Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Structure

Third Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2026-27
Revision 01

Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405 Ph: 02563 259 802,
Web: www.rcpit.ac.in/mechanical-engineering-syllabus

Institute Vision and Mission

Vision of the Institute

"To become a leading Institute in Technical education fostering innovation, research, ethical values, and sustainable development for the betterment of society."

Mission of the Institute

To impart high quality Technical Education through:

M1: Innovative and Interactive learning process and high quality globally recognized instructional programs.

M2: Fostering a collaborative scientific temper among students with ethical responsibility towards the society.

M3: Preparing students from diverse backgrounds to have aptitude for employment, entrepreneurship and research with a spirit of Professionalism.

M4: To contribute to nations sustainable development.

Mechanical Engineering Department

Vision of the Department

" To achieve excellence in Mechanical Engineering education through innovation, research, and strong ethical values for sustainable societal development."

Mission of the Department

M1: To deliver innovative and practical mechanical engineering education through quality instruction and hands-on learning.

M2: To promote teamwork, ethical values, and scientific curiosity through collaborative and socially relevant projects.

M3: To develop competent engineers with technical expertise, research aptitude, and entrepreneurial spirit for sustainable national growth.

Programme Educational Objectives (PEOs)

PEO 1: Graduates will apply scientific, mathematical, and engineering principles to solve complex mechanical problems ethically and sustainably.

PEO 2: Graduates will design and implement efficient mechanical solutions addressing societal needs through innovation, collaboration, and environmental stewardship.

PEO 3: Graduates will demonstrate professional competence, communication, teamwork, and life-long learning for career growth, entrepreneurship, and higher education.

Programme Specific Outcomes (PSOs)

PSO 1: Students will be able to apply Mechanical Engineering principles and modern tools to design and improve mechanical systems with innovative solutions.

PSO 2: Students will demonstrate ethical practice, teamwork, and communication to develop engineering solutions for societal and sustainable development.

Department of Mechanical Engineering

(Autonomous - RCP23 NEP)

Semester – V (w.e.f.2025-26)

Sr. No	Course Category	Course Code	Course Title	Teaching Scheme (hrs.)			Evaluation Scheme (CA) (marks)				ESE (marks)	Total	Credit	
				L	T	P	TA [A]	Term Test 1 (TT1)	Term Test 2 (TT2)	Average (TT1 & TT2) [B]	[C]	[A+B+C]		
1	PC	RCP23MPC301	Theory of Machines	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPC301L	Theory of Machines Laboratory	-	-	2	25	-	-	-	-	25	1	
2	PC	RCP23MPC302	Mechanical Measurements and Metrology	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPC302L	Mechanical Measurements and Metrology Laboratory	-	-	2	25	-	-	-	-	25	1	
3	PC	RCP23MPC303	Fluid Mechanics and Machinery	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPC303L	Fluid Mechanics and Machinery Laboratory	-	-	2	25	-	-	-	25	50	1	
4	MD	RCP23MMD301	Industrial Electronics	2	-	-	25	15	15	15	60	100	2	3
		RCP23MMD301L	Industrial Electronics Laboratory	-	-	2	25	-	-	-	-	25	1	
5	MD	RCP23MMD302L	Database Management System Laboratory	-	-	2	25	-	-	-	25	50	1	1
6 @	PE	RCP23MPE311	Reliability Engineering	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPE311L	Reliability Engineering Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE312	Renewable Energy Systems	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE312L	Renewable Energy Systems Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE313	Advance Materials and Processes	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE313L	Advance Materials and Processes Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE314	Automotive Prime Movers	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE314L	Automotive Prime Movers Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE315	Adhesive Technology	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE315L	Adhesive Technology Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE316	Data Analytics	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE316L	Data Analytics Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE317	Innovation and Problem-Solving	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE317L	Innovation and Problem-Solving Laboratory	-	-	2	25	-	-	-	-	25	1	
7	HS	RCP23XHS331T	Environmental Studies	-	1	-	25	-	-	-	-	25	1	1
8	SC	RCP23XSC301P	Semester Project - III	-	-	2	25	-	-	-	25	50	1	1
9	SC	RCP23MSC301	Data Science for Mechanical Engineers	1	-	-	40	-	-	-	-	40	1	1
			Total	**15**	**1**	**14**	**365**	**75**	**75**	**75**	**375**	**815**	**23**	**23**

PC-Programme Course, MD- Multidisciplinary, SC- Skill Course, PE- Programme Elective, HS – Humanity and science.

@ Any 1 form Department Elective - I from given list.

Prepared by	Checked by	BOS Chairman	Dean Academic &Dy. Director	C.O.E.	Director
Mr. R. R. Ozarkar	Mr. S. V. Yeole	Prof. Dr. P. L. Sarode	Prof. Dr. P. J. Deore	Mr. S. P. Shukla	Prof. Dr. J. B. Patil

Department of Mechanical Engineering

(Autonomous - RCP23 NEP)

Semester – VI (w.e.f.2025-26)

Sr. No	Course Category	Course Code	Course Title	Teaching Scheme (hrs.)			Evaluation Scheme (CA) (marks)				ESE (marks)	Total	Credit	
				L	T	P	TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average (TT1 & TT2)				
							[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23MPC351	Design of Machine Elements	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPC351L	Design of Machine Elements Laboratory	-	-	2	25	-	-	-	25	50	1	
2	PC	RCP23MPC352	Finite Element Analysis	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPC352L	Finite Element Analysis Laboratory	-	-	2	25	-	-	-	25	50	1	
3	PC	RCP23MPC353	Heat Transfer	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPC353L	Heat Transfer Laboratory	-	-	2	25	-	-	-	-	25	1	
4	MD	RCP23MMD351	Control Systems	3	-	-	25	15	15	15	60	100	3	4
		RCP23MMD351L	Control Systems Laboratory	-	-	2	25	-	-	-	-	25	1	
5	SC	RCP23MSC351L	CAD CAM Laboratory	-	-	2	25	-	-	-	25	50	1	1
6 #	PE	RCP23MPE361	Vibration Analysis and Smart Monitoring	3	-	-	25	15	15	15	60	100	3	4
		RCP23MPE361L	Vibration Analysis and Smart Monitoring Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE362	Refrigeration and Air Conditioning	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE362L	Refrigeration and Air Conditioning Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE363	Quality Engineering and Management	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE363L	Quality Engineering and Management Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE364	Automotive Systems	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE364L	Automotive Systems Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE365	Industrial Robotics	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE365L	Industrial Robotics Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE366	Artificial Intelligence and Machine Learning	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE366L	Artificial Intelligence and Machine Learning Laboratory	-	-	2	25	-	-	-	-	25	1	
		RCP23MPE367	Entrepreneurial Business Models	3	-	-	25	15	15	15	60	100	3	
		RCP23MPE367L	Entrepreneurial Business Models Laboratory	-	-	2	25	-	-	-	-	25	1	
7	EL	RCP23XEL351P	Project Stage - I	-	-	4	50	-	-	-	50	100	2	2
8	HS	RCP23XHS381	Constitution of India	1	-	-	-	-	-	-	-	-	A	A
9	SC	RCP23MSC352	Machine Learning for Mechanical Engineers	1	-	-	40	-	-	-	-	40	1	1
			Total	**17**	**0**	**16**	**365**	**75**	**75**	**75**	**425**	**865**	**24**	**24**

PC-Programme Course, MD- Multidisciplinary, SC- Skill Course, PE- Programme Elective, EL-Experiential Learning, HS – Humanity and science.

Any 1 form Department Elective - II from given list.

Prepared by	Checked by	BOS Chairman	Dean Academic &Dy. Director	C.O.E.	Director
Mr. R. R. Ozarkar	Mr. S. V. Yeole	Prof. Dr. P. L. Sarode	Prof. Dr. P. J. Deore	Mr. S. P. Shukla	Prof. Dr. J. B. Patil

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R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Details of Semester-V

Third Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2026-27
(Revision 01)

Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405 Ph: 02563 259 802,
Web: www.rcpit.ac.in/mechanical-engineering-syllabus

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Theory of Machines (RCP23MPC301)		
Theory of Machines Laboratory (RCP23MPC301L)		

Prerequisites:

1. Computational engineering mechanics.

Course Objectives:

1. To understand the basics of kinematics, including different types of mechanisms, and the velocity and acceleration analysis methods.
2. To learn the principles of power transmission using chains, gears, and gear trains.
3. To understand the basics of vibration and analyse systems subjected to free undamped vibrations.
4. To study different types of damping and the behaviour of damped vibration systems.
5. To study forced vibrations, vibration isolation, and the use of measuring instruments for vibration analysis.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Determine the velocity and acceleration of mechanism links.	L3	Apply
CO2	Determine basic design parameters of power transmission elements like chains and gears.	L3	Apply
CO3	Analyze the vibration response of systems subjected to free undamped vibrations.	L4	Analyze
CO4	Analyze the vibration response of systems subjected to free damped vibrations.	L4	Analyze
CO5	Analyze the vibration response of systems subjected to forced vibrations.	L4	Analyze

Theory of Machines (RCP23MPC301)

Course Contents

Unit-I **08 Hrs.**

Basic Kinematics, Velocity & Acceleration Analysis

Basic Kinematics: Kinematic link and types, Kinematic pairs and types, Types of constrained motions, Kinematic chains, Types of joints, Degree of freedom (mobility), Kutzbach mobility criteria, Grubler's criteria & its limitations, Grashoff's law, Four bar chain and its inversions, Slider crank chain and its inversions, Double slider crank chain and its inversions.
Velocity and Acceleration Analysis of Mechanisms using Graphical Approach (mechanisms up to 6 links): Velocity analysis by instantaneous centre of rotation method and relative velocity method, Rubbing velocities at joints, Mechanical advantage, Acceleration analysis by relative method (Excluding pairs involving Coriolis component).

Unit-II **08 Hrs.**

Power transmission drives

Chains: Chain terminology, Relationship between pitch and pitch circle diameter, Classification of chains, Chordal action, Length of chain.
Gears: Introduction to gears and terminology, Types of gears, Law of gearing, Involute and cycloidal tooth profile, Arc of contact and contact ratio, Interference in involute gears, Critical numbers of teeth for interference-free motion, Methods to control interference in involute gears, Static force analysis in spur gears.
Gear Trains: Kinematic analysis of simple, compound, reverted, and epicyclic gear trains with spur gear combination.

Unit-III **08 Hrs.**

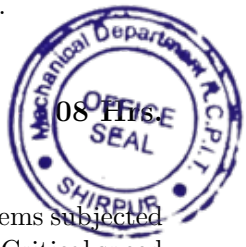
Introduction to Vibration

Basic Concepts of Vibration: Vibration and oscillation, Causes and effects of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, nonperiodic, Degree of freedom, Static equilibrium position, Vibration classification, Steps involved in vibration analysis.
Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, and torsional vibration systems, Methods for formulating differential equations by Newton, Energy, Lagrangian and Rayleigh's method.

Unit-IV **07 Hrs.**

Free Damped Single Degree of Freedom Vibration System

Introduction to different methods of damping, Study and analysis of viscous damped system (under damped, critically damped, over damped; logarithmic decrement), Coulomb's damping.



Unit-V **08 Hrs.**

Forced Vibratory System and Measuring Instruments

Forced Single Degree of Freedom Vibratory System: Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper), Critical speed

of shaft with single rotor, Balancing of rotating and reciprocating masses (numerical excluded).
Vibration Isolation and Transmissibility: Force Transmissibility and isolation, Typical isolators & mounts.
Vibration Measuring Instruments: Principle of seismic instruments, Vibrometer, Accelerometer - undamped and damped, Case studies on diagnostics maintenance and condition-based monitoring approach.

Theory of Machines Laboratory (RCP23MPC301L)

Suggested Experiments

A Group A (all six are compulsory):

1 Velocity analysis of mechanisms by Instantaneous Centre of Rotation (3-5 problems)
2 Acceleration analysis of mechanisms by the Relative method (Problems on pairs involving Coriolis component to be included) (3-5 problems)
3 Plotting of motion graphs for cams and followers (3-5 problems)
4 Layout of cam profiles (3-5 problems)
5 Experimental verification of the principle of Gyroscopic couple
6 Experimental balancing of single and multi-rotor systems

B Group B (any four):

1 Determination of the natural frequency of compound pendulum, equivalent simple pendulum system
2 Determination of natural frequency for longitudinal vibrations of helical springs
3 Determination of natural frequency and nodal points for single rotor and two-rotor vibratory systems
4 Experiment on the whirling of shaft
5 Determination of the damping coefficient of any system/media
6 Condition monitoring using an FFT analyzer
7 Vibration analysis of mechanical systems using MATLAB/SCILAB/Python

C A mini project:

Involving one of the mechanisms, such as straight-line generating mechanisms, offset slider-crank mechanisms, Geneva mechanism, inversions, or others, will also be included.

A minimum of ten experiments (all six from the group A list and any four from the group B list) or any other experiment based on the syllabus will be included, which would help the learner apply the concept.

Books Recommended

Textbooks

1 P. L. Ballaney, Theory of Machines, Khanna Publishers, 2014.
2 S. S. Ratan, Theory of Machines, McGraw-Hill Education (India), 2019.
3 R. S. Khurmi and J. K. Gupta, Theory of Machines, S. Chand Publishing, 2020.

Reference Books

1 Thomas Bevan, The Theory of Machines, Pearson Education, 2010

2 Jagdish Lal, Theory of mechanisms and machines, Metropolitan Books Co., 2006

3 John J. Uicker, Gordon R. Pennock and Joseph E. Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2014

4 William T. Thomson, Theory of Vibration with Applications, Pearson Education, 2008

5 S. S. Rao, Mechanical Vibrations, Pearson Education, 2018

6 S. Graham Kelly, Fundamentals of Mechanical Vibrations, McGraw-Hill Inc. (US), 2000

7 Benson H. Tongue, Principles of Vibration, Oxford University Press, 2012

8 J. S. Rao and K. Gupta, Theory and Practice of Mechanical Vibrations, New Age International Pvt. Ltd., 2023

9 Amitabh Ghosh and A. Kumar Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press, 2011

10 Arthur G. Erdman and George N. Sandor, Mechanism Design: Analysis and Synthesis, Volume 1, Pearson Education, 2001

11 Jeremy Hirschhorn, Kinematics and Dynamics of Plane Mechanisms, McGraw-Hill, 1962

12 W. G. Green, Theory of Machines, Blackie Son Ltd., 1960

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Mechanical Measurements and Metrology (RCP23MPC302)		
Mechanical Measurements and Metrology Laboratory (RCP23MPC302L)		

Prerequisites:

1. Knowledge of basic concepts of Engineering Drawing
2. Knowledge of basic concepts of Machine Drawing
3. Knowledge of basic concepts of Manufacturing Processes.

Course Objectives:

1. To impart knowledge of the architecture of the measurement system.
2. To deliver the working principle of the mechanical measurement system.
3. To acquaint with measuring equipment used for linear and angular measurements.
4. To familiarize with different classes of measuring instruments and the scope of measurement in industry and research.
5. To acquaint with the operations of precision measurement, the instrument/equipment for measurement.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply the concepts of static characteristics and types of errors occurring in measurement systems.	L3	Apply
CO2	Select proper measuring instrument for displacement, strain, pressure, and temperature measurement.	L3	Apply
CO3	Select proper measuring instrument for linear and angular measurement.	L4	Analyze
CO4	Demonstrate inspection methods and design of different limit gauges.	L4	Analyze
CO5	Demonstrate characteristics of surface texture, screw threads, and gear measurements.	L3	Apply

Mechanical Measurements and Metrology (RCP23MPC302)

Course Contents

Unit-I **08 Hrs.**

Introduction

Introduction to mechanical measurements and metrology: Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying Inputs.
Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static Error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc. Introduction to Metrology: Fundamental Definitions, Types of Standards, Precision and Accuracy, Errors in measurement: Types of errors, Effect of component errors, Probable errors.

Unit-II **06 Hrs.**

Displacement and Strain Measurement

Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle, Flapper Transducer.
Strain Measurement: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge-based load cells and torque sensors.

Unit-III **07 Hrs.**

Pressure, Flow and Temperature Measurement

Pressure Measurement: Mechanical Pressure-Measurement Devices, High Pressure Measurements, Bridge man Gauge. Vacuum measurement: Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges.
Flow Measurement: Ultrasonic Flow meter, Magnetic flow meter, The Laser Doppler Anemometer and Hot-Wire and Hot-Film Anemometers.
Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples and Pyrometers.

Unit-IV **08 Hrs.**

Linear measurements and Angular Measurement

Linear measurements and Angular Measurement
Design of Gauges: Limits, Fits, Tolerances, Types of Gauges, Taylor's Principle of Limit Gauges, IS 919 for design of gauges.
Gear Measurement by Parkinson Gear tester and Gear tooth Vernier Caliper.
Screw Thread Measurement: Effective diameter measurement of screw thread by Floating Carriage micrometer.

Unit-V **05 Hrs.**

Surface Texture measurement

Surface roughness, Waviness, Roughness Parameter Ra, Rz, RMS etc., working of Tomlinson surface meter, Tally-surf surface roughness tester, Surface roughness symbols.

Unit-VI **05 Hrs.**

Advances in metrology

Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructional features, applications.

Mechanical Measurements and Metrology Laboratory (RCP23MPC302L)

Suggested Experiments:

A Minimum six experiments from list below:

1 Calibration and Health Monitoring of Pressure Gauges using Cyber-Physical System.
2 Real-time Pressure Monitoring using IoT-enabled Pressure Sensors.
3 Real-time Torque Monitoring in Rotating Machinery with Predictive Analytic.
4 Wireless Strain Monitoring System using IoT/Study of Strain Gauges.
5 IoT-integrated LVDT Displacement Measurement.
6 Speed measurement using optical or Hall-effect sensors.
7 Speed Measurement using tachometer, optical and magnetic pickup.
8 Gear measurement using Gear tooth Vernier caliper
9 Automated Gear Inspection using Machine Vision and AI
10 Thread Measurement using Floating carriage micrometer

Minimum six experiments from the above-suggested list or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt.

B Assignments (minimum 5): Minimum five assignments based on syllabus will be conducted or Mini project relevant to the subject, which would help the learner to apply the concept learnt.

Experiential learning is a powerful way to help mechanical engineering students gain practical knowledge of mechanical measurement and metrology through Laboratory experiments, Field trips, and Case studies.

- **Laboratory Work:** Provide hands-on training for using various measuring tools such as micrometers, vernier calipers, dial indicators, strain gauges, LVDT, Floating carriage micrometer, etc. through laboratory experiments.
- **Industrial Visits:** Organize industrial visits to companies that specialize in mechanical measurement and metrology to give students an opportunity to see how these concepts are applied in real-world settings. Encourage students to ask questions and interact with professionals who are working in the field. Encourage students to network with industry professionals and seek out internships

- **Case Studies:** Use case studies to give students an opportunity to apply their knowledge of mechanical measurement and metrology to real-world problems. Encourage students to work in teams to analyze case studies and develop solutions.

Books Recommended

Textbooks

1 K. Sawhney and Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation Control, Dhanpat Rai Co., 2017.

2 A. K. Thayal, Instrumentation Mechanical Measurements, Galgotia Publications Pvt Ltd, 1999.

3 K. J. Hume, Engineering Metrology, Kalyani Publications, 2018.

4 I. C. Gupta, A Textbook of Engineering Metrology, Dhanpat Rai Publications, 2018.

5 John P. Bentley, Principles of Measurement Systems, Pearson Education, 2004.

Reference Books

1 Ernest O. Doebelin, Measurement Systems: Applications and Design, 5th Edition, McGraw Hill, 2008.

2 W. Bolton, Instrumentation and Control Systems, Elsevier, 2023. . P. Venkateshan, Mechanical Measurements, Ane Books, India, 2015.

3 R. K. Jain, Mechanical Measurements and Metrology, Khanna Publishers, 1995.

4 Anand Bewoor and Vinay Kulkarni, Metrology and Measurement, McGraw Hill, 2017.

5 N. V. Raghavendra and L. Krishnamurthy, Engineering Metrology and Measurement, Oxford University Press, 2013.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Fluid Mechanics and Machinery (RCP23MPC303)		
Fluid Mechanics and Machinery Laboratory (RCP23MPC303L)		

Prerequisites:

1. Fundamentals of Engineering Mechanics
2. Fundamentals of Applied Mathematics.

Course Objectives:

1. To provide knowledge on fundamentals of fluid properties, fluid statics, and evaluate fluid kinematic properties.
2. To solve the practical problems based on mass, momentum and energy balance equations.
3. To determine the major and minor losses in a pipe and pipe fittings.
4. To study the performance of hydraulic turbines.
5. To study the performance of centrifugal pumps

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Evaluate fluid properties, hydrostatic pressure, and fluid kinematic characteristics in practical problems.	L5	Evaluate
CO2	Apply the governing equations for mass, momentum and energy based on Reynolds Transport Theorem and Navier-Stokes equations to flow.	L3	Apply
CO3	Analyze pumping power requirements considering major and minor losses in pipe flow.	L4	Analyze
CO4	Evaluate the performance of hydraulic turbines.	L5	Evaluate
CO5	Evaluate the performance of centrifugal pumps.	L5	Evaluate

Fluid Mechanics and Machinery (RCP23MPC303)

Course Contents

Unit-I **10 Hrs.**

Properties of Fluid

Properties of Fluid: Definition of Fluid, Newton's law of viscosity, Units and dimensions, physical properties of fluids, pressure measurement, Hydrostatic forces on plane and curved surfaces.
Fluid Kinematics: Eulerian and Lagrangian method of fluid flow description, Flow visualization, Types of flow, Strain rate, Streamline, Streak line, Path lines and Stream tubes, three dimensional continuity equation in Cartesian coordinates, Velocity and acceleration of fluid particles, vorticity, circulation, velocity potential function and stream function.

Unit-II **08 Hrs.**

Fluid Dynamics

Reynolds transport theorem, Momentum equation and its application to flow through pipe bend, Navier Stokes equations, exact solution of Navier-Stokes equations for simple flows, Euler's equation of motion along a streamline, Bernoulli's equation and its applications, flow through orifice meter, Venturimeter, Pitot tube.

Unit-III **08 Hrs.**

Laminar and Turbulent Flow

Laminar flow through circular pipes, Loss of head and power absorbed in viscous flow;
Turbulent flow – Reynolds experiment, Frictional losses in pipe flow; Shear stress in turbulent flow; major and minor losses (Darcy's and Chezy's equation);
Flow through pipes in series, pipes in parallel; branching pipes and equivalent pipe.

Unit-IV **06 Hrs.**

Hydraulic Turbines

Classification of water turbines, Heads and efficiencies, Velocity triangles, Axial, radial and mixed flow turbines, Pelton wheel, Francis turbine and Kaplan turbines – working and design principles.

Unit-V **07 Hrs.**

Rotodynamic Machines

Euler's equation, Theory of Rotodynamic machines, Various efficiencies, Velocity components at entry and exit of the rotor, Velocity triangles;
Centrifugal pumps – Working principle, Work done by the impeller and performance curves, Cavitation in pumps.

Fluid Mechanics and Machinery (RCP23MPC303L)

Suggested Experiments

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1 Verification of Bernoulli's Theorem (Bernoulli's Apparatus)
2 Determination of coefficient of discharge of a Venturimeter
3 Determination of coefficient of discharge of orifice meter
4 Determination of friction factor for Pipes
5 Determination of minor losses in Pipe system
6 Experiment on Laminar flow in pipes (Reynolds Apparatus).
7 Verification of impulse momentum principle
8 Determination of efficiency of a centrifugal pump
9 Determination of overall efficiency of an impulse turbine (Pelton Wheel)
10 Determination of overall efficiency of a Francis / Kaplan turbine
11 Simulation of Flow over an aerofoil in a Wind Tunnel

A minimum of eight experiments or any other experiment based on the syllabus will be included, which would help the learner apply the concept.

Books Recommended

Textbooks

1 R K Bansal: A Textbook on Fluid Mechanics and Hydraulic Machines, Laxmi Publications, New Delhi, 2019.
2 S. K. Som and Gautam Biswas: Introduction to Fluid Mechanics and Fluid Machines, Mc Graw Hill Publication, New Delhi, 2017.

Reference Books

1 Frank W. White: Fluid Mechanics, McGraw Hill Education, 2021.
2 Yunus A. Cengel and John M Cimbala: Fluid Mechanics, McGraw Hill Education, 2024.
3 Bruce Munson, John Wiley and sons: Fundamentals of Fluid Mechanics, Wiley, 2012.
4 Fox and McDonald: Introduction to Fluid Mechanics, Wiley, 2020.
5 Russel C. Hibbeler: Fluid Mechanics, Pearson, 2023.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Industrial Electronics (RCP23MMD301)		
Industrial Electronics Laboratory (RCP23MMD301L)		

Prerequisites:

1. Knowledge of essential electronic devices like Semiconductor Diodes

Course Objectives:

1. To understand power electronic switches and circuits in industrial applications.
2. To Analyse operational amplifiers and digital circuits for signal processing.
3. To Introduce microcontrollers and their role in industrial electronics.
4. To Study industrial sensors and motors for automated systems.
5. To Implement industrial electronics concepts through hands-on experiments.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Describe electronic switch construction, work- ing principles, and applications.	L2	Understand
CO2	Design rectifiers and inverters for DC and AC motor speed control.	L6	Create
CO3	Apply digital circuits in industrial control applications.	L3	Apply
CO4	Develop circuits using operational amplifiers and timer IC555 for signal processing.	L6	Create
CO5	Evaluate appropriate sensors and motors for various industrial applications.	L5	Evaluate

Industrial Electronics (RCP23MMD301)

Course Contents

Unit-I **08 Hrs.**

Semiconductor Devices

Review of Semiconductor Devices: Diodes, Zener Diodes, LEDs, Photodiodes.
Electronics Switches: SCR (V-I Characteristics, Triggering, Turn-off Mechanisms), GTO, Triac-Diac Circuit Applications.
Power Transistors: BJT, MOSFET, IGBT – Construction, Characteristics, and Industrial Applications.
Comparison of Power Devices: SCR vs. Triac vs. MOSFET vs. IGBT.
Applications: Industrial Power Control, Soft Starters, Speed Controllers.

Unit-II **08 Hrs.**

Phase-controlled rectifiers and Bridge inverters

Phase-Controlled Rectifiers: Half-wave and Full-wave Rectifiers using SCR (Resistive Loads) .
H-Bridge and PWM Control: DC Motor Speed Control using Power Electronics.
Single-phase & Three-phase Inverters: Working Principles, Pulse Width Modulation (PWM) Techniques.
Closed-loop Speed Control: Block Diagram and Implementation for DC & AC Motors.

Unit-III **08 Hrs.**

Element of Signal Conditioning

Amplifiers & Filters: Types (Inverting, Non-Inverting, Buffer, Comparator, Instrumentation Amplifier), Active Filters.
IC-555 Timer: Modes of Operation (Monostable, Astable Multivibrator), PWM Generation.
Analog Signal Processing: Attenuators, Signal Amplification, Noise Reduction.
Application in Industrial Systems: Temperature Sensors, Motor Feedback Control.

Unit-IV **08 Hrs.**

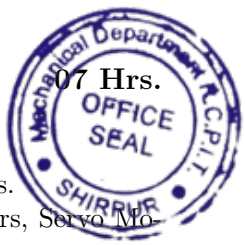
Digital Logic and Microcontrollers

Logic Gates & Boolean Algebra: TTL vs. CMOS Logic Families, Multiplexer & Demultiplexer Applications.
Microcontrollers vs. Microprocessors: Features, I/O Operations, Interrupts, and Timer Modules.
Analog to Digital Conversion (ADC) & Communication Protocols: UART, SPI, I2C.
Case Study & Industrial Applications: Temperature Measurement, Speed Control, Solenoid & Relay Control , AI-driven Automation and Smart Manufacturing.

Unit-V **07 Hrs.**

Sensors and Motors

Industrial Sensors: Displacement, Temperature, Acceleration, Pressure, Optical Sensors.
Motor Technologies: DC Motors, AC Induction Motors, Stepper Motors, BLDC Motors, Servo Motors, Linear Actuators.



Speed Control Methods: Microcontroller-based Speed Control for DC and AC Motors.
Motor Selection and Sizing: Duty Cycles, Power Rating Considerations.
Case Study: Motors in Pumps, Conveyors, CNC Machines, and Robotics.

Industrial Electronics Laboratory (RCP23MMD301L)

Suggested Experiments:

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1 Dynamic analysis of MOSFET / IGBT as a switch devices
2 Evaluation of a Single phase Bridge inverter with rectifier load
3 Design and simulation of OPAMP as integrator
4 Implementing the study of gates and Logic Operations like NOT, AND, OR
5 Realization of basic gates using universal gates
6 Designing of an Light dimmer circuit using Diac-Triac
7 Designing a mechanism of Speed control of DC motor
8 Simple microcontroller-based applications like Temp Measurement/ Speed Measurement using Proximity
9 Speed control of the induction motor
10 Speed control of the BLDC motor
11 Study of Sensors kit.

Minimum of eight experiments from the above-suggested list or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt.

Books Recommended

1 Rashid M.H., Power Electronics: Circuits, Devices & Applications, 4th Edition. Pearson, New York, NY, USA; 2023
2 Boylestad R.L., Nashelsky L., Electronic Devices and Circuit Theory, 11th Edition. Pearson, New York, NY, USA; 2020
3 Mohan N., Undeland T., Robbins W., Power Electronics: Converters, Applications, and Design, 3rd Edition. Wiley, Hoboken, NJ, USA; 2002.
4 Jain R.P., Modern Digital Electronics, 4th Edition. Tata McGraw-Hill, New Delhi, India; 2009.
5 Malvino A.P., Leach D.P., Digital Principles and Applications, 7th Edition. Tata McGraw-Hill, New Delhi,India; 2011.
6 Davies J.H., MSP430 Microcontroller Basics. Newnes, Oxford, UK; 2008.
7 Ogata K., Modern Control Engineering, 5th Edition. Prentice-Hall, New York, NY, USA; 2010.
8 Raghavendra N.V., Krishnamurthy L., Engineering Metrology and Measurements. Oxford University Press, Oxford, UK; 2013.
9 Bolton W., Instrumentation and Control Systems, 2nd Edition. Elsevier, Amsterdam, Netherlands; 2015.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Database Management System Laboratory (RCP23MMD302L)		

Prerequisites:

1. Computer Basics

Course Objectives:

1. To introduce the students to database systems management.
2. To emphasizing how to design, organize, maintain, and retrieve information efficiently and effectively from a database.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Design a normalized relational database schema for a given application.	L6	Create
CO2	Construct SQL queries to perform operations on the database.	L3	Apply
CO3	Describe transactions, concurrency control and recovery mechanisms in database systems.	L2	Understand

Database Management System Laboratory (RCP23MMD302L)

Course Content

Unit-I **03 Hrs.**

Introduction to Database Concepts

Introduction, Characteristics of databases, File system vs. Database system, Users of Database system, Schema and Instance, Data Independence, DBMS system architecture, Database Administrator.

Unit-II **05 Hrs.**

Entity–Relationship Model

Relational Database Design, Introduction, Entity types, Entity sets, weak and strong entity, types of attributes, keys, and relationships, Relationship constraints: cardinality and participation, Generalization and specialization, Mapping the ER Model to the Relational Model.

Unit-III **12 Hrs.**

Structured Query Language (SQL)

Overview of SQL,
Data Definition Commands,
Data Manipulation commands,
Integrity constraints - key constraints, Domain Constraints, Referential integrity, check constraints,
Data Control commands,
Transaction Control Commands,
Set and String operations,
aggregate function - group by, having.
Views in SQL, joins,
Nested and complex queries,
Triggers.

Unit-IV **03 Hrs.**

Relational–Database Design

Pitfalls in Relational-Database designs, Concept of normalization, Function Dependencies, Normal Forms- 1NF, 2NF, 3NF, BCNF.

Unit-V **03 Hrs.**

Transaction Management and Recovery

Transaction Concept, ACID properties, Transaction States, Implementation of atomicity and durability, Concurrent Executions, Serializability, Concurrency Control Protocols: Lock-based, Timestamp based, Log based recovery.

Database Management System Laboratory (RCP23MMD302L)

Suggested Experiments

A Group A : List of general experiments

1. Output all the data entered in the table
2. Create a table from the given data
3. Insert Data into the table
4. Add a column to the table and set default values
5. Update the data in the given row(s) of the given table
6. Delete all rows in the table
7. Create a table with the given constraints
8. Use a select query to fetch data
9. Use distinct queries to fetch unique data
10. Use the where clause to obtain information that meets specific conditions
11. Use the BETWEEN clause along with WHERE to filter the table based on 2 values
12. Use the AND clause with WHERE to filter the table based on 2 separate conditions
13. Use the OR clause is used along with WHERE to filter the table that meets any one of the given multiple conditions.
14. Use the LIKE operator along with WHERE to filter similar values.
15. Use of additional queries - IS NULL, ORDER BY & LIMIT
16. Renaming of columns during output
17. Use the MAX() and MIN() functions to retrieve the maximum and minimum values from a column
18. Combining table - Joins two tables and outputs a single table
19. Use a left join to output data
20. Use a cross join to output the data
21. Use UNION to place a table right on top of another table.
22. Use the WITH query to create temporary tables
23. Use the EXCEPT query to output the data
24. Use the INTERSECT query to output the data
25. Execute a non-correlated subquery independently of the outer query

B Group B: Mechanical Applications

1. To draw an ER diagram for a problem statement and map the ER diagram to relations.
2. Introductions to SQL Mechanical Data
3. Data Handling from PSG Handbook
4. Bill of Materials (BoM) Structure
5. Normalization of Mechanical Data
6. Design a Fastener Lookup Tool (Mini Project – Part 1)
7. Query Interface for Fastener Lookup (Mini Project – Part 2)
8. Machine Maintenance Database
9. Performance Tracking Database for Equipment

10 Case Study for a specific product/process:
    1 Schema Design
    2 Database instance on cloud.
    3 Build visualizations using SQL Queries.
11 DBMS and Industry 4.0 (Demo/Research-based)

Minimum eight experiments from the above suggested list (any from group A and B) or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt.

Books Recommended

Textbooks

1 Korth, Silberschatz, Sudarshan, "Database System Concepts", 7th Edition, McGraw-Hill, 2019.

2 Elmasri and Navathe, "Fundamentals of Database Systems", 7th Edition, Pearson Education, 2021.

3 G. Peter Rob and Carlos Coronel, "Database Systems Design, Implementation and Management", 5th Revised Edition, Thomson, 2002.

4 G. K. Gupta, "Database Management Systems", 3rd Edition, McGraw-Hill, 2018.

Reference Books

1 Dr. P.S. Deshpande, "SQL and PL/SQL for Oracle 10g, Black Book", Dreamtech Press, 2012.

2 Sharanam Shah, Vaishali Shah, "Oracle for Professional", 1st Edition, Shroff Publishers Distributors Private Limited, 2008.

3 Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems", 3rd Edition, McGraw-Hill, 2014.

4 Patrick Dalton, "Microsoft SQL Server Black Book", 11th Edition, Coriolis Group, U.S., 1997.

5 Lynn Beighley, "Head First SQL", 1st Edition, O'Reilly Media, (28 August 2007).

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Reliability Engineering (RCP23MPE311)		
Reliability Engineering Laboratory (RCP23MPE311L)		

Prerequisites:

1. Basics of Probability and Statistics

Course Objectives:

1. To impart a basic understanding of probability and statistical techniques used in reliability engineering.
2. To make the learner aware of applications of probability distributions in modeling and analyzing failure data.
3. To be familiar with the techniques used in system reliability modeling and analyze warranty data.
4. To provide a basic understanding of the use of probabilistic approaches to design components and predict reliability
5. To introduce the concepts of reliability testing.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze components and system using the basics of reliability and its measures.	L3	Apply
CO2	Apply probability distributions to estimate reliability functions such as reliability, CDF, PDF, hazard rate, etc.	L3	Apply
CO3	Develop system reliability models to solve system reliability problems and analyze warranty data.	L6	Create
CO4	Apply probabilistic approaches for component design and reliability prediction.	L3	Apply
CO5	Select a suitable reliability testing method.	L4	Analyze

Reliability Engineering (RCP23MPE311)

Course Contents

Unit-I **07 Hrs.**

Basic Reliability Mathematics

Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem.
Reliability Concepts: Reliability Engineering in the 21st Century, Reliability definitions, Importance of Reliability, Reliability objectives.
Failure Data Analysis: PDF, Reliability function, CDF, Moments of time to failure - MTTF, MTBF, the median time to failure, mode, skewness, kurtosis, variance and standard deviation, Hazard rate function, Bathtub curve.

Unit-II **07 Hrs.**

Probability Distributions

Discrete probability distribution - Binomial distribution and Poisson distribution.
Continuous Probability Distributions – Weibull, exponential, normal (Gaussian), and lognormal. Concept of confidence interval.

Unit-III **08 Hrs.**

System Reliability & Reliability Improvement

System Reliability: System Configurations: Series, parallel, mixed configuration, k out of n structure, and Complex systems. Success path method, Decomposition method. Tie-set and Cut-set methods. Logic diagrams.
Reliability Improvement: Redundancy Techniques: Element redundancy, Unit redundancy, and Standby redundancies.

Unit-IV **07 Hrs.**

System Reliability Modeling and Warranty Analysis

Failure Modes and Effects Analysis (FMEA), and Fault Tree Analysis (FTA). Product warranty and reliability.
Probabilistic Design: Design for Reliability, Reliability models for probabilistic design, Relationship between reliability, Factor of safety, and variability.

Unit-V **10 Hrs.**

Product Life Cycle Assessment and Sustainable Development Goals

Maintainability: Types of maintenance, and Models for maintenance data.
Availability: Types, Markov chains.
Reliability Testing: Stress strength interaction, Accelerated Life Testing (ALT), Highly Accelerated Life Testing (HALT), and Highly Accelerated Stress Screening (HASS). Handbook-based reliability predictions.
Product Life Cycle Costing (LCC): Concept, LCC models, Product recycling, Resource optimization, and Circular economy. Human reliability and sustainability.
Reliability Engineering and Sustainable Development Goals (SDG's): Renewable Energy Systems,

Reliability-Centered Maintenance (RCM) in Waste Management Systems, Water Supply and Sanitation System, Sustainable Manufacturing, Food Supply Chain Reliability in Climate-Vulnerable Regions.

Reliability Engineering Laboratory (RCP23MPE311L)

Suggested Experiments

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1 Reliability data collection, sorting, classification, Pareto analysis/ bar chart plotting (paper clips experiments). Plotting reliability characteristics for a given data set.

2 Select the best-fit probability distributions for reliability modeling using a suitable approach (Use data from paper clips experiments).

3 Reliability analysis of engineering systems using Reliability Block Diagrams (RBD).

4 Reliability and safety evaluation of a mechanical system using Fault Tree Analysis (FTA).

5 Failure Mode and Effects Analysis (FMEA) of a mechanical system such as CNC machine using MIL-STD-1629A Standard.

6 Reliability evaluation of a two-state mechanical system using Markov chains or Monte Carlo Simulation.

7 Failure prediction and warranty cost estimation for an automotive alternator using physics of failure and warranty data analysis.

8 Reliability allocation for a hydraulic brake system using ARINC/ AGREE/ Feasibility-of- Objectives/ and Integrated Factor Methods

9 Handbook based reliability predictions - FIDES, 217+, Bellcore/ Telcordia SR-332, ANSI/VITA51.1, NSWC-11, or GJB/z 299 (any one).

10 Analyse life testing data for the following cases:

- Life testing with censoring.
- Life testing with replacement.
- Life testing without replacement

11 Environmental stress screening (e.g., temperature and humidity simulation, thermal stress cycling) to assess product and material durability under different environmental conditions.

12 Human Reliability Assessment (HRA) in the operation and maintenance of mechanical systems using the Human Error Assessment and Reduction Technique (HEART).

The above experiments/ exercises should be performed using a suitable software package/ programming language whenever required. The first 6 experiments are mandatory. Any two from experiment no. 7 to 13 can be performed.

Books Recommended

Textbooks

1 C. E. Ebeling, An Introduction to Reliability and Maintainability Engineering, Waveland Press Inc., 2019.

2 K. C. Kapur, and M. Pecht, Reliability Engineering, Wiley, 2014.

3 B. S. Dhillon, Design Reliability: Fundamentals and Application, CRC Press, 1999.

4 V. N. A. Naikan, Reliability Engineering and Life Testing, PHI Learning, 2008.

5 L. S. Srinath, Reliability Engineering, Affiliated East-West Press (P) Ltd., 2016.

Reference Books

1 E. Balagurusamy, Reliability Engineering, Tata McGraw Hill, 2017.

2 M. Modarres, K. Kaminsky, and V. Krivstov, Reliability Engineering and Risk Analysis – A Practical Guide, CRC Press, Taylor and Francis Group, 2017.

3 P. D. T. O'Conner, Practical Reliability Engineering, John Wiley and Sons, 2012.

4 G. Yang, Life cycle reliability engineering, John Wiley and Sons, 2007.

5 B. S. Dhillon, Engineering Maintainability, Prentice Hall of India, 1999.

Web References

1 Statistical Learning in Reliability Analysis
`https://onlinecourses.nptel.ac.in/noc22_cs120/preview`

2 Introduction to Reliability Engineering
`https://onlinecourses.nptel.ac.in/noc23_ge20/preview`

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Renewable Energy Systems (RCP23MPE312)		
Renewable Energy Systems Laboratory (RCP23MPE312L)		

Prerequisites:

1. Knowledge of Energy science, Energy sources.
2. Fundamentals of Thermodynamics, Heat Transfer and Fluid mechanics.

Course Objectives:

1. To study working principles of various renewable energy sources and their utilities.
2. To study the economics of harnessing energy from renewable energy sources.
3. To gain the knowledge of renewable energy conversion systems design.
4. To develop skills to analyse industry and domestic applications of RES.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the need for different renewable energy sources.	L2	Understand
CO2	Apply knowledge to demonstrate the importance of renewable energy sources.	L3	Apply
CO3	Interpret various renewable energy sources in the Indian context.	L2	Understand
CO4	Calculate and analyse utilization of solar and wind energy.	L4	Analyze
CO5	Illustrate design of biogas plant.	L3	Apply
CO6	Interpret basics of hydrogen energy.	L2	Understand

Renewable Energy Systems (RCP23MPE312)

Course Contents

Unit-I **04 Hrs.**

Introduction to Energy Sources

Renewable and non-renewable energy sources, Energy policy and sustainability, Energy Consumption as a measure of Nation's development; Strategy for meeting the future energy requirements, Global and National scenarios, Prospects of renewable energy sources, Present status and current installations, Emerging and future energy technologies, various MNRE programmes.

Unit-II **09 Hrs.**

Solar Engergy

Merits and demerits, Solar radiation - beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solar radiation, local solar time, derived solar Angles, sunrise, sunset and day length, Principle of solar energy conversion. Types of Solar Energy Technologies. Components of a Solar Power System.
Solar Energy collection devices and Classification: Flat plate collectors, concentrating collectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating & cooling of buildings,
Solar Photovoltaic systems & applications. Solar Energy in the Global Context. Future of Solar Energy.

Unit-III **08 Hrs.**

Wind Energy

Principle of wind energy conversion; Basic components of wind energy conversion systems; Wind turbine technologies, wind mill components, various types and their constructional features;
design considerations of horizontal and vertical axis wind machines: analysis of Aerodynamic forces acting on wind mill blades and estimation of power output;
wind data and site selection Considerations. Global Wind Energy Development. Future Trends in Wind Energy.

Unit-IV **10 Hrs.**

Ocean & Geothermal Energy

Energy from the ocean: Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India. Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy.
Geothermal Energy: Estimation and nature of geothermal energy, geothermal sources and Resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and Application of geothermal energy, prospects of geothermal energy in India.

Unit-V **08 Hrs.**

Biomass & Hydrogen Energy

Energy from Biomass: Biomass conversion technologies, Biogas generation plants, classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of biogas, utilization of biogas. Hydrogen Energy: Methods of Hydrogen production, Hydrogen Storage, Fuel Cells and Types of Fuel Cells.

Renewable Energy Systems Laboratory (RCP23MPE312L)

Suggested Experiments

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1. Measurement of Solar Radiation (Irradiance) Using a Pyranometer.
2. Study of Solar Energy Potential for a Specific Location.
3. Study on the Impact of Climate Change on Solar Energy Generation.
4. Performance Study of a Flat Plate Solar Collector.
5. Study of Comparison of Solar Collectors (Flat Plate vs. Evacuated Tube vs. Parabolic).
6. Study of Solar Photovoltaic Power Generation.
7. Study of a Solar-Powered Desalination System.
8. Study of Vertical Axis vs. Horizontal Axis Wind Turbines.
9. Performance Analysis of a Small Wind Turbine.
10. Study of Biogas Production from Organic Waste.
11. Study of Bioethanol Production from Biomass.

A minimum of eight experiments from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1. G. D. Rai, Non-conventional energy sources, 6th edition, Khanna Publishers, 1988.
2. S. P. Sukhatme, and J. K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, 4th edition, TMH, 2017.
3. H. P. Garg, and Jai Prakash, Solar Energy: Fundamentals and Applications, 1st revised edition, TMH, 1997.
4. Joshua Earnest, Wind Power Technology, PHI Learning, 2014.
5. J. W. Twidell, and Anthony D. Weir, Renewable Energy Sources, ELBS Publication, 1986.
6. D. Begamudre, Energy Conversion Systems, R. New Age International (P) Ltd. Publishers, 1998.
7. C. S. Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, 3rd Edition, PHI Learning, 2013.

Reference Books

1 D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.

2 Mukund R. Patel, Wind and Solar Power Systems, 2nd edition, CRC Press, 2005.

3 J. F. Manwell, J. G. McGowan, and A. L. Rogers, Wind Energy Explained: Theory, Design and Application, John Wiley and Sons, 2009.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Advance Materials and Processes (RCP23MPE313)		
Advance Materials and Processes Laboratory (RCP23MPE313L)		

Prerequisites:

1. Knowledge of Engineering Materials.
2. Knowledge of Manufacturing Processes.

Course Objectives:

1. To provide the comprehensive exposure to new and advanced materials such as smart materials, high temperature materials, nanomaterials, energy storage materials, biomaterials and advanced functional materials, etc.
2. To make the students familiarize with the development of new materials and processes to cater the application requirements of real world.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply the principles of smart materials in the development of integrated systems such as mechatronic systems and structural health monitoring systems.	L3	Apply
CO2	Design smart materials for their applications in sensors, actuators, self-healing mechanism.	L6	Create
CO3	Analyze the need for high temperature material, Biomaterials and select an appropriate material for their application.	L4	Analyze
CO4	Correlate structure, properties and synthesis of functional and nanostructured materials and analyze the materials used for energy storage, harvesting and hydrogen storage and their application in sustainable energy systems.	L4	Analyze
CO5	Apply advanced manufacturing techniques to produce smart and novel materials for diverse engineering applications.	L3	Apply

Advance Materials and Processes (RCP23MPE313)

Course Contents

Unit-I **08 Hrs.**

Smart Materials – Part I

Introduction: Concept of smart and intelligent materials, Overview and classification, Active and passive smart materials, HBLS and LBHS materials, Applications for sensors and actuators (mechatronic aspect).
Shaper Memory Alloys: Brief history, Shape memory materials and their properties, One way and two-way shape memory effect, Pseudo elasticity and pseudo plasticity effect, Examples, Applications and related manufacturing processes. Piezoelectric Materials: Piezoelectricity, Materials- processing & properties, piezoelectric effects, Constituent equations and Applications.
Structural Health Monitoring: Integration of smart materials into structures. Applications of SMA and Piezoelectric in constructions, vibrations isolation systems, dampers, restoration of old structures, bimorphs, inkjet printers, transformers, transducers etc.

Unit-II **08 Hrs.**

Smart Materials – Part II

Brief overview of Related materials – Composition, properties & processing, Effects, Constituting or governing equations and Industrial applications associated with following smart materials.
Magnetorheological & Electrorheological fluids.
Magnetostrictive and Electrostrictive materials.
Electroactive polymers (EAP's): IPMC's, Dielectric polymers, Conductive polymers etc. Soft matter.
Smart composites: Active fiber composites/smart polymer matrix composites
Applications: Automotive clutches, brakes, animatronics, human machine interface, biological muscles, microsurgery etc.

Unit-III **08 Hrs.**

High Temperature Materials & Super Alloys

Introduction, Materials behavior at high temperature, Characteristics of high temperature materials, their composition, properties and applications (Steels, intermetallic, ceramics and composites).
Super Alloys: Common features, synthesis and applications of Ni and Co based super alloys Biomaterials: Introduction, structure–property relationships of biomaterials, classes and their biocompatibility, and the design principles for implants, prosthetics, drug delivery systems, and tissue engineering etc.

Unit-IV **08 Hrs.**

Functional Materials, Nanomaterials and Energy Storage

Functional Materials: Classes, Properties, and applications of functionally graded materials and multifunctional materials for additive manufacturing, self-healing materials, and chromogenic material.
Nanomaterials: Concept, Classification, Size effect on structural and functional properties, Top-down and Bottom-up approach, Special nanostructures (Fullerene, Graphene, Carbon nanotubes etc) and their application, Nanocomposites and Nanotechnology.
Energy storage: Energy harvesting, Hydrogen Technology: Production and storage of cryogenic, gaseous and solid hydrogen.

Unit-V **07 Hrs.**

Processing of Advanced Materials

Manufacturing of smart and new materials by additive manufacturing, powder metallurgy, vacuum arc melting, mechanical alloying, single crystal growth, rapid solidification processing, sol-gel, physical and chemical vapour deposition technique etc.

Advance Materials and Processes Laboratory (RCP23MPE313L)

Suggested Experiments

A Assignments based on syllabus.

B Case study or literature based presentation/seminar.

C Mathematical modelling and simulation of smart and new materials based systems and devices.

Books Recommended

Textbooks

1 Chander Prakash, Sunpreet Singh, and J. Paulo Davim, Functional and Smart Materials, CRC Press, 2021.

2 Rachid Bouhfid Abou el Kacem Qaiss Mohammad Jawaid, Polymer Nanocomposite-Based Smart Materials: From Synthesis to Application, Elsevier, 2020.

3 Masoud Mozafari, Handbook of Biomaterials Biocompatibility, Elsevier, Woodhead Publishing, 2020.

4 Maria Rosa Aguilar, Julio San Roman, Smart Polymers and Their Applications, Elsevier, Woodhead Publishing, 2019.

5 Anca Filimon, Smart materials- Integrated Design, Engineering Approaches, and Potential Applications, CRC Press, 2019.

6 Kuan Yew Cheong, Giuliana Impellizzeri and Mariana Fraga, Emerging Materials for Energy Conversion and Storage, Elsevier, 2018.

7 Ying-Pin Chen, Sajid Bashir, Jingbo Louise Liu, Nanostructured Materials for Next-Generation Energy Storage and Conversion, Springer, 2017.

8 Qing Li, Yiu-Wing Mai, Biomaterials for Implants and Scaffolds, Springer, 2017.

9 Jayantha Ananda Epaarachchi, Gayan Chanaka Kahandawa, Structural Health Monitoring Technologies and Next-Generation Smart Composite Structures, CRC Press, 2016.

10 Xu Hou, Design, Fabrication, Properties, and Applications of Smart and Advanced materials, CRC Press, 2016.

11 David Julian McClements, Nano Particle and Micro Particle Based Delivery Systems, CRC Press, 2015.

12 Yoseph Bar-Cohen, High Temperature Materials and Mechanisms, CRC Press, 2014.

13 William G. Fahrenholtz, Eric J. Wuchina, William E. Lee, Yanchun Zhou, Ultra-High Temperature Ceramics: Materials for Extreme Environment Applications, Wiley, 2014.

14 C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford, Gopinath Mani, Introduction to Biomaterials: Basic Theory with Engineering Applications, Cambridge University Press, 2014.

15 Rani Elhajjar, Valeria La Saponara, Anastasia Muliana, Smart Composites: Mechanics and Design, CRC Press, 2013.

16 Mel Schwartz, Smart Materials, CRC Press, 2009.

Web References

1 Prof. Jayanta Das, Advanced Materials and Processes, NPTEL Course, IIT Kharagpur.

2 Prof. Kaushik Pal., Selection of Nanomaterials for Energy Harvesting and Storage Application, NPTEL Course, IIT Roorkee.

3 Bhattacharya B, Smart Materials and Intelligent System Design, NPTEL Course, IIT Kanpur.

4 Prof. Indranil Ghosh, Cryogenic Hydrogen Technology, NPTEL Course, IIT Kharagpur.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Automotive Prime Movers(RCP23MPE314)		
Automotive Prime Movers Laboratory (RCP23MPE314L)		

Prerequisites:

1. Thermodynamics.
2. Engineering materials.

Course Objectives:

1. To comprehend the functions of components of an internal combustion engine and its systems.
2. To familiarise with different systems in SI and CI engines.
3. To analyze engine performance and emissions.
4. To acquaint with modern hybrid and electric powertrains.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply the fundamentals of thermodynamics and analyze engine cycles.	L4	Analyze
CO2	Demonstrate the working systems of spark ignition & compression ignition engines.	L2	Understand
CO3	Analyze various engine performance parameters and emission control strategies.	L4	Analyze
CO4	Evaluate the energy flow and control in hybrid powertrain systems.	L5	Evaluate
CO5	Evaluate the energy flow and control in electric powertrain systems.	L5	Evaluate

Automotive Prime Movers (RCP23MPE314)

Course Contents

Unit-I **09 Hrs.**

Introduction

Introduction:
Classification, components and materials of I.C. Engines, Four stroke, two stroke engines, Fuel-air cycles and their analysis, Actual cycle, Valve timing diagram. Cooling systems and their comparison: Air cooling, Liquid cooling, Troubleshooting aspects, Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems and their applications.
Spark Ignition (SI) Engines:
Fuel Injection system: Air-Fuel mixture requirements for steady state and transient operations. Types of fuel injection systems. Engine Control Unit, Sensors and actuators, Open loop and closed loop modes. Analysis of fuel injection parameters.
Ignition systems: Battery ignition system, Magneto ignition system, Electronic ignition systems.
Combustion: Combustion phenomenon in SI Engines, Pressure-crank angle diagram, abnormal combustion, Factors affecting combustion and detonation, Types of combustion chambers. Troubleshooting aspects.

Unit-II **08 Hrs.**

Compression Ignition (CI) Engines

Fuel Injection Systems:
Types of fuel injection systems, Types of nozzles, role of fuel atomization and spray structures, electronically controlled unit fuel injection system. Load and speed control of CI engines. Analysis of fuel injection parameters.
Combustion:
Combustion phenomenon in CI engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers. Troubleshooting aspects.

Unit-III **09 Hrs.**

Engine Performanceand Emissions

Engine Performance
Measurement and analysis of engine performance parameters, Performance characteristic of SI and CI engines, Effect of load and speed on engine performance heat balance sheet. Bharat Stage VI emission norms, emission control systems. Alternative fuels: Ethanol, Bio-diesel, CNG, LPG, Hydrogen, Synthetic fuels - Merits, demerits and engine modifications.
Supercharging/Turbo-charging:
Objectives and limitations, Methods, types and different arrangements of superchargers and turbochargers.
Recent developments:
Cam-less engine, VVT, Stratification in GDI engine, LHR engine, HCCI engine six-stroke engine.

Unit-IV **08 Hrs.**

Hybrid Powertrain

Hybrid powertrain architecture, Hybrid powertrain performance - Series architecture and Parallel architecture, Hybrid power system components, Degree of hybridization, Regenerative braking, Effect of driving cycles on hybrid performance, Hybrid powertrain control algorithms and thermal management.

Unit-V **07 Hrs.**

Electric Powertrain

Introduction to components used in electric vehicles, Energy storage systems and their characteristics. Battery energy and thermal management systems. Types of motors employed in EVs. Configuration and control of motor drives. Drive system efficiency calculations.

Automotive Prime Movers Laboratory (RCP23MPE314L)

Suggested Experiments

A Study-Type/ Case-Study-based Experiments:

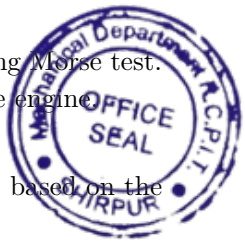
1 Study of components of an internal combustion engine.
2 Study of fuel injection system in SI engines.
3 Study of fuel injection system in CI engines.
4 Study of electric motor test methods.
5 Perform a case study on the hybrid and electric vehicles.

B Numerical Analysis/ Simulation-based Experiments:

1 Analysis of supercharging and turbo charging of I C engines.
2 Simulation of engine parameters on any simulation software (LOTUS/Ricardo/Diesel-RK)
3 Simulation of ICE powertrain on MATLAB Simulink software.
4 Simulation of electric powertrain on MATLAB Simulink software.
5 Simulation of hybrid powertrain on MATLAB Simulink software.
6 Model and compare the energy efficiency of ICE vehicles, Hybrid vehicles and BEVs under similar conditions.

C Performance-Based Experiments:

1 Experimental estimation and validation of valve timing for four stroke SI / CI Engine.
2 Load Test on CI engine.
3 Speed Test on SI engine.
4 Heat Balance test on SI or CI engines
5 Experimental determination of friction power of multi-cylinder SI engine using Morse test.
6 Experimental determination of Air fuel ratio and volumetric efficiency of the engine.



A minimum of nine experiments from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1 Ganesan V., Internal Combustion Engines, McGraw Hill, 4th Edition, 2020.

2 Mathur and Sharma, Internal Combustion Engines, Dhanpat Rai Publications, 2018.

3 R K Rajput, Internal Combustion Engines, Laxmi Publications, 3rd Edition, 2016.

4 Tom Denton, Automotive Electrical and Electronic Systems, Routledge, 5th Edition, 2017.

5 Lowry J., Electric vehicle technology explained, 2nd edition, Wiley, 2012.

Reference Books

1 Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Practice, CRC Press, 2018.

2 Chris Mi, M. Abul Masrur, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd, 2018.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Adhesive Technology (RCP23MPE315)		
Adhesive Technology Laboratory (RCP23MPE315L)		

Prerequisites:

1. Basics of Mechanical Engineering.
2. Probability and Statistics.
3. Basics of Physics and Chemistry.

Course Objectives:

1. To impart a basic understanding of adhesives and the bonding process.
2. To make the learner aware of applications of adhesives in improving the reliability of threaded joints and assemblies.
3. To be familiar with different dispensing methods.
4. To provide a basic understanding of the shelf life and various failure modes observed in shelf life.
5. To explain the use of test standards and certification processes of ISO 10964, ISO 10123, and ISO 16047.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply the concept of adhesion and bonding processes in various applications.	L3	Apply
CO2	Apply suitable adhesives in threaded joints and assemblies and estimate/predict its performance.	L4	Analyze
CO3	Demonstrate different dispensing techniques and select suitable dispensing techniques.	L3	Apply
CO4	Analyze a suitable method to estimate the reliability of assembly/joints.	L4	Analyze
CO5	Develop a system reliability model using FMEA/FTA and identify root causes of the failures.	L6	Create
CO6	Apply test standards and certification processes provided in ISO 10964, ISO 10123, and ISO 16047.	L3	Apply

Adhesive Technology (RCP23MPE315)

Course Contents

Unit-I **06 Hrs.**

Basics of Adhesives

Introduction, Definition of adhesives, Basics of bonding, Adhesion, Cohesion, Bonding process – surface preparation, cleaning, application of adhesive, curing process, performance, and testing cured adhesive strength, Effect of environment on cured bondline.

Unit-II **07 Hrs.**

Threaded Assemblies

Threaded fastener mechanics, Clamping loads, Controlled clamp loads, Fastener failures, Threadlockers, Application of adhesives, Testing, and validation, Pipe joints, Thread sealing, Retaining for cylindrical assembly.

Unit-III **09 Hrs.**

Gasketing, Bonding and Dispensing

Gasketing and Bonding : Types of gasketing, Materials used for gasketing, Issues with gasketing, Adhesive applications for gasketing, Types of bonding, Performance of gasketing with and without application of adhesive bonding.
Dispensing: Why dispensing equipment? Dispensing technology – pressure/ time dispensing, volumetric dispensing, peristaltic pump, progressive cavity pump, Manual dispensing, Automatic dispensing, Equipment selection.

Unit-IV **10 Hrs.**

Troubleshooting and Shelf Life

Troubleshooting : Failure modes, causes, mechanisms, Root cause analysis, Failure mode analysis, Fault tree analysis, Failure modes and effects analysis, Fishbone diagram.
Shelf Life: Definition of shelf life, Failure modes observed, Product performance, Packaging Stabilizer, Estimation of reliability and life of the product, Effect of temperature and humidity on the life.

Unit-V **07 Hrs.**

Certification and Standards

Certification organizations, Certification processes, Test standards, Practical's and experience sharing ISO 10964, ISO 10123, ISO 16047.

Adhesive Technology Laboratory (RCP23MPE315L)

Suggested Experiments

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1 Joint strength of a lap joint subjected to tensile load.

2 Break-loose strength of various thread locking options and commonly accepted mechanical locking devices.

3 Threadlocker in a blind hole and through holes.

4 Mechanical locking device.

5 Large nuts and bolts.

6 Anaerobic technology for bonding.

7 Preventive maintenance and repairs using adhesives.

8 Thread sealant pressurized pipe.

9 Gasketing with adhesives.

10 Pre-cut gasket.

11 Pressurized flange sealing.

A minimum of ten experiments or any other experiment based on the syllabus will be included, which would help the learner apply the concept.

Books Recommended

Textbooks

1 LOCTITE Handbook on "How to Increase Reliability and Prevent Threaded Assembly failure", ISBN: 9783941 517769.

Reference Books

1 E. M. Petrie, An Introduction to Adhesive and Sealants. In: Handbook of Adhesives and Sealants, McGraw- Hill Professional, New York, NY, USA; 1999.

2 S. Ebnesajjad, Adhesive Technology Handbook, William Andrew Inc., Norwich, NY, USA; 2008.

3 I. Skeist, and J. Miron, Introduction to Adhesives, Handbook of Adhesives, Boston, Springer; 1990.

4 K. C. Kapur, and M. Pecht, Reliability Engineering, Wiley, 2014.

Web References

1 Methods of Adhesion Measurement for Pressure Sensitive Adhesives: Theory and Practice
`https://nptel.ac.in/courses/103104569`

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Data Analytics (RCP23MPE316)		
Data Analytics Laboratory (RCP23MPE316L)		

Prerequisites:

1. Fundamentals of Mechanical Engineering.
2. Engineering Mathematics and Statistics.
3. Basics of Probability and Statistics.

Course Objectives:

1. To explore the fundamental concept of data analytics and its relationship with AI-ML-DL.
2. To apply descriptive and inferential statistics to solve mechanical engineering problems.
3. To understand the various data analytics approaches and visualization techniques
4. To apply various machine learning techniques for data analysis.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the fundamentals of data analytics and select a suitable approach for data analytics.	L2	Understand
CO2	Apply descriptive analytics to describe and analyze the data.	L3	Apply
CO3	Apply descriptive, diagnostic, predictive, and prescriptive analytics techniques to withdraw useful conclusions from the acquired data set.	L4	Analyze
CO4	Evalute inferential analytics to draw critical inferences from the given data.	L5	Evaluate
CO5	Select suitable plots for the given data and draw practical interpretations.	L4	Analyze

Data Analytics (RCP23MCPE316)

Course Contents

Unit-I **07 Hrs.**

Introduction

Data science and data analytics, Types of data, Data collection and data generation methods, Data storing, Data pre-processing, Data describing/ visualization, Statistical modelling, Algorithmic modelling, Missing data treatment, Relationship between AI, ML, DL, and data science, Big data, and Database system

Unit-II **07 Hrs.**

Descriptive Statistics

Universe, population, and sample, Measures of central tendency and their characteristics, outlier detection, histogram, and central tendency, measures of spread, variance, and percentiles, Effect of transformation of measure of spread.

Unit-III **09 Hrs.**

Inferential Statistics

Sampling distribution, Hypothesis testing, Types of errors, level of significance, p- test, Chi-Square test, z-test, t-test, ANOVA, K-S test, Correlation analysis, Maximum likelihood test, Taguchi analysis.

Unit-IV **08 Hrs.**

Data Analytics Approaches

Predictive analytics – predictions using statistical modeling and machine learning techniques; demand forecasting; anomaly detection.
Prescriptive analytics – process improvement decisions; supplier reviewing, maintenance scheduling.
Descriptive analytics – trends and patterns in the data, data visualization tools.
Diagnostics analytics – root cause analysis, data mining, correlation, product quality analysis.

Unit-V **09 Hrs.**

Data Visualization using Python/R/Tableau / Power BI

Histogram, Bar/ line chart, Box plots, swarm plot, Violin plot, faceted plot, boxen plot, leaf and stem plots, Scatter plots, Heat map, Bubble chart, pie chart, line plot.

Note: Numerical/ case studies should be solved/ presented related to mechanical and allied engineering domains. The following are some of the domains: Thermal/ Heat Transfer/ HVAC/ Fluid Mechanics/ Fluid Power, Solid Mechanics/ Design, Machining/ Manufacturing, Automation and Robotics, Maintenance/ reliability/ condition monitoring, Quality Control, Materials and metallurgy, Energy Conservation and Management, Industrial Engineering, Estimation, and Management, Automotive Technology.

Data Analytics Laboratory (RCP23MLPE316L)

Suggested Experiments

A Group A : Any five experiments from the following list should be performed for a data set using a suitable software package/ programming language.

1 To study data science, data analytics, and AI-ML-DL.

2 To perform descriptive statistical analysis by using the data from the literature or mechanical laboratory. Data can be generated by performing bending tests on the paper clips. The minimum number of data points should be 30.

3 Development and performance evaluation of a linear regression model for predicting component failure time in mechanical systems.

4 Development and performance evaluation of a decision tree classification model for predicting failure risk level of mechanical components.

5 Hypothesis testing of mechanical system parameters using parametric and non-parametric statistical tests.

6 Optimization of Surface Roughness in Turning Operation Using Taguchi Method

7 To visualize a given data set (paperclip tests/ literature/ laboratory) - scattered diagram, Bar/ line chart, histogram, Box plots, and pie charts.

8 To visualize a given data set (paperclip tests/ literature/ laboratory) - swarm plot, Violin plot, faceted plot, boxen plot, leaf and stem plots, Heat map, Bubble chart, line plot.

9 To estimate the best-fit probability distribution for a given data set - Weibull, Exponential, Normal, and Lognormal.

B Group B : A mini project (Mandatory)

1 One mini project (in a group of 2-3 students) based on the above contents and using the mechanical engineering application dataset.

Books Recommended

Textbooks

1 S. L. Brunton, and J. N. Kutz, Data-driven science and engineering: Machine learning, dynamical systems, and control, Cambridge University Press, 2022.

2 P. F. Dunn, and M. P. Davis, Measurement and data analysis for engineering and science, CRC Press, 2017.

3 S. S. Roy, P. Samui, R. Deo, and S. Ntalampiras, Big data in engineering applications (Vol. 44), Berlin/Heidelberg, Springer, Germany, 2018.

4 J. A. Middleton, Experimental Statistics and Data Analysis for Mechanical and Aerospace Engineers, Chapman and Hall/CRC, 2021.

5 E. L. Robinson, Data analysis for scientists and engineers. In Data Analysis for Scientists and Engineers, Princeton University Press, 2017.

6 S. Araghinejad, Data-driven modeling: using MATLAB® in water resources and environmental engineering (Vol. 67), Springer Science & Business Media, 2013.

7 G. Niu, Data-driven technology for engineering systems health management, Springer, Beijing, China, 2017.

Reference Books

1 Zsolt Nagy, Artificial Intelligence and Machine Learning Fundamentals, Packt Publishing, 2018.

2 Hastie Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. The elements of statistical learning: data mining, inference, and prediction. Vol. 2. New York: Springer, 2009.

3 M. J. Zaki, M. Wagner, and Wagner Meira. Data mining and analysis: fundamental concepts and algorithms. Cambridge University Press, 2014.

Web References

1 Foundations of Data Science
`https://padhai.onefourthlabs.in/courses/data-science`

2 Data Analytics with Python s
`https://nptel.ac.in/courses/106107220`

3 Introduction to Data Analytics
`https://nptel.ac.in/courses/110106072`

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Fundamentals of Business Development (RCP23MPE317)		
Fundamentals of Business Development Laboratory (RCP23MPE317L)		

Prerequisites:

-

Course Objectives:

1. Gain insights into essential concepts and principles for effective business development.
2. Develop the ability to think strategically, analyse markets, and create sound business strategies.
3. Learn methods to attract and retain customers, focusing on building lasting relationships.
4. Acquire proficiency in essential sales techniques, negotiation skills, and effective communication for successful business development.
5. Understand the importance of partnerships, learn collaboration strategies, and explore models for mutual benefit

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Demonstrate a comprehensive understanding of essential concepts and principles foundational to effective business development.	L2	Understand
CO2	Apply strategic thinking, analyse market dynamics, and formulate robust business strategies to address diverse challenges.	L6	Create
CO3	Apply methods for customer attraction and retention, emphasizing the establishment and nurturing of enduring customer relationships.	L3	Apply
CO4	Apply proficiency in essential sales techniques, negotiation skills, and articulate communication for successful business development.	L3	Apply
CO5	Evalute the importance of partnerships, implement effective collaboration strategies, and explore models fostering mutual benefit.	L5	Evaluate

Fundamentals of Business Development (RCP23MPE317)

Course Contents

Unit-I **08 Hrs.**

Strategic Business Planning

- Fundamentals of Strategic Planning
- Case studies on failed ventures and reflections on personal setbacks
- Market Trends and Competitive Analysis
- Formulating Business Strategies
- Value-Based Learning & SDG Alignment
- Case Studies on Successful Business Planning

Unit-II **08 Hrs.**

Customer Acquisition and Retention

- Methods for Acquiring and Retaining Customers
- Building and Maintaining Customer Relationships
- Customer Loyalty Programs
- Case Studies on Successful Customer Engagement

Unit-III **08 Hrs.**

Sales and Negotiation Skills

- Essential Sales Techniques
- Negotiation Skills in Business Development
- Effective Communication in Sales
- Role-Playing Exercises on Sales and Negotiation

Unit-IV **07 Hrs.**

Partnership and Collaboration Strategies

- Importance of Partnerships in Business Development
- Strategies for Building Successful Partnerships
- Collaborative Business Models
- Case Studies on Partnership Success and Failures
- Proposal Development for Potential Partnerships

Unit-V **08 Hrs.**

Financial Modeling for Business Growth

- Principles of Financial Modelling
- Key Financial Metrics for Decision-Making
- Financial Analysis for Business Growth
- Investment Scenarios and Decision-Making
- Discussion on Financial Models
- Innovative Approaches to Business Development
- Adaptive Strategies for Changing Business Environments
- Case Studies on Business Innovation
- Innovative Business Plan Presentation
- Course Review and Reflection

Fundamentals of Business Development Laboratory (RCP23MPE317L)

Suggested Experiments

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1 : Strategic Business Plan Development

- Conduct market research and competitive analysis.
- Formulate clear business objectives and strategies.
- Identify potential challenges and propose mitigation strategies.
- Create a detailed implementation plan.

2 : Customer Journey Mapping

- Identify touchpoints in the customer journey.
- Analyze customer interactions and experiences.
- Develop strategies to enhance customer satisfaction and loyalty.
- Create a visual representation of the customer journey.

3 : Sales Pitch and Negotiation Simulation

- Develop a compelling sales pitch for a product or service.
- Participate in simulated negotiation scenarios.
- Receive constructive feedback from peers and instructors.
- Refine sales and negotiation skills through practice.

4 : Partnership Identification and Proposal

- Research potential partners in the industry.

- Assess compatibility and alignment of goals.
- Develop a partnership proposal highlighting collaborative opportunities.
- Present the proposal effectively to a simulated audience.

5 : Financial Modelling Project

- Create a detailed financial model using relevant metrics.
- Analyze financial data to assess project viability.
- Consider different investment scenarios and their impact.
- Present findings and recommendations based on financial modeling.

6 : Innovation Challenge

- Identify a real or simulated business innovation challenge.
- Formulate innovative solutions through brainstorming and ideation.
- Develop a detailed plan for implementing the proposed solutions.
- Present the innovation challenge solution for evaluation.

Any other exercise/experiment based on syllabus may be included, which would help the learner to apply the concept learnt.

Books Recommended

Textbooks

1 Skripak, Stephen J. Fundamentals of Business. OpenStax, Virginia Tech Publishing, 2023.

Reference Books

1 F. R. David, Strategic Management: Concepts and Cases. Pearson Education, 17th Edition, 2017.

2 J. Kaufman, The Personal MBA, Penguin Books, 2010.

3 A. T. Lawrence, and J. Weber, Business and Society: Stakeholders, Ethics, Public Policy, McGraw-Hill Education, 15th Edition, 2016.

4 W. M. Pride, R. J. Hughes, and J. R. Kapoor, Foundations of Business, Cengage Learning, 6th Edition, 2020.

5 E. Ries, The Lean Startup, Crown Business, 2011.

6 S. P. Robbins, T. A. Judge. Organizational Behavior. Pearson Education, 13th Edition, 2009.

7 S. Ross, R. Westerfield, and J. Jaffe, Corporate Finance: Core Principles and Applications. McGraw-Hill Education, 5th Edition, 2019.

8 P. Thiel, and M. Masters. Zero to One, Crown Business, 2014.

9 D. Besanko, D. Dranove, M. Shanley, and S. Schaefer, Economics of Strategy, Wiley, 6th Edition, 2012.

10 S. R. Covey, The 7 Habits of Highly Effective People. Free Press, 1989.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Environmental Studies (RCP23XHS331T)		

Prerequisites:

1. Interest in Environment and its impact on Human

Course Objectives:

1. Familiarize students with environment related issues such as depleting resources, pollution, ecological problems and the renewable energy scenario.
2. Give overview of Green Technology options.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Describe how human activities affect environment.	L2	Understand
CO2	Describe the various technology options that can make a difference.	L2	Understand
CO3	Describe the advantages of solar energy over the other forms of energy.	L2	Understand

Environmental Studies (RCP23XHS331T)

Course Contents

Unit-I **01 Hr.**

Air Pollution

- Air Quality Index
- Case study on Smog

Unit-II **01 Hr.**

Water Pollution

- Presentation on Water Pollution (Industrial, Sewage, etc.) explaining any specific case

Unit-III **01 Hr.**

Noise Pollution

- Decibel limits for hospital, library, silence zone
- List effects of noise pollution on human health
- Measure decibel level in college library, canteen, classroom

Unit-IV **01 Hr.**

Biodiversity loss

- Case study on effect of pollution on biodiversity loss

Unit-V **01 Hr.**

Deforestation

- Debate for and against "To promote Economic growth Deforestation is required".

Unit-VI **01 Hr.**

Renewable Energy sources

- Presentation on different Renewable Energy Technologies.

Unit-VII **01 Hr.**

Climate change

- Report on major Impact of Global warming on Environment giving real examples.

Unit-VIII **01 Hr.**

Green Technology

- Advantages and Examples of Green Building for Sustainable development,
- Sustainable Software Design,
- Data Center Energy Efficiency,
- Thin-Client and Energy Efficiency.

Books Recommended

Textbooks

1 R. Rajagopalan, Environmental Studies: From Crisis to Cure, Oxford University Press, 2011.

2 Erach Bharucha, Textbook of Environmental Studies For Undergraduate Courses, Universities Press (India) Pvt. Limited, 2005.

3 Mohammad Dastbaz, Colin Pattinson, Babak Akhgar, Morgan and Kaufman, Green Information Technology A Sustainable Approach, Elsevier, 2015.

Reference Books

1 Paulina Golinska, Marek Fortsch, Jorge Marx-Gómez, Information Technologies in Environmental Engineering: New Trends and Challenges, Springer, 2011.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Semester Project-III (RCP23XSC301P)		

Prerequisites:

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Course Objectives:

1. Students are expected to design, simulate/implement a project based on the knowledge acquired from current semester subjects.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze a survey of several available literatures in the preferred field of study.	L4	Analyze
CO2	Describe various/alternate approaches to complete a project.	L2	Understand
CO3	Apply a collaborative project environment by interacting and dividing project work among team members.	L3	Apply
CO4	Use technical communication skills to present project work in the form of a technical report/paper.	L3	Apply
CO5	Apply teamwork and project management skills to plan, execute, and manage the research study.	L3	Apply

Semester Project III (RCP23XSC301P)

The purpose of introducing a semester project at the Third-year level is to provide exposure to students with a variety of projects based on the knowledge acquired from the semester subjects. This activity is supposed to enrich their academic experience and bring enough maturity to the student while selecting the project. Students should take this as an opportunity to develop skills in implementation, presentation, and discussion of technical ideas/topics. Proper attention shall be paid to the content of report, which is being submitted in partial fulfillment of the requirements of the Third-year, and it is imperative that a standard format be prescribed for the report.
Each student shall work on a project approved by the departmental committee approved by the Head of the Department. A group of 3 to 5 students (maximum allowed: 5 students in extraordinary cases, subject to the approval of the department committee and the Head of the department) shall be allotted for each Semester Project. Each group shall submit at least 3 topics for the Semester Project. The departmental committee shall finalize one topic for every group. The Semester Project Title or Theme should be based on the knowledge acquired during the semester. The project work shall involve sufficient work so that students get acquainted with different aspects of knowledge acquired from semester subjects.

Student is expected to:

- Select an appropriate project title based on acquired knowledge from current semester subjects.
- Maintain a Log Book of weekly work done (Log Book Format will be as per Table 1).
- Report weekly to the project guide along with the log book.

Table 1: Log Book Format

Sr	Week (Start Date:End Date)	Work Done	Sign of Guide	Sign of Coordinator
1				

Assessment Criteria:

- At the end of the semester, after confirmation by the project guide, each project group will submit a project completion report in the prescribed format for assessment to the departmental committee (including project guide).
- Assessment of the project (at the end of the semester) will be done by the departmental committee (including project guide).

Prescribed project report guidelines:

The Project Report (minimum of 25 pages) should include appropriate content for:

- Introduction
- Literature Survey,
- Related Theory
- Implementation details
- Project Outcomes, Conclusion
- References

Assessment criteria for the departmental committee (including project guide) for Continuous Assessment:

Guide will monitor weekly progress, and marks allocation will be as per Table 2.

Table 2: Continuous Assessment table

Sr	PRN	Name of Student	Student Attendance	Log Book Maintain	Literature Review	Depth of Understanding	Report	Total
			5	5	5	5	5	25

Assessment criteria for the departmental committee (including project guide) for End Semester Exam:

The departmental committee (including project guide) will evaluate the project as per Table 3.

Table 3: Evalution Table

Sr	PRN	Name of Student	Project Selection	Design/ Simulation	model/ programming	Result Verification	Presentation	Total
			5	5	5	5	5	25

Each group shall present/publish a paper based on the semester project in reputed/peer-reviewed Conference/Journal/TechFest/Magazine before the end of the semester.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Data Science for Mechanical Engineers (RCP23MSC301)		

Prerequisites:

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Course Objectives:

1. To understand the fundamentals of engineering data science and industrial analytics.
2. To analyze engineering datasets using statistical and visualization techniques.
3. To perform pre-processing and cleaning of industrial data.
4. To create meaningful visualizations and dashboards for engineering decision-making.
5. To apply data science concepts to mechanical engineering applications.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the role of data science in mechanical engineering industries.	L2	Understand
CO2	Analyze engineering datasets using basic statistical methods.	L4	Analyze
CO3	Apply data analytics techniques to manufacturing and maintenance datasets.	L3	Apply
CO4	Create visualizations and dashboards for engineering interpretation.	L6	Create
CO5	Perform preprocessing and cleaning of industrial datasets.	L3	Apply

Data Science for Mechanical Engineers

(RCP23MSC301)

Course Contents

Unit-I **01 Hrs.**

Introduction to Engineering Data Science

- Introduction to data science;
- Role of data science in engineering industries;
- Data-driven decision-making;
- Data science workflow;
- Applications of data science in mechanical engineering;
- Introduction to industrial analytics.

Unit-II **02 Hrs.**

Engineering Data and Industrial Datasets

- Types of engineering data:
- Structured data, Unstructured data, Sensor data, Time-series data;
- Introduction to industrial datasets;
- Characteristics of engineering data;
- Data collection and management in industries.

Unit-III **02 Hrs.**

Engineering Statistics and Data Interpretation

- Introduction to engineering statistics;
- Measures of central tendency;
- Measures of dispersion;
- Histograms and frequency distribution;
- Probability basics for engineering applications;
- Engineering data interpretation.

Unit-IV **02 Hrs.**

Correlation, Regression, and Engineering Analytics

- Correlation analysis;
- Introduction to regression analysis;
- Trend identification;
- Data relationships and engineering insights;
- Applications of correlation and regression in mechanical engineering.

Unit-V **02 Hrs.**

Data Preprocessing and Data Cleaning Techniques

- Importance of data preprocessing;
- Handling missing data;
- Data cleaning techniques;
- Duplicate data handling;
- Outlier detection basics;
- Introduction to engineering data preparation workflows.

Unit-VI **02 Hrs.**

Data Transformation and Feature Engineering

- Data normalization and standardization;
- Feature selection basics;
- Data transformation techniques;
- Preparing engineering datasets for analysis;
- Improving data quality for predictive applications.

Unit-VII **01 Hrs.**

Data Visualization and Dashboard Development

- Importance of visualization in engineering;
- Principles of effective data visualization;
- Introduction to visualization tools;
- Plotting techniques (Line plots, Scatter plots, Histograms, Box plots, Heat maps);
- Introduction to dashboards;
- Interactive visualization concepts;
- Introduction to Power BI;
- Data storytelling for engineering systems.

Unit-VIII **02 Hrs.**

Engineering Data Science Applications

- Introduction to predictive analytics;
- Engineering trend analysis;
- Quality control analytics;
- Maintenance analytics;
- Energy system analytics;
- Industrial IoT data interpretation;
- Case studies on smart manufacturing;
- Introduction to AI-enabled industrial analytics;
- Mini-project development using engineering datasets.

Suggested Coursera Mapping

Module	Suggested Coursera Content Provider
Introduction to Data Science	IBM Data Science, Google
Engineering Statistics	University of Michigan, Stanford
Visualization and Dashboards	IBM, Microsoft
Data Analytics and Visualization	Google Data Analytics, Microsoft Power BI
Industrial Analytics Applications	AWS, DeepLearning, AI

Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Details of Semester-VI

Third Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2026-27
(Revision 01)

Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405 Ph: 02563 259 802,
Web: www.rcpit.ac.in/mechanical-engineering-syllabus

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Design of Machine Elements (RCP23MPC351)		
Design of Machine Elements Laboratory (RCP23MPC351L)		

Prerequisites:

1. Mechanics of Materials
2. Engineering Materials

Course Objectives:

1. To study basic principles of the design of machine elements.
2. To familiarize with the use of design data books & various codes of practice.
3. To acquaint with functional and strength design principles of commonly used machine elements.
4. To make conversant with the preparation of working drawings based on designs.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply design data books for designing machine components considering practical design constraints.	L3	Apply
CO2	Explain the fundamental principles of machine design.	L2	Understand
CO3	Interpret various design considerations, theories of failure, and relevant standards/codes.	L4	Analyze
CO4	Design machine elements subjected to static and dynamic loading conditions.	L6	Create
CO5	Develop machine elements based on strength and rigidity criteria.	L6	Create
CO6	Design power transmitting shafts and flexible drives for mechanical systems.	L6	Create

Design of Machine Elements (RCP23MPC351)

Course Contents

Unit-I **07 Hrs.**

Introduction to Design of Machine elements

Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Material properties and their uses in design, Manufacturing consideration in design, Design consideration of casting and forging.
Basic Principle of Machine Design: Modes of failures, Factor of safety, Design stresses, Theories of failures, Standards, I.S. Codes, Preferred Series and Numbers.

Unit-II **12 Hrs.**

Design against Static Loads

Cotter joint (Socket and spigot type), Knuckle joint, Bolted and welded joints under eccentric loading; Curved Beams: Assumptions made in the analysis of curved beams, Design of curved beams: Bending stresses in curved beams such as crane hook, C-frame, etc.
Power Screw and its application along with the design of Frame- Screw Jack.

Unit-III **06 Hrs.**

Design against Fluctuating Loads

Variable stresses - reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Estimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria, Fatigue design under combined stresses.

Unit-IV **11 Hrs.**

Design of Shaft, Keys, Couplings, drives

Shaft: power transmitting and power distribution shafts (excluding crankshaft) under static and fatigue loading,
Keys: Types of Keys and their selection.
Couplings: Classification of coupling, Design of rigid flange couplings, Bush pin type flexible couplings.
Design of Flexible curvature drive: Flat belt, V-belt, Rope, Selection of Roller Chain drive.

Unit-V **06 Hrs.**

Design of springs

Design of helical compression and tension springs under Static and Variable loads, design of laminated springs.

Design of Machine Elements Laboratory

(RCP23MPC351L)

Suggested Experiments

A The following assignments are to be solved in the lab sessions in the form of tutorials or any software-based exercises such as MS Excel, MATLAB etc. (Minimum six):

1. Design of Curved Beams.
2. Design of Cotter Joint.
3. Design of Knuckle Joint.
4. Design of the screw jack along with the frame.
5. Design of bolted and welded joints.
6. Design under fluctuating loads (finite and infinite life).
7. Design of Shaft.
8. Design of Coupling.
9. Design of Helical Spring.
10. Design of a Laminated spring.

B Prepare a layout of the following using any CAD software (Minimum two):

1. Layout of Cotter Joint.
2. Layout of Knuckle Joint.
3. Layout of C-clamp.
4. Layout of the Screw jack.

Books Recommended

Textbooks

1. V. B. Bhandari, Design of Machine Elements, Tata McGraw-Hill Education, 3rd Edition, 2010.
2. J.E.Shigley, Mechanical Engineering Design, McGraw Hill, Sixth Edition, 2001.
3. Merhyle Franklin Spotts, Terry E. Shoup, Lee EmreyHornberger, Design of Machine Elements, Pearson/Prentice Hall, Eighth Edition, 2004.

Reference Books

1. Robert L. Norton, Machine Design- An Integrated Approach, Pearson Education Asia, Fifth Edition, 2013.
2. M. F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, Elsevier, 5th Edition, 2017.
3. D N Reshetov, Machine Design, Mir Publishers.
4. Black Adams, Machine Design, McGraw Hill, Third Edition.
5. Hawrock, Jacobson, Fundamental of Machine Elements, McGraw Hill, Third Edition, 2011.
6. V.M. Faires, Design of Machine Elements, The Macmillan Co., Fourth Edition.
7. P. Orlov, Fundamentals of Machine Design, Mir Publishers.
8. Design Data Book, PSG, 2012.
9. Design Data Book, Mahadevan, CBS Publishers and Distributors Pvt Ltd, Fourth Edition, 2013.

Web References

1 Design of Machine Elements https://nptel.ac.in/courses/112105124

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Finite Element Analysis (RCP23MPC352)		
Finite Element Analysis Laboratory (RCP23MPC352L)		

Prerequisites:

1. Matrices, Differential Equations, and Numerical Integrations.
2. Basics of Mechanics of solids, Thermodynamics, and Fluid mechanics.
3. Solid Modelling software.

Course Objectives:

1. To acquaint learners with the principles of finite element analysis (FEA).
2. To acquaint learners with the applications of FEA for solving engineering problems.
3. To acquaint learners with FEA software for solving real-life engineering problems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Summarize the finite element method and develop algorithms for the analysis of mechanical systems.	L4	Analyze
CO2	Evaluate differential equations using weak and Non-weak form methods.	L5	Evaluate
CO3	Apply the basic finite element formulation techniques to solve one-dimensional engineering problems using bar, beam, and link elements.	L3	Apply
CO4	Apply the basic finite element formulation techniques to solve two-dimensional engineering problems using triangular and quadrilateral elements.	L3	Apply
CO5	Apply the finite element methods to find the natural frequency of dynamic systems.	L3	Apply
CO6	Use modern FEA software/tools to find field variables.	L3	Apply

Finite Element Analysis (RCP23MPC352)

Course Contents

Unit-I **07 Hrs.**

Introduction to FEA

Introductory Concepts: Historical Background, General FEA procedure, Applications of FEM in various fields, Advantages and disadvantages of FEA.
Definitions of Various Terms used in FEA: Element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables and boundary conditions.
Mathematical modelling/governing differential equations in structural, thermal and fluid engineering fields.

Unit-II **07 Hrs.**

Non-Weak and Weak Form Methods

Non-Weak form Methods: Collocation, Sub-domain, Petrov-Galerkin, Galerkin and Least square method.
Weak form method: Rayleigh Ritz method for general elements and for the entire domain. Principle of minimum potential energy.

Unit-III **12 Hrs.**

One-Dimensional Finite Element Formulations

One-dimensional second-order equations. Linear and higher order elements. Global, Local, and Natural coordinates. Derivation of shape functions, stiffness matrices and force vectors.
Assembly of Matrices: solution of problems in one-dimensional structural analysis, heat transfer, and fluid flow (stepped and tapered bars, fluid network, and spring-cart systems). Analysis of plane trusses and beams.

Unit-IV **10 Hrs.**

Two-Dimensional Finite Element Formulations

Constant Strain Triangular (CST) and Linear Strain Triangular (LST) element, four-node rectangular element, four-node and eight-node quadrilateral element. Derivation of shape functions for triangular and quadrilateral elements. sub-parametric, isoparametric, super-parametric elements, Compatibility conditions, Patch test, Convergence criterion, and sources of errors in FEA.
Stress Analysis of Two-Dimensional Elements: Equations of elasticity-Plane stress, plane strain, and axisymmetric problems. Jacobian matrix, stress analysis of CST element.

Unit-V **06 Hrs.**

FEA of Dynamic Systems and Non-Linear FEA

Finite Element Formulation of Dynamic System: Applications of FEA to free longitudinal vibration problems. Lumped and consistent mass matrices.
Introduction to Non-linear FEA: Geometric, material, and contact nonlinearity.

Finite Element Analysis Laboratory (RCP23MPC352L)

Suggested Experiments

A Any 8 experiments:

1 Introduction to ANSYS software.
2 Analysis of a bar subjected to an axial load (Stepped/Tapered bar).
3 Analysis of a bar subjected to an axial load with thermal effects.
4 Analysis of a beam under various loads.
5 Steady state thermal analysis of a composite wall.
6 Analysis of Plane Truss.
7 Analysis of a plate with a circular hole at the centre using plane stress/plane strain conditions.
8 Modal analysis of a Mechanical component.
9 Analysis of the component using an axisymmetric element.

B Course Project:

A group of not more than four students shall do Finite Element Analysis (using commercial software or program codes) of any mechanical engineering component/system, which involves element selection, assigning material properties, meshing, assigning boundary conditions, analysis, and interpretation of results.

Learners shall use the commercial software (ANSYS/ABAQUS/NASTRAN/HYPERWORKS) or programs (Codes) to perform the above experiments. Learners shall also validate the experimental results with manual calculations (wherever applicable). Any other experiment based on the syllabus may be included, which would help the learner to understand the topic/concept. While performing the analysis of the above suggested experiments, the learners should understand the concepts of selection of element type, meshing and convergence of solution.

Books Recommended

Textbooks

1 Seshu P., "Text book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi, 2012.

2 S S Rao., "The Finite Element Method Engineering", Butter worth Heinemann, 2010. Pasquale Corbo, Fortunato Migliardini, and Ottorino Veneri, Hydrogen Fuel Cells for Road Vehicles, Springer London, 2011.

Reference Books

1 J N Reddy., "Finite Element Method", Tata McGraw Hill, 2019.

2 R Dhanraj and K Prabhakaran Nair, "Finite Element Methods", Oxford University Press, 2015.

3 Logan D L ., "A first course in Finite Element Method", Thomson Asia Pvt Ltd, 2002.

4 Cook R D, Malkus D S, Plesha M E., "Concepts and Applications of Finite Element Analysis", John Wiley Sons, 2001.

5 Chandrupatla and Belegundu , "Introduction to Finite Elements in Engineering", Prentice Hall, 2002.

6 M. Asghar Bhatti., " Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations", Wiley India Pvt. Ltd, 2005.

7 Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Practice, CRC Press, 2009.

Web References

1 NPTEL course on Basics of Finite Element Analysis-1 (https://nptel.ac.in/courses/112104193)

2 NPTEL course on Finite Element Method: Variational Methods to Computer Programming https://nptel.ac.in/courses/112103295

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Heat Transfer (RCP23MPC353)		
Heat Transfer Laboratory (RCP23MPC353L)		

Prerequisites:

1. Engineering Mathematics
2. Applied Thermodynamics
3. Fluid Mechanics

Course Objectives:

1. To introduce the basic principles of heat transfer and steady state conduction.
2. To determine heat transfer from extended surfaces and unsteady state conduction.
3. To familiarize the principles of convection and the significance of dimensionless numbers.
4. To introduce different types of heat exchangers and their analysis.
5. To describe the principles of radiation heat transfer.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the basic laws and modes of heat transfer and analyze one-dimensional steady-state conduction problems in simple geometries (walls, cylinders, spheres), including effects of thermal resistance and insulation.	L4	Analyze
CO2	Evaluate heat transfer performance of extended surfaces (fins) and apply analytical/graphical methods to solve transient heat conduction problems using Biot number, Fourier number, and Heisler charts.	L5	Evaluate
CO3	Apply dimensional analysis and empirical correlations to estimate heat transfer coefficients for natural and forced convection in various flow configurations.	L3	Apply
CO4	Analyze heat exchangers using LMTD and NTU methods, and explain heat transfer mechanisms during boiling and condensation processes.	L4	Analyze
CO5	Explain radiation laws, calculate radiative heat exchange between surfaces using view factors and electrical analogy, and apply concepts of radiation shields.	L3	Apply

Heat Transfer (RCP23MPC353)

Course Contents

Unit-I **09 Hrs.**

Introduction and 1-D Steady State Conduction

Thermodynamics and Heat Transfer, Applications of Heat Transfer, Basic Modes of Heat Transfer, Physical Mechanism of Heat Transfer, Fourier's Law of Heat Conduction, Newton's Law of Cooling, Stefan-Boltzmann Law.
One-Dimensional Steady State Conduction: Thermal Conductivity, Variation of Thermal Conductivity in Solids, Liquids, and Gases, Thermal Diffusivity, General Heat Conduction Equation, Electrical Network Analogy, Boundary and Initial Conditions, Steady State Heat Conduction in Walls, Cylinders, and Spheres, Thermal Contact Resistance, Critical Thickness of Insulation.

Unit-II **09 Hrs.**

Heat transfer from Extended Surface

Heat transfer from Extended Surface: Types of fins and their applications, Heat transfer from finned surface of uniform cross-sectional area, Effectiveness and Efficiency of fins, proper length of a fin.
Unsteady state Conduction: Lumped Capacitance method, Biot number, Fourier number and their significance, Heisler charts.

Unit-III **09 Hrs.**

Convection

Natural and Forced Convection, Hydrodynamic and Thermal Boundary Layers, Heat Transfer Coefficient, Principle of Dimensional Analysis, Buckingham's πTheorem, Application of Buckingham's to Forced and Natural Convection, Physical Significance of Dimensionless Numbers, Nusselt Number, Grashof Number, Prandtl Number, Reynolds Number, and Stanton Number, Empirical Relations for Free and Forced Convection for Standard Cases.

Unit-IV **07 Hrs.**

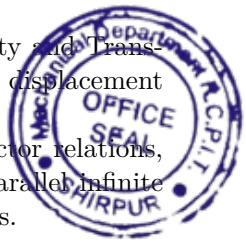
Heat Exchangers, boiling, and Condensation

Heat Exchangers: Types of Heat Exchangers, Overall Heat Transfer Coefficient, Fouling Factor, Heat Exchanger Analysis using Log Mean Temperature Difference and Effectiveness-NTU method, Selection of heat exchangers, compact heat exchangers.
Boiling and Condensation: Boiling heat transfer, Pool boiling, Boiling Regimes and Boiling Curve, Flow boiling, Condensation heat transfer, Film condensation, Dropwise Condensation.

Unit-V **08 Hrs.**

Radiation:

Radiation: Emissive power, Emissivity, Irradiation, Radiosity, Absorptivity, Reflectivity and Transmissivity, Black body, Grey body, Opaque body, Kirchhoff's law, Planck's law, Wein's displacement law, Lambert cosine law, Intensity of Radiation, Solid Angle.
Radiation heat exchange between two black and gray surfaces, View factor, View Factor relations, Application of Electrical Analogy to thermal radiation heat exchange between two parallel infinite plates, concentric infinitely long cylinders and two concentric spheres, Radiation shields.



Heat Transfer Laboratory (RCP23MPC353L)

Suggested Experiments

A Performance-Based Experiments

1 Determination of Thermal Conductivity of Solid and Liquid Materials
2 Measurement of Heat Transfer Coefficient in Natural Convection
3 Measurement of Heat Transfer Coefficient in Forced Convection
4 Study of Unsteady State Heat Transfer in a Cylinder, Rod, or Wall
5 Performance Analysis of Fins – Determination of Fin Efficiency and Effectiveness
6 Determination of Critical Heat Flux in Pool Boiling
7 Evaluation of Overall Heat Transfer Coefficient and Effectiveness of a Heat Exchanger
8 Verification of Stefan–Boltzmann Law using Stefan–Boltzmann Apparatus
9 Determination of Emissivity of a Grey Surface

B Assignments/Mini project/case study/literature based seminar/presentation relevant to the subject may be included.

1 Numerical Modeling of a Heat Transfer Problem using Finite Difference Method (FDM)
2 Simulation of any conduction, convection problem.

A minimum of eight experiments from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1 C. P. Kothandaraman, Fundamentals of Heat and Mass Transfer, 4th Edition, New Age International Publishers, New Delhi, 2012.

2 D. S. Kumar, Basics of Heat and Mass Transfer, S. K. Kataria & Sons, New Delhi, 2018.

3 P. S. Ghoshdastidar, Heat Transfer, Oxford University Press, New Delhi, 2012.

4 R. K. Rajput, A Textbook of Heat and Mass Transfer (SI Units), S. Chand, New Delhi, 2018.

Reference Books

1 Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, and David P. DeWitt, Fundamentals of Heat and Mass Transfer, 8th Edition, Wiley, Hoboken, 2018.

2 Yunus Çengel and Afshin Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill, New York, 2020.

3 S. P. Sukhatme, Textbook of Heat Transfer, 4th Edition, Universities Press, Hyderabad, 2005.

Web References

1 Heat Transfer (https://onlinecourses.nptel.ac.in/noc23$_{c}$h65/preview)

2 Heat Transfer https://onlinecourses.nptel.ac.in/noc25$_{m}$e171/preview

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Control Systems (RCP23MMD351)		
Control Systems Laboratory (RCP23MMD351L)		

Prerequisites:

1. Engineering Mathematics: Laplace Transform and Differential Equations.
2. Fundamentals of Electrical, Mechanical, and Mechatronic Systems.
3. Basic concepts of Dynamics and Signal Representation.
4. Exposure to MATLAB/Scilab or equivalent simulation tools.

Course Objectives:

1. To introduce mathematical modeling and representation of mechanical, electrical, and electromechanical systems.
2. To analyze control system behavior in time and frequency domains.
3. To study classical stability criteria and control design techniques.
4. To understand and apply PID controllers and compensators in engineering systems.
5. To introduce modern control theory and state-space representation.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Describe the principles, terminology, and types of control systems (open-loop, closed-loop) and their real-world significance.	L2	Understand
CO2	Design a mathematical model of the system/process for standard input responses.	L6	Create
CO3	Analyze error and differentiate various types of control systems.	L4	Analyze
CO4	Analyze for stability of the given system using different approaches.	L4	Analyze
CO5	Apply the basics of Ladder Programming for given control system.	L3	Apply

Control Systems (RCP23MMD351)

Course Contents

Unit-I **09 Hrs.**

Introduction and System Modeling

1 Introduction to control systems: open-loop and closed-loop concepts.

2 Mathematical modeling of mechanical, electrical, thermal, and fluid systems.

3 Analogies: force-current and force-voltage.

4 Transfer functions, block diagram reduction, and signal flow graphs.

Unit-II **08 Hrs.**

Time Domain Analysis

1 Standard test signals: step, ramp, impulse, and sinusoidal inputs.

2 Time response of first and second-order systems.

3 Time-domain specifications: rise time, settling time, overshoot, peak time.

4 Steady-state errors and error constants.

Unit-III **10 Hrs.**

Stability and Root Locus

1 Stability criteria: Routh-Hurwitz method.

2 Root locus technique – rules, construction, and interpretation.

3 Determination of gain and phase margins.

4 Sensitivity analysis and stability improvement.

Unit-IV **09 Hrs.**

Frequency Domain Analysis and Controllers

1 Frequency response characteristics: Bode and Nyquist plots.

2 Gain and phase margins, bandwidth, resonant frequency.

3 Design of lag, lead, and lag-lead compensators.

4 Introduction to P, PI, PD, and PID controllers and tuning techniques.

Unit-V **06 Hrs.**

State Space and Modern Control Theory

1 State-space representation and comparison with the transfer function model.

2 State equations, eigenvalues, and system stability.

3 Controllability and observability.

4 Modern control applications in robotics, mechatronics, and automation.

Control Systems Laboratory (RCP23MMD351L)

Suggested Experiments

A Study / Case Study-based Experiments

1 Study of control system components: servo motors, potentiometers, tachometers.
2 Comparison of open-loop and closed-loop systems.
3 Case study: Application of control systems in robotics, mechatronics, or process

B Simulation/Software-based Experiments

1 Simulation of first and second-order system responses using MATLAB/Scilab.
2 Root locus analysis of given transfer functions.
3 Frequency response analysis using Bode and Nyquist plots.
4 State-space modeling and stability analysis using MATLAB/Simulink.
5 Design and tuning of PID controllers for speed or temperature control systems.

C Performance / Hands-on Experiments

1 Experimental verification of time response for a second-order system.
2 PID control implementation on Arduino/PLC for DC motor speed control.
3 Stability testing of an electromechanical system using sensors and DAQ interface.

Any 8 Experiments to be performed based on the above list, and not limited to only the list. Any other relevant experiment/s can be added.

Books Recommended

Textbooks

1 Katsuhiko Ogata, Modern Control Engineering, Pearson Education, 5th Edition, 2010.
2 Norman S. Nise, Control Systems Engineering, Wiley India, 8th Edition, 2019.
3 I.J. Nagrath & M. Gopal, Control Systems Engineering, New Age International, 5th Edition, 2018.

Reference Books

1 Richard C. Dorf & Robert H. Bishop, Modern Control Systems, Pearson, 13th Edition, 2017.
2 Benjamin C. Kuo, Automatic Control Systems, Wiley, 9th Edition, 2014.
3 Gene Franklin, J. Powell, A. Emami-Naeini, Feedback Control of Dynamic Systems, Pearson, 8th Edition, 2019.
4 Brian Douglas, Control System Concepts for Engineers, Pearson, 2020.
5 Ashish Tiwari, Control Systems: Principles and Design, McGraw-Hill, 2022.

Web References

1 NPTEL - Digital Twin: https://nptel.ac.in/courses/112107322

2 NPTEL – Control Engineering (IIT Madras): https://nptel.ac.in/courses/108101174

3 NPTEL – Modern Control Theory (IIT Kharagpur): https://nptel.ac.in/courses/108105130

4 MIT OpenCourseWare – Feedback Control Systems: https://ocw.mit.edu

5 Coursera – Modern Robotics and Control: https://www.coursera.org/learn/modern-robotics

6 MathWorks Tutorials – Control System Design: https://www.mathworks.com/help/control

Program: Mechanical Engineering	Y.Y. B.Tech.	Semester: VI
CAD CAM Laboratory (RCP23MSC351L)		

Prerequisites:

-

Course Objectives:

1. To introduce the concepts of computer-aided engineering for design & manufacture and familiarize them with the mathematical basis of computer graphics.
2. To impart knowledge on computer graphics, which are used routinely in diverse areas like science, engineering, medicine, etc.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain software configuration of graphic packages.	L2	Understand
CO2	Explain use of Computer graphics in design.	L2	Understand
CO3	Model simple machine parts and assemblies from the part drawings using standard CAD packages.	L3	Apply
CO4	Demonstrate the generation of CNC Turning and Milling codes for different operations using standard CAM packages and prepare manual part programming using ISO codes for turning and milling operations.	L3	Apply

CAD CAM Laboratory (RCP23MSC351L)

Suggested Experiments

1. Programming for transformations by using coding language (Translation, Rotation, Scaling & Magnification)
2. Part programming and part fabrication on CNC trainer (Turning / Milling)
3. Creating a script for generating a component or a sketch on software.
4. Simulation of the turning operation program on the software.
5. Simulation of the milling operation program on the software.
6. Program and Process Sheet Generation for turning operation by using CAM Software. (Two components)
7. Program and Process Generation for Milling operation by using CAM Software (Two components)
8. Development of a physical 3D mechanical component using any one of the additive manufacturing techniques 3 3D printer.
9. Development of a physical 3D mechanical component on the Automatic Turning Centre (Computerized)
10. Development of a physical 3D mechanical component on a vertical Machining Centre (Computerized).

Minimum eight experiments from the above suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept learnt.

Books Recommended

Textbooks

1. Mikell P. Groover and Emory W. Zimmers; CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education, 2013.
2. Ibrahim Zeid, R. Sivasubramanian; CAD/ CAM: Theory & Practice, Tata McGraw Hill Publications, 2009.
3. P.N. Rao; CAD/CAM Principles and Applications, Tata McGraw-Hill Publications, 2017.

Reference Books

1. Donald Hearn and M. Pauline Baker; Computer Graphics, Pearson Education, 2006.
2. William M. Neumann and Robert F. Sproul; Principles of Interactive Computer Graphics, McGraw-Hill Publishers, 1979.
3. David L. Goetsch; Fundamentals of CIM technology, Delmar publication, 1988.
4. David Bedworth; Computer Integrated Design and Manufacturing, McGraw-Hill Publishers, 1991.
5. B.S. Pabla and M. Adithan; CNC Machines, New Age International Publishers, 2018.
6. T.K. Kundra, P.N. Rao, and N.K. Tiwari, Numerical Control and Computer Aided Manufacturing, Tata McGraw-Hill Publishers, 1985.
7. Krar S. and Gill A.; CNC Technology and Programming, McGraw-Hill Publishers, 1990.

8 Paul G. Ranky; Computer Integrated Manufacturing - An Introduction with Case Studies, Prentice Hall International. 1986.

9 Ian Gibson, David W Rosen, Brent Stucker, and Mahyar Khorasani. Additive Manufacturing Technologies, Springer, 2021.

10 Juan Pou, Antonio Riveiro and J. Paulo Davim; Additive Manufacturing, Elsevier, 2021.

11 M. Manjaiah, K. Raghavendra, N. Balashanmugam, J. Paulo Davim; Additive Manufacturing (A Tool for Industrial Revolution 4.0), Woodhead Publishing, 2021.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Vibration Analysis and Smart Monitoring (RCP23MPE361)		
Vibration Analysis and Smart Monitoring Laboratory (RCP23MPE361L)		

Prerequisites:

1. Engineering Mechanics
2. Theory of Machines (Basic Vibrations)
3. Introduction to Programming (Python/MATLAB)
4. NPTEL Course Recommendations: "Introduction to Machine Learning", "Introduction to Internet of Things", "Introduction to Industry 4.0 and Industrial Internet of Things"

Course Objectives:

1. Understand and analyze multi-degree-of-freedom vibration systems using analytical and computational methods.
2. Apply signal processing techniques for vibration data analysis in both time and frequency domains.
3. Implement smart vibration sensors using ESP32 microcontrollers for real-time data acquisition and processing.
4. Design and develop IoT-based vibration monitoring systems with cloud integration and remote dashboards.
5. Apply machine learning techniques for intelligent fault detection and predictive maintenance in vibration systems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze multi-DOF vibration systems using matrix methods and Rayleigh/Holzer techniques.	L4	Analyze
CO2	Perform signal processing and feature extraction on vibration data using MATLAB/Python/Arduino programming.	L4	Analyze
CO3	Calibrate MEMS sensors with ESP32 for vibration monitoring applications.	L3	Apply
CO4	Develop and deploy IoT-based systems for real-time vibration data transmission and cloud storage.	L6	Create
CO5	Apply supervised and unsupervised machine learning algorithms for fault classification and anomaly detection in vibration systems.	L3	Apply

Vibration Analysis and Smart Monitoring (RCP23MPE361)

Course Contents

Unit-I **08 Hrs.**

Multi-Degree-of-Freedom Vibration Systems

Two-DOF undamped systems, Mode shapes and natural frequencies, Matrix formulation of equations of motion, Eigenvalue problems, Natural frequency determination using Rayleigh's Method, Holzer's Method for torsional and flexural vibrations.

Unit-II **08 Hrs.**

Signal Processing for Vibration Analysis

Time-domain and frequency-domain analysis, FFT analysis and spectral methods, Statistical analysis of vibration signals, Power spectral density, Feature extraction techniques, Signal pre-processing and noise reduction

Unit-III **08 Hrs.**

Smart Vibration Sensors and ESP32 Implementation

ESP32 microcontroller fundamentals, MEMS accelerometers (ADXL345, MPU6050) interfacing, Sensor calibration and data acquisition, Digital signal processing on microcontrollers, Circuit design for vibration monitoring

Unit-IV **09 Hrs.**

IoT-Based Vibration Monitoring Systems

Introduction to IoT fundamentals and protocols, Real-time data acquisition and transmission, Cloud connectivity and data storage, Remote monitoring dashboards, Wireless sensor networks for vibration monitoring, IoT-Based Vibration Monitoring: Bearing Defect Frequencies Case Study

Unit-V **09 Hrs.**

Machine Learning for Intelligent Vibration Analysis

Introduction to AI/ML fundamentals and applications in engineering, Introduction to ML in vibration analysis, Supervised learning for fault classification (SVM, Decision Trees), Unsupervised learning for anomaly detection (K-means, PCA), Feature selection and model validation, Integration of ML with monitoring systems, Machine Learning for Gear Meshing Frequency Analysis: A Case Study in Intelligent Vibration Diagnostics

Vibration Analysis and Smart Monitoring Laboratory (RCP23MPE361L)

Suggested Experiments

A Group 1: Fundamental Vibration Analysis (Experiments 1-4):

1 Matrix methods for multi-DOF vibration analysis using MATLAB/Python
2 Holzer's method for torsional and flexural vibration analysis using computational tools
3 Natural frequency experimental validation of multi-DOF systems
4 Signal processing and FFT analysis of vibration data using MATLAB/Python

B Group 2: Smart Sensor Implementation (Experiments 5-8)

1 ESP32 setup and MEMS accelerometer interfacing with breadboard design
2 ESP32 sensor programming: Data filtering, signal processing, and interrupt handling
3 Vibration sensor calibration and data validation using ESP32
4 ESP32-based vibration data acquisition with custom circuit design

C Group 3: IoT Integration and Connectivity (Experiments 9-12)

1 Real-time vibration data transmission using ESP32 and wireless protocols
2 IoT-based vibration monitoring with cloud connectivity (ThingSpeak/Firebase)
3 Remote vibration monitoring dashboard development
4 Multi-sensor vibration monitoring network implementation

D Group 4: Intelligent Analysis and Prediction (Experiments 13-16)

1 Feature extraction and statistical analysis of collected vibration data
2 Supervised learning for vibration-based fault classification using Python
3 Unsupervised anomaly detection in vibration patterns using ML algorithms
4 Integration of ML models with IoT monitoring systems for predictive maintenance

E Mini Project

Research-based project on Industry 4.0 vibration monitoring or IoT applications in predictive maintenance

At least 1 experiment from each group A,B,C,D (minimum 5 experiments total)

ESE Exam: Students will be permitted to use PSG Design Data Book / Formula Sheet for ESE

Books Recommended

Textbooks

1 S. S. Rao, Mechanical Vibrations, Pearson Education, 6th Edition, 2017.
2 S. Graham Kelly, Fundamentals of Mechanical Vibration, Tata McGraw Hill, 2nd edition, 2000.

Reference Books

1 J. S. Rao and K. Gupta, Theory and Practice of Mechanical Vibrations, New Age International Publications, 2nd edition, 1999.

2 William W. Seto, Schaum's Outline of Theory and Problems of Mechanical Vibration, McGraw Hill, 1964.

3 G. K. Grover, Mechanical Vibrations, Nem Chand and Bros., Paper Back Edition, 2009.

4 Daniel J. Inman, Engineering Vibration, Pearson, 4th Edition, 2014.

5 Rao Singiresu S., Vibration of Continuous Systems, John Wiley and Sons, 2007.

6 Kolban Neil, ESP32 Programming and IoT Development, Leanpub, 2017.

7 Marco Schwartz, Internet of Things with ESP32, Packt Publishing, 2018.

8 Vedat Ozan Oner, Practical IoT Projects with ESP32, Apress, 2020.

Web References

1 Introduction to Vibrations and Waves: https://nptel.ac.in/courses/122104019

2 Mechanical Vibrations: https://nptel.ac.in/courses/112103174

3 Internet of Things: https://nptel.ac.in/courses/106105166

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Refrigeration and Air Conditioning (RCP23MPE362)		
Refrigeration and Air Conditioning Laboratory (RCP23MPE362L)		

Prerequisites:

1. Thermodynamics
2. Heat transfer

Course Objectives:

1. To gain an understanding of the principles of refrigeration and air-conditioning systems.
2. To analyse the performance of different refrigeration and air-conditioning systems.
3. To gain skills in designing, selecting, and sizing refrigeration and air-conditioning systems for various applications.
4. To develop lab skills related to the testing of refrigeration and air-conditioning systems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply the principles of thermodynamics to air refrigeration systems.	L3	Apply
CO2	Analyze the performance of vapour compression refrigeration systems.	L4	Analyze
CO3	Apply the principles of psychrometric properties and processes to air-conditioning systems.	L3	Apply
CO4	Design air-conditioning systems using cooling load calculations and duct design.	L6	Create
CO5	Analyze the role of sensors & control techniques used in modern HVAC systems.	L4	Analyze

Refrigeration and Air Conditioning (RCP23MPE362)

Course Contents

Unit-I **08 Hrs.**

Introduction to Refrigeration

First and Second Law applied to refrigerating machines, Carnot refrigerator & heat pump. Unit of refrigeration, Energy Efficiency Ratio (EER) and BEE star rating.
Air refrigeration systems: Bell Coleman cycle, analysis and applications. Aircraft refrigeration systems: Simple, Bootstrap, Reduced ambient & Regenerative aircraft cooling system, Importance of Dry Air Rated Temperature.

Unit-II **10 Hrs.**

Vapour Compression Refrigeration and Non-Conventional System

Vapour Compression Refrigeration Systems:
Analysis of simple vapour compression cycle, effect of liquid sub cooling & superheating, effect of evaporator and condenser pressures, methods of sub-cooling, Use of P-h charts, Actual VCR cycle, Analysis of 2 stage VCR systems & its applications.
Refrigerants:
Properties, ASHRAE numbering system, Secondary refrigerants, Low ODP and GWP refrigerants, International regulations and India's commitment towards sustainable refrigerants, sustainable cooling solutions, global climate protocols & Life cycle assessment for refrigerants. Non-Conventional Systems:
Thermoelectric refrigeration, Thermo-acoustic refrigeration, Vortex tube refrigeration systems & Radiant heating and cooling systems.

Unit-III **07 Hrs.**

Psychrometry

Need for air conditioning, Principle of psychrometry, Psychrometric properties, chart and processes, Bypass factor, Sensible heat factor, Adiabatic mixing of two air streams, Air washers, Requirements of comfort air conditioning, Summer and winter air conditioning.

Unit-IV **10 Hrs.**

Design of Air Conditioning Systems and Ducts

Design of Air Conditioning Systems :
Different Heat sources, Cooling Load estimation, Ventilation and infiltration, Inside and Outside Design conditions, Room apparatus dew point and coil apparatus dew point temperature, RSHF, GSHF, ERSHF. Human Comfort, Effective temperature, Comfort chart, and Indoor Air Quality (IAQ). Ducts:
Types of ducts, air flow in a duct, Equivalent diameter of a circular duct for rectangular ducts, Methods of duct design, Factors considered in air distribution systems, Air distribution systems for cooling and heating. Air Handling: Fan coil unit, Types of fans used in air conditioning applications, Fan laws, supply and return grills, Standards on ventilation and IAQ.

Unit-V **07 Hrs.**

Components and Controls

Components:
Filters, Compressors, Condensers, Expansion devices, and Evaporators. Room/Split and Packaged Air Conditioners, VRF systems, VAV systems, Inverter Units. Cooling towers, types, tower approach, tower range, tower efficiency, tower losses, and tower maintenance.
Controls:
Digital controls, Control strategies, Electronic Controllers, LP/HP cut-off, Sensors: Temperature sensor, Humidity sensor, IAQ sensors, Green Buildings, Building Management Systems (BMS), smart sensors, and AI-based HVAC controls for predictive maintenance and energy optimization, IoT in the HVAC industry.

Refrigeration and Air Conditioning Laboratory (RCP23MPE362L)

Suggested Experiments

A Simulation / Study based experiments

1 Energy efficiency analysis and comparison of a conventional and inverter refrigerator
2 Simulation of Bell-Coleman cycle using any code
3 Study of refrigerant leak detection, recovery and charging techniques
4 Simulation of vapor compression cycle using any software (Coolpack, Refprop, DWSim)
5 Study of refrigerant properties and international regulations
6 Case study on IoT implementation in HVAC industry

B Performance based experiments

1 Performance Testing of a vapor compression refrigeration unit
2 Performance Testing of a domestic air-conditioning unit
3 Performance Testing of an Automotive Air-Conditioning Unit
4 Cooling Load Estimation for a building / room using ASHRAE / ISHRAE standards
5 Cooling Load Estimation for a building / room using E20 load sheet, HAP Codec
6 Visit report of a manufacturing unit of refrigerator/air-conditioner or a cold storage plant

A minimum of nine experiments from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1 Refrigeration and air-conditioning, C P Arora, McGraw Hill Education, 4th Edition, 2021
2 Refrigeration and Air Conditioning, R.S. Khurmi & J.K. Gupta, S. Chand, 5th Edition, 2022
3 Refrigeration and air-conditioning – Domkundwar, Arora, Domkundwar, Dhanpat Rai, 8th Edition, 2018
4 Basic Refrigeration and air-conditioning- P.Ananthanarayana, McGraw Hill, 4th Edition, 2013

Reference Books

1 Principles of refrigeration – R J Dossat, Pearson Education, 4th Edition, 2014

2 Air Conditioning System Design – Roger Legg, Butterworth Heinemann, 2017

3 ASHRAE Handbook of Fundamentals, 2021

4 ISHRAE Refrigeration Handbook, 2015

5 ISHRAE HVAC Data book, 2025

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Quality Engineering and Management (RCP23MPE363)		
Quality Engineering and Management Laboratory (RCP23MPE363L)		

Prerequisites:

1. Fundamentals of Mechanical Engineering.
2. Fundamentals of Statistics.

Course Objectives:

1. To proactively integrate quality into the entire product lifecycle by developing methodologies and processes that ensure products and services reliably meet and exceed customer expectations, leading to higher satisfaction, reduced costs, and faster, more dependable delivery.
2. To monitor a process over time to determine if it is stable and predictable, identify variations that indicate potential issues, and ultimately improve process performance and quality.
3. To assess the quality of a batch or lot of products by examining a representative sample, rather than inspecting every item.
4. To enhance customer satisfaction, improve product and service quality, reduce operational costs by minimizing errors and waste, and achieve long-term organizational success through continuous improvement and process efficiency.
5. To systematically identify, analyze, and solve quality problems to improve products and processes, reduce costs, enhance customer satisfaction, and establish a culture of data-driven continuous improvement.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Develop the methodologies and processes to enhance the quality of products and services.	L6	Create
CO2	Analyze and interpret control charts to enhance the quality of products and services by controlling the processes and measuring the performance consistency in industries.	L4	Analyze
CO3	Develop the acceptance sampling procedures for incoming raw material.	L6	Create
CO4	Analyze operational efficiency, reduce waste, and decrease defects to improve the product and service quality, leading to increased customer satisfaction and loyalty.	L4	Analyze
CO5	Determine root causes of problems, make informed decisions, and implement continuous improvements, ultimately boosting competitiveness.	L4	Analyze

Quality Engineering and Management (RCP23MPE363)

Course Contents

Unit-I **09 Hrs.**

Basic concepts in Quality Engineering

1. Definitions, approaches, and relevance to organizational excellence.
2. Quality Dimensions for Products and Services
3. Introduction to Design for Quality
4. Inspection and Quality control
5. Quality planning and Quality Assurance
6. Quality costs and Quality loss function
7. Fundamental principles of Statistical Process Control (SPC)
8. Chance and assignable causes of process variation
9. Control chart patterns
10. Rules for application of control charts

Unit-II **10 Hrs.**

Control Charts

1. Control Charts for Variables
    1. Control chart for mean and range
    2. Moving Average charts
    3. CUSUM charts
    4. Trend control charts
    5. Multivariate control charts.
2. Control Charts for Attributes
    1. Control charts for proportion non-conforming (p)
    2. number of nonconforming items (np)
    3. number of non-conformities (c)
    4. number of non-conformities per unit (u)
3. Process Capability studies
    1. Various indices and approaches
    2. Discussions on the capabilities of Process
    3. Setting specification limits.

Unit-III **07 Hrs.**

Product Quality Control

1. Acceptance Sampling methods
2. Single, Multiple, and sequential sampling plans
3. Evaluation of Sampling Plans: AOQ, AOQL, ATI, ASN
4. Operating Characteristic Curves
5. Recent developments in inspection methods

Unit-IV **09 Hrs.**

Basic concepts in Quality Management

1 Total Quality Management: An Overview
2 The 8 Primary Principles of Total Quality Management
3 Deming's 14 Points on Quality Management
4 Crosby's 14 steps of quality management to achieve zero defects
5 Introduction to ISO 14001 and ISO 45001

Unit-V **07 Hrs.**

Quality Management Tools

1 5 Whys
2 Ishikawa Diagram
3 Measurement System Analysis (MSA)
4 Pareto chart
5 Quality Function Deployment (QFD)
6 Failure Mode and Effects Analysis (FMEA)
7 Fault Tree Analysis (FTA)
8 Total Productive Maintenance (TPM)

Quality Engineering and Management Laboratory (RCP23MPE363L)

Suggested Experiments

A Study-Type/ Case-Study-based Experiments (Theoretical and Conceptual Learning)

1 A case study on Design for Quality
2 A case study on Robust Design.
3 A case study on ISO 14001 or ISO 45001
4 A case study on any one Quality Management Tool

B Numerical Analysis/ Simulation-based Experiments (Python/ MATLAB/ Simulink, etc.)

1 Construction and usage of Control charts for Variables
2 Construction and usage of Control charts for Attributes
3 A study on Acceptance Sampling.

All 7 experiments from the above-suggested list and any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1 D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 2019

2 K. Krishnaiah, Applied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012

3 N. Logothetis, Managing for Total Quality, Prentice Hall of India,1997

4 D. R. Kiran, Total Quality Management, Butterworth-Heinemannm,2016

5 Poornima M. Charantimath, Total Quality Management, Dorling Kindersley (India), 2011

Reference Books

1 Rajesh Kumar R, Quality Engineering and Management, Jyothis Publishers, 2023

2 Scott A. Laman, The ASQ Certified Quality Engineer Handbook, ASQ Quality Press, 2022

3 Madhav Phadke, Quality Engineering Using Robust Design, Phadke Associates, Incorporated,2021

4 Jong S. Lim, Quality Management in Engineering: A Scientific and Systematic Approach, CRC Press, 2019

5 Chao-Ton Su, Quality Engineering: off-Line Methods and Applications, CRC Press, 2016

6 K.S. Krishnamoorthi, V. Ram Krishnamoorthi , A First Course in Quality Engineering: Integrating Statistical and Management Methods of Quality, Taylor & Francis, 2011

7 Sung H. Park, Jiju Antony, Robust Design for Quality Engineering and Six Sigma, World Scientific, 2008

8 Jeff Tian, Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement, Wiley, 2005

Web References

1 Quality Design and Control https://onlinecourses.nptel.ac.in/noc21$_{m}$g24

2 Inspection and Quality Control in Manufacturing https://onlinecourses.nptel.ac.in/noc21$_{m}$e16

3 Quality Control and Improvement with MINITAB https://onlinecourses.nptel.ac.in/noc22$_{m}$g40

4 Design And Analysis of Experiments https://www.youtube.com/playlist?list=PLPjSqITyvDeWS9Lxp4jreG. sxHxJA8

5 Total Quality Management I https://nptel.ac.in/courses/110104080

6 Total Quality Management – II https://onlinecourses.nptel.ac.in/noc21$_{m}$g72/preview

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Automotive Systems (RCP23MPE364)		
Automotive Systems Laboratory (RCP23MPE364L)		

Prerequisites:

1. Manufacturing processes, mechanics of materials
2. Fluid mechanics
3. Basic electronics

Course Objectives:

1. To impart an understanding of important mechanical systems of an automobile.
2. To impart an understanding of the electrical and electronic systems of an automobile.
3. To familiarize with the latest technological developments in automotive technology.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Describe the types and working of the clutch and transmission system.	L2	Understand
CO2	Illustrate the working of steering and braking systems.	L2	Understand
CO3	Describe the role of vehicle suspension systems and the vehicle body.	L2	Understand
CO4	Describe the different automotive electrical and electronic systems.	L2	Understand
CO5	Acquaint with recent developments in automobiles.	L2	Understand

Automotive Systems (RCP23MPE364)

Course Contents

Unit-I **09 Hrs.**

Introduction, Clutch, and Transmission

Introduction:
Classification of automobiles, Importance of various sub-systems of an automobile, development of an automobile, and aspects of automotive engineering.
Clutch:
Performance characteristics of a prime mover, requirements & types of clutches, single plate, multi-plate, wet clutch, centrifugal clutch. Clutch materials. Clutch operating mechanisms - Mechanical, Electric, Hydraulic, and Vacuum. Troubleshooting and remedies. Clutch-by-wire.
Transmission:
Requirements of the gearbox. Sliding mesh, Constant mesh, and Synchromesh Gearbox. Gear selector mechanisms. Overdrives, under-gearing, over-gearing, tractive effort, and hydrodynamic torque converter, Epicyclic gear train, and automatic transmissions. Troubleshooting and remedies. Automated Manual Transmission (AMT), Continuously Variable Transmission (CVT), Dual Clutch Transmission (DCT).

Unit-II **09 Hrs.**

Driveline, Steering, breaking System

Driveline sub-systems:
Propeller shafts and universal joints: Types and construction, Different types of universal joints and constant velocity joints. Classification of axles, Loads on axles, Semi, Three-quarter, and Full floating axles. Troubleshooting and remedies. Types of Final drives: spiral, bevel, Hypoid, and worm drives. Necessity of differential, Working of a differential, Conventional and limited-slip differential, Troubleshooting and remedies.
Steering System:
Steering requirements, Steering linkages, and steering gears. Steering geometry parameters, Analysis of steering geometry, Over-steer and Under-steer characteristics, Reversibility of steering gears. Troubleshooting and remedies.
Braking System:
Requirements of brakes, Classification of brakes, Brake Actuation Methods: Mechanical, Hydraulic, Pneumatic, Electro, and vacuum brakes. Types of Disc brakes and Drum Brakes, Brake troubleshooting, and Anti-lock braking system (ABS).

Unit-III **08 Hrs.**

Suspension System, Wheels and Tyres

Suspension System:
Objects of suspension, Basic requirements, Sprung and unsprung mass, Types of Independent, semi-independent, and rigid axle suspension. Air suspension and its features. Pitching, rolling, and bouncing. Shock absorbers and their types, Troubleshooting and remedies. Electronically controlled active suspension system.
Wheels and Tyres:
Requirements of wheels and tyres. Types of wheels, tyres, and carcass materials. Tyre and wheel manufacturing processes. Troubleshooting and remedies. Airless tyres & run flat tyres.

Unit-IV **08 Hrs.**

Vehicle Structure

Importance of the vehicle body and its types. Loads on the vehicle body, materials for body construction. Layouts of passenger cars, buses, and truck bodies. Chassis types and structure types: Open, semi-integral, and integral structures. Frames: Types of frames and their functions, Loads on frames, Load distribution of structure. Importance of crumple zone in vehicles, Crash safety ratings in India.

Unit-V **08 Hrs.**

Automotive electronics and recent developments

Storage Systems:
Lead-Acid Battery; construction, working, ratings, types of charging methods, Alkaline battery, ZEBRA, and Sodium Sulphur battery. Lithium-ion battery, battery pack for electric vehicles, Battery management system. Solid-state battery. Alternative fuel storage systems for CNG and Hydrogen vehicles.
Vehicle Sensors:
Vehicle speed sensor, Mass air flow sensor, temperature sensor, MAP sensor, Lambda sensor, TP sensor, Steering angle sensor, Acceleration sensor, Yaw rate sensor, Airbag sensor, Radar, LiDAR sensor.
Recent developments:
Active and Passive Safety systems in an automobile. Cruise Control, Adaptive Cruise Control, Predictive Cruise Control, Electronic Stability Program, Electronic Brake Distribution System, Traction Control System, Integrated Starter-Alternator, Hill Assist, Launch Control, Connected Cars with V2V Communication & Pre-Collision Technology.

Automotive Systems Laboratory (RCP23MPE364L)

Suggested Experiments

A Any 8 experiments:

1. Identify and illustrate various components in a clutch assembly.
2. Simulation of powertrain systems on Lotus Engineering Software
3. Simulation of powertrain systems on MATLAB Simulink software.
4. Simulation and analysis of transmission system gear ratio using MATLAB Simulink software
5. Simulation and analysis of the braking system using MATLAB Simulink software
6. Modeling and FEA analysis of vehicle frame designs on ANSYS / Solidworks
7. Modeling and FEA analysis of vehicle frame materials on ANSYS / Solidworks
8. Characterization and visualization of the output of various sensors, such as TPS, MAP, and ECT sensors.
9. Simulation of a cruise control system using MATLAB Simulink software
10. Case study presentation and report on upcoming vehicle technologies
11. Field visit to an automotive manufacturing plant / service station

A minimum of eight experiments from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1 Automobile Engineering, Dr. Kirpal Singh, Standard publishers, Vol I & II, 14th Edition, 2018

2 Automobile Engineering, Devendra Vashist & Mukhtar Ahmad, Dreamtech Press, Publications, 2022

3 Automobile Engineering, R. K. Rajput, 2nd Edition, Laxmi Publications, 2012

Reference Books

1 Encyclopedia of Automotive Engineering, David Crolla, Wiley Publication, 2015

2 Automotive Electrical and Electronic Systems, Tom Denton, Routledge, 5th Edition, 2017

3 Automotive Engineering Fundamentals, Jeffrey Ball, Richard Stone, SAE International, 2004

4 Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad, Yimin, Sebastian, Ali, CRC Press, 3rd Edition, 2019

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Industrial Robotics (RCP23MPE365)		
Industrial Robotics Laboratory (RCP23MPE365L)		

Prerequisites:

1. Fundamentals of mechanical, electronics, and electrical engineering.
2. Fundamentals of chemistry, physics, and engineering mechanics

Course Objectives:

1. To study the various types of industrial robots, their anatomy, safety protocols, and work environments, with attention to emerging designs and cost considerations.
2. To understand modelling, analysis, and integration of robotic kinematics, dynamics, and work cell architectures, including collaborative and multi-robot systems.
3. To evaluate drive systems, actuator technologies, sensor integration, and machine vision, focusing on reliability, efficiency, and recent advancements.
4. To design, simulate, and program robotic systems using contemporary platforms, and implement control strategies suitable for industrial automation tasks.
5. To explore advancements in robotics applications, artificial intelligence, and expert systems, emphasizing trends in industrial, service, and field robotics.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Evaluate industrial robot anatomy, configurations, safety practices, and economic factors for deploying robots in manufacturing and allied industries.	L5	Evaluate
CO2	Analyze robotic manipulators for kinematics and dynamics; design robust work cells for both standalone and collaborative robotic applications.	L4	Analyze
CO3	Select and integrate appropriate drive systems, actuators, and sensors; apply machine vision principles for process automation and quality assurance.	L4	Analyze
CO4	Design, program, and simulate industrial robots, implementing control architectures for real-world path planning and automation workflows.	L6	Create
CO5	Analyze current and future trends in robotics, covering AI integration, expert systems, and innovative application areas in heavy industry and emerging sectors.	L4	Analyze

Industrial Robotics (RCP23MPE365)

Course Contents

Unit-I **07 Hrs.**

Introduction and Fundamentals

1 Definition and scope, history, and evolution of robots

2 Robot anatomy: links, joints, coordinate systems, degrees of freedom, work volume

3 Classification of robots and robot configurations (Cartesian, Cylindrical, SCARA, Articulated, etc.)

4 Social issues, safety, and ethics in robotics

5 Overview of industrial and non-industrial applications

Unit-II **09 Hrs.**

Robot Kinematics, Dynamics, and Intelligence

1 Homogeneous Transformations

2 Kinematic modelling: forward and inverse kinematics, Denavit-Hartenberg parameters

3 Basics of robot dynamics, motion interpolation, and trajectory analysis

4 Robot Intelligence & Task Planning Introduction,

5 State space search, Problem reduction, use of predictive Logic,

6 Problem solving, Robot learning and Robot task planning.

Unit-III **09 Hrs.**

Drives, Actuators, Sensors and Machine Vision

1 Types of drives: electrical, hydraulic, pneumatic

2 Actuators: DC/AC servo, stepper motors, transmission systems

3 Feedback devices: position, velocity, force sensors

4 Robot control systems: open vs. closed-loop, path/trajectory control

5 Internal and external sensors: tactile, proximity, vision, force/torque, range sensors

6 Machine vision: image acquisition, pre-processing, segmentation, feature extraction

7 Applications of machine vision in robotics

Unit-IV **09 Hrs.**

Robot Programming and Work Cell Design

1 Programming methods: teach pendant, lead-through, offline programming

2 Robot languages; introduction to programming platforms (e.g., VAL, AML, Python, C/C++)

3 Task-level programming and simulation environments

4 Robot Work Cell Design and Integration: Robot work cell layouts, robot cycle time analysis, safety in robotic work cells

5 Multiple robots and machine interference, collaborative robotics

6 Human-robot interaction basics

Unit-V **08 Hrs.**

Advanced Applications, AI and Trends

1 Robot applications in manufacturing: material handling, assembly, welding, painting, inspection

2 Field robots: agriculture, mining, underwater, civil, military, and space

3 Latest trends: mobile robots, UAVs, service robots, Industry 4.0 integration

4 Industrial applications: material handling, welding, inspection, modern field robots

5 Artificial intelligence in robotics: expert systems, robot learning, knowledge representation, Industry 4.0, mobile & collaborative robots, future directions

Industrial Robotics Laboratory (RCP23MPE365L)

Suggested Experiments

A Study-Type/ Case-Study-based Experiments (Theoretical and Conceptual Learning)

1 Industrial Robot Selection and Application Analysis : Analyze the selection criteria, deployment factors, and program structure for a robot used in a real-world industry (automotive, packaging, or medical). Include safety, cost, and technical factors.

2 Robot Work Cell Layout and Cycle Time Study : Review a typical work cell setup using multiple robots and machines. Calculate cycle time, analyze bottlenecks, and propose layout or task sequencing improvements for productivity.

3 Sensor Integration and End Effector Case Study : Evaluate a manufacturing cell where complex sensing and tailored end effectors are used. Discuss challenges and strategies in selecting and integrating multiple sensor types for real applications

4 Comparison of Robot Programming Methods : Examine case studies of different programming approaches (teach pendant, offline, simulation-based) for industrial robots, outlining pros and cons, use cases, and programming safety.

5 Industry 4.0 and Collaborative Robotics Evaluation : Conduct a guided review of robotics adoption for smart factories, focusing on collaborative robots and human-robot interaction, referencing recent industry case studies

B Simulation-based Experiments (Python/ MATLAB/ Simulink, etc.)

1 Forward and Inverse Kinematics Simulation for 2- and 4-Axis Arms : Simulate both forward and inverse kinematics of articulated and SCARA robots using Python or MATLAB. Analyze arm configurations and reach within spatial constraints.

2 Workspace Envelope Visualization using Python/MATLAB : Develop a program that graphically simulates workspace envelopes of different robot architectures (Cartesian, polar, cylindrical, articulated). Evaluate their suitability for industrial tasks.

3 Robot Trajectory Planning and Path Optimization : Use MATLAB Simulink to design and simulate trajectory planning—linear, parabolic, and cubic polynomial path generation for pick-and-place operations with obstacle avoidance.

4 Simulation of Machine Vision-Based Inspection : Build a Python/MATLAB program that uses image processing (thresholding, segmentation, feature extraction) to simulate a robotic vision inspection task in manufacturing.

5 Robot Cell Coordination and Collision Avoidance Simulation : Use Simulink or Python to model robot cell control, including interlocks and collision detection algorithms for multiple robots working in a shared space.

C Case Study based Experiments (Mini-Projects)

1. Develop a semi-virtual model of an industrial robot cell that automates material handling, assembly, and inspection.
2. Integrate kinematic modeling, trajectory planning, and sensor-based decision logic using Python/MATLAB/Simulink.
3. Evaluate cell layout, cycle time, safety protocols, and scalability with collaborative robotic arms.
4. Document design choices, software implementation, and test scenarios in alignment with current Industry 4.0 trends.

A minimum of 5 experiments from the above-suggested list or any other experiment based on the syllabus will be included, along with one mini-project assigned to students in a group of 4, which would help the learner to apply the concept.

Books Recommended

Textbooks

1. Isak Karabegović (Ed.), Industrial Robots: Design, Applications and Technology, Nova Science Publishers, 2020.
2. Antoni Grau and Zhuping Wang, Industrial Robotics: New Paradigms, BoD – Books on Demand, 2020.
3. Ganesh S. Hegde, A Textbook of Industrial Robotics, Laxmi Publications, 2023.
4. T. C. Manjunath, "Fundamentals of Robotics Vol-I", Nandu Publishers, 5th Edn., Mumbai, 2014.
5. Elaine Rich & Kevin Knight, "Artificial Intelligence", McGraw-Hill, Singapore, 3rd Edn., 2017.
6. T. C. Manjunath, "Fast Track to Robotics", Nandu Publishers, 5th Edn., Mumbai, Maharashtra, India, 2017.
7. K. S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision & Intelligence", McGraw-Hill, USA, 5th Edition, 2010.
8. Robin R. Murphy, "Introduction to AI and Robotics", MIT Press, Second Edition, 648 pp., Oct. 2019.

Reference Books

1. Divya Mishra and Shanu Sharma (Eds.), Revolutionizing Industrial Automation Through the Convergence of Artificial Intelligence and the Internet of Things, IGI Global, 2022.
2. Lejla Banjanović-Mehmedović, Industrial Robotics, DOAB Open Access, 2021.
3. Yingjie Qian, Jianjun Yuan, Liming Gao, and Zhaojiang Yu, AI Developments for Industrial Robotics and Intelligent Drones, IGI Global, 2023.
4. Divya Mishra and Shanu Sharma (Eds.), AI and Blockchain Applications in Industrial Robotics, IGI Global, 2023.
5. John Billingsley, Control Basics for Mechatronics, Emerald Group Publishing, 2024.
6. S. R. Deb, Sankha Deb, Robotics Technology and Flexible Automation, McGraw-Hill, 2nd Edition, 2021
7. Yoram Koren, Robotics for Engineers, McGraw-Hill Book Co., 1st Edition, 1985
8. Larry Heath, Fundamentals of Robotics: Theory and Applications, Reston Publishing Co., 1984

9 Harry Asada and Jean-Jacques Slotine, Robot Analysis and Control, John Wiley & Sons, 1st Edition, 1986

10 Alan Pugh, Robot Technology, Peter Peregrinus Ltd./IEE Control Engineering Series, 1983

11 Shimon Y. Nof (Ed.), Handbook of Industrial Robotics, John Wiley & Sons, 2nd Edition, 1999

12 Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, 2nd Edition, 2011

13 Robert J. Schilling, Fundamentals of Robotics: Analysis and Control, Prentice Hall, 1990

14 P. A. Janaki Raman, Robotics and Image Processing: An Introduction, Tata McGraw Hill Publishing Company Ltd., 1st Edition, 1995

Web References

1 Industrial Robotics: Theories for Implementation, IIT-ISM Dhanbad https://onlinecourses.nptel.ac.in/noc25_me161/preview

2 Robotics Basics and Selected Advanced Concepts (IISc Bangalore) https://nptel.ac.in/courses/112108298

3 Advanced Robotics Applications (IIT Kanpur) https://nptel.ac.in/courses/112104620

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Artificial Intelligence and Machine Learning (RCP23MPE366)		
Artificial Intelligence and Machine Learning Laboratory (RCP23MPE366L)		

Prerequisites:

1. Linear Algebra, Probability, Statistics, Logical Reasoning.
2. Fundamentals of Mechanical Engineering.

Course Objectives:

1. To acquaint students with the fundamentals of artificial intelligence and machine learning.
2. To learn feature extraction and selection techniques for processing a data set.
3. To impart the basic algorithms used in classification and regression problems.
4. To outline the steps involved in the development of a machine learning model.
5. To familiarize with concepts of reinforced and deep learning.
6. To analyze a machine learning model in mechanical engineering problems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Demonstrate the fundamentals of artificial intelligence and machine learning in the context of mechanical engineering.	L3	Apply
CO2	Apply feature extraction and selection techniques for the mechanical engineering dataset.	L3	Apply
CO3	Apply machine learning algorithms for classification and regression problems.	L3	Apply
CO4	Develop a machine learning model using various steps.	L6	Create
CO5	Use the reinforced and deep learning model in mechanical engineering problems.	L4	Analyze

Artificial Intelligence and Machine Learning (RCP23MPE366)

Course Contents

Unit-I **08 Hrs.**

Introduction to AI-ML

History of AI, Comparison of AI with data science, Need for AI in mechanical engineering, Introduction to ML. Basics: Reasoning, problem solving, knowledge representation, planning, learning, perception, motion, and manipulation.
Approaches to AI: Cybernetics and brain simulation, symbolic, sub-symbolic, and statistical.
Approaches to ML: Supervised learning, unsupervised learning, reinforcement learning.

Unit-II **09 Hrs.**

Feature Extraction and Selection

Feature extraction: Statistical features, PCA.
Feature selection: Ranking, decision tree - entropy reduction and information gain, exhaustive, best first, greedy forward backward, applications of feature extraction and selection algorithms in mechanical engineering.

Unit-III **09 Hrs.**

Classification and Regression Models

Classification Models: Random forest, logistic regression, decision tree, SVM, KNN, K-means, Naive Bayes.
Regression Models - Linear and non-linear regression, neural network regression, overfitting, and underfitting.
Applications of classification and regression models in Mechanical Engineering. Explainable AI (XAI) in safety-critical systems.

Unit-IV **08 Hrs.**

Development of ML Model

Understanding and preparing data: Data types, data collection methods, data preprocessing techniques: Missing data handling, noise filtering, outlier detection, normalization, standardization.
Problem identification: Classification, clustering, regression, ranking.
Steps in ML modeling: Data collection, data pre-processing, model selection, model training (training, testing, K-fold cross-validation), model evaluation (Understanding and interpretation of confusion matrix, accuracy, precision, recall, true positive, false positive, etc.), hyperparameter tuning, predictions.
Ethics and bias in AI: Ethical considerations in ML applications, bias in datasets and algorithms, implications in safety-critical systems such as quality control and industrial automation.
Basics of model deployment.

Unit-V **08 Hrs.**

Reinforced and Deep Learning

What is reinforcement learning? terms used, key features, working process, approaches: value-based, policy-based, and model-based; Elements: policy, reward signal, value function, model of the environment; The Bellman equation, Types: positive and negative, RL algorithms, Q-learning, comparison

between RL and supervised learning. Transfer learning.
Characteristics of deep learning, ANN, CNN, etc.

Note: Numerical should be related to mechanical and allied engineering domains. Some of the domain areas are: Thermal/ Heat Transfer/ HVAC/ Fluid Mechanics/ Fluid Power, Solid Mechanics/ Design, Machining/ Manufacturing, Automation and Robotics, Maintenance/ reliability/ condition monitoring, Quality Control, Materials and metallurgy, Energy Conservation and Management, Industrial Engineering, Estimation, and Management, Automotive Technology.

Artificial Intelligence and Machine Learning Laboratory (RCP23MPE366L)

Suggested Experiments

A Group A: Any five experiments from the following list for a data set using a suitable software package/ programming language:

1 To study supervised/unsupervised/Reinforcement learning approach.
2 To acquire, visualize, and analyze the data set (from time-domain/ frequency-domain/ etc.).
3 To extract features from the given data set and establish training data.
4 To select relevant features using a suitable technique.
5 To use PCA for dimensionality reduction.
6 To classify features/to develop a classification model and evaluate its performance (any one classifier).
7 To develop a regression model and evaluate its performance (any one algorithm).
8 Markov process for modelling manufacturing processes.
9 Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation.
10 GA for optimization of multi-dimensional function/path planning in robotics.
11 NN for parameter and model identification/tuning of Control Algorithms.

B Group B (Mandatory)

One mini project (in a group of 2 students) based on the above contents and using a mechanical engineering application dataset.

Minimum 8 experiments from the above-suggested list or any other experiments based on syllabus will be included, which would help the learner to apply the concept learnt.

Books Recommended

Textbooks

1 Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2 B. Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3 Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems," PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015

4 Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.

5 Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, ISBN:9781098122478, 109812247X, 2022.

6 Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, ISBN:9780262035613, 0262035618, 2016.

7 Nathan George, Practical Data Science with Python: Learn Tools and Techniques from Hands-on Examples to Extract Insights from Data, Packt Publishing, ISBN:9781801076654, 1801076650, 2021.

Reference Books

1 Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.

2 Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.

3 Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

4 Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)

Web References

1 An Introduction to AI https://archive.nptel.ac.in/content/syllabus$_{\text{p}}$df/106102220.pdf

2 Fundamentals of Artificial Intelligence https://nptel.ac.in/courses/112103280

3 Machine Learning https://nptel.ac.in/courses/106/106/106106202/

4 Introduction to Machine Learning https://nptel.ac.in/courses/106106139

5 Deep Learning https://padhai.onefourthlabs.in/courses/dl-feb-2019

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Entrepreneurial Business Models (RCP23MPE367)		
Entrepreneurial Business Models Laboratory (RCP23MPE367L)		

Prerequisites:

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Course Objectives:

1. To enable learners to understand business model frameworks:
2. To enable learners to analyse value creation strategies:
3. To enable learners to assess revenue and cost structures:
4. To enable learners to evaluate customer segmentation and market fit:
5. To enable learners to integrate innovation into business models:
6. To enable learners to apply business model frameworks effectively:

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Illustrate the components of a business model.	L2	Understand
CO2	Analyse market needs and develop value propositions.	L4	Analyze
CO3	Evaluate cost and revenue structures for financial sustainability.	L5	Evaluate
CO4	Assess customer segmentation strategies for market alignment.	L5	Evaluate
CO5	Apply innovation-driven strategies to enhance business models.	L3	Apply
CO6	Construct adaptive and scalable business models for various industries.	L6	Create

Entrepreneurial Business Models (RCP23MPE367)

Course Contents

Unit-I **08 Hrs.**

Introduction to Business Models

1 Definition and Importance
2 Components of a Business Model
3 Case Studies on Successful Business Models

Unit-II **08 Hrs.**

Value Creation and Market Positioning

1 Identifying Customer Needs
2 Competitive Advantage and Differentiation
3 Market Research and Business Fit

Unit-III **06 Hrs.**

Revenue and Cost Considerations

1 Revenue Models and Pricing Strategies
2 Cost Structure and Financial Sustainability
3 Key Financial Metrics

Unit-IV **07 Hrs.**

Customer Segmentation and Market Alignment

1 Identifying Target Segments
2 Business Model Adaptation for Different Markets
3 Consumer Behavior and Decision
4 Making Collaborative Business Models

Unit-V **07 Hrs.**

Innovation and Disruptive Business Models

1 Leveraging Technology in Business Models
2 Business Model Evolution in Emerging Industries
3 Digital Transformation Strategies

Unit-VI **06 Hrs.**

Developing and Validating Business Models

1 Business Model Testing and Refinement
2 Risk Assessment and Contingency Planning
3 Final Business Model Development and Evaluation

Entrepreneurial Business Models Laboratory (RCP23MPE367L)

Exercise

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1 Business Model Analysis :
Study and evaluate business models of successful companies using real-world case studies. Identify key components such as value proposition, revenue streams, and customer segments.

2 Customer Value Proposition Mapping :
Develop customer value propositions for a selected business idea. Define key benefits offered to customers and create differentiation strategies.

3 Business Model Canvas Development:
Construct a Business Model Canvas for a proposed startup, detailing key partners, activities, customer relationships, cost structure, and revenue models.

4 Revenue and Cost Structure Analysis:
Identify and analyze various revenue streams and cost drivers for a given business idea. Assess financial sustainability and explore monetization strategies.

5 Market Opportunity Identification:
Conduct primary and secondary market research to validate business ideas. Identify customer needs, potential market size, and growth opportunities.

6 Competitive Analysis and Positioning:
Assess competition in a given industry. Identify direct and indirect competitors, analyze market positioning, and develop differentiation strategies.

7 Business Model Testing and Validation:
Apply structured testing frameworks (e.g., Lean Startup methodology) to refine business assumptions. Conduct customer interviews and prototype testing.

8 Scalability and Sustainability Assessment:
Evaluate the long-term scalability and sustainability of a business model. Assess factors such as resource allocation, market expansion potential, and financial growth.

9 Innovative Business Model Design:
Design a business model for an emerging industry or disruptive technology. Develop creative approaches to solving market problems.

10 Final Business Model Presentation:
Prepare and present a refined business model to a panel. Justify business assumptions, financial projections, and growth strategies. Receive feedback for improvement.

Books Recommended

1 Baisya, Rajat K. Indian Entrepreneurship: Analysis of Business Practices. SAGE Publications, New Delhi, 2021.

2 Blank, Steve, and Bob Dorf. The Startup Owner's Manual. K&S Ranch Publishing, Pescadero, 2012.

3 Desai, Vasant. Entrepreneurship Development in India. Himalaya Publishing House, Mumbai, 2019.

4 Joshi, M.V. Entrepreneurship Development and Startup India. Himalaya Publishing House, Mumbai, 2020.

5 Kumar, S. Ramesh. Business Development: A Comprehensive Approach. McGraw Hill, New Delhi, 2018.

6 Osterwalder, Alexander. Value Proposition Design. Wiley, New Jersey, 2014.

7 Osterwalder, Alexander, and Yves Pigneur. Business Model Generation. Wiley, New Jersey, 2010.

8 Prasad, Rohit. Start-up Sutra: What the Angels Won't Tell You About Business and Life. Hachette India, New Delhi, 2013.

9 Purohit, Prachi. Startup India: The Complete Guide to Launching and Managing a Business. Notion Press, Chennai, 2021.

10 Ries, Eric. The Lean Startup. Crown Business, New York, 2011.

11 Thiel, Peter. Zero to One. Crown Business, New York, 2014.

12 van der Pijl, Patrick. Business Model Shifts. Wiley, New Jersey, 2020.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Project Stage-I (RCP23XEL351P)		

Prerequisites:

-

Course Objectives:

1. To understand the basic concepts and principles of project development.
2. To formulate/identify the problem statement.
3. To implement the solution as per the problem statement.
4. To develop the team building, writing, logical reasoning and management skills.
5. To provide the connections between the designs and concepts across different disciplinary boundaries.
6. To encourage students to become independent personnel, critical thinkers and lifelong learners.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze the problem statement and produce solution of the problem considering cultural, social, environmental and economic factors using appropriate tool and method.	L4	Analyze
CO2	Interpret project based learning that allows students to transfer existing ideas into new applications.	L2	Understand
CO3	Apply the ability to work in teams and manage to conduct the project development activity.	L3	Apply
CO4	Use different perspectives from relevant disciplines which help them to get internships, jobs, and admission for higher studies.	L3	Apply
CO5	Explain the project development in the form of technical writing, and interpret what constitutes plagiarism and the use of proper referencing styles.	L2	Understand

- To proceed with the project work, it is very important to select a right topic. Project can be undertaken on any subject addressing Mechanical and/or inter-disciplinary concepts.
- Research and development projects on problems of practical, theoretical and societal interest should be encouraged.
- Project work must be carried out by the group of at least two students and maximum five and must be original.
- Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements.
- The main purpose of project stage I is to improve the students technical skills, communication skills by integrating writing, presentation and teamwork opportunities.

Guidelines for Assessment of Project Stage I

- Each student shall work on project stage-I as approved by the departmental committee, a group of 02 to 04 students (max allowed: 5 students in extraordinary cases, subject to the approval of the departmental committee) shall be allotted for each Project stage-I. The departmental committee shall include Head of Department, project coordinator and guide(s).
- Each group shall submit at least 3 topics for the Project stage-I. The departmental committee shall finalize one topic for every group.
- Each group is required to maintain separate log book for documenting various activities of the project stage-I (Refer Table 1).
- Each group will be reviewed twice in a semester and marks will be allotted based on the various points mentioned in the evaluation scheme.
- In the first review of this semester, each group is expected to complete 30% of project stage-I.
- In the second review of this semester, each group is expected to complete 50% of project stage-I.

Table 1: Log Book Format

Sr	Week (Start Date:End Date)	Work Done	Sign of Guide	Sign of Coordinator
1				

Prescribed project report guidelines:

Size of report shall be of minimum 30 pages (excluding cover and front pages). Project stage-I report should include appropriate content for:

- Abstract
- Introduction
  - Background
  - Motivation
  - Problem Statement
  - Objectives
  - Scope

- Literature Survey
  - Review of Existing System(s)/Design
  - Limitations of Existing System(s)/Design
- Methodology - your approach to solve problem
- Design/Simulation of proposed system
- Implementation Plan for Project Stage-II
- Conclusion
- References

Assessment criteria

Continuous Assessment : for the departmental committee (including project guide)

The guide will monitor weekly progress and assign the marks to students as per Table 2.

Table 2: Continuous Assessment Sheet

Sr	PRN	Name of Student	Student Attendance	Log Book Maintain	Literature Review	Depth of Understanding	Report	Total
			10	10	10	10	10	50

End Semester Exam : for the departmental committee

- At the end of the semester, after confirmation by the project guide, each project group will submit a project report in the prescribed format for assessment to the departmental committee.
- Assessment of the project (at the end of the semester) will be done by the departmental committee as per Table 3.

Table 3: Evalution Table

Sr	PRN	Name of Student	Project Selection	Design/ Simulation	model/ programming	Result Verification	Presentation	Total
			10	10	10	10	10	50

Each group shall present/publish a paper based on the project stage - I in reputed/peer-reviewed Conference/Journal/TechFest/Magazine before the end of the semester.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Constitution of India (RCP23XHS381)		

Prerequisites:

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Course Objectives:

1. To provide basic information about the Indian Constitution.
2. To identify individual roles and ethical responsibilities towards society.
3. To understand human rights and their implications.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the historical background, philosophy, and salient features of the Indian Constitution.	L2	Understand
CO2	Interpret the fundamental rights, duties, and directive principles enshrined in the Constitution for responsible citizenship.	L2	Understand
CO3	Describe the structure, roles, and functions of the legislative, executive, and judiciary branches of government.	L2	Understand
CO4	Analyze the federal structure, center-state relations, and constitutional provisions for governance and emergency powers.	L4	Analyze
CO5	Apply constitutional principles to contemporary socio-political and legal issues, fostering ethical and democratic values.	L3	Apply

Constitution of India (RCP23XHS381)

Course Contents

Unit-I **02 Hrs.**

Introduction to the Constitution of India

The Making of the Constitution and Salient Features of the Constitution.
Preamble to the Indian Constitution.
Fundamental Rights & its limitations.

Unit-II **02 Hrs.**

Directive Principles of State Policy

Relevance of Directive Principles, State Policy, Fundamental Duties.
Union Executives – President, Prime Minister, Parliament, Supreme Court of India.

Unit-III **03 Hrs.**

State Executives

Governor, Chief Minister, State Legislature, and High Court of the State. Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th & 91st Amendments.

Unit-IV **03 Hrs.**

Special Provisions

For SC & ST, Special Provision for Women, Children & Backward Classes, Emergency Provisions.

Unit-V **02 Hrs.**

Human Rights

Meaning and Definitions, Legislation Specific Themes in Human Rights, Working of National Human Rights Commission in India, Powers and functions of Municipalities, Panchayats and Co-Operative Societies.

Unit-VI **02 Hrs.**

Scope & Aims of Engineering Ethics

Responsibility of Engineers and Impediments to Responsibility.
Risks, Safety, and Liability of Engineers.
Honesty, Integrity & Reliability in Engineering.

Books Recommended

Textbooks

1 Durga Das Basu, "Introduction to the Constitution on India", (Students Edition) Prentice Hall EEE, 19th / 20th Edition, 2001.

2 Charles E. Haries, Michael S. Pritchard and Michael J. Robins, “Engineering Ethics”, Thompson Asia, 2003.

Reference Books

1 M. V. Pylee, “An Introduction to Constitution of India”, Vikas Publishing, 3rd Edition, 2003.

2 M. Govindarajan, S. Natarajan, V. S. Senthilkumar, “Engineering Ethics”, Prentice Hall of India Pvt. Ltd. New Delhi, 2013.

3 Brij Kishore Sharma, “Introduction to the Constitution of India”, PHI Learning Pvt. Ltd., New Delhi, 7th Edition 2015.

4 Latest Publications of Indian Institute of Human Rights, New Delhi

Website Resources

1 www.nptel.ac.in

2 www.hnlu.ac.in

3 www.nspe.org

4 www.preservearticles.com

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Machine Learning for Mechanical Engineers (RCP23MSC352)		

Prerequisites:

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Course Objectives:

1. To understand the fundamentals of machine learning and intelligent systems.
2. To apply supervised and unsupervised learning techniques to engineering datasets.
3. To analyze engineering problems using machine learning workflows.
4. To evaluate machine learning model performance for industrial applications.
5. To develop awareness of AI-enabled mechanical engineering systems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the concepts and workflow of machine learning systems.	L2	Understand
CO2	Apply regression and classification algorithms to engineering datasets.	L3	Apply
CO3	Analyze industrial datasets using clustering and predictive models.	L4	Analyze
CO4	Evaluate machine learning model performance using suitable metrics.	L2	Understand
CO5	Interpret machine learning applications in mechanical engineering industries.	L2	Understand

Machine Learning for Mechanical Engineers

(RCP23MSC352)

Course Contents

Unit-I **01 Hrs.**

Introduction to Artificial Intelligence and Machine Learning

- Introduction to Artificial Intelligence and Machine Learning;
- Role of ML in engineering industries;
- Difference between AI, ML, and Deep Learning;
- Machine learning workflow;
- Applications of ML in mechanical engineering;
- Challenges and limitations of ML systems.

Unit-II **02 Hrs.**

Machine Learning Fundamentals and Data Preparation

- Types of machine learning:
- Supervised learning, Unsupervised learning, Reinforcement learning (overview), Deep learning (overview);
- Training data and testing data;
- Features and labels;
- Data preparation for ML models.

Unit-III **02 Hrs.**

Regression-Based Supervised Learning Techniques

- Introduction to supervised learning;
- Linear regression;
- Polynomial regression;
- Model training and prediction;
- Applications of regression models in engineering systems.

Unit-IV **02 Hrs.**

Classification Techniques for Engineering Applications

- Logistic regression;
- Decision Trees;
- K-Nearest Neighbor (KNN);
- Classification workflow;
- Introduction to feature engineering;
- Industrial classification problems.

Unit-V **02 Hrs.**

Unsupervised Learning and Clustering Techniques

- Introduction to unsupervised learning;
- Clustering concepts;
- K-Means clustering;
- Hierarchical clustering;
- Industrial data grouping and segmentation;
- Pattern recognition concepts.

Unit-VI **02 Hrs.**

Dimensionality Reduction and Pattern Discovery

- Dimensionality reduction basics;
- Similarity and distance measures;
- Feature extraction concepts;
- Pattern discovery in engineering datasets;
- Data visualization for clustering results.

Unit-VII **01 Hrs.**

Model Evaluation and Predictive Analytics

- Model evaluation concepts;
- Accuracy, Precision, Recall, and F1-score;
- Confusion Matrix;
- Training-validation-testing concepts;
- Cross-validation basics;
- Error analysis;
- Introduction to predictive analytics;
- Industrial analytics workflow;
- Interpretation of machine learning results.

Unit-VIII **02 Hrs.**

Machine Learning Applications in Mechanical Engineering

- Predictive maintenance systems;
- Smart manufacturing analytics;
- AI-enabled quality inspection;
- Industrial automation analytics;
- ML applications in automotive engineering;
- Robotics analytics; Energy system optimization;

- Industrial IoT and ML integration;
- Case studies on engineering ML applications;
- Mini-project development using engineering datasets.

Suggested Coursera Mapping

Module	**Suggested Coursera Content Provider**
Introduction to Machine Learning	Andrew Ng, Stanford, DeepLearning.AI
Supervised Learning	IBM, University of Michigan
Clustering and Unsupervised Learning	Google, IBM
Model Evaluation and Analytics	Microsoft, AWS
Industrial ML Applications	NVIDIA, DeepLearning.AI