Shirpur Education Society's

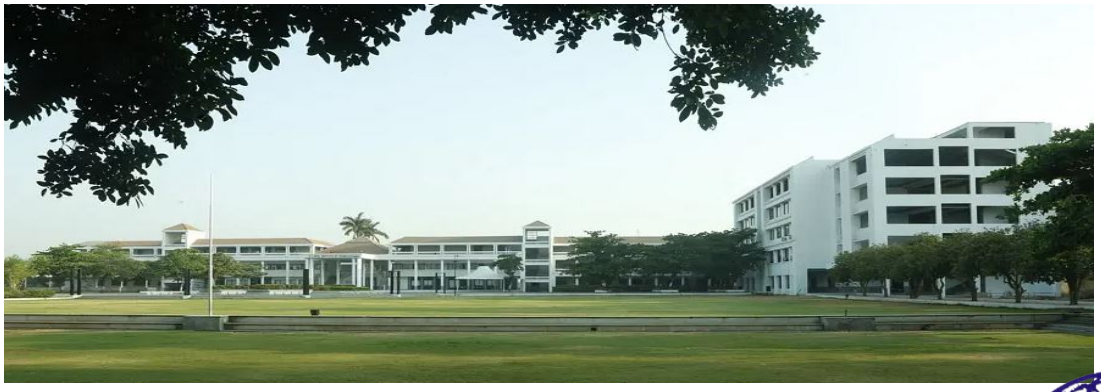
R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Structure

Third Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2025-26



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

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	Credits	
				L	T	P	TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average (TT1 & TT2)				
							[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23MCPC501	Theory of Machines	3	-	-	25	15	15	15	60	100	3	4
	PC	RCP23MLPC501	Theory of Machines Laboratory	-	-	2	25	-	-	-	-	25	1	
2	PC	RCP23MCPC502	Mechanical Measurements and Metrology	3	-	-	25	15	15	15	60	100	3	4
	PC	RCP23MLPC502	Mechanical Measurements and Metrology Laboratory	-	-	2	25	-	-	-	-	25	1	
3	PC	RCP23MCPC503	Fluid Mechanics and Machinery	3	-	-	25	15	15	15	60	100	3	4
	PC	RCP23MLPC503	Fluid Mechanics and Machinery Laboratory	-	-	2	25	-	-	-	25	50	1	
4	MD	RCP23MCMD501	Industrial Electronics	2	-	-	25	15	15	15	60	100	2	3
	MD	RCP23MLMD501	Industrial Electronics Laboratory	-	-	2	25	-	-	-	-	25	1	
5	MD	RCP23MLMD502	Database Management System Laboratory	-	-	2	25	-	-	-	25	50	1	1
6 @	PE	RCP23MCPE51_	Department Elective - I	3	-	-	25	15	15	15	60	100	3	4
	PE	RCP23MLPE51_	Department Elective - I Laboratory	-	-	2	25	-	-	-	-	25	1	
7	HS	RCP23ITHSX06	Environmental Science Tutorial	-	1	-	25	-	-	-	-	25	1	1
8	SC	RCP23IPSC501	Semester Project - III	-	-	2	25	-	-	-	25	50	1	1
			Total	14	1	14	325	75	75	75	375	775	22	22

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

@ Any 1 Departmental Elective from given list.

Prepared by
Prof. R. R. Ozarkar

Checked by
Prof. S. V. Yeole

BOS Chairman
Prof. Dr. P. L. Sarode

Dean Academic &Dy. Director
Prof. Dr. P. J. Deore

C.O.E.
Prof. S. P. Shukla

Mechanical Department R.C.P.I.T. OFFICE SEAL SHIRPUR

Director
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	Credits	
				L	T	P	TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average (TT1 & TT2)				
							[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23MCPC601	Design of Machine Elements	3	-	-	25	15	15	15	60	100	3	4
	PC	RCP23MLPC601	Design of Machine Elements Laboratory	-	-	2	25	-	-	-	25	50	1	
2	PC	RCP23MCPC602	Finite Element Analysis	3	-	-	25	15	15	15	60	100	3	4
	PC	RCP23MLPC602	Finite Element Analysis Laboratory	-	-	2	25	-	-	-	-	25	1	
3	PC	RCP23MCPC603	Heat Transfer	3	-	-	25	15	15	15	60	100	3	4
	PC	RCP23MLPC603	Heat Transfer Laboratory	-	-	2	25	-	-	-	-	25	1	
4	MD	RCP23MCMD601	Control Systems	3	-	-	25	15	15	15	60	100	3	4
	MD	RCP23MLMD601	Control Systems Laboratory	-	-	2	25	-	-	-	-	25	1	
5	SC	RCP23MLSC601	CAD CAM Laboratory	-	-	2	25	-	-	-	25	50	1	1
6 #	PE	RCP23MCPE62_	Department Elective - II	3	-	-	25	15	15	15	60	100	3	4
	PE	RCP23MLPE62_	Department Elective - II Laboratory	-	-	2	25	-	-	-	-	25	1	
7	EL	RCP23IPEL601	Project Stage-I	-	-	4	50	-	-	-	50	100	2	2
8	HS	RCP23ICHSX07	Constitution of India	1	-	-	-	-	-	-	-	-	A	A
8	SC	RCP23MLSC602	Full Stack Development Laboratory - I	-	-	2	25	-	-	-	25	50	1	1
			Total	16	0	18	350	75	75	75	425	850	24	24

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

Any 1 Departmental Elective from given list.

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Course Code	Semester V: Department Elective - I
RCP23MCPE511	Reliability Engineering
RCP23MCPE512	Renewable Energy Systems
RCP23MCPE513	Advance Materials and Processes
RCP23MCPE514	Automotive Prime Movers
RCP23MCPE515	Adhesive Technology
RCP23MCPE516	Data Analytics
RCP23MCPE517	Fundamentals of Business Development

Course Code	Semester V: Department Elective-I Laboratory
RCP23MLPE511	Reliability Engineering Laboratory
RCP23MLPE512	Renewable Energy Systems Laboratory
RCP23MLPE513	Advance Materials and Processes Laboratory
RCP23MLPE514	Automotive Prime Movers Laboratory
RCP23MLPE515	Adhesive Technology Laboratory
RCP23MLPE516	Data Analytics Laboratory
RCP23MLPE517	Fundamentals of Business Development Laboratory

Course Code	Semester VI : Department Elective - II
RCP23MCPE621	Mechanical Vibrations
RCP23MCPE622	Refrigeration and Air Conditioning
RCP23MCPE623	Quality Engineering
RCP23MCPE624	Automotive Systems
RCP23MCPE625	Industrial Robotics
RCP23MCPE626	Artificial Intelligence and Machine Learning
RCP23MCPE627	Entrepreneurial Business Model

Course Code	Semester VI : Department Elective-II Laboratory
RCP23MLPE621	Mechanical Vibrations Laboratory
RCP23MLPE622	Refrigeration and Air Conditioning Laboratory
RCP23MLPE623	Quality Engineering Laboratory
RCP23MLPE624	Automotive Systems Laboratory
RCP23MLPE625	Industrial Robotics Laboratory
RCP23MLPE626	Artificial Intelligence and Machine Learning Laboratory
RCP23MLPE627	Entrepreneurial Business Model Laboratory

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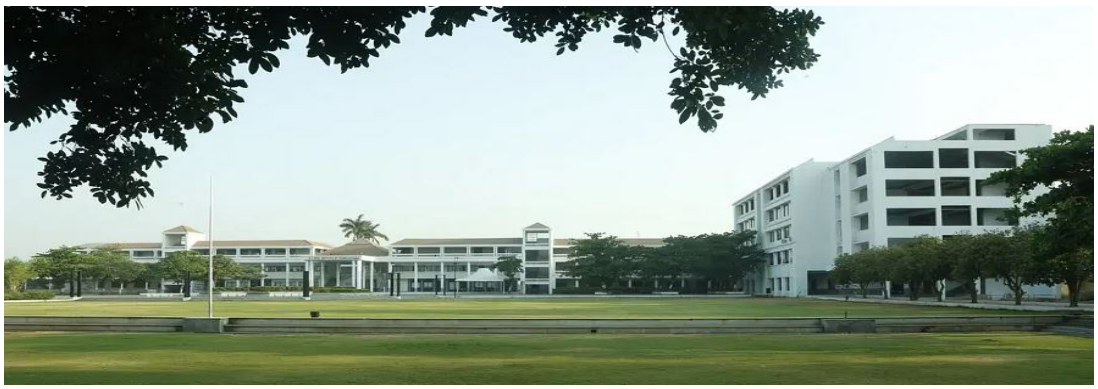
Syllabus Details of Semester-V

Third Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2025-26



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Mechanical Department R.C.P.I.T. OFFICE SEAL SHIRPUR

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Theory of Machines (RCP23MCPC501)		
Theory of Machines Laboratory (RCP23MLPC501)		

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	Analyse the vibration response of systems subjected to free undamped vibrations.	L4	Analyze
CO4	Analyse the vibration response of systems subjected to free damped vibrations.	L4	Analyze
CO5	Analyse the vibration response of systems subjected to forced vibrations.	L4	Analyze

Theory of Machines (RCP23MCPC501)

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 (RCP23MLPC501)

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 (RCP23MCPC502)		
Mechanical Measurements and Metrology Laboratory (RCP23MLPC502)		

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	Classify various types of static characteristics and types of errors occurring in the system.	L2	Understand
CO2	Classify and select proper measuring instrument for displacement, strain, pressure, and temperature measurement.	L3	Apply
CO3	Classify and select proper measuring instrument for linear and angular measurement.	L3	Apply
CO4	Demonstrate inspection methods and design of different limit gauges.	L3	Apply
CO5	Demonstrate characteristics of surface texture, screw threads, and gear measurements.	L3	Apply

Mechanical Measurements and Metrology (RCP23MCPC502)

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 (RCP23MLPC502)

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 (RCP23MCPC503)		
Fluid Mechanics and Machinery Laboratory (RCP23MLPC503)		

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	Solve practical problems involving fluid properties, hydrostatic pressure and evaluate fluid kinematic properties.	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	Estimate the power required for pumping by considering major and minor losses in flow through pipes.	L4	Analyze
CO4	Evaluate the performance of hydraulic turbines.	L5	Evaluate
CO5	Evaluate the performance of centrifugal pumps.	L5	Evaluate

Fluid Mechanics and Machinery (RCP23MCPC503)

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 (RCP23MLPC503)

Suggested Experiments

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 (RCP23MCMD501)		
Industrial Electronics Laboratory (RCP23MLMD501)		

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 and Explain electronic switch construction, working principles, and applications.	L2	Understand
CO2	Design and select 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 and recommend appropriate sensors and motors for various industrial applications.	L5	Evaluate

Industrial Electronics (RCP23MCMD501)

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 (RCP23MLMD501)

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 (RCP23MLMD502)		

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 an optimized database.	L6	Create
CO2	Construct SQL queries to perform operations on the database.	L3	Apply
CO3	Demonstrate the concept of transaction, concurrency, and recovery.	L2	Understand

Database Management System Laboratory (RCP23MLMD502)

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 (RCP23MLMD502)

Suggested Experiments

A Minimum six experiments from list below:

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 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 (RCP23MCPE511)		
Reliability Engineering Laboratory (RCP23MLPE511)		

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	Use the basics of reliability and its measures for analyzing components and systems.	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 (RCP23MCPE511)

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 (RCP23MLPE511)

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 (RCP23MCPE512)		
Renewable Energy Systems Laboratory (RCP23MLPE512)		

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	Discuss importance of renewable energy sources.	L2	Understand
CO3	Discuss 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	Explain basics of hydrogen energy.	L2	Understand

Renewable Energy Systems (RCP23MCPE512)

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 (RCP23MLPE512)

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 (RCP23MCPE513)		
Advance Materials and Processes Laboratory (RCP23MLPE513)		

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	Comprehend stimuli-response behavior in smart materials and apply the principles of smart materials in the development of integrated systems such as mechatronic systems and structural health monitoring systems.	L3	Apply
CO2	Analyse and design smart materials for their applications in sensors, actuators, self-healing mechanism.	L6	Create
CO3	Recognize 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 analyse 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 (RCP23MCPE513)

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 (RCP23MLPE513)

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(RCP23MCPE514)		
Automotive Prime Movers Laboratory (RCP23MLPE514)		

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	Analyse 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(RCP23MCPE514))

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 (RCP23MLPE514)

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 (RCP23MCPE515)		
Adhesive Technology Laboratory (RCP23MLPE515)		

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:

CO1	Use 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	Use 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	Use test standards and certification processes provided in ISO 10964, ISO 10123, and ISO 16047.	L3	Apply

Adhesive Technology (RCP23MCPE515)

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 (RCP23MLPE515)

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 (RCP23MCPE516)		
Data Analytics Laboratory (RCP23MLPE516)		

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	Use 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 (RCP23MCPE516)

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 (RCP23MLPE516)

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 (RCP23MCPE517)		
Fundamentals of Business Development Laboratory (RCP23MLPE517)		

Prerequisites:

Nil

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:

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	Effectively employ methods for customer attraction and retention, emphasizing the establishment and nurturing of enduring customer relationships.	L3	Apply
CO4	Showcase proficiency in essential sales techniques, negotiation skills, and articulate communication for successful business development.	L3	Apply
CO5	Assess the importance of partnerships, implement effective collaboration strategies, and explore models fostering mutual benefit.	L5	Evaluate

Fundamentals of Business Development (RCP23MCPE517)

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 (RCP23MLPE517)

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 Science Tutorials (RCP23ITHSX06)		

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	Understand how human activities affect environment.	L2	Understand
CO2	Understand the various technology options that can make a difference.	L2	Understand

Environmental Science Tutorials (RCP23ITHSX06)

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 (RCP23IPSC501)		

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	Conduct a survey of several available literatures in the preferred field of study.	L4	Analyze
CO2	Demonstrate various/alternate approaches to complete a project.	L3	Apply
CO3	Ensure a collaborative project environment by interacting and dividing project work among team members.	L4	Analyze
CO4	Present their project work in the form of a technical report/paper and thereby improve technical communication skills.	L2	Understand
CO5	Demonstrate the ability to work in teams and manage the conduct of the research study.	L2	Understand

Semester Project III (RCP23IPSC501)

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.