Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Structure

Third Year B.Tech in Mechanical Engineering

(RCP22 Scheme) with effect from Year 2024-25

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 nation's sustainable development.

Mechanical Engineering Department

Vision Statement

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

Mission Statements

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 lifelong 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 - RCP22)

Semester – V (w.c.f.2024-25)

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	22PCME5010T	Automotive Prime Movers	3	-	-	25	10	10	10	65	100	3	4
		22PCME5010L	Automotive Prime Movers Laboratory	-	-	2	25	-	-	-	-	25	1	
2	PC	22PCME5020T	Heat Transfer	3	-	-	25	10	10	10	65	100	3	4
		22PCME5020L	Heat Transfer Laboratory	-	-	2	25	-	-	-	-	25	1	
3	PC	22PCME5030T	Dynamics of Machinery	3	-	-	25	10	10	10	65	100	3	4
		22PCME5030L	Dynamics of Machinery Laboratory	-	-	2	25	-	-	-	-	25	1	
4	PC	22PCME5040T	Industrial Electronics	3	-	-	25	10	10	10	65	100	3	4
		22PCME5040L	Industrial Electronics Laboratory	-	-	2	25	-	-	-	-	25	1	
5	PC	22PCME5050L	Database Management Systems	-	-	2	25	-	-	-	25	50	1	1
6 @	PE	22PEME5061T	Advance Materials & Processes	3	-	-	25	10	10	10	65	100	3	4
		22PEME5061L	Advance Materials & Processes Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME5062T	Automobile Engineering	3	-	-	25	10	10	10	65	100	3	
		22PEME5062L	Automobile Engineering Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME5063T	Reliability Engineering	3	-	-	25	10	10	10	65	100	3	
		22PEME5063L	Reliability Engineering Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME5064T	Power Engineering	3	-	-	25	10	10	10	65	100	3	
		22PEME5064L	Power Engineering Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME5065T	Data Analytics	3	-	-	25	10	10	10	65	100	3	
		22PEME5065L	Data Analytics Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME5066T	Incubation, Entrepreneurship and Start-ups	3	-	-	25	10	10	10	65	100	3	
		22PEME5066L	Incubation, Entrepreneurship and Start-ups Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME5067T	Design Validation through Prototyping	3	-	-	25	10	10	10	65	100	3	
		22PEME5067L	Design Validation through Prototyping Laboratory	-	-	2	25	-	-	-	-	25	1	
7	MC	22MCME5070T	Environmental Studies	1	-	-	-	-	-	-	-	-	A	A
8	PJ	22PJME5080L	Semester Project III	-	-	2	25	-	-	-	25	50	1	1
9	HM	22HMME5090L	Employability Skill Development Program- II	-	-	2	50	-	-	-	-	50	1	1
			Total	**16**	**0**	**16**	**350**	**50**	**50**	**50**	**375**	**775**	**23**	**23**

PC-Professional Course, PE- Professional Elective, MC- Mandatory Course, HM- Humanity and Management, PJ-Project, A-Audit

@ Any 1 form Professional 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 - RCP22)

Semester – VI (w.e.f.2024-25)

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	22PCME6010	Design of Machine Elements	3	-	-	25	10	10	10	65	100	3	4
		22PCME6010	Design of Machine Elements Laboratory	-	-	2	25	-	-	-	-	25	1	
2	PC	22PCME6020	Finite Element Analysis	3	-	-	25	10	10	10	65	100	3	4
		22PCME6020	Finite Element Analysis Laboratory	-	-	2	25	-	-	-	-	25	1	
3	PC	22PCME6030	Control Systems	3	-	-	25	10	10	10	65	100	3	4
		22PCME6030	Control Systems Laboratory	-	-	2	25	-	-	-	-	25	1	
5 #	PE	22PEME6041T	Quality Engineering	3	-	-	25	10	10	10	65	100	3	4
		22PEME6041L	Quality Engineering Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6042T	Vehicle Dynamics and NVH	3	-	-	25	10	10	10	65	100	3	
		22PEME6042L	Vehicle Dynamics and NVH Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6043T	Mechanical Vibrations	3	-	-	25	10	10	10	65	100	3	
		22PEME6043L	Mechanical Vibrations Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6044T	Refrigeration and Air Conditioning	3	-	-	25	10	10	10	65	100	3	
		22PEME6044L	Refrigeration and Air Conditioning Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6045T	Machine Learning	3	-	-	25	10	10	10	65	100	3	
		22PEME6045L	Machine Learning Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6046T	Fundamental of Business Development	3	-	-	25	10	10	10	65	100	3	
		22PEME6046L	Fundamental of Business Development Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6047T	Creative Engineering Design	3	-	-	25	10	10	10	65	100	3	
		22PEME6047L	Creative Engineering Design Laboratory	-	-	2	25	-	-	-	-	25	1	
		22PEME6048T	Mechatronics	3	-	-	25	10	10	10	65	100	3	
		22PEME6048L	Mechatronics Laboratory	-	-	2	25	-	-	-	-	25	1	
6	HM	22HMME6050T	Professional and Business Communication Tutorial	-	2	-	25	-	-	-	-	25	2	2
7	PC	22PCME6060L	CAD CAM Laboratory	-	-	2	25	-	-	-	25	50	1	1
8	PJ	22PJME6070L	Project Stage - I	-	-	4	25	-	-	-	25	50	2	2
			Total	**12**	**2**	**14**	**275**	**40**	**40**	**40**	**310**	**625**	**21**	**21**

PC- Professional Course, PE- Professional Elective, HM – Humanity and Management, PJ-Project

Any 1 form Professional Elective - II from given list.

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

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

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Syllabus Details of Semester-V

Third Year B.Tech in Mechanical Engineering

(RCP22 Scheme) with effect from Year 2024-25

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
Automotive Prime Movers (22PCME5010T		
Automotive Prime Movers Laboratory (22PCME5010L)		

Prerequisites:

1. Thermodynamics

Course Objectives:

1. To study the components of an internal combustion engine and its systems.
2. To familiarize with different systems in SI & 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	Explain the construction and working of internal combustion engines.	L2	Understand
CO2	Demonstrate the working systems of spark ignition & compression ignition engines.	L3	Apply
CO3	Demonstrate the engine cooling, lubrication, and supercharging systems.	L3	Apply
CO4	Analyze various engine performance parameters.	L4	Analy
CO5	Explain the different hybrid and electric powertrain systems.	L2	Understand

Automotive Prime Movers (22PCME5010T)

Course Contents

Unit-I **07 Hrs.**

Introduction

Classification, components and materials of I.C. Engines, Four-stroke, two-stroke engines, Fuel-air cycles and their analysis, Actual working cycle, Valve timing diagram.
Spark Ignition (SI) Engines
Fuel supply system: Air-Fuel mixture requirements for steady state and transient operations.
Fuel Injection Systems: Single-point and Multipoint injection systems, Gasoline Direct Injection. Engine Control Unit (ECU), Important sensors & actuators, Open loop and closed loop modes of operation.
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.

Unit-II **07 Hrs.**

Compression Ignition (CI) Engines

Fuel Injection Systems: Fuel injection systems, Common rail, individual pump, distributor and unit systems, Types of nozzle, fuel atomization and spray structures, Electronically controlled unit fuel injection system. Load and speed control of CI engines.
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.

Unit-III **06 Hrs.**

Engine Cooling Systems & Lubrication Systems

Engine Cooling Systems: Necessity of engine cooling, Cooling systems and their comparison: Air cooling, Liquid cooling, Troubleshooting & maintenance.
Engine Lubrication Systems: Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems and their applications.
Supercharging/Turbo-charging: Objectives and limitations, Methods, types, and different arrangements of superchargers and turbochargers.

Unit-IV **09 Hrs.**

Engine Performance & Emissions

Measurement and analysis of engine performance parameters, Performance characteristics of SI and CI engines, Effect of load and speed on engine performance & heat balance sheet. Emission control systems, Bharat Stage VI emission norms.
Alternative Fuels: Ethanol, Bio-diesel, CNG, LPG, Hydrogen - Merits, demerits, and engine modifications.
Recent Developments: Camless engine, Variable valve timing, Stratification in GDI engines, EHR engine, HCCI engine & six-stroke engine.

Unit-V **06 Hrs.**

Hybrid Powertrain

Hybrid Powertrain Architecture, Hybrid Powertrain Performance - Series architecture and Parallel architecture, Hybrid Power System Components, Degree of hybridization, Regenerative Braking, Hybrid Power System Components – Battery, Hybrid Powertrain Energy Management.

Unit-VI **06 Hrs.**

Electric Powertrain

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, Drive system efficiency.

Automotive Prime Movers Laboratory (22PCME5010L)

Suggested Experiments

Any 8 experiments:

1. Study of components of an internal combustion engine
2. Estimation of valve timing for four SI / CI Engine.
3. Study of ignition system of SI engines.
4. Study of fuel injection system in CI engines
5. Analysis of supercharging and turbocharging of I C engines.
6. Load Test on CI engine.
7. Speed Test on SI engine.
8. Heat Balance test on SI or CI engines
9. Experimental determination of friction power of multi-cylinder SI engine using Morse test method.
10. Experimental determination of Air fuel ratio and volumetric efficiency of the engine.
11. Simulation of electric/hybrid powertrain on MATLAB Simulink software.
12. Study of electric motor test methods.

Minimum 8 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. V. Ganesan, 'Internal Combustion Engine', 4th Edition, 2017, McGraw Hill
2. Mathur and Sharma, 'Internal Combustion Engine', 2014, Dhanpat Rai Publications
3. H. N. Gupta, 'Internal Combustion Engines', 2nd Edition, 2012, PHI
4. R. K. Rajput, 'Internal Combustion Engines', 3rd Edition, 2016, Laxmi Publications
5. Tom Denton, 'Automotive Electrical and Electronic Systems', 5th Edition, 2017, Routledge

Reference Books

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

2 Colin Ferguson and Allan Kirkpatrick, 'Internal Combustion Engines', 2nd Edition, Wiley India Pvt. Ltd

3 Willard W. Pulkrabek, 'Internal Combustion Engines', 2nd Edition, 2013, Pearson Education

4 Richard Stone, 'Introduction to Internal Combustion Engines', 4th Edition, 2012, Palgrave Publication

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

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Heat Transfer (22PCME5020T)		
Heat Transfer Laboratory (22PCME5020L)		

Prerequisites:

1. Engineering Mathematics
2. Engineering 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 with 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.
6. To practice computational techniques used in heat transfer and their applications.

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 heat transfer to solve problems related to steady state conduction.	L3	Apply
CO2	Analyze and solve problems involving heat transfer from extended surfaces and unsteady state conduction.	L4	Analyze
CO3	Apply the principles of convection to solve heat transfer problems.	L3	Apply
CO4	Analyze heat exchangers for various applications.	L4	Analyze
CO5	Apply the principles of radiation to solve heat transfer problems.	L3	Apply
CO6	Apply various numerical methods to solve heat transfer problems.	L3	Apply

Heat Transfer (22PCME5020T)

Course Contents

Unit-I **07 Hrs.**

Introduction and One-Dimensional Steady State Conduction

Introduction: 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 **06 Hrs.**

Heat Transfer from Extended Surface and Unsteady State Conduction

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 **06 Hrs.**

Convection

Natural and Forced Convection, Hydrodynamic and Thermal Boundary Layers, Heat Transfer Coefficient, Principle of Dimensional Analysis, Buckingham's Theorem, Application of Buckingham's π Theorem 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 and Boiling/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

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.

Unit-VI **06 Hrs.**

Computational Techniques in Heat Transfer

(NOT INCLUDED IN ESE) Overview of computational techniques in heat transfer, Importance and applications, Numerical Methods in Heat Transfer: Finite Difference Method, Finite Element Method, and Finite Volume Method, Central, Forward, and Backward difference expressions for a uniform grid, Numerical errors, Finite difference solution for a one-dimensional steady state problem using Gaussian elimination and Gauss-Seidel iterative methods, Finite difference solution for transient one-dimensional problems: Euler, Crank-Nicolson, and pure implicit methods, Accuracy, stability of transient heat transfer problems.

((*) This module is not included in the End Semester Examination. Instead, students are required to submit two assignments. The first assignment involves modeling a steady state heat transfer problem, while the second one involves an unsteady state heat transfer problem. Students must validate their results with analytical calculations. These assignments will serve as a practical evaluation of the students' ability to apply computational techniques in heat transfer problems.)

Heat Transfer Laboratory (22PCME5020L)

Suggested Experiments

Any 7 experiments:

1 Thermal conductivity of solid/liquid
2 Heat transfer coefficient in natural convection heat transfer
3 Heat transfer coefficient in forced convection heat transfer
4 Unsteady state heat transfer in cylinder/rod/wall
5 Fin efficiency and fin effectiveness
6 Critical heat flux
7 Overall heat transfer coefficient and effectiveness of heat exchanger
8 Stefan-Boltzmann apparatus
9 Emissivity of Grey surface
10 Numerical modelling of any heat transfer problem using FDM

Minimum seven 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 Yunus Cengel and Afshin Ghajar, 'Heat and Mass Transfer: Fundamentals and Applications', 6th Edition, McGraw Hill, 2020.
2 P. S. Ghoshdastidar, 'Heat Transfer', Second Edition, Oxford University Press, 2012.
3 R.K. Rajput, 'A Textbook of Heat and Mass Transfer (SI Units)', S. Chand, 2018.

Reference Books

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

2 S.P. Sukhatme, 'Textbook of Heat Transfer', Fourth Edition, Universities Press, 2005.

3 C.P. Kothandaraman, 'Fundamentals of Heat and Mass Transfer', 4th Edition, New Age International Press, 2012.

4 Dr. D.S. Kumar, S.K. Kataria, 'Basics of Heat and Mass Transfer', 2018.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Dynamics of Machinery (22PCME5030T)		
Dynamics of Machinery Laboratory (22PCME5030L)		

Prerequisites:

1. Engineering Mechanics
2. Strength of Materials
3. Kinematics of Machinery

Course Objectives:

1. To acquaint with working principles and applications of Gyroscope.
2. To study static and dynamic force analysis in mechanisms.
3. To familiarize with basics of mechanical vibrations.
4. To study the balancing of mechanical 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 effect of gyroscopic couple in various engineering applications.	L2	Understand
CO2	Analyze forces and torques that act on mechanisms.	L4	Analyze
CO3	Apply governing equations to determine vibration response of free undamped systems.	L3	Apply
CO4	Evaluate the vibration characteristics of free damped systems under different damping conditions.	L5	Evalute
CO5	DMeasure and interpret vibration response of systems subjected to forced vibrations using experimental methods.	L4	Analyze
CO6	Design force and couple balancing systems to solve practical engineering problems.	L6	Create

Dynamics of Machinery (22PCME5030T)

Course Contents

Unit-I **06 Hrs.**

Static and Dynamic Force Analysis

Analysis of slider crank mechanism (neglecting mass of connecting rod and crank), Turning moment on crank shaft, fluctuation of energy, flywheel analysis - fluctuation of speed, energy stored, dimensions of flywheel rims, dynamically equivalent systems to convert rigid body into two masses with and without correction couple.

Unit-II **05 Hrs.**

Gyroscope

Gyroscopic couple and its effect on spinning bodies, naval ships during steering, pitching, rolling and their stabilization, Effect of gyroscopic and centrifugal couples on vehicles moving along a curved path, permissible speeds on curved paths.

Unit-III **06 Hrs.**

Rotor Dynamics and Balancing

Unbalance in machines, Critical speed of shaft with single rotor, Static and dynamic balancing of multi rotor system (up to four rotors), Balancing of reciprocating masses in In-line engines (up to four cylinders), Balancing machines.

Unit-IV **07 Hrs.**

Basic Concepts of Vibration

Vibration and oscillation, causes and effects of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis.
Free Undamped Single Degree of Freedom Vibration System
Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's method.

Unit-V **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-VI **08 Hrs.**

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).

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.

Dynamics of Machinery Laboratory (22PCME5030L)

Suggested Experiments

A Any 8 experiments:

1. Experiments on Governors- Porter Governor, Hartnell Governor
2. Experimental verification of principle of Gyroscopic couple
3. Determine natural frequency of compound pendulum, equivalent simple pendulum system
4. Determine natural frequency for longitudinal vibrations of helical springs
5. Determine natural frequency and nodal points for single rotor and two-rotor vibratory system
6. Experiment on whirling of shaft
7. Determination of damping coefficient of any system/media
8. Experimental balancing of single and multi-rotor system
9. Measurement of vibration response of a system
10. Condition monitoring using FFT analyzer
11. Vibration analysis of mechanical system using MATLAB/SCILAB/Python

B Assignments or Mini project

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.
Mini project/Assignments relevant to the subject may be included, which would help the learner to apply the concept learnt.

Books Recommended

Textbooks

1. S. S. Ratan, 'Theory of Machines', Tata McGraw Hill
2. J. K. Gupta and R. S. Khurmi, 'Theory of Machines', S. Chand Publishing.

Reference Books

1. Thomas Bevan, 'Theory of Machines', CSB Publishers & Distributors
2. Jagdishlal, 'Theory of Machines', Metropolitan Book New Delhi
3. P. L. Bellaney, 'Theory of Machines', Khanna publication
4. John J. Uicker, Gordon R. Pennock and Joseph E. Shigley, 'Theory of Machines and Mechanisms', Oxford University Press
5. W. Thomson, 'Theory of Vibration with Applications', Pearson Education

6 S. S. Rao, 'Mechanical Vibrations', Pearson Education

7 S. Graham Kelly, 'Fundamentals of Mechanical Vibration', Tata McGraw Hill

8 Benson H Tongue, 'Principles of Vibration', 2nd Edition, Oxford University Press

9 William W. Seto, 'Mechanical Vibrations- Schaum's outline series', McGraw Hill

10 J. S. Rao and K. Gupta, 'Theory and Practice of Mechanical Vibrations', New Age International

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Industrial Electronics (22PCME5040T)		
Industrial Electronics Laboratory (22PCME5040T)		

Prerequisites:

1. Knowledge of basic electronic devices like Semiconductor Diodes.

Course Objectives:

1. To study power electronic switches and circuits and their applications.
2. To familiarize with Op-amp and digital circuits and their applications.
3. To acquaint with the basics of microcontrollers.
4. To study the working of Sensors and Motors.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Describe construction, working principles and applications of power electronic switches.	L2	Understand
CO2	Examine rectifiers and inverters for DC and AC motor speed control.	L3	Apply
CO3	Apply digital circuits for industrial applications.	L3	Apply
CO4	Evaluate circuits using OPAMP and timer IC555.	L5	Evalute
CO5	Analyze specific sensors and motors.	L4	Analyze

Industrial Electronics (22PCME5040T)

Course Contents

Unit-I **09 Hrs.**

Semiconductor Devices

Review of diodes, V-I characteristics and Applications of: rectifier diode, zener diode, LED, photodiode; SCR V-I characteristics, UJT triggering circuit, turning-off of a SCR (preliminary discussion), basics of Gate Turn Off (GTO), Structure and V-I characteristics of Triac (modes of operation not needed) and Diac, Applications of Triac-Diac circuit; Characteristics of Power BJT, power MOSFET, IGBT; Comparison of SCR, Triac, Power BJT, power MOSFET, IGBT.

Unit-II **09 Hrs.**

Phase-Controlled Rectifiers and Bridge Inverters

Half and Full wave controlled rectifiers using SCRs with R load only, H-Bridge for DC Motor, Block diagram of closed-loop speed control of DC motors, Basic principle of single phase and three phase bridge inverters, block diagrams including rectifier and inverter for speed control of AC motors (frequency control only)

Unit-III **08 Hrs.**

Elements of Signal Conditioning

Amplifiers, Attenuators, Filter Circuits
Operational amplifier: Ideal and Practical OPAMP Characteristics, Basic OPAMP circuits- Inverting amplifier, Non-inverting amplifier, Voltage follower (Buffer), Comparator, Instrumentation Amplifier, Active filters; Power Op Amps, IC-555 timer-Operating modes: monostable, astable multivibrator.

Unit-IV **08 Hrs.**

Digital Logic and Microcontrollers

Boolean algebra and logic gates. TTL and CMOS logic families, Multiplexer and Demultiplexer applications, Flip flops: Set Reset (SR), Trigger (T), clocked F/Fs; Overview of generic microprocessor and Microcontrollers, Comparison of microprocessor and microcontroller, Features of Microcontroller General purpose i/o toggle and its applications, Interrupts and ISR, Analog to digital converter, Serial communications - UART, SPI and I2C, Timer module, precise delay generation, timer waveforms, counting applications, Interrupt and polling mode of control.
Basics of interfacing with external input/output devices (like reading external analog voltages, digital input-output)
Applications of the microcontroller: Temperature measurement, Speed Measurement, Solenoid, Relay, Motor Control, etc.

Unit-V **08 Hrs.**

Sensors and Motors

Industrial Sensors: Displacement, temperature, acceleration, force/pressure and optical sensors, static and dynamic characteristics.
Motors: Review and comparison of DC motors and AC induction motors, Basic principles of speed

control of DC motor, microcontroller-based speed control for DC Motor. Basic principles of speed control of AC induction motor, Basics of BLDC motor, Linear Actuators, Servo Motor; Motor Specifications, suitability of each motor for various industrial applications, Selection and sizing of motors for different applications.
Applications for pumps, conveyors, machine tools

Industrial Electronics Laboratory (22PCME5040T)

Suggested Experiments

Any 8 experiments:

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

Textbooks

1. Power Electronics by M.H. Rashid, Prentice-Hall of India
2. Power Electronics by P. S. Bhimbra
3. Power Electronics by Vedam Subramanyam, New Age International
4. Power Electronics by Ned Mohan, Undeland, Robbins, John Wiley Publication
5. Electronic Devices and Circuits by Robert Boylestad and Louis Nashelsky, Prentice-Hall
6. Industrial Electronics and Control by S.K. Bhattacharya, S. Chatterjee, TTTI Chandigarh
7. Modern Digital Electronics by Jain R. P., Tata McGraw Hill
8. Digital Principles and Applications by Malvino and Leach, Tata McGraw Hill
9. Fundamentals of Microcontrollers and Embedded Systems by Ramesh Gaonkar, PENRAM
10. MSP430 Microcontroller Basics by John H. Davies, Newnes
11. Modern Control Engineering by Ogata, Prentice Hall

12 Control Systems by Dhanes Manik, Cengage Learning

13 Engineering Metrology and Measurements by N.V. Raghavendra and L. Krishnamurthy, Oxford University Press

14 Instrumentation and Control Systems by W. Bolton, Elsevier

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Database Management System Laboratory (22PCME5050L)		

Prerequisites:

1. Computer Basics

Course Objectives:

1. To introduce students to the management of database systems.
2. To emphasize the design, organization, maintenance, and retrieval of information 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.	L6	Create
CO3	Demonstrate the concept of transaction, concurrency, and recovery.	L2	Understand

Database Management System Laboratory)
(22PCME5050L

Course Contents

Unit-I **04 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 **04 Hrs.**

Entity–Relationship Model

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 **10 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 **06 Hrs.**

Relational–Database Design

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

Unit-V **04 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 (22PCME5050L)

Suggested Experiments

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1 To draw an ER diagram for a problem statement and map the ER diagram to relations.

2 To implement DDL and DML queries.

3 Write queries using aggregate functions.

4 Write queries using Joins.

5 Write queries using sub-queries.

6 To implement Integrity Constraints.

7 To implement triggers.

8 To Study and Implement TCL Commands.

9 Examine the consistency of database using concurrency control technique (Locks).

10 Case Study for a specific product/process:

1. Schema Design
2. Database instance on cloud.
3. Build visualizations using SQL Queries.

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

Text Books

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, [illegible] S., 1997.

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

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Advanced Materials and Processes (22PEME5061L)		
Advanced Materials and Processes Laboratory (22PEME5061L)		

Prerequisites:

1. Engineering Materials
2. Manufacturing Processes

Course Objectives:

1. To provide comprehensive exposure to new and advanced materials such as smart materials, high temperature materials, nanomaterials, energy storage materials, etc.
2. To familiarize students with the development of new materials and processes to meet real-world 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	Describe the stimuliresponse behavior of various smart materials along with their properties and processing.	L2	Understand
CO2	Select an appropriate smart material and analyze it for applications such as sensors, actuators, self-healing, and health monitoring of structures.	L3	Apply
CO3	Explain the behavior of material at elevated temperatures and select an appropriate material for high temperature applications.	L2	Understand
CO4	Correlate structure, properties, and synthesis of nanostructured materials and biomaterials, and appreciate their engineering importance.	L4	Analyze
CO5	Demonstrate various materials and methods for energy storage and harvesting.	L3	Apply

Advanced Materials and Processes (22PEME5061L)

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).
Shape 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.

Unit-II **08 Hrs.**

Smart Materials – Part II

Brief overview, Related materials – composition, properties & processing, Effects, Constituting or governing equations and Industrial applications associated with the following smart materials:
Magnetorheological & Electrorheological fluids, Magnetostrictive & Electrostrictive materials, Electroactive polymers (EAP's): IPMC's, Dielectric polymers, Conductive polymers etc., Soft matter, Smart composites: Active fiber composites/smart polymer matrix composites.

Unit-III **06 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.

Unit-IV **08 Hrs.**

Nanomaterials and Biomaterials

Nanomaterials: Concept, classification, Size effect on structural and functional properties, Synthesis of nanomaterials – Top down and bottom up approaches, Issues and applications of nanomaterials in various industries, Special nanostructures (Fullerene, Graphene, Carbon nanotubes etc) and their application, Nanocomposites and Nanotechnology.
Biomaterials: Need for biomaterials, biocompatibility, types of biomaterials and applications in orthopedic, dental, cardiovascular and biomedical devices.

Unit-V **06 Hrs.**

Materials for Energy Storage and Harvesting

Materials used for storage and conversion of various sources of energy such as electrical, electrochemical, photo-electrochemical, thermal, and mechanical energy.
Smart materials for energy harvesting.

Hydrogen storage materials.

Unit-VI **06 Hrs.**

Processes Applied for 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 vapor deposition techniques, etc.

Advanced Materials and Processes Laboratory (22PEME5061L)

Assignment / Case study / Mathematical modelling

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1 Assignments based on syllabus

2 Case study or literature based presentation/seminar.

3 Mathematical modelling and simulation of smart and new materials based systems and devices

Minimum 5 assignments based on syllabus will be included, which would help the learner to apply the concept learnt.

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, Elsevier Science, 2020.

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

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

5 Anca Filimon, Smart Materials- Integrated Design, Engineering Approaches, and Potential Applications, Apple Academic Press, 2019.

6 Cheong K.Y., Impellizzeri, G., and Fraga, M.A., Emerging Materials for Energy Conversion and Storage, 1st Edition, Elsevier, 2018.

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

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

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

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

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

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

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

14 C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford, Gopinath Mani, Introduction to Biomaterials: Basic Theory with Engineering Applications, Cambridge University Press, 2013.

15 J. L. Zhong, Smart Materials and Nanotechnology in Engineering, Trans Tech Pubn, 2012.

16 Mel Schwartz, Smart Materials, CRC Press, 2008.

Other Resource

1 Prof. Jayanta Das, Advanced Materials and Processes, NPTEL Course, IIT Kharagpur, 2019.

2 Prof. Kaushik Pal, Selection of Nanomaterials for Energy Harvesting and Storage Application, NPTEL Course, IIT Roorkee, 2019.

3 Bhattacharya B, Smart Materials and Intelligent System Design, NPTEL, IIT Kanpur, 2018.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Automobile Engineering (22PEME5062T)		
Automobile Engineering Laboratory (22PEME5062L)		

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 clutch and transmission systems.	L2	Understand
CO2	Illustrate the working of steering and braking systems.	L3	Apply
CO3	Describe the role of vehicle suspension systems and vehicle body.	L2	Understand
CO4	Describe the different automotive electrical and electronic systems.	L2	Understand
CO5	Identify with recent developments in automobiles.	L3	Apply

Automobile Engineering (22PEME5062T)

Course Contents

Unit-I **08 Hrs.**

Introduction, Clutch, Transmission, Final Drive, and Differential

Introduction: Classification of automobiles, Importance of various sub-systems of an automobile, development of an automobile, 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. Trouble shooting and remedies. Clutch-by-wire.
Transmission: Requirements of gear box. 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. Trouble shooting and remedies. Automated Manual Transmission (AMT), Continuously Variable Transmission (CVT), Dual Clutch Transmission (DCT).
Final Drive and Differential: Types of Final drive; spiral, bevel, Hypoid and worm drives. Necessity of differential, Working of differential, Conventional and limited-slip differential, Trouble shooting and remedies.

Unit-II **08 Hrs.**

Propeller Shaft, Axle, Steering System, and Braking System

Propeller Shaft and Axle: 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. Trouble shooting and remedies.
Steering System: Steering requirements, steering linkages and steering gears. Steering geometry, Analysis of steering geometry, Over-steer and Under-steer, Reversibility of steering gears. Trouble shooting and remedies.
Braking System: Requirement of brakes, Classification of brakes, Brake Actuation Methods: Mechanical, Hydraulic, Pneumatic, Electro and vacuum brakes. Types of Disc brakes and Drum Brakes, Brake trouble shooting, Antilock braking system (ABS).

Unit-III **08 Hrs.**

Suspension System, Wheels, and Tyres

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

Unit-IV **07 Hrs.**

Body Engineering

Importance of vehicle body and its types. Loads on vehicle body, materials for body construction. Layouts of passenger cars, Bus 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 **06 Hrs.**

Automotive Electronics

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.
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.

Unit-VI **05 Hrs.**

Recent Developments in Automobiles

Active and Passive Safety systems in an automobile. Cruise Control, Adaptive Cruise Control (ACC), Predictive Cruise Control, Electronic Stability Program (ESP), Electronic Brake Distribution System (EBD), Traction Control System (TCS). Integrated Starter Alternator (ISA), Hill assist, Launch control, Connected cars with V2V communication & pre-collision technology.

Automobile Engineering Laboratory (22PEME5062L)

Suggested Experiments

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 Modeling and FEA analysis of vehicle frame designs and materials on ANSYS / Solidworks
6 Characterization and visualization of output of various sensors such as TPS, MAP, ECT sensor.
7 Simulation of cruise control system using MATLAB Simulink software
8 Case study presentations on upcoming vehicle technologies

Minimum seven 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 Automobile Engineering, Dr. Kirpal Singh, Vol I & II, 13th Edition, Standard Publishers
2 Automobile Engineering, S. K. Gupta, S Chand Publications
3 Automobile Engineering, R. K. Rajput, 2nd Edition, Laxmi Publications.

Reference Books

1 Automotive Engineering Fundamentals, Jeffrey Ball, Richard Stone, SAE International.

2 Encyclopedia of Automotive Engineering, David Crolla, Wiley Publication

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

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

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Reliability Engineering (22PEME5063T)		
Reliability Engineering Laboratory (22PEME5063L)		

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 inculcate basic knowledge on the 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 acquaint with 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	Apply 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	Analyze the system reliability models to solve system reliability problems and analyze warranty data.	L4	Analyze
CO4	Apply probabilistic approaches for component design and reliability prediction.	L3	Apply
CO5	Select a suitable reliability testing method for testing of components.	L3	Apply

Reliability Engineering (22PEME5063T)

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, Poisson distribution.
Continuous Probability Distributions: Weibull, exponential, normal (Gaussian), and lognormal. Concept of confidence interval.

Unit-III **07 Hrs.**

System Reliability

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

Unit-IV **07 Hrs.**

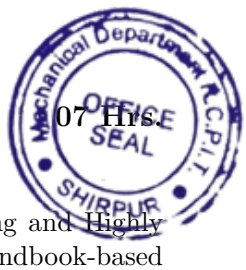
System Reliability Modelling and Warranty Analysis

Failure Modes and Effects Analysis (FMEA), and Fault Tree Analysis (FTA). Product warranty and reliability.

Unit-V **07 Hrs.**

Probabilistic Design

Design for Reliability: Reliability models for probabilistic design, Relationship between reliability, the factor of safety and variability.
Maintainability: Types of maintenance, models for maintenance data.
Availability: Types, Markov chains.



Unit-VI **07 Hrs.**

Reliability Testing

Introduction to reliability testing, Stress strength interaction, Accelerated Life Testing and Highly Accelerated Life Testing (HALT), and highly accelerated stress Screening (HASS). Handbook-based

reliability predictions.

Reliability Engineering Laboratory (22PEME5063L)

Suggested Experiments/ Exercises

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

3 A case study on reliability block diagrams.

4 A case study on fault tree analysis.

5 A case study FMEA analysis using MIL-STD-1629.

6 A case study on Markov chains/ Monte Carlo simulation

7 Physics of failure models/ Warranty data analysis

8 A case study on reliability allocation (ARINC/ AGREE/ Feasibility of objectives/ Aggarwal's method/ and Integrated factor).

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

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 10 can be performed.

Books Recommended

Textbooks

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

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

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

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

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

Reference Books

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

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

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

4 Life Cycle Reliability Engineering, G. Yang, John Wiley and Sons, 2007.

5 Engineering Maintainability, B. S. Dhillon, 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
Power Engineering (22PEME5064T)		
Power Engineering Laboratory (22PEME5064L)		

Prerequisites:

1. Thermodynamics

Course Objectives:

1. To study boilers, boiler mountings and accessories.
2. To study steam turbines, hydraulic turbines and their utilities.
3. To study pumps, compressors and their utilities.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Describe different types of boilers and evaluate steam generator, steam turbine performance.	L2	Understand
CO2	Identify basic concepts in the case of centrifugal compressors and evaluate their performance.	L3	Apply
CO3	Demonstrate working of axial flow compressors and evaluate their performance.	L3	Apply
CO4	Identify basic difference between impulse and reaction water turbines, investigate various parameters and design turbine runners.	L3	Apply
CO5	Expalain operating principles of reciprocating and centrifugal pumps and evaluate their performance.	L2	Understand

Power Engineering (22PEME5064T)

Course Contents

Unit-I **05 Hrs.**

Steam Generators

Fire tube and Water tube boiler, Low pressure and high-pressure boilers, once through boiler, examples, and important features of HP boilers, Mountings and accessories, Equivalent evaporation of boilers, Boiler performance and Boiler efficiency.

Unit-II **07 Hrs.**

Steam Nozzle & Steam Turbine

Flow through steam nozzle-velocity at exit and condition for maximum discharge, nozzle efficiency. Basics of steam turbine, Classification, compounding of turbine, Impulse turbine – velocity diagram, Condition for max efficiency, Reaction turbine - velocity diagram, degree of reaction, Parson's turbine, Condition for maximum efficiency.

Unit-III **05 Hrs.**

Rotary Compressors & Centrifugal Compressors

Vane type compressors, Scroll & Screw compressors etc.
Work required, polytropic efficiency, pressure rise, slip, effect of blade shape, two-dimensional flow through impeller; Vaned diffuser and volute casing; Surging and choking of compressors; Compressor performance and characteristic curves.

Unit-IV **05 Hrs.**

Axial Flow Compressors

Work required, polytropic efficiency, pressure rise, degree of reaction; Simple design calculations; Surging and stalling of compressors; Compressor performance and characteristic curves.

Unit-V **10 Hrs.**

Hydraulic Turbines

Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat & curve), Types of hydro turbines - impulse and reaction, definition of various turbine parameters like gross head, discharge, work done, input power, output power, efficiencies etc., Eulers' equation applied to a turbine, turbine velocities and velocity triangles, expression for work done.
Impulse Turbine: Components of Pelton turbine, definition of design parameters like speed ratio, jet ratio, and estimation of various parameters like head, discharge, and efficiency etc., determination of number of buckets.
Reaction Turbines: Types of reaction turbines - inward and outward flow, Francis turbine, Kaplan turbine; elements of the turbine, estimation of various parameters. Unit quantities in turbines.

Unit-VI **10 Hrs.**

Pumps

Classification of pumps: positive displacement and non-positive displacement.
Positive Displacement pumps: Types and applications, general features of rotary pumps, general feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram, use of air vessel.
Centrifugal Pumps: Types - radial flow, mixed flow and axial flow, priming of pumps, components of the pump, Euler's equation and velocity triangles, correction factors for the head, design constant e.g., head constant, flow constant etc. self-priming pumps, series and parallel operation of pumps, system curve, determination of operating point, Cavitation in pumps, Determination of available and required NPSH, Model testing, Dimensional analysis.
Submersible Pumps: Types and applications, general features of submersible pumps, work done and efficiency.

Power Engineering Laboratory (22PEME5064L)

Suggested Experiments

A Any 8 experiments:

1. Study/Demonstration of Boilers
2. Study/Demonstration of Boiler mountings and accessories
3. Study of Steam Turbine
4. Trial on Impulse turbine (Pelton Wheel)
5. Trial on Reaction water turbine (Francis / Kaplan turbine)
6. Study of Rotary compressors
7. Trial on Positive displacement pump
8. Trial on Single stage centrifugal pump
9. Trial on Multistage centrifugal pump
10. Demonstration of different components of Centrifugal pump by dismantling the pump system.

B Assignments or Mini project

Minimum five assignments based on syllabus (covering numerical).
A Mini project relevant to the subject may be included, which would help the learner to apply the concept learnt.

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 Thermal Engineering, R. K. Rajput, 10th edition, Laxmi Publication

2 Thermal Engineering, Kothandraman, Domkundwar, Khajuria, Arora, 5th edition, 2002, Dhanpatrai & Sons

3 Thermal Engineering, Ballaney P.L., 25th edition, 2015, Khanna Publishers.

4 Steam & Gas Turbines and Power Plant Engineering, R. Yadav, 7th edition, 2000, Central Publishing house Allahabad

5 Fluid Mechanics and Fluid Machines, D.S. Kumar, 2013, S.K. Kataria & Sons

6 Fluid Mechanics and Machinery, C. S. P. Ojha, P. N. Chandramouli, R. Berndtsson, 2010, Oxford University Press

7 Fluid Mechanics and Hydraulic Machinery, P. N. Modi and S. M. Seth, 17th edition, 2011, Standard Book House.

8 Hydraulic Machines, R. K. Rajput, S. Chand Publication.

9 Fluid Mechanics and Fluid Machines, Bansal R.K, 9th edition, 2015, Laxmi Publications.

10 Turbines, Fans and Compressors, Yahya S.M, 4th edition, 2011, Tata McGraw Hill.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Data Analytics (22PEME5065T)		
Data Analytics Laboratory (22PEME5065L)		

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.	L3	Apply
CO5	Select suitable plots for the given data and draw practical interpretations.	L3	Apply
CO6	Apply data science concepts and methods to solve problems in a real-world context.	L4	Analyze

Data Analytics (22PEME5065T)

Course Contents

Unit-I **06 Hrs.**

Introduction

Data science and data analytics, Types of data, Data recording/collecting, Data storing, Data preprocessing, Data describing/visualization, Statistical modelling, Algorithmic modelling, Missing data treatment, Relationship between AI, ML, DL, and Data Science, Big data, Database system.

Unit-II **06 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 **10 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.

Unit-IV **06 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.
Diagnostic analytics : root cause analysis, data mining, correlation, product quality analysis.

Unit-V **08 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.

Unit-VI **06 Hrs.**

Applications

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 (22PEME5065L)

Suggested Experiments

A Any 5 experiments:

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 To develop a regression model and evaluate its performance (any one algorithm).

4 To develop a classification model and evaluate its performance (any one algorithm).

5 To conduct hypothesis tests using p-test/ Chi-Square test/ z-test/ t-test/ ANOVA/ K-S test.

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

7 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.

8 To estimate the best-fit probability distribution for a given data set - Weibull, Exponential, Normal, and Lognormal.
Many five experiments from the following list should be performed for a data set using a suitable software package/ programming language.

B Group B : Mini project (Mandatory)

One mini project (in a group of 3-4 students)
based on the above contents and using the 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 Brunton, S. L., & Kutz, J. N. (2022). Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press.

2 Dunn, P. F., & Davis, M. P. (2017). Measurement and data analysis for engineering and science. CRC press.

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

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

5 Brandt, S. (1970). Statistical and computational methods in data analysis.

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

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

8 Niu, G. (2017). Data-driven technology for engineering systems health management. Beijing, China: Springer.

Reference Books

1 Zsolt Nagy, "Artificial Intelligence and Machine Learning Fundamentals", Packt Publishing, 2018, ISBN: 978-1-78980-165-1

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

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

Web References

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

2 Data Analytics with Python
`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
Incubation, Entrepreneurship and Startups (22PEME5066T)		
Laboratory		

Prerequisites:

-

Course Objectives:

1. To enable participants in exploring the Startup World: Investigate global startup stories and the role of incubators in fostering growth.
2. To foster an entrepreneurial mindset in participants: Develop creative problem-solving skills applicable to diverse challenges.
3. To guide participants in building effective Business Models: Learn the art of creating versatile business plans and understanding customer needs.
4. To assist participants in understanding Tech and Innovation: Explore the intersection of technology and entrepreneurship, and basics of idea protection.
5. To educate participants on Fundraising for Innovative Ventures: Explore diverse fundraising avenues and strategies to impress potential investors.
6. To equip participants for Execution and Growth: Develop skills for turning plans into action and strategies for sustained startup growth.

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 global startup ecosystem, recognizing the role of incubators.	L2	Understand
CO2	Apply creative problem-solving skills applicable to diverse challenges.	L3	Apply
CO3	Develop versatile business plans, applying lean startup methodologies and addressing customer needs.	L6	Create
CO4	Explain the intersection of technology and entrepreneurship, including the protection of intellectual property.	L2	Understand
CO5	Evaluate diverse fundraising avenues and impress potential investors with innovative ideas.	L5	Evaluate
CO6	Apply skills for effective startup execution and explore strategies for sustained growth.	L3	Apply

Incubation, Entrepreneurship and Startups (22PEME5066T)

Course Contents

Unit-I **08 Hrs.**

Understanding the Entrepreneurial Ecosystem

- Introduction to Entrepreneurship and Startups
- Global and Local Entrepreneurial Landscapes
- Role of Incubators and Accelerators
- Case Studies of Successful Startups
- Guest Lectures from Entrepreneurs and Incubator Managers

Unit-II **08 Hrs.**

Developing a Startup Mindset

- Cultivating an Entrepreneurial Mindset
- Design Thinking and Creativity in Mechanical Engineering
- Innovation and Idea Generation
- Practical Exercises and Workshops on Creative Problem Solving
- Group Projects: Ideation and Concept Development

Unit-III **08 Hrs.**

Business Model Development

- Introduction to Business Models
- Lean Startup Methodology
- Customer Validation and Market Research
- Prototyping and Minimum Viable Product (MVP)
- Business Model Canvas Workshop
- Pitching Practice: Presenting Business Models

Unit-IV **06 Hrs.**

Technological Innovation and Intellectual Property

- Technology Readiness Levels (TRLs)
- Technology and Entrepreneurship
- Intellectual Property Basics (Patents, Trademarks, Copyrights)
- Patent Search and Analysis
- Strategies for Protecting Intellectual Property
- Ethical Considerations in Technology and Innovation

Unit-V **06 Hrs.**

Fundraising and Investment Strategies

- Fundraising Options for Start-ups
- Indian Government Schemes for Start-ups and Entrepreneurs
- Angel Investors and Venture Capital
- Crowdfunding Platforms
- Financial Modelling for Startups
- Crafting an Effective Pitch
- Mock Pitch Sessions and Feedback

Unit-VI **06 Hrs.**

Execution and Scaling

- Challenges in Startup Execution
- Operations and Logistics for Startups
- Scaling Strategies for Mechanical Engineering Startups
- Case Studies of Startup Success and Failure
- Final Project: Develop and Present a Comprehensive Startup Plan
- Course Review and Reflection

Incubation, Entrepreneurship and Startups Laboratory (22PEME5066L)

Suggested Experiments

Any 8 experiments:

1. Market Research Simulation:
   Conduct a simulated market research project to identify potential customer needs and preferences for a startup idea.
2. Business Model Canvas Workshop:
   Collaboratively create a Business Model Canvas for a startup concept, emphasizing key components like value proposition, customer segments, and revenue streams.
3. Prototyping Challenge:
   Design and build a prototype of a product or service related to mechanical engineering, emphasizing rapid prototyping techniques.
4. Intellectual Property Workshop:
   Explore case studies and scenarios related to intellectual property in the context of startups, fostering an understanding of patenting, trademarks, and copyrights.
5. Pitching Practice Session:
   Engage in pitching sessions where students present their startup ideas, receiving constructive feedback from peers and instructors.
6. Financial Modelling Exercise:
   Develop a financial model for a startup project, considering costs, revenue projections, and potential investment scenarios.

7. Angel Investing Simulation:
   Simulate an angel investing scenario where students evaluate and decide on potential investments in startup projects.
8. Crowdfunding Campaign Design:
   Design a crowdfunding campaign for a startup idea, including the creation of promotional materials, goals, and rewards.
9. Startup Execution Simulation:
   Participate in a simulation that mirrors the challenges of executing a startup plan, allowing students to make decisions and adapt to changing circumstances.
10. Scaling Strategies Discussion:
    Analyse and discuss different strategies for scaling a startup, considering factors such as market expansion, partnerships, and technology adoption.

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 learn.

Books Recommended

Textbooks

1 Technology Entrepreneurship, Taking Innovation to the Marketplace by Thomas N. Duening.

2 Entrepreneurship Trajectories, by Diego Matricano

3 Entrepreneurship Development in India, by Vasant Desai

Reference Books

1 The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, by Eric Ries

2 Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, by Alexander Osterwalder and Yves Pigneur

3 Zero to One: Notes on Startups, or How to Build the Future, by Peter Thiel and Blake Masters

4 The Art of Startup Fundraising: Pitching Investors, Negotiating the Deal, and Everything Else Entrepreneurs Need to Know, by Alejandro Cremades

5 The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, by Clayton M. Christensen

6 Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist, by Brad Feld and Jason Mendelson

7 Disciplined Entrepreneurship: 24 Steps to a Successful Startup, by Bill Aulet

8 The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, by Steve Blank and Bob Dorf

9 Crossing the Chasm: Marketing and Selling Disruptive Products to Mainstream Customers, by Geoffrey A. Moore

10 The Founder's Dilemmas: Anticipating and Avoiding the Pitfalls That Can Sink a Startup, by Noam Wasserman

11 Entrepreneurship Development in India, by S. Anil Kumar

12 Entrepreneurship: Theory and Practice, by Dr. S. Ramesh Kumar

13 Indian Entrepreneurship: Analysis of Business Practices, by Rajat K Baisya

14 Start-up Sutra: What the Angels Won't Tell You About Business and Life, by Rohit Prasad

15 Entrepreneurship Development in India, by Vasant Desai

16 Startup Capitals: Discovering the Global Hotspots of Innovation, by Zafar Anjum

17 From Start-Up to Global Success: The Zensar Story, by Ganesh Natarajan

18 India's Intellectual Property Landscape: Lessons from the Biotechnology and Pharmaceutical Industries, by Kshama V. Kaushik

19 The Making of India: Gamechanging Transitions, by Akhilesh Tilotia

20 The Mouse Charmers: Digital Pioneers of India, by Anuradha Goyal

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Design Validation through Prototyping (22PEME5067T)		
Design Validation through Prototyping Laboratory (22PEME5067L)		

Prerequisites:

1. Fundamentals of Mechanical Engineering

Course Objectives:

1. Understand the importance of prototyping in product development and design validation.
2. Learn various prototyping techniques and tools, including low-fidelity and high-fidelity prototyping methods.
3. Develop skills in gathering and interpreting user feedback to inform prototyping decisions.
4. Explore strategies for rapidly iterating on prototypes to refine product concepts.
5. Gain experience in effectively communicating and presenting prototype designs to stakeholders.

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 prototyping in product development and design validation.	L2	Understand
CO2	Compare various methods of prototyping and select a suitable method for a given application.	L3	Apply
CO3	Demonstrate proficiency in utilizing various prototyping technologies and techniques.	L3	Apply
CO4	Execute design validation tests, including usability, functional, and compliance testing.	L4	Analyze
CO5	Describe regulatory and compliance requirements and integrate them into the design validation process.	L2	Understand

Design Validation through Prototyping (22PEME5067T)

Course Contents

Unit-I **06 Hrs.**

Introduction to Prototyping and Design Validation

- Product design and development process
- Need and role of prototyping in product development
- Dimensions of prototyping (four quadrants)
- Prototyping process
- Business case for prototyping
- Concept, need, and goals of product validation
- Overview of design validation methodologies
- Challenges and considerations

Unit-II **10 Hrs.**

Classification of Prototyping Techniques

- Low-fidelity prototyping: sketching, wireframing, paper, storyboarding, and card sorting
- Mid-fidelity prototyping
- High-fidelity prototyping: interactive, functional, Augmented Reality (AR), Virtual Reality (VR), simulation and emulators, high-fidelity mockups
- Other approaches: digital/virtual prototyping, physical prototyping, functioning prototyping, iterative prototyping
- Selecting the appropriate prototyping method
- Prototype scale: Full-, half-, quarter-, desktop-, micro-, and macro-scale

Unit-III **05 Hrs.**

Prototyping Technologies - I

- 3D printing, CNC machining, Injection molding, Vacuum casting, Laser cutting and engraving, Foam modeling, and Soft prototyping
- Physical prototyping materials and tools

Unit-IV **05 Hrs.**

Prototyping Technologies - II

- Prototyping software for 3D modeling and CAD
- Interactive mockup tools
- Code-based prototyping
- Accessibility and inclusive design tools
- Prototyping kits and templates
- Cloud-based prototyping and collaboration platforms

Unit-V **08 Hrs.**

Prototyping Planning, Execution, and Design Validation

- Planning prototyping activities: define goals, objectives, requirements and constraints
- Conceptualize and ideate: generate initial design concept
- Select prototyping method
- Develop prototype design: translating requirements and constraints into prototype
- Prototype fabrication
- Tests for design validation: functionality, performance, usability, reliability, etc. qualitative and quantitative testing methods to gather feedback from users and stakeholders
- Iterate and refine
- Finalize Design
- Document and communicate

Unit-VI **08 Hrs.**

Regulatory Compliance and Standards

- Importance of regulatory requirements, compliance, and industry standards
- Regulatory agencies and bodies: FDA, ISO, ASTM, etc.
- Industry-specific regulations: medical devices, automotive, aerospace, etc.
- Types of compliance testing: safety, performance, environmental, electromagnetic compatibility (EMC), etc.
- Laboratory testing vs. field testing: advantages and limitations
- Impact of regulatory requirements on prototype planning, design and materials selection
- Incorporating compliance considerations into the design validation process
- Risk assessment and mitigation strategies in compliance testing
- Documentation and recordkeeping; data management strategies
- Case studies: Compliance testing and regulatory challenges

Design Validation through Prototyping Laboratory (22PEME5067L)

Suggested Experiments

Any 8 experiments: Design Validation through Prototyping Laboratory (22PEME5067L)

1 Study the role of prototyping in the product design and development process.

2 Low-fidelity prototyping: sketching, wireframing, paper, storyboarding, and card sorting

3 Mid-fidelity prototyping.

4 High-fidelity prototyping: interactive, functional, Augmented Reality (AR), Virtual Reality (VR), simulation and emulators, high-fidelity mockups.

5 Selecting the appropriate prototyping method and scale (Full-, half-, quarter-, desktop-, micro- and macro-scale).

6 3D printing/ CNC machining/ Injection molding/ Vacuum casting/ Laser cutting and engraving/ Foam modeling/ and Soft prototyping.

7 Prototyping software for 3D modeling and CAD/ Interactive mockup tools/ Code-based prototyping/ Accessibility and inclusive design tools/ Prototyping kits and templates.

8 Cloud-based prototyping and collaboration platforms.

9 Prototyping materials and tools.

10 Study on the prototyping planning and execution process

11 Study on the various regulatory compliance and standards (in a group of 3-4 students)

12 Types of compliance testing: safety, performance, environmental, electromagnetic compatibility (EMC), etc.

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

Books Recommended

Textbooks

1 Prototyping and Modelmaking for Product Design by Bjarki Hallgrimsson, 2nd Edition, Quercus Publishing, 2023.

2 Rapid Prototyping: Principles and Applications in Manufacturing by Chua, C.K., Leong, K.F., John Wiley and Sons Inc., 2003.

3 Rapid Prototyping: Principles and Applications by Noorani, R., John Wiley & Sons, Inc., New Jersey, 2006.

Reference Books

1 Prototyping: A Practitioner's Guide by Todd Zaki Warfel, Rosenfeld Media 2009.

2 Prototype: Design and Craft in the 21st Century, by Louise Valentine, Bloomsbury Publishing 2013.

3 Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, McGraw-Hill/Irwin, 2012.

Web References

1

2 Electronics equipment integration and Prototype building - https://nptel.ac.in/courses/108108157

3 Physical Modelling for Electronics Enclosures using Rapid prototyping - https://nptel.ac.in/courses/108108115

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Environmental Studies (22MCME5070T)		

Prerequisites:

1. Interest in Environment and its impact on Human.

Course Objectives:

1. Understand environmental issues such as depleting resources, pollution, ecological problems and the renewable energy scenario.
2. Familiarize environment related legislation.
3. Understand and compare solar energy.

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 other forms of energy.	L2	Understand

Environmental Studies (22MCME5070T)

Course Contents

Unit-I **05 Hrs.**

Social Issues and Environment

- Ecological footprint and Carrying Capacity
- Depleting nature of Environmental resources such as soil, water, minerals and forests
- Carbon emissions and Global Warming
- Concept of Carbon credit
- Green Building

Unit-II **05 Hrs.**

Technological Growth for Sustainable Development

- Social, Economical and Environmental aspects of Sustainable Development
- Renewable Energy Harvesting
- Power and functions of Central Pollution Control Board and State Pollution Control Board

Unit-III **04 Hrs.**

Solar Energy

- Basic concept of Solar Radiation
- Study of Solar panels
- Comparative study of Solar energy with other energy sources

Performance in the assignments / quiz / power point presentation / poster presentation / group project / any other tool.

Books Recommended

Textbooks

1 Environmental Studies from Crisis to Cure, R. Rajagopalan, 2012

2 Textbook of Environmental Studies for Undergraduate Courses, Erach Bharucha

3 Solar Engineering Sukhatme

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: V
Semester Project III (22PJME5080L)		

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 (22PJME5080L)

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 Second-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
Employability Skill Development Program- II (22HMME5090L)		

Prerequisites:

1. Basic Mathematics
2. Basic knowledge of C programming

Course Objectives:

1. To enhance problem-solving skills with real-life examples.
2. To enable students to express their thoughts and knowledge on various platforms.
3. To describe basic database management systems.
4. To implement basic programming projects using Python.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Solve logical problems based on words, Venn diagrams, etc.	L3	Apply
CO2	Solve English comprehension, sentence completion, and sentence correction problems.	L3	Apply
CO3	Illustrate the concepts of Exception Handling and Garbage Collection.	L3	Apply
CO4	Describe the fundamentals of DBMS, NoSQL, and MongoDB.	L2	Understand

Employability Skill Development Program- II (22HMME5090L)

Course Contents

Unit-I **06 Hrs.**

Aptitude

Reasoning: Data sufficiency, logical deductions, logical sequence of words, logical Venn diagrams, statement and arguments, statement and assumptions, statement and conclusions, syllogism.
English: Reading comprehension, para jumbles, cloze test, tenses/ voice/ speech, prepositions/ SVA/ articles, vocab/ verbal analogy, sentence completion, sentence correction.

Unit-II **06 Hrs.**

Fundamental of Programming - I

Modules: Introduction, importance of modularity programming, import keyword, user-defined modules creation, function-based modules, classes based modules, connecting modules, 'from' keyword.
Exception Handling: Introduction, the need for exception handling, getting exceptions, default exception handler, handling exception, try, except.
Garbage Collection: Introduction, importance of manual GC, self-referenced objects, 'gc' module, collect() method, threshold function.

Unit-III **06 Hrs.**

Fundamental of Programming - II

Collections Framework: Introduction to collection of data types, importance of data processing, DS algorithms introduction.
List: Create a list, adding elements, deleting elements, predefined functionality of List, nested List, immutability and mutability of List.
Set: The functionality of Set object, frozen set, dictionaries, create a dictionary, adding elements.
Dict: Predefined functions of Dict class, programs using collection types.

Unit-IV **02 Hrs.**

Tkinter-GUI

Tkinter-GUI: Types of layouts, create labels and display images, create buttons, create events, StringVar class, calculator program using GUI.
Basic ML AI including projects iterators, nested functions, generators, closures, decorators, basic ML and AI, PIP, visualization, etc.

Project Domain (Per domain 1 or 2 projects)

1. ML/AI Based Projects
2. Data Analysis Based projects
3. Test Summarization based projects
4. Web scraping and crawling

Unit-V **08 Hrs.**

DBMS

DBMS Using Python: Introduction to MySQL, MySQL-Python connectivity, execute DDL commands, execute DRL commands, execute DML commands, transaction management examples (rollback and commit), GUI-Database connectivity.
NoSQL Using Python: Installation and configuration, MongoDB advantages, MongoDB data modeling, MongoDB tools, collection and documents, CRUD and the MongoDB shell, introduction to CRUD, introduction to the MongoDB API, creating a database, collection and documents.
Data Modeling and Schema Design: MongoDB database references model tree structures, MongoDB analyzing queries, MongoDB atomic operations, MongoDB MapReduce, MongoDB text search, MongoDB regular expression, MongoDB capped collections.
Administration: MongoDB deployment and cluster setup, MongoDB GridFS, Trident Spout, working with replica sets, MongoDB sharding.

Books Recommended

Reference Books

1 Dr. R S Aggarwal, "Quantitative Aptitude for Competitive Examinations", S. Chand Publication.

2 M. G. Venkateshmurthy, "Programming Techniques through C", Pearson Publication.

3 Behrouz Forouzan, "A Computer Science Structure Programming Approaches using C", Cengage Learning.

4 Yashwant Kanetkar, "Let Us C", BPB Publication.

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

(RCP22 Scheme) with effect from Year 2024-25

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 (22PCMEC6010T)		
Design of Machine Elements Laboratory (22PCMEC6010L)		

Prerequisites:

1. Mechanics of Materials
2. Engineering Materials

Course Objectives:

1. To study basic principles of design of machine elements.
2. To familiarize with 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 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	Use design data books in designing various components.	L3	Apply
CO2	Illustrate basic principles of machine design.	L3	Apply
CO3	Demonstrate understanding of various design considerations, theories of failures, Standards/Codes.	L3	Apply
CO4	Design machine elements for static as well as dynamic loading.	L6	Create
CO5	Design machine elements on the basis of strength/ rigidity concepts.	L6	Create
CO6	Design of clutches and flexible drives.	L6	Create

Design of Machine Elements (22PCMEC6010T)

Course Contents

Unit-I **06 Hrs.**

Introduction to Design of Machine elements

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 **10 Hrs.**

Design of Static Loads

Design against Static Loads: Cotter joint, 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 of Fluctuating Loads

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 **06 Hrs.**

Design of Shaft, Key & Coupling

Design of 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.

Unit-V **06 Hrs.**

Design of spring & Shells

Design of springs: Design of helical compression and tension springs under Static and Variable loads, design of laminated springs.
Design of Thin Cylindrical and Spherical Shells: Design of Cylinders, Cylindrical shell with hemispherical ends and Spheres.

Unit-VI **08 Hrs.**

Design of Flexible Drive & Clutches

Design of Flexible curvature drive: Flat belt, V-belt, Rope drive, Selection of Roller Chain drive. Design of friction Clutches: Type of Clutches, Analysis of clutches, design of friction clutch.

Design of Machine Elements Laboratory (22PCMEC6010L)

Suggested Experiments

A The following assignments are to be solved in the lab sessions in the form of a tutorial or any software-based exercises (Minimum six):

1. Design of Curved Beams
2. Design of Cotter Joint
3. Design of Knuckle Joint
4. Design of screw jack along with 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 Laminated Spring

B Prepare a layout of 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 Screw jack

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. V. B. Bhandari, Design of Machine Elements, Tata McGraw-Hill Education, Third 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, Elesevier, 5th Edition, 2017.

3 D. N. Reshetov, Machine Design, Mir Publishers Black Adams, Machine Design, McGraw Hill, Third Edition

4 Hawrock, Jacobson, Fundamental of Machine Elements, McGraw Hill, Third Edition, 2014.

5 V.M. Faires, Design of Machine Elements, The Macmillan Co., Fourth Edition

6 P. Orlov, Fundamentals of Machine Design, Mir Publishers, Design Data Book, PSG, 2012

7 Design Data Book, Mahadevan, CBS Publishers and Distributors Pvt Ltd, Fourth Edition, 2013.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Finite Element Analysis (22PCMEC6020T)		
Finite Element Analysis Laboratory (22PCMEC6020L)		

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.	L5	Evaluate
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 (22PCMEC6020T)

Course Contents

Unit-I **06 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 of field problems in engineering, Governing Differential equations in different fields.

Unit-II **06 Hrs.**

Non-Weak & 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 element and for entire domain. Principle of minimum potential energy.

Unit-III **10 Hrs.**

1-D Finite Element

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 taper bars, fluid network and spring-Cart Systems). Analysis of Plane trusses and Analysis of Beams.

Unit-IV **08 Hrs.**

2-D Finite Element

Three node triangular element, four node rectangular element, four node and eight node quadrilateral element. Derivation of shape functions for triangular and quadrilateral element. Sub parametric, Isoparametric, super parametric elements, Compatibility conditions, Patch test, Convergence criterion and sources of errors in FEA.

Unit-V **06 Hrs.**

Stress Analysis of 2-D Elements

Stress Analysis of Two Dimensional Elements: Equations of elasticity-Plane stress, plane strain and axisymmetric problems. Jacobian matrix, stress analysis of CST and four node Quadrilateral element.

Unit-VI **06 Hrs.**

Dynamic & 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 (22PCMEC6020L)

Suggested Experiments

A Experiments:

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

B Mini course project

- Learners shall use the commercial software (ANSYS/ABAQUS/NASTRAN/HYPERWORKS) or programs (Codes) to perform above experiments. Learners shall also validate the experimental results with manual calculations (wherever applicable).
- Any other experiment based on syllabus may be included, which would help the learner to understand 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.
- **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.

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, 2019.

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.

Web References

1 NPTEL Course on Basics of Finite Element Analysis
https://archive.nptel.ac.in/courses/112/104/112104193/

2 NPTEL Course on Finite Element Method
https://archive.nptel.ac.in/courses/112/105/112105308/

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Control Systems (22PCMEC603T)		
Control Systems Laboratory (22PCMEC603L)		

Prerequisites:

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Course Objectives:

1. To study concept of mathematical modelling of the control system.
2. To acquaint with control system under different time domain.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Represent the systems in Blocks and apply the reduction technique to simplify the system.	L3	Apply
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 (22PCMEC603T)

Course Contents

Unit-I **08 Hrs.**

Introduction

Introduction to control systems, Classification of control system. Open loop and closed loop systems. Mathematical modeling of control systems, the concept of the transfer function.

Unit-II **08 Hrs.**

Control Systems

Block diagram algebra, Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graphs, State diagram from differential equations.

Unit-III **09 Hrs.**

Time response of dynamic systems

Time domain performance of control systems: Typical test signal, Unit step response and time domain specifications of first order, second order system. Steady-state error, error constants.

Unit-IV **09 Hrs.**

Stability Analysis

Control system design and analysis by Root Locus Method, Control system Design by Frequency response method, stability margin, Nyquist diagram, Bode diagram. P, I and D control actions, P, PI, PD and PID control systems, Transient response: Percentage overshoot, Rise time, Delay time, Steady state error, PID tuning (manual), Zigler Method.

Unit-V **08 Hrs.**

Discrete Control System PLC (Programming Logic Control

Introduction to PLC, Architecture, Ladder Logic programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming.

Control Systems Laboratory (22PCMEC603L)

Suggested Experiments

Any 8 experiments:

1 Different Toolboxes in MATLAB, Introduction to Control Systems Toolbox.

2 Determine transpose, inverse values of given matrix

3 Plot the pole-zero configuration in s-plane for the given transfer function.

4 Determine the transfer function for given closed loop system in block diagram representation.

5 Plot unit step response of given transfer function and finds delay time, rise time, peak time and peak overshoot.

6 Determine the time response of given system subjected to any arbitrary input.

7 Plot root locus of given transfer function, locate closed loop poles for different values of k.

8 Determine the steady state errors of a given transfer function.

9 Plot bode plot of given transfer function. Also determine the relative stability by measuring gain and phase margins.

10 Experiments on feedback control systems and servomechanisms

11 System Identification of any one of the sensors

12 Experiment on frequency response system identification

13 Experiment on transient state response of a control system

14 Experiment on transient response of a control system

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. The mode of conduction of experiments can be in either physical mode or Soft mode using the inbuilt Apps or Matlab.

Books Recommended

Textbooks

1 Franklin G. F., Powell J. D., Emami-Naeini A., Feedback Control of Dynamic Systems, Pearson, Upper Saddle River, New Jersey, 5th edition, 2006.

2 K. Ogata, Modern Control Engineering, Prentice Hall of India, 4th edition, 2002

3 B. C. Kuo, Farid Gdna Golnaraghi, Automatic Control Systems, PHI, 7th edition, 2003.

Reference Books

1 M. Gopal, Control Systems Principles and Design, TMH, New Delhi, 2nd edition,2002

2 Norman S. Nise, Control Systems Engineering, John Wiley and Sons, Inc. 2000.

3 Francis Raven, Automatic Control Engineering, 5th edition McGraw-Hill International Edition.

4 G. C. Goodwin, S. F. Graebe, M.E. Salgado, Control System Design, Pearson education

5 Gopal, Control Systems Principles and Design, TMH, New Delhi, 2nd edition, 2002.

6 Stefani, Shahian, Savant, Hostetter, Design of Feedback Control Systems, Oxford University Press, 4th edition, 2007.

7 Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Addition-Wesley,1999.

8 I. J. Nagrath and M. Gopal, Control System Engineering, 3rdEdition, New Age International (P) Ltd., Publishers - 2000.

9 M. N. Bandopadhay, Control Engineering - Theory & Practice, PHI, 2003.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Quality Engineering (22PCMEC6041T)		
Quality Engineering Laboratory (22PCMEC6041L)		

Prerequisites:

1. Knowledge of Probability and Statistics.
2. Knowledge of MS Excel, Mini Tab basics.

Course Objectives:

1. Understand basic quality management principles.
2. Understand the relationship of the quality engineer to the quality system.
3. Analyze the relationship of statistics to a process.
4. Understand process capability and use statistical process control to monitor a process.
5. Generate acceptance sampling plans and identify and use technical quality tools.
6. Apply problem-solving tools and basic statistical concepts, process control and process capability plans, acceptance sampling, and attribute controls

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 importance of Quality for survival and growth of any business.	L2	Understand
CO2	Apply the different control charts for quality improvement.	L3	Apply
CO3	Evaluate Process capability and determine tolerance limits for different processes.	L5	Evaluate
CO4	Apply ANOVA test and decide the degree of relation between independent variables.	L3	Apply
CO5	Describe the significance of quality and application of Six Sigma in the service sector.	L2	Understand

Quality Engineering (22PCMEC6041T)

Course Contents

Unit-I **06 Hrs.**

Introduction

Introduction: Different Definitions and Dimensions of Quality, Historical Perspective, Contribution of Renowned Quality Gurus, Total Quality Management Basic Philosophy, Approach, Barriers.
Mindset of Quality Improvements: High quality of product and service and their associated customer satisfaction are the key to the survival and growth for any enterprises. Management culture advocating a total commitment to customer satisfaction through continuous improvement and innovation in all aspects of the business must be discussed in detail.

Unit-II **09 Hrs.**

Control charts

Introduction to Control charts, construction, and application. Chance and assignable causes of process variation, Statistical basis of the control chart for variable, Attribute control charts -p, n, np, c, and u charts.

Unit-III **06 Hrs.**

Acceptance Sampling

Acceptance Sampling Fundamental, QC Curves, Sampling Plans for Attributes, Signal and double sampling plans, Multiple and Sequential sampling plans, sampling plans for variables Demo on use of software like MS Excel, Minitab and JMP for control charts and acceptance sampling.

Unit-IV **12 Hrs.**

Introduction to Design of Experiments

Introduction, Methods, Taguchi approach, achieving robust design, Steps in experimental design. Introduction to ANOVA, Need for ANOVA, NO-way ANOVA, One-way ANOVA, Two-way ANOVA, ANOVA for four level factors, multiple level factors. Introduction to t-test, f-test and hypothesis in connection with ANOVA.
Demo on use of software like MS Excel, Minitab and JMP for DOE.

Unit-V **06 Hrs.**

Quality in Service Sectors

Characteristics of Service Sectors, Quality Dimensions in Service Sectors, Measuring Quality in Different Service Sectors, Six sigma DMAIC methodology, and tools for process improvement, six sigma in services and small organizations, statistical foundations, statistical methodology.

Quality Engineering Laboratory (22PCMEC6041L)

Suggested Experiments

Any 8 experiments:

1. Case studies on Statistical Process Control
    1. Control Charts for Variable Data
    (Plotting of X bar and R chart and evaluation of process capability)
    2. Control Charts for Attribute Data
    (Plotting of p- chart, np-chart, u-chart, and c- chart)
2. Case studies on Design of Experiments
    1. Single-factor experiment
    (In single factor experiments only one factor is investigated)
    2. Multi-factor factorial experiment
    (In factorial experiments, combination of two or more levels of more than one factor is the treatment)
    3. The 2k Factorial Experiments
    (A factorial design with k-factors, each at only two levels is called 2k design, a special case of multi- factor factorial experiment)
    4. Design of experiments using orthogonal array
    (Data collected from Taguchi/Orthogonal Array (OA) experiments can be analysed using response graph method or Analysis of Variance (ANOVA))
    5. Robust design
    (experiments can be analysed using S/N RATIOS)

In term work all experiments as listed above or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt. All case studies shall be solved using available software tools (MS Excel, Minitab, JMP (statistical software), etc.) and concluded.

Books Recommended

Textbooks

1. D. C. Montgomery; Introduction to Statistical Quality Control;Edition 6; 2009;John Wiley & Sons
2. Tapan P. Bagchi; Taguchi Methods explained: Practical steps to Robust Design; 1993; Prentice Hall Pvt. Ltd., New Delhi.
3. N. Logothetis; Managing for Total Quality; 1997; Prentice Hall of India
4. K. Krishnaiah; Applied Design of Experiments and Taguchi Methods; 2012; Prentice Hall of India

Reference Books

1. Grant and Leavenworth; Statistical Quality Control; 1996; McGraw-Hill
2. R.E. Devor, T. Chang; J.W. Sutherland, Statistical Quality Design and Control; 2003; Prentice Hall
3. D.A. Garvin; Managing Quality; 1988; Free Press
4. G. Taguchi; Introduction to Quality Engineering; 1986; Asian productivity organization

5 H.J. Harrington; Poor Quality Cost; 1987; Tayler and Francis

6 M.S. Phadke; Quality Engineering Using Robust Design; 1989; Prentice Hall.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Vehicle Dynamics and NVH (22PCMEC6042T)		
Vehicle Dynamics and NVH Laboratory (22PCMEC6042L)		

Prerequisites:

1. Manufacturing processes, mechanics of materials.
2. Mechanical vibrations.
3. Automotive systems.

Course Objectives:

1. To analyze the behavior of vehicles under different dynamic conditions.
2. To impart the knowledge of automotive noise and vibration sources and their measurement techniques

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 knowledge of automotive systems and analyse the vehicle dynamic performance.	L4	Analyze
CO2	Evaluate the Tyre forces during the vehicle acceleration and braking dynamics.	L5	Evaluate
CO3	Analyze the steering & suspension systems and their influence on vehicle handling.	L4	Analyze
CO4	Analyze the sources of noise and vibration in automotive applications.	L4	Analyze

Vehicle Dynamics and NVH (22PCMEC6042T)

Course Contents

Unit-I **07 Hrs.**

Introduction to vehicle dynamics

Introduction to vehicle dynamics: Dynamics of the motor vehicle, Vehicle fixed coordinates system, Earth fixed coordinates system, Details of vehicle systems, wheel angles and Typical data of vehicles. Forward Vehicle Dynamics : Resistance to the Motion of Vehicle, Road Performance curve, Resistances at various vehicle speeds, Traction and Tractive effort, Acceleration, power required for propulsion of vehicle, gear ratio for maximum acceleration. Analysis of parked car on a level road, parked car on an inclined road, accelerating car on a level road, accelerating car on an inclined road, Parked car on a banked road, Vehicles on crest and rip.

Unit-II **07 Hrs.**

Longitudinal dynamics

Forces and moments on vehicle, Equation of motion, Tire forces, rolling resistance, weight distribution, Tractive effort and Power available from the engine, Evaluation of maximum acceleration, braking torque, braking force, brake proportioning, braking efficiency, stopping distance, prediction of vehicle performance.

Unit-III **07 Hrs.**

Lateral Dynamics

Steering geometry, Types of steering systems, Fundamental condition for true Rolling, Evaluation of lateral forces. Steady state handling characteristics. Yaw velocity, Lateral Acceleration, Curvature response & directional stability.

Unit-IV **07 Hrs.**

Vertical Dynamics

Sources of Vibration, Suspension systems, Functions of suspension system. Body vibrations: Bouncing and pitching riding comfort, vibration transmission to the passengers; Analysis of vehicle suspension models.

Unit-V **07 Hrs.**

Noise, Vibration & Harshness

Introduction to types of automotive noises, noise propagation, measurement, Noise limits for vehicles, Acoustic source characteristics of I.C. Engines, Mufflers, Noise control strategies, estimation and control of noise of prime movers.

Unit-VI **07 Hrs.**

Vibration Measurement

Vibration and its measurement, vibration control, vibration isolators, passive and active engine mounts, crankshaft damping, active vibration control.

Vehicle Dynamics and NVH Laboratory (22PCMEC6042L)

Suggested Experiments

Any 6 experiments:

1 Numerical investigation of different vehicle resistances on flat and inclined roads.

2 Simulation of different vehicle resistances on flat and inclined roads on MATLAB Simulink.

3 Experimental determination of damping coefficient of any system.

4 Simulation of steering / suspension system using Adams / Solidworks software / any other software.

5 Stress analysis of ladder frame chassis on ANSYS / Solidworks under different loading conditions.

6 Investigation of vibration in light motor vehicle in dynamic conditions.

7 Case study on noise control strategies deployed in the automotive industry.

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.

Books Recommended

Textbooks

1 Bruce P. Minaker, Fundamentals of Vehicle Dynamics and Modelling, 2019, John Wiley & Sons.

2 Martin Meywerk, Vehicle Dynamics, 2015, Wiley.

3 M L Munjal, Noise and vibration control, 2013, IISC Press.

Reference Books

1 Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, 2021, SAE International

2 Rajesh Rajamani, Vehicle Dynamics and Control, 2012, Springer US.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Mechanical Vibrations (22PCMEC6043T)		
Mechanical Vibrations Laboratory (22PCMEC6043L)		

Prerequisites:

1. Engineering Mechanics
2. Differentiation, Integration and Matrix Operations
3. Dynamics of Machinery

Course Objectives:

1. To formulate the equations of motion of multi degree-of-freedom systems
2. To find the natural frequencies of vibration and the modal shapes of multi degree-of-freedom systems
3. To develop response equations for undamped system under support excitation, rotary unbalance and reciprocating unbalance
4. To analyze the effects of vibration for systems with vibrating base.
5. To evaluate the various aspects of machine-condition monitoring
6. To develop the applications of vibration absorbers.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze systems with multi degree of freedom system.	L4	Analyze
CO2	Evaluate response of undamped systems under support excitation, rotary unbalance and reciprocating unbalance.	L5	Evaluate
CO3	Create a vibration and shock isolation system for systems with vibrating base.	L6	Create
CO4	Analyze various aspects of machine-condition monitoring.	L4	Analyze
CO5	Develop systems with undamped and damped vibration absorbers to control vibrations in machines and structures.	L6	Create

Mechanical Vibrations (22PCMEC6043T)

Course Contents

Unit-I **10 Hrs.**

Multi Degree of Freedom System (more than 2 DOF)

Basic Concepts of Vibration: Introduction, Free and Forced Vibrations, Damped and Un-damped Vibrations, Degree of Freedom.
Two-Degree-of-Freedom Systems: Introduction, Mode Shapes, Free Vibration. Analysis of an Un damped Systems – Translational and Torsional, using Newton's second law, and Lagrange s Equations.

Unit-II **06 Hrs.**

Forced Vibrations

Introduction, Mode Shapes, Determination of Natural Frequencies, Modelling of Continuous Systems as Multi degree of-Freedom Systems, Using Newton s Second Law to Derive Equations of Motion, Influence Coefficients, Equations of Motion of Un damped Systems in Matrix Form, Eigenvalue Problem, Solution of the Eigenvalue Problem (Undamped and Free Vibrations systems only), Dunkerley's Formula, Rayleigh's Method, and Holzer's Method.

Unit-III **07 Hrs.**

Machine Condition Monitoring and Diagnosis

Analysis of Forced Vibration System systems under support excitation, rotary unbalance and reciprocating unbalance.

Unit-IV **07 Hrs.**

Machine Condition Monitoring and Diagnosis

Vibration Severity Criteria, Machine Maintenance Techniques, Machine Condition Monitoring Techniques, Vibration Monitoring Techniques, Instrumentation Systems, Choice of Monitoring Parameter.

Unit-V **06 Hrs.**

Vibration Isolation

Vibration Isolation: Vibration Isolation System with Flexible Foundation, Vibration Isolation System with Partially Flexible Foundation, Shock Isolation, Active Vibration Control.

Unit-VI **06 Hrs.**

Vibration Absorbers

Vibration Absorbers: Undamped Dynamic Vibration Absorber, Damped Dynamic Vibration Absorber.

Mechanical Vibrations Laboratory (22PCMEC6043L)

Suggested Experiments

Any 8 experiments:

1. Modal Analysis of Impact Test on cantilever
2. Sine Sweep of base excitation of cantilever
3. Find MI of irregularly shaped solid body using tri-filar suspension
4. Analysis of System with Single Degree under Arbitrary Excitation
5. Analyze Working of Tuned Vibration Absorber
6. Evaluation of Effects of Base Excitation
7. Analyze the Effects of Rotating Unbalance
8. Simulate System with Two Degree of Freedom under Forced vibration
9. Study the Working of Dynamic Vibration Absorber
10. Evaluate the Effects of Mechanical Looseness
11. Analyze Sympathetic Vibrations and evaluate its Effects
12. Simulation of FFT Analyzer using MATLAB
13. Vibration Analysis using MATLAB – SIMULINK

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. S.S.Rao, Mechanical Vibrations, Pearson Education, 6th edition 2018
2. G. K. Grover, Mechanical Vibraitons, Nem Chand & Bros, 2009.
3. S.Graham Kelly, Fundamentals of Mechanical Vibration, Tata McGraw Hill, Edition. 2nd, 2000.
4. P. Srineevasan, Vibration Analysis, Tata McGraw Hill, 1982
5. William W.Seto, Mechanical Vibrations- Schaum's outline series, McGraw Hill, 1964.
6. J.S.Rao, K. Gupta, Theory and Practice of Mechanical Vibrations, New Age International Publications, Second Edition, 1999.

Reference Books

1. Leonard Meirovitch, Elements of Vibration Analysis, McGraw - Hill, New York, 1986.
2. Antony J. Pettofrezzo, Matrices and Transformations, Dover, New York, 1978.
3. Benson H. Tongue, Principles of Vibration, Oxford University Press, 2001.
4. W. Thomson, Theory of Vibration with Applications, Pearson Education, 2008.
5. Balakumar Balachandan, Edward Magrab, Vibrations, Cengagae Learning, 2008.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Refrigeration and Air-Conditioning (22PCMEC6044T)		
Refrigeration and Air-Conditioning Laboratory (22PCMEC6044L)		

Prerequisites:

1. Thermodynamics
2. Heat transfer

Course Objectives:

1. To discuss the principles of refrigeration and air-conditioning systems.
2. To analyze and compare the performance of different refrigeration and air-conditioning systems.
3. To discuss the controls and applications 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 fundamentals of refrigeration cycles and calculate the coefficient of performance of 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 principles.	L6	Create
CO5	Examine the role of sensors & controls techniques used in modern HVAC systems.	L5	Examine

Refrigeration and Air-Conditioning (22PCMEC6044T)

Course Contents

Unit-I **06 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.**

Refrigeration Systems

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: Desirable properties of refrigerants, ASHRAE numbering system for refrigerants, Secondary refrigerants, ODP and GWP, Montreal & Kyoto protocol and India's commitment & Recent developments in refrigerants.
Non-Conventional Refrigeration Systems: Thermoelectric refrigeration, Thermo-acoustic refrigeration, Vortex tube refrigeration systems & Radiant heating and cooling systems.

Unit-III **06 Hrs.**

Psychrometry

Need for air conditioning, Principle of psychromerty, 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

Different Heat sources, Cooling Load estimation, Ventilation and infiltration, Inside and Outside Design condition, Room apparatus dew point and coil apparatus dew point temperature, RSHF, GSHF, ERSHF.
Human Comfort, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone, Indoor Air Quality, Green Buildings. Sustainable techniques

Unit-V **06 Hrs.**

Duct Design

Introduction to 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 system. Air distribution systems for cooling and heating.
Air Handling: Fan coil unit, Types of fans used air conditioning applications, Fan laws, supply and

return grills.

Unit-VI **06 Hrs.**

Components and Control

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, IoT in HVAC industry.

Refrigeration and Air-Conditioning Laboratory (22PCMEC6044L)

Suggested Experiments

Any 7 experiments:

1 Comparison and analysis of different refrigerator systems along with troubleshooting.
2 Research on leak detection, evacuation methods and charging of refrigerant.
3 Report on different refrigerant protocols to regulate global warming.
4 Experimental analysis of refrigeration test rig performance parameters.
5 Experimental analysis of an air conditioning test rig performance parameters.
6 Steady state simulation of VCR system with an analytical software.
7 Cooling load estimation exercise for an actual room/auditorium.
8 Visit report of a manufacturing unit of refrigerator/air-conditioner or a cold storage plant/ice plant.
9 Report on IoT implantation in HVAC industry.

Minimum seven 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 C P Arora, Refrigeration and air-conditioning, 2018, TMH
2 Domkundwar, Arora, Refrigeration and air-conditioning, 2017, Dhanpat Rai
3 P.Ananthanarayana, Basic Refrigeration and air-conditioning, 2016, TMH

Reference Books

1 R J Dossat, Principles of refrigeration, 2002, Willey Eastern Publication
2 Roger Legg, Air Conditioning System Design, 2017, BH
3 ASHRAE Handbook of Fundamentals
4 ISHRAE Refrigeration Handbook
5 ISHRAE Air Conditioning Handbook

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Machine Learning (22PCMEC6045T)		
Machine Learning Laboratory (22PCMEC6045L)		

Prerequisites:

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

Course Objectives:

1. Acquaint with fundamentals of artificial intelligence and machine learning.
2. Learn feature extraction and selection techniques for processing data sets.
3. Understand basic algorithms used in classification and regression problems.
4. Outline the steps involved in the development of the machine learning model.
5. Familiarize with concepts of reinforced and deep learning.
6. Implement and analyze machine learning models 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	Apply the fundamentals of artificial intelligence and machine learning.	L3	Apply
CO2	Apply feature extraction and selection techniques.	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	Apply the concepts of reinforced and deep learning to solve mechanical engineering problems.	L3	Apply
CO6	Analyze machine learning models in mechanical engineering problems.	L4	Analyze

Machine Learning (22PCMEC6045T)

Course Contents

Unit-I **06 Hrs.**

Feature Extraction and Selection

Introduction to AI-ML: History of AI, Comparison of AI with Data science, Need of AI-ML-DL in Mechanical Engineering, Introduction to Machine Learning. Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation.
Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical.
Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning.

Unit-II **06 Hrs.**

Classification and Regression Models

Feature extraction: Statistical features, Principal Component Analysis.
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 **08 Hrs.**

Classification Models - Random Forest, Logistic regression, decision tree, Support Vector Regression, K-Nearest Neighbor (KNN), K-Means, Naive Bayes.
Regression Models - Linear and non-linear regression, neural network regression, overfitting and underfitting. Applications of classification models in Mechanical Engineering.

Unit-IV **08 Hrs.**

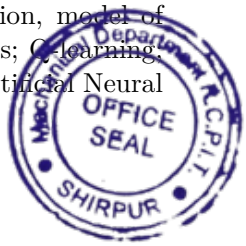
Development of ML Model

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.

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. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network.



Unit-VI **06 Hrs.**

Applications

Applications should be related to the following 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.
(Note – Numerical should be related to mechanical and allied engineering domains.)

Machine Learning Laboratory (22PCMEC6045L)

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, and reinforcement learning approach: Explore applications of these learning methods to analyze mechanical systems, control processes, or material behavior. acquire, visualize and analyze the data set (from time-domain/ frequency-domain/ etc.): Work with data sets from time-domain, frequency-domain, or strain gauges, vibration analysis, or thermal data from mechanical systems.

2 To extract features from given data set and establish training data: Extract relevant features from datasets obtained from sensors, strain gauges, or operational data of mechanical systems, and prepare it for machine learning. select relevant features using suitable technique: Use suitable techniques (e.g., statistical tests, mutual information) to select relevant features for analysis in mechanical performance prediction or failure analysis.

3 To use PCA for dimensionality reduction: Apply PCA to reduce the number of features in complex mechanical data sets, like vibration signatures or temperature-time histories, while retaining critical information.

4 To classify features/ To develop classification model and evaluate its performance (any one classifier): Develop a classification model (e.g., SVM, decision trees) to categorize mechanical system behavior (e.g., fault detection or material property prediction) and evaluate its performance.

5 To develop regression model and evaluate its performance (any one algorithm): Build a regression model (e.g., linear regression, random forest) to predict continuous mechanical system parameters (e.g., stress, strain, or failure times) and evaluate its performance.

6 Markov process for modelling manufacturing processes: Apply Markov processes to model manufacturing processes, such as assembly lines or material flow in production systems, considering states and transitions of various process stages.

7 Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation: Use reinforcement learning to optimize engineering design processes (e.g., material selection or structural design) or for robot guidance and navigation in manufacturing and assembly environments.

8 GA for optimization of multi-dimensional function / path planning in robotics: Apply GA to optimize multi-dimensional functions in mechanical design (e.g., shape optimization of components) or path planning in robotics.

9 NN for parameter and model identification / tuning of Control Algorithms: Utilize neural networks to identify system parameters or tune control algorithms in mechanical systems (e.g., thermal control systems, robotic arms).

B Group B : Mini project (Mandatory)

One mini project (in a group of 3-4 students) based on the above contents and using mechanical engineering application dataset

In term work all experiments as listed above or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt. All case studies shall be solved using available software tools (MS Excel, Minitab, JMP (statistical software), etc.) and concluded.

Books Recommended

Textbooks

1 M. P. Deisenroth, A. A. Faisal, C. S. 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 (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.

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)

5 Elaine Rich, and Kevin Knight, Artificial Intelligence, TATA McGraw Hill, 1991.

Web Reference

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
Fundamentals of Business Development (22PCMEC6046T)		
Fundamentals of Business Development Laboratory (22PCMEC6046L)		

Prerequisites:

1. Incubation, Entrepreneurship and Startups

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.
6. Gain a solid understanding of financial modelling principles and key metrics, enabling informed decision-making for business growth.

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.	L3	Apply
CO2	Analyze market dynamics, and formulate robust business strategies to address diverse challenges.	L4	Analyze
CO3	Employ methods effectively for customer attraction and retention, emphasizing the establishment and nurturing of enduring customer relationships.	L3	Apply
CO4	Apply essential sales techniques, negotiation skills, and articulate communication for successful business development.	L3	Apply
CO5	Evaluate the importance of partnerships, implement effective collaboration strategies, and explore models fostering mutual benefit.	L5	Evaluate
CO6	Apply a solid understanding of financial modelling principles and key metrics to make informed decisions driving business growth.	L3	Apply

Fundamentals of Business Development (22PCMEC6046T)

Course Contents

Unit-I **08 Hrs.**

Strategic Business Planning

- Fundamentals of Strategic Planning
- Market Trends and Competitive Analysis
- Formulating Business Strategies
- 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 **07 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 **06 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

Unit-VI **06 Hrs.**

Innovation and Adaptation

- Innovative Approaches to Business Development
- Adaptive Strategies for Changing Business Environments
- Case Studies on Business Innovation
- Innovation Challenges and Solutions
- Final Project: Innovative Business Plan Presentation
- Course Review and Reflection

Fundamentals of Business Development Laboratory (22PCMEC6046L)

Suggested Exercises

A **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.

B **Customer Journey Mapping:**

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

C **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.

D **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.

E **Financial Modelling Project:**

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

F **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 experiment based on syllabus will 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 Covey, Stephen R. The 7 Habits of Highly Effective People. Free Press, 1989.

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

3 Drucker, Peter F. The Effective Executive. Harper Business, 1967.

4 Kaufman, Josh. The Personal MBA. Penguin Books, 2010.

5 Koontz, Harold, and Heinz Weihrich. Principles of Management. McGraw-Hill Education, 10th Edition, 1988.

6 Lawrence, Anne T., and James Weber. Business and Society: Stakeholders, Ethics, Public Policy. McGraw-Hill Education, 15th Edition, 2016.

7 Porter, Michael E. Competitive Strategy: Techniques for Analyzing Industries and Competitors. Free Press, 1980.

8 Pride, William M., Robert J. Hughes, and Jack R. Kapoor. Foundations of Business. Cengage Learning, 6th Edition, 2020.

9 Ries, Eric. The Lean Startup. Crown Business, 2011.

10 Robbins, Stephen P., and Timothy A. Judge. Organizational Behavior. Pearson Education, 13th Edition, 2009.

11 Ross, Stephen, Randolph Westerfield, and Jeffrey Jaffe. Corporate Finance: Core Principles and Applications. McGraw-Hill Education, 5th Edition, 2019.

12 Thiel, Peter, and Blake Masters. Zero to One. Crown Business, 2014.

13 Besanko, David, David Dranove, Mark Shanley, and Scott Schaefer. Economics of Strategy. Wiley, 6th Edition, 2012.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Creative Engineering Design (22PCMEC6047T)		
Creative Engineering Design Laboratory (22PCMEC6047L)		

Prerequisites:

1. No prerequisites required. However, the knowledge of the fundamentals of mechanical engineering can have an advantage.

Course Objectives:

1. To understand the importance of identifying and analyzing customer requirements in the product design and development process.
2. To learn techniques for gathering, prioritizing, and interpreting customer needs and preferences.
3. To develop skills in problem definition and ideation, enabling students to creatively generate solutions to identified problems.
4. To explore methods for generating and evaluating design concepts, with an emphasis on feasibility, desirability, and viability.
5. To gain proficiency in translating selected concepts into detailed designs through embodiment design, considering materials, manufacturing processes, and assembly methods.
6. To familiarize students with prototyping techniques and tools for validating design concepts and uncovering potential issues.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze customer requirements to inform the design process effectively.	L4	Analyze
CO2	Apply problem definition and ideation techniques to generate innovative solutions to real-world problems.	L3	Apply
CO3	Evaluate and select design concepts based on feasibility, desirability, and viability criteria.	L5	Evaluate
CO4	Develop detailed designs considering materials, manufacturing processes, and assembly methods.	L6	Create
CO5	Apply the design principles to create prototypes using appropriate tools and techniques to validate design concepts.	L3	Apply
CO6	Evaluate prototypes to ensure they meet design requirements and user needs.	L5	Evaluate

Creative Engineering Design (22PCMEC6047T)

Course Contents

Unit-I **08 Hrs.**

Customer Requirements

- Importance of identifying and analyzing customer needs and preferences.
- Types of customer requirements: functional, performance, usability, reliability, safety, regulatory and compliance, environmental, cost and price, aesthetics and ergonomics.
- Steps involved in gathering raw data from customers.
- Gathering customer requirements: surveys, interviews, focus groups, observations, customer feedback, market research, etc.
- Techniques to prioritize customer requirements: Pareto analysis, Importance-Performance Analysis (IPA), Kano model, Analytic Hierarchy Process (AHP), Decision matrix, etc.
- Case studies on understanding customer requirements deeply.

Unit-II **08 Hrs.**

Problem Definition (Ideation)

- The role of clearly defining and framing the problem in the design process.
- What are product specifications? When are the specifications established?
- Steps involved in establishing target specifications.
- Ideation techniques for generating creative solutions, such as brainstorming, mind mapping, and SCAMPER.
- Setting the final specifications.
- Case studies on converting customer requirements into product specifications.

Unit-III **08 Hrs.**

Concept Generation and Selection

- Concept generation and selection phase in product design and development.
- Creativity and innovation in novel concept generation.
- Activities and methods for concept generation and selection.
- Criteria for evaluating design concepts: feasibility, desirability, viability, and alignment with user needs and business goals.
- Concept testing: iterative refinement and feedback; decision-making and communication.
- Case studies on concept generation and selection.

Unit-IV **06 Hrs.**

Detailed Design/Embodiment Design

- Detailed design phases.
- Translating selected concepts into detailed designs through embodiment design.
- Materials and manufacturing processes: selection based on availability, properties, cost, and manufacturability.
- Design For Manufacturability and Assembly (DFMA).
- Computer-Aided Design (CAD) modeling and technical drawing, parametric modeling, feature-based modeling, and assembly modeling.
- Design for reliability and maintainability.
- Modular design, standardization, and component reuse.
- Considerations for minimizing part count, simplifying assembly processes, and improving maintenance accessibility.

Unit-V **06 Hrs.**

Prototyping

- Importance of prototyping in design validation and uncovering potential issues.
- Types of prototypes: low-fidelity, medium-fidelity, and high-fidelity prototypes.
- Principles of prototyping: cost of comprehensive prototypes (time or money).
- Dimensions of prototyping: physical, analytical, focused, and comprehensive.
- Prototyping technologies such as 3D printing, CNC machining, laser cutting, and rapid prototyping.
- Planning for prototypes.
- Case studies on prototyping.

Unit-VI **06 Hrs.**

Testing and Validation for Design Solution

- Importance of testing for verifying design solutions, uncovering issues, and ensuring product quality and reliability.
- Testing and validation phases in product design and development.
- Types of testing: usability, functional, performance, reliability, and environmental testing.
- Laboratory vs. field testing.
- Prototyping and simulation testing: FEA, CFD, tolerance analysis.
- Optimization for cost, size, reliability, etc.
- Compliance and regulatory testing.
- Iterative refinement based on feedback gathered during testing and validation.

Creative Engineering Design Laboratory (22PCMEC6047L)

Suggested Experiments/ Exercises/ Assignments/ Activities/ Discussions/ Case studies

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Any 6 experiments:

1 Customer requirements analysis: A case study.

2 Customer need/ requirements prioritization exercise.

3 Mock customer feedback session.

4 Problem framing and ideation.

5 Establishing target specifications exercise.

6 Creative design challenge.

7 Concept Selection Simulation.

8 Prototype Comparison and Evaluation.

9 Prototyping Case Study Analysis.

10 Study on the usability testing and iterative refinement.

11 Compliance Testing and Regulatory Compliance.

A minimum of six experiments/ exercises/ assignments/ activities/ discussions/ Case studies from the above- suggested list or any other experiment/exercise based on the syllabus will be included, which would help the learner to apply the concept learned.

Books Recommended

Textbooks

1 Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw Hill Education, 6th Edition, 2016.

2 C. Charyton, Creative Engineering Design Assessment: Background, Directions, Manual, Scoring Guide, and Uses, Springer London, 2013.

Reference Books

1 A. Chakrabarti, Engineering Design Synthesis: Understanding, Approaches and Tools, Springer, 2002.

2 K. Otto, and K. Wood, Product Design, Prentice Hall, 2000.

3 T. Taura, Creative Design Engineering: Introduction to an Interdisciplinary Approach, Elsevier Science, 2016.

Web References

1 Creative Engineering Design : https://nptel.ac.in/courses/107108010

2 Understanding Creativity and Creative Writing : https://nptel.ac.in/courses/109101017

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Mechatronics (22PCMEC6048T)		
Mechatronics Laboratory (22PCMEC6048L)		

Prerequisites:

1. Basic knowledge of Motors and actuators
2. Basic knowledge of controls

Course Objectives:

1. To study key elements of the Mechatronics system and its integration.
2. To familiarize concepts of sensor characterization and its interfacing with microcontrollers.
3. To Design Pneumatic and Hydraulic Circuits for Industrial purposes.

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 Mechatronics system with block diagrams.	L3	Apply
CO2	Determine the suitable sensors and actuators for a given mecha- tronics system.	L3	Apply
CO3	Classify and analyze various circuits for signal condition- ing and their interfacing with microcontrollers.	L4	Analyze
CO4	Design hydraulic/pneumatic circuits for industrial applications.	L6	Create
CO5	Explain modern trends of Automation.	L2	Understand

Mechatronics (22PCMEC6048T)

Course Contents

Unit-I **06 Hrs.**

Introduction of Mechatronics and automation

Key elements of mechatronics and automation, Applications of Mechatronics domestic, industrial etc. Levels of automation Automation principles and strategies: ten strategies of automation and production system, automation migration strategy Advanced automation functions: safety, maintenance & repair diagnosis, error detection and recovery.

Unit-II **08 Hrs.**

Sensors and actuators

Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics. Actuators: Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety etc.
Selection process of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC.

Unit-III **08 Hrs.**

Mechanization, Automation and Interfacing

Mechanization and automation, product cycle, hard Vs flexible automation, Capital- intensive Vs low-cost automation Types of systems-mechanical, electrical, hydraulic, pneumatic and hybrid systems Automation using CAMS, Geneva mechanisms, gears etc. Assembly line Automation: automated assembly systems, transfer systems, vibratory bowl feeders, non-vibratory feeders, part orienting, feed track, part placing & part escapement systems Introduction to Material storage/ handling and transport systems, and its automation using AS/RS, AGVS and conveyors etc. Interfacing: Interfacing of 8051 with Different types of Motors.

Unit-IV **12 Hrs.**

Industrial Circuits

Pneumatic and hydraulic devices-Different types of valves, Actuators and auxiliary elements in Pneumatics & hydraulics, their applications and use of their ISO symbols Synthesis and design of circuits (up to 3 cylinders)–pneumatic, electro pneumatics and hydraulics Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping.

Unit-V **08 Hrs.**

Introduction to Robotics

Introduction to Robotics, IoT and Artificial Intelligence: Automation and Robotics, Robot types, anatomy and related attributes, accuracy, repeatability Trajectory planning, Robot control system and end effector, Sensors in robotics, Industrial application and future applications, Introduction to IoT Introduction to Artificial Intelligence.

Mechatronics Laboratory (22PCMEC6048L)

Suggested Experiments/ Exercises/ Assignments/ Activities/ Discussions/ Case studies

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A Any 8 experiments:

1 Interfacing of different types of Sensors
2 Interfacing of different types of Actuators
3 Developing Automatic Systems *
4 Developing Automatics /Control systems *
5 Report on comparison between traditional manufacturing and Automated manufacturing with a case study.

B * The Automatic / control systems can be generated using Electro-pneumatic/ electro Hydraulic / Pneumatic or Hydraulic circuit sequencing. The circuits must be analyzed and verified onto FluidSim Software before they get performed onto the Equipment. Minimum of 2 different sequential circuits on each category as mentioned above.

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

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

1 Ahmad Smaili and Fouad Mrad, Applied Mechatronics, Oxford University Press, ISBN: 9780195307023, 2008.

2 Godfrey Onwubolu, Mechatronics Principles and Applications, Butterworth-Heinemann, ISBN: 9780080492902, 2005.

3 Aydin Azizi, Emerging Trends in Mechatronics, IntechOpen, ISBN: 9781789843194, 2020.

4 William Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited, ISBN: 9781292250977, 2019.

5 William Bolton, Mechatronics, Pearson, ISBN: 9781292250991, 2018.

6 Sergey Edward Lyshevski, Mechatronics and Control of Electromechanical Systems, CRC Press, ISBN: 9781351651462, 2017.

7 Bogdan M. Wilamowski and J. David Irwin, Control and Mechatronics, CRC Press, 2011.

Program: Mechanical Engineering	T.Y. B.Tech.	Semester: VI
Professional and Business Communication Tutorial (22HMME6050T)		

Prerequisites:

1. Basic course in Effective Communication Skills.

Course Objectives:

1. To inculcate professional and ethical attitude at the workplace
2. To enhance communication and interpersonal skills
3. To develop effective employability skills
4. To hone written skills for technical documentation

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Design and produce technical documents using appropriate style, format, and language.	L6	Create
CO2	Use employability skills to optimize career opportunities.	L3	Apply
CO3	Apply storytelling techniques appropriately in various corporate situations.	L3	Apply
CO4	Design and develop effective meeting structures and create comprehensive documentation of the meeting process.	L6	Create
CO5	Demonstrate interpersonal skills in professional and personal situations.	L3	Apply
CO6	Use knowledge of cultural differences and professional etiquettes to interact appropriately in workplace scenarios.	L3	Apply

Professional and Business Communication Tutorial (22HMME6050T)

Course Contents

Unit-I **06 Hrs.**

Technical Writing

Report Writing: Types of reports, Basic structure of a report, collection of data through questionnaires, survey analysis, language, and style in reports.
Business Proposal Writing: Types of business proposals, format of proposal, language and style, presentation of proposal.
Plagiarism: Types of plagiarism, consequences of plagiarism.

Unit-II **08 Hrs.**

Employment Skills

Group Discussion: Purpose of a GD, types of GD, criteria for evaluating GD, Dos and Don'ts of GD
Resume Writing: Types of resumes, structure, content, and formatting of resume
Interview Skills: Types and modes of interview, Preparation for interview, Dos and Don'ts of interview, frequently asked questions during interview.
Presentation Skills: Presentation strategies, overcoming stage fear, techniques to prepare effective PowerPoint presentation.

Unit-III **04 Hrs.**

Corporate Story Telling

noindent Basics of storytelling: Setting, characters, plot, crisis, climax, resolution, Benefits of storytelling.
Types of stories: Elevator pitch, product stories, event stories, stories in presentations, storytelling in SOP's and interviews, storytelling to manage conflict or to motivate.
Storytelling techniques: Narration using verbal and non-verbal communication, Analysis of storytelling strategies of corporate master storytellers.

Unit-IV **02 Hrs.**

Meetings and Documentation

noindent Planning and preparation for meetings: Planning layout of meetings, arranging logistics, defining roles and responsibilities.
Strategies for conducting effective meetings: Follow the agenda, record discussion, observe meeting decorum.
Documentation: Draft notice, agenda, and minutes of meeting Business meeting etiquettes: Verbal and non-verbal aspects of etiquettes.

Unit-V **06 Hrs.**

Introduction to Interpersonal Skills

Emotional Intelligence: Definition, difference between IQ and EQ, how to develop EQ.
Leadership: Types of leadership, leadership styles, case studies.
Team Building: Difference between group and team, importance of teamwork, strategies to be a good team player.
Time Management:Importance of time management, cultural views of time, 80/20 rule, time wasters, setting priorities and goals.
Conflict Management: Types of conflicts, strategies to manage conflict, case studiess.

Unit-VI **02 Hrs.**

Cross-cultural communication and Professional ethics

Communication across cultures: Understanding cultures and developing sensitivity towards cultural differences.
Corporate etiquettes: Telephone, dining, cubicle etiquette, etc..
Professional ethics: Effective work habits, accountability, integrity, and excellence.

Professional and Business Communication Tutorial (22HMME6050T)

Suggested exercises/experiments

Any 8 experiments:

1. Draft a questionnaire for survey analysis
2. Prepare individual resume
3. Compose responses for frequently asked questions in an interview
4. Create a Power point presentation
5. Use storytelling in a given corporate situation
6. Conduct a mock meeting and prepare the related documents
7. Perform a team building activity
8. Perform an interpersonal skills related activity
9. Discuss a case related to professional ethics
10. Perform a role play on corporate etiquette

Batch-wise tutorial work of minimum eight assignments from the above suggested list or any other assignments based on the syllabus will be included, which would help the learner to apply the concepts learned.

Books Recommended

1. Fred Luthans, “Organizational Behavior”, McGraw Hill, edition
2. Lesiker and Petit, “Report Writing for Business”, McGraw Hill, edition

3 Huckin and Olsen, “Technical Writing and Professional Communication”, McGraw Hill

4 Wallace and Masters, “Personal Development for Life and Work”, Thomson Learning, 12th edition

5 Heta Murphy, “Effective Business Communication”, Mc Graw Hill, edition

6 Sharma R.C. and Krishna Mohan, “Business Correspondence and Report Writing”, Tata McGraw-Hill Education

7 Ghosh, B. N., “Managing Soft Skills for Personality Development”, Tata McGraw Hill. Lehman,

8 Bell, Smith, “Management Communication” Wiley India Edition, 3rd edition.

9 Dr. Alex, K.,” Soft Skills”, S Chand and Company

10 Subramaniam, R., “Professional Ethics” Oxford University Press.

11 Sandeep Das, “How Business Story Telling Works: Increase Your Influence and Impact” Penguin Random House India Pvt. Ltd.

Program: Mechanical Engineering	Y.Y. B.Tech.	Semester: VI
CAD CAM Laboratory (22PCME6060L)		

Prerequisites:

1. Knowledge of Engineering Graphics, Machine Drawing.
2. Knowledge of Drafting softwares such as AutoCAD, Autodesk Inverter etc.
3. Knowledge of Lathe, Milling, CNC Turning, CNC Milling Machines and 3 D Printers.

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 (22PCME6060L)

Suggested Experiments

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1 Programming for transformations by using coding language (Translation, Rotation, Scaling & Magnification)
2 Solid modelling using any 3D modeling software
3 Part programing and part fabrication on CNC trainer (Turning / Milling)
4 Creating a script for generating a component or a sketch on software.
5 Simulation of turning operation program on software.
6 Simulation of milling operation program on software.
7 Program and Process Sheet Generation for turning operation by using CAM Software. (Two components)
8 Program and Process Generation for Milling operation by using CAM Software (Two components)
9 Development of physical 3D mechanical component using any one of the additive manufacturing technique 3 D printer.
10 Development of physical 3D mechanical component on Automatic Turning centre (Computerized)
11 Development of physical 3D mechanical component on 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
Project Stage-I (22PJME6070L)		

Prerequisites:

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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

Domain knowledge (any beyond) is needed from the areas of Mechanical Engineering for the effective implementation of the project.
The areas can be updated on the basis of the technological innovations and development needed for a specific project.

- 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
			05	05	05	05	05	25

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
			05	05	05	05	05	25

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.