Statement of Purpose

Module 4: Meeting Documentation (Notice, Agenda & Minutes)

Module 5: Activities on Interpersonal Skills

Module 6: Case study on Ethical Dilemma

(To be conducted in the form of short notes, quizzes, role plays, case studies, presentations or MCQs)

SUGGESTED ASSIGNMENTS

Module No. & Title	Assignments and Activities
Module 1 Employability Skills: Advanced Speaking	• Conduct 4-5 types of Group Discussions and attach the summary and photographs as proof of activity • Prepare group presentation slides, based on the report topic (Examinational or Analytical) using the latest presentation software (PowerPoint, Canva, Prezi etc.) and engage students in giving critical feedback • Present an 'Elevator Pitch 'for either self-introduction or product or new business idea • Conduct mock interviews
Module 2 Critical AI Literacy	• Select an essay/article/video generated by AI (or give a general prompt) and analyse and detect AI bias (gender pronouns, gender-based occupational stereotypes, racial identifiers, historical bias etc.) • Differentiate between weak and strong prompts • Source verification task • AI versus human writing analysis

Module 3 Employability Skills: Advanced Technical Writing	• Draft a professional Cover Letter and Resume • Write a Statement of Purpose (SOP) for higher studies or internships • Develop or enhance a LinkedIn profile showcasing technical and project achievements • Prepare a book-format analytical/informational report using IEEE/APA/MLA referencing and plagiarism check tools (Grammarly/Turnitin). Main body should be minimum 20 pages excluding the Preparatory and Appended parts
Module 4 Workplace Managerial Skills	• Conduct a mock meeting with assigned roles (Chairperson, Secretary, Members) and generate documentation with the help of the latest software • Write a short proposal addressing an engineering or sustainability problem • A quiz on the formatting aspects of a Technical Paper
Module 5 21st Century Professional Skills	• Activities for developing team work, leadership, emotional intelligence etc. • Problems and Puzzles on Critical thinking • Case-studies or Role-plays or Questionnaires on Conflict Resolution, Negotiation Skills and Decision Making • Application of SWOT analysis • Eisenhower Matrix to analyse a daily time log
Module 6 Digital Ecosystems and Ethics	• Conduct an awareness quiz on IPR laws and ethical business practices. • Analyse a corporate ethics case study • Digital footprint audit of Self Profile • Fake News and Deep Fake verification task

IMPORTANT NOTE :

1. The main project/book report should contain a minimum of 20 pages, excluding prefatory and appended matter.
2. Each project group must consist of a minimum of 4 and a maximum of 6 students.
3. End-semester presentation will be based on the book/project report.

GUIDELINES FOR TERM WORK MARKS DISTRIBUTION

Components	Marks 25	Description
6 Compulsory Assignments	5	Based on completion and quality of module-wise tasks.
Attendance & Participation	5	Class engagement, teamwork, and professionalism.
GD	5	Based on group and individual performance
Report Hardcopy	5	Quality, structure and originality of the report
Oral Report Presentation	5	Based on group and individual performance

RECOMMENDED RESOURCES:

1. Raman, M., & Sharma, S. (2022). Technical communication: Principles and practice (4th ed.). Oxford University Press.
2. Anderson, P. V. (2018). Technical communication: A reader-centred approach (9th ed.). Cengage Learning.
3. Lesikar, R. V., Flatley, M. E., & Rentz, K. (2008). Basic business communication (11th ed.). McGraw-Hill.
4. Institute of Electrical and Electronics Engineers. (2020). IEEE code of ethics. IEEE.
5. American Society of Mechanical Engineers. (2021). ASME code of ethics of engineers. ASME.
6. Guffey, M. E., & Loewy, D. (2018). Essentials of business communication (11th ed.). Cengage Learning.

7. Sharma, R. C., & Mohan, K. (2017). Business correspondence and report writing (4th ed.). Tata McGraw-Hill Education.
8. Ram, A. (2018). Place mentor: Tests of aptitude for placement readiness. Oxford University Press.
9. Kumar, S., & Lata, P. (2018). Communication skills: A workbook. Oxford University Press.
10. Butterfield, J. (2017). Verbal communication: Soft skills for a digital workplace. Cengage Learning.
11. Crawford, K. (2021). Atlas of AI: Power, politics, and the planetary costs of artificial intelligence. Yale University Press.
12. Kearns, M., & Roth, A. (2019). The ethical algorithm: The science of socially aware algorithm design. Oxford University Press.

ONLINE RESOIRCES:

1. Ravichandran, T. (n.d.). Enhancing soft skills and personality [NPTEL course]. National Programme on Technology Enhanced Learning. https://nptel.ac.in
2. Ravichandran, T. (n.d.). Developing soft skills and personality [SWAYAM MOOC]. SWAYAM. https://swayam.gov.in
3. Coursera. (n.d.). Business communication for success [Online course]. https://www.coursera.org
4. edX. (n.d.). Business communication for success [Online course]. https://www.edx.org
5. All India Council for Technical Education. (n.d.). Employability enhancement and life skills modules. AICTE NEAT. https://neat.aicte-india.org
6. Indian Institute of Technology Guwahati. (n.d.). Virtual English and communication virtual lab. Virtual Labs. https://ve-iitg.vlabs.ac.in/
7. Indian Institute of Technology Bombay. (n.d.). Professional communication virtual lab. Virtual Labs. http://vlabs.iitb.ac.in/vlabs-dev/labs/communication/
8. TCS iON. (n.d.). Communication skills [Online course]. https://www.tcsion.com/courses/tcs-ion/communication-skills/
9. TCS iON. (n.d.). Introduction to soft skills [Online course]. https://www.tcsion.com/courses/interview-and-job-prep/introduction-to-soft-skills/
10. TCS iON. (n.d.). Presentation skills [Online course]. https://www.tcsion.com/courses/tcs-ion/presentation-skills/

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 – 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sd/-

Dr. S. M. Khot
BoS-Chairman-Mechanical Engineering
Faculty of Technology

Sd/-

Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-

Prof. Shivram S. Garje
Dean
Faculty of Science & Technology