Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum Structure and Syllabus

of

M. Tech. Mechanical Engineering Design

(Approved by BoS Mechanical Engineering)

(Regulation 2024)

Effective from Academic Year 2024-25

(Updated with minor Changes from 2025-26)

Institute Vision

To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value-added Quality Education through a matching ecosystem for building successful careers.

Institute Mission

1. Serving the needs of the society at large through establishment of a state-of-art Engineering Institute
2. Imparting right Attitude, Skills, Knowledge for self-sustenance through Quality Education
3. Creating globally competent and Sensible engineers, researchers and entrepreneurs with an ability to think and act independently in demanding situations.

EOMS Policy

"We at PCCOE are committed to offer exemplarily Ethical, Sustainable and Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders.

We shall strive for technical development of students by creating globally competent and sensible engineers, researchers and entrepreneurs through Quality Education.

We are committed for Institute's social responsibilities and managing Intellectual property.

We shall achieve this by establishing and strengthening state-of-the-art Engineering Institute through continual improvement in effective implementation of Educational Organizations Management Systems (EOMS)."

Course Approval Summary – M. Tech. Mechanical Engineering Design

Board of study -Department of Mechanical Engineering

Sr. No.	Course Name	Course Code	Page Number	Signature and Stamp of BoS Chairman
FY M Tech – Semester I				
1.	Stress Analysis	MMD21PC01	12	
2.	Finite Element Method	MMD21PC02	14	
3.	Professional Elective - I	MMD21PE01	16-22	
4.	Professional Elective - II	MMD21PE02	23-26	
5.	Stress Analysis Lab	MMD21PC03	27	
6.	Finite Element Method Lab	MMD21PC04	28	
7.	Professional Elective Lab - I	MMD21PE03	29-33	
8.	Professional Elective Lab - II	MMD21PE04	34-38	
FY M Tech – Semester II				
9.	Optimization Techniques	MMD22PC05	40	
10.	Professional Elective III	MMD22PE05	41-44	
11.	Professional Elective IV	MMD22PE06	45-48	
12.	Optimization Techniques Lab	MMD22PC06	49	
13.	Professional Elective Lab - III (Elective III & IV)	MMD22PE07	50-54	
14.	Research Methodology	MMD22AE01	55	
15.	Research Internship (INTR) / Field Visit based Case Study/ Experiential Learning	MMD22EL01	57-59	
16.	Research Writing	MMD22AE02	60	

Sr. No.	Course Name	Course Code	Page Number	Signature and Stamp of BoS Chairman
SY M Tech – Semester III				
17.	MOOCs (Eight Week Courses - 2 Nos)	MMD23EL02	62	
18.	On Job Training / Core mini Project / Development of Experimental Setup / Field Project, Community Engagement Project / Interdisciplinary Project (with one conference / research paper)	MMD23EL03	63-66	
19.	Dissertation/Specialization Project - Phase I [Company/ In-house project]	MMD23EL04	67	
SY M Tech – Semester IV				
20.	Dissertation/Specialization Project - Phase II [Company/ In-house project]	MMD24EL05	69	

Approved by Academic Council:

Chairman, Academic Council
Pimpri Chinchwad College of Engineering

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ABBREVIATION

Abbreviations	Course Full Name
PCC	**P**rogramme **C**ore **C**ourse
PEC	**P**rofessional **E**lective **C**ourse
OJT	**O**n **J**ob **T**raining
AEC	**A**bility **E**nhancement **C**ourse
PROJ	**Proj**ect, Mini / Minor **Proj**ects, Integrated **Proj**ects
INTR	**Inter**nship
MO	**M**assive **O**pen Online **C**ourses
EL	**E**xperiential **L**earning

Note: * Indicates that these courses are at institute level

The Course offered by other departments

SR No	Course Type	TYPE OF COURSE	NO. OF CREDITS (Semester-wise)				CREDITs	
			I	**II**	**III**	**IV**	**Total**	**%**
1	PCC	Professional Core Course	10	5	-	-	15	18.75
2	PEC	Professional Elective Course (Specialized)	10	6	-	--	16	20
3	AEC	Ability Enhancement Course	-	3	-	-	03	3.75
5	EL	Research Internship / Field Visit based Case Study/ Experiential Learning/On Job Training / Core mini Project / Development of Experimental Setup / Community Engagement Project / Interdisciplinary Project / Dissertation / MOOC's	-	6	20	20	46	57.5
Total			**20**	**20**	**20**	**20**	**80**	**100**

Curriculum Structure

CURRICULUM STRUCTURE

STRUCTURE FOR 1ST YEAR

M. TECH. MECHANICAL ENGINEERING DESIGN

SEMESTER – I

First Year Mechanical Engineering Design (Regulation 2024) (With effect from Academic Year 2024-25)														
Semester I														
Course Code	Course Name	Credit Scheme				Teaching Scheme (Hours/Week)			Evaluation Scheme and Marks					
		L	P	T	Total	L	P	T	FA	SA	TW	PR	OR	Total
MMD21PC01	Stress Analysis	3	-	-	3	3	-	-	40	60	-	-	-	100
MMD21PC02	Finite Element Method	3	-	-	3	3	-	-	40	60	-	-	-	100
MMD21PE01	Professional Elective - I	3	-	-	3	3	-	-	40	60	-	-	-	100
MMD21PE02	Professional Elective - II	3	-	-	3	3	-	-	40	60	-	-	-	100
MMD21PC03	Stress Analysis Lab	-	2	-	2	-	4	-	-	-	25	-	25	50
MMD21PC04	Finite Element Method Lab	-	2	-	2	-	4	-	-	-	25	-	25	50
MMD21PE03	Professional Elective Lab - I	-	2	-	2	-	4	-	-	-	50	-	-	50
MMD21PE04	Professional Elective Lab - II	-	2	-	2	-	4	-	-	-	50	-	-	50
Total		**12**	**8**	**-**	**20**	**12**	**16**	**-**	**160**	**240**	**150**	**-**	**50**	**600**

L-Lecture, **P**-Practical, **T**-Tutorial, **FA**-Formative Assessment, **SA**- Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

LIST OF PROFESSIONAL ELECTIVE COURSES

Course Code	Elective-I	Course Code	Elective-II
MMD21PE01A	Advanced Vibrations and Acoustics	MMD21PE02A	Mechanics of Composites
MMD21PE01B	Mechanical Behavior of Materials	MMD21PE02B	Computer Aided Design
MMD21PE01C	Analysis and Synthesis of Mechanisms	MMD21PE02C	Fatigue and Fracture Analysis
MMD21PE01D	Tribology in Design	MMD21PE02D	Advanced Machine Design

LIST OF PROFESSIONAL ELECTIVE LABS

Course Code	Elective Lab - I	Course Code	Elective Lab - II
MMD21PE03A	Advanced Vibrations and Acoustics	MMD21PE04A	Mechanics of Composites
MMD21PE03B	Mechanical Behavior of Materials	MMD21PE04B	Computer Aided Design
MMD21PE03C	Analysis and Synthesis of Mechanisms	MMD21PE04C	Fatigue and Fracture Analysis
MMD21PE03D	Tribology in Design	MMD21PE04D	Advanced Machine Design

STRUCTURE FOR 1ST YEAR

M. TECH. MECHANICAL ENGINEERING DESIGN

SEMESTER – II

First Year Mechanical Engineering Design (Regulation 2024) (With effect from Academic Year 2024-25)														
Semester II														
Course Code	**Course Name**	**Credit Scheme**				**Teaching Scheme (Hours/ Week)**			**Evaluation Scheme and Marks**					
		L	**P**	**T**	**Total**	**L**	**P**	**T**	**FA**	**SA**	**TW**	**PR**	**OR**	**Total**
MMD22PC05	Optimization Techniques	3	-	-	3	3	-	-	40	60	-	-	-	100
MMD22PE05	Professional Elective - III	2	-	-	2	2	-	-	20	30	-	-	-	50
MMD22PE06	Professional Elective - IV	2	-	-	2	2	-	-	20	30	-	-	-	50
MMD22PC06	Optimization Techniques Lab	-	2	-	2	-	4	-	-	-	25	-	25	50
MMD22PE07	Professional Elective Lab - III (Elective III & IV)	-	2	-	2	-	4	-	-	-	50	-	-	50
MMD22AE01	Research Methodology	2	-	-	2	2	-	-	20	30	-	-	-	50
MMD22EL01	Research Internship (INTR) / Field Visit based Case Study/ Experiential Learning	-	6	-	6	-	12	-	-	-	100	-	100	200
MMD22AE02	Research Writing	-	1	-	1	-	2	-	-	-	50	-	-	50
Total		**9**	**11**	**-**	**20**	**9**	**22**	**-**	**100**	**150**	**225**	**-**	**125**	**600**

L-Lecture, **P**-Practical, **T**-Tutorial, **FA**-Formative Assessment, **SA**- Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

"Knowledge Brings Freedom"

LIST OF PROFESSIONAL ELECTIVE COURSES

Course Code	**Elective-III**	**Course Code**	**Elective-IV**
MMD22PE05A	Vehicle Dynamics	MMD22PE06A	Reliability in Engineering Design
MMD22PE05B	Multi-body Dynamics	MMD22PE06B	Robotics
MMD22PE05C	Mechatronics and Control Systems	MMD22PE06C	Failure Analysis and Prevention
MMD22PE05D	Systems Engineering	MMD22PE06D	Design of Material Handling Equipment

STRUCTURE FOR 2ND YEAR
M. TECH. MECHANICAL ENGINEERING DESIGN
SEMESTER-III

Second Year Mechanical Engineering Design (Regulation 2024) (With effect from Academic Year 2024-25)														
Semester III														
Course Code	**Course Name**	**Credit Scheme**				**Teaching Scheme (Hours/Week)**			**Evaluation Scheme and Marks**					
		L	**P**	**T**	**Total**	**L**	**P**	**T**	**FA**	**SA**	**TW**	**PR**	**OR**	**Total**
MMD23EL02	MOOCs (Eight Week Courses - 2 Nos)	4	-	-	4	4	-	-	-	-	100	-	-	100
MMD23EL03	On Job Training / Core mini Project / Development of Experimental Setup / Field Project, Community Engagement Project / Interdisciplinary Project (with one conference / research paper)	-	10	-	10	-	20	-	-	-	200	-	100	300
MMD23EL04	Dissertation/Specialization Project - Phase I [Company/ In-house project]	-	6	-	6	-	12	-	-	-	100	-	100	200
Total		**4**	**16**	**-**	**20**	**4**	**32**	**-**	**-**	**-**	**400**	**-**	**200**	**600**

STRUCTURE FOR 2ND YEAR
M. TECH. MECHANICAL ENGINEERING DESIGN
SEMESTER-IV

Second Year Mechanical Engineering Design (Regulation 2024) (With effect from Academic Year 2024-25)														
Semester IV														
Course Code	**Course Name**	**Credit Scheme**				**Teaching Scheme (Hours/Week)**			**Evaluation Scheme and Marks**					
		L	**P**	**T**	**Total**	**L**	**P**	**T**	**FA**	**SA**	**TW**	**PR**	**OR**	**Total**
MMD24EL05	Dissertation/Specialization Project - Phase II [Company/ In-house project]	-	20	-	20	-	40	-	-	-	400	-	200	600
Total		**-**	**20**	**-**	**20**	**-**	**40**	**-**	**-**	**-**	**400**	**-**	**200**	**600**

L-Lecture, **P**-Practical, **T**-Tutorial, **FA**-Formative Assessment, **SA**- Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

Course Syllabus

Semester-I

Program:	M. Tech. Mechanical Engineering Design			Semester: I		
Course :	Stress Analysis			Code :	MMD21PC01	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
3	3	-	-	40	60	100

Prior knowledge of Strength of Materials, Machine Design is essential

Course Objectives:

This course will enable students to:

1. Understand and analyse stress and strain at a point in deformable solids.
2. Understand different approaches to obtain stresses, strains and deformations induced in the solids.
3. Solve thin section members for bending and torsion.
4. Evaluate stresses, and deflection due to line or point contact in solids.

Course Outcomes:

After learning the course, the students should be able to:

1. Formulate and Analyse Stress Field equations such as equilibrium equations, compatibility and constitutive relationship
2. **Formulate and Analyse** Stresses in a pressurised cylinder and rotating disc.
3. **Apply** Energy methods to evaluate stresses and strains.
4. **Analyse and Determine** the Torsion and Bending of a thin wall section
5. **Analyse and estimate** contact stresses in conforming and non-conforming shapes.
6. **Understand** experimental methods for stress evaluation estimate the same using resistance strain gauging technique and Photoelasticity technique.

Detailed Syllabus:

Unit	Description	Duration (H)
I.	**Theory of Elasticity** Analysis of Stresses and Analysis of Strain. Stress Tensor, Compatibility equations in two and three dimensions, Thermal stresses, Airy's stress functions in rectangular and Polar coordinate systems.	7
II.	**Pressurized Cylinders and Rotating Disks,** Governing equations, stress in thick-walled cylinder under internal and external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk of uniform strength,	8
III.	**Energy Methods** Energy method for analysis of stress, strain and deflection Theorem's - theorem of virtual work, theorem of least work, Castiglioni's theorem,	7
IV.	**Thin Wall Members:** Torsion of thin walled members of open cross section. Torsion of Multiply Connected Thin-Walled Sections. Bending: design for strength stiffness and stress concentration for various sections.	7
V.	**Contact stresses** Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, Stress for two bodies inline contact with load normal to contact area and load normal and tangent to contact area, For cases like - gear contacts, contacts between cam and follower, ball bearing contacts.	8
VI.	**Experimental stress analysis** Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photo-elasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns.	8
	Total	**45**

Text Books:

1. Theory of Elasticity–Timoshenko and Goodier, McGrawHill
2. Advanced Strength and Applied Stress Analysis–Richard G. Budynas, McGrawHill
3. Advanced Mechanics of Materials–Boresi, Schmidt, Sidebottom,Willey

Reference Books:

1. Advanced Mechanics of Materials– Cook and Young, Prentice Hall
2. Advanced Mechanics of Solids, L S Shrinath, Tata McGrawHill
3. Advanced Strength of Materials,Vol.1, 2–Timoshenko, CBS
4. Advanced Strength of Materials–Den Hartog
5. Experimental Stress Analysis–Dally & Riley
6. Mechanics of Materials E J Hern, Buttorwoth
7. Strength of Materials, Singer Andrue Pytel, Pearson

Program:	M. Tech. Mechanical Engineering Design			Semester: I		
Course :	Finite Element Method			Code :	MMD21PC02	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
3	3	-	-	40	60	100

Prior knowledge of Engineering Mathematics, Machine Design, and Strength of Material is **essential.**

Course Objectives:

This course aims to enable students to,

1. Develop a deep understanding of the theoretical foundations of the Finite Element Method (FEM), including variational formulations, discretization techniques, and numerical integration methods.
2. Learn how to create accurate and efficient finite element models by selecting appropriate element types, meshing strategies, and boundary conditions based on engineering principles and problem requirements.
3. Acquire skills to perform static and dynamic analyses, linear material behaviour simulations, eigenvalue analyses, Heat and mass transfer, and transient response simulations using FEM.
4. Enhance problem-solving skills by applying FEM to real-world engineering problems across various disciplines such as structural mechanics, and heat transfer problems.

Course Outcomes:

After learning the course, the students should be able to,

1. **Apply** different variation methods for deriving the stiffness matrices of bar and beam element
2. **Apply** the Iso-parametric Elements and Formulation of Plane Elasticity Problems
3. **Create and solve** the governing equations for plates using Kirchoff theory and Mindlin plate element theory
4. **Derive and solve** heat and mass transfer numerical
5. **Understand** the nonlinear behaviour related to geometry, material, and contact.
6. **Formulate** and solve the dynamic problems related to eigenvalue and eigenvectors

Detailed Syllabus:

Unit	Description	Duration (H)
I.	**One dimensional problem** Finite element method, brief history, basic steps, advantages and disadvantages, variational methods of approximation – Rayleigh-Ritz methods, Galerkin method of Weighted Residuals. Variational formulation of 1D bar and beam elements (Euler Bernoulli and Timoshenko beam) – governing equation, domain discretization, elemental equations, assembly and element connectivity, application of boundary condition, solution of equations, post processing of the results.	8
II.	**Two-Dimensional Isoperimetric Formulation** Introduction, types of 2D elements (CST & Isoparametric), shape functions – linear & quadratic, displacement function – criteria for the choice of the displacement function, polynomial displacement functions, displacement function in terms of nodal parameters, strain-nodal parameter relationship, stress-strain relationship, element stiffness matrix, convergence of isoparametric elements, rate of convergence, plane elasticity problems – plane stress, plane stain and axisymmetric problems Automatic mesh generation techniques, Mesh quality checks, h & p refinements	8
III.	**Plate Theories** Thin and thick plates – Kirchhoff theory, Mindlin plate element, triangular and rectangular, conforming and nonconforming elements, degenerated shell elements, shear locking and hour glass phenomenon	7
IV.	**Heat Transfer and Mass transport** Derivation of basic differential equation, 1D and 2D Finite element formulation using variational method, 1D heat transfer with mass transport with formulation, Formulation of thermal stress problems	8
V.	**Non-Linear Analysis** Introduction to non-linear analysis, formulation for geometrical, material and contact nonlinear problems, Nonlinear equation solving procedure - direct iteration, Newton- Raphson method, modified Newton-Raphson method, incremental techniques	6

VI.	**Dynamic Problems – Eigenvalue and Time-Dependent Problems** Formulation of dynamic problems, consistent and lumped mass matrices Solution of eigenvalue problems – transformation methods, Jacobi method, Vector Iteration methods, subspace iteration method [Theoretical Treatment]	8
	Total	**45**

Text Books:

1. Seshu P., ―Text book of Finite Element Analysis, PHI Learning Private Ltd., New Delhi, 3rd Edition 2019.
2. Logan D, ―First course in the Finite Element Method, Cengage Learning, 6th Edition 2016

e-sources:

1. https://onlinecourses.nptel.ac.in/noc22_me43/preview [NPTEL COURSE]
2. https://nptel.ac.in/courses/112104193 [NPTEL COURSE]

Program:	M. Tech. Mechanical Engineering Design			Semester: I		
Course :	**Advanced Vibrations and Acoustics** (Professional Elective - I)			Code :	MMD21PE01A	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
3	3	-	-	40	60	100

Prior knowledge of

a. Physics
b. Engineering Mathematics
c. Dynamics of Machinery is essential

Course Objectives:

This course will enable students to

1. Model physical systems, categorize systems and apply principles of Vibrations to obtain responses to different excitation conditions.
2. Apply acoustic design principles and design noise control elements.

Course Outcomes:

After learning the course, the students should be able to:

1. **Formulate and Evaluate** problems of MDOF mechanical vibrations. Apply the understanding to design the system.
2. **Formulate** the mathematical models Transient Vibrations and study its impact on design of system.
3. **Analyse** Vibration in System and Design a Vibration Control Strategies,
4. **Understand** Random process parameters and **analyze** vibration response of single degree linear system.
5. **Understand and Evaluate** basic acoustic parameters
6. **Apply** acoustic principles to design elements for noise control applications.

Detailed Syllabus:

Unit	Description	Duration (H)
I.	**Multi Degree Freedom System** Free vibration equation of motion, influence coefficient i) stiffness coefficient (ii) flexibility coefficient generalized coordinates, coordinate couplings, Lagrange's equations matrix method Eigen values Eigen vector problems, modal analysis, forced vibrations of un-damped system and modal analysis.	7
II.	**Transient vibrations** Response to an impulsive input, Response to step input, Response to a pulse input-rectangular pulse and half sinusoidal pulse.	8
III.	**Vibration Control** Balancing of rotating machine, in-situ balancing of rotors, control of natural frequency, vibration isolation and vibration absorbers, Passive, active and semi-active control, free layer and constrained layer damping.	7
IV.	**Random Vibrations** Probability, Auto and cross correlation function, spectral density, response of linear systems, and analysis of narrow band systems	8
V.	**Acoustics** Basics of acoustics – Terminologies speed of sound, wavelength, frequency, and wave number, acoustic pressure and particle velocity, acoustic intensity and acoustic energy density, spherical wave, Directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels. Sound Power measurement in a reverberant room, Sound power measurement in an anechoic, sound power survey measurements,	6
VI.	**Acoustics of Partitions, Enclosures, Barriers and Mufflers** Transmission of Sound: changes in media with normal incidence, changes in media with oblique incidence, sound transmission through a wall, transmission loss for walls - stiffness-controlled region- mass-controlled region - damping-controlled region, Design of Acoustic Enclosures, Barriers, muffler elements. Noise control strategies and Applications	9
	Total	**45**

Text Books:

1. Mechanical Vibrations, S. S. Rao, Pearson Education, Delhi
2. Theory of Vibrations with Applications, W. T. Thomson, Pearson Education, Delhi
3. Industrial Noise Control, Randell Barron, Marcel Dekker, Inc.
4. Noise and Vibration Control, IISc Lecture notes Series vol 8, M L Munjal, World Scientific Publication Co. Ed 2, 2024

Reference Books:

1. Mechanical Vibrations, G K Groover, Nem Chand & Bros, Roorkee, India
2. Fundamentals of Vibration, Leonard Meirovitch, McGraw Hill International Edison
3. Principles of Vibration Control: Ashok Kumar Mallik, Affiliated East-West Press, New Delhi.
4. Mechanical Vibrations, A H Church, John Wiley & Sons Inc
5. Mechanical Vibrations & Noise Engineering, A.G.Ambekar, Prentice Hall of India, New-Delhi.

Program :	**M. Tech. Mechanical Engineering Design**				**Semester: I**	
Course :	**Mechanical Behaviour of Materials** (Professional Elective - I)				**Code :**	**MMD21PE01B**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	3	-	-	40	60	100

Prior knowledge of Material science, Mechanics of materials is essential

Course Objectives: This course aims at enabling students,

1. To explore modern materials with their applications.
2. To provide an ability to identify the response of materials under complex loading.
3. To make students able to interpret the behaviour of plastic & Visco-elastic material

Course Outcomes: After learning the course, the students should be able to:

1. **Apply** the mechanics of modern materials in recent engineering applications.
2. **Solve** the basics problems of finding stresses and strains at a point under complex loading conditions
3. Study material behavior under forms of loading other than uniaxial tension
4. **Identify** and investigate engineering problems involving plastic deformation during strain hardening.
5. **Realize** the plastic and elastic- plastic behaviour of materials under different loading conditions
6. **Formulate** the mathematical modeling of Visco-Elastic materials and apply to engineering materials for behavioural study

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Modern Materials in Design Engineering** Dual phase alloy, HSLA, lightweight non-ferrous alloy and their full range stress strain behaviour subjected quasi-static and high strain rate loading, Composites and its orthotropic properties, Plastics, Nano-materials – types, applications and its properties	7
II.	**Response of metals and alloys under applied loading** Stress, strain transformations, Mohr's circle, Isotropic elasticity, Anisotropic elasticity, Anisotropic thermal expansion, Octahedral shear stress, Yield criteria, Yield surface, Yield curve.	8
III.	**Mechanical testing** Uni-axial and biaxial tension test, Full range stress-strain curves, True stress-strain curve, Bridgman correction, Temperature rise, Bauschinger effect, Combined bending and torsion test, Three points bend test, Elastic recovery	7
IV.	**Stress- Strain relations for work hardening materials** Experimental studies of plastic deformations under simple and complex loading, Strain hardening, Power law approximations, Isotropic, Kinematic and combined hardening models, Theory of plastic flow, Strain-rate and temperature dependence of flow stress	8
V.	**Plastic and Elastic-Plastic Behaviour** Deformation theory of plasticity, Thermo-plasticity, Behaviour of metals with initial deformations. Equations of Elastic-Plastic Equilibrium, Residual stresses and strains, Plastic-rigid body, Elastic-Plastic bodies under different loading conditions	7
VI.	**Elasto-Visco-Plasticity** Visco-elasticity, Rheological models, Maxwell model, Voigt model, Voigt–Maxwell model, Natural decay, Dependence of damping and elastic modulus on frequency, Thermo-Elastic effect, Low temperature and high temperature Visco-plastic deformation models, Rubber elasticity, Damping, yielding, effect of strain rate, Crazing.	8
	Total	**45**

Text Books:

1. Mechanical Behaviour of Materials, W.F.Hosford, Cambridge University Press, 2005
2. Mechanical Metallurgy, George E. Dieter, McGraw Hill Book Company, 1988

Reference Books:

1. Fundamentals of Materials SIEnce and Engineering, William D. Callister, Jr., John Wiley & Sons,
2. Theory of Plasticity and Metal Forming Processes, Sadhu Singh, Khanna Publishers
3. Theory of Plasticity, J. Chakrabarty, Elsevier, 2006
4. Foundations of Theory of Plasticity, L. M. Kachanov, Dover Publications, 2004
5. Plasticity for Structural Engineers, W.F. Chen, Da-Jian Han, Springer
6. Mechanical Behavior of Materials, Meyers M A and Chawla K K

Program :	**M. Tech. Mechanical Engineering Design**			**Semester: I**		
Course :	**Analysis and Synthesis of Mechanisms** (Professional Elective-I)			**Code:**	**MMD21PE01C**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	3	-	-	40	60	100

Prior knowledge of Velocity and Acceleration analysis of mechanisms **is essential.**

Course Objectives: This course aims to enable students,

1. To analyse the simple and complex mechanisms
2. To analytically and graphically synthesize mechanisms

Course Outcomes: After learning the course, the students should be able to:

1. **Analyze** the velocity and acceleration of Simple Mechanisms
2. **Analyze** the velocity and acceleration of Complex Mechanisms
3. **Identify** the centre of curvature and **design** mechanism with dwell
4. **Synthesize** mechanisms using graphical methods
5. **Synthesize** mechanisms using analytical methods

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Introduction to Kinematics** Kinematic analysis of mechanisms, degree of freedom, Graphical method of velocity and acceleration analysis of simple mechanism.	7
II.	**Complex Mechanisms** Types of complex mechanisms, velocity-acceleration analysis of complex mechanisms by the Normal Acceleration Method and Auxiliary Point Method.	7
III.	**Curvature theory** Fixed and moving centrodes, inflection circle, Euler-Savary equation, cubic of stationary curvature.	7
IV.	**Synthesis of Planar Mechanisms - Graphical I** Types, number and dimensional synthesis, Accuracy (precision) points, Chebychev spacing, errors in synthesis, branch and order defects. Function generation and rigid body guidance with two and three accuracy points using the Relative pole method and Inversion method.	8
V.	**Synthesis of Planar Mechanisms - Graphical II** Synthesis of four bar mechanism for path generation and rigid body guidance tasks (two, three and four positions) with and without timing.	8
VI.	**Synthesis of Planar Mechanisms - Analytical** Freudenstein equation for the synthesis of four bar mechanism. Four-position synthesis of slider crank mechanism, Complex numbers method of synthesis, Synthesis using dyad method (two and three positions)	8
	Total	**45**

Text Books:

1. Theory of Machines and Mechanisms, A. Ghosh and A.K. Mallik, Affiliated East-West Press.
2. Theory of machines – S. S. Rattan McGraw-Hill Publications

Reference Books:

1. Mechanism Design - Analysis and Synthesis (Vol.1and 2), A.G. Erdman and G.N. Sandor, Prentice Hall.
2. Kinematic Synthesis of Linkages, R.S. Hartenberg and J. Denavit, McGraw-Hill
3. Theory of Machines and Mechanisms, J. E. Shigley and J. J. Uicker,2nd Ed. McGraw-Hill.
4. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines,
5. Robert L. Norton, Tata McGraw-Hill,3rd Edition.
6. Mechanisms and Machine Theory- A.G. Ambekar. PHI Learning Pvt. Ltd.

Program :	**M. Tech. Mechanical Engineering Design**				**Semester: I**	
Course :	**Tribology in Design** (Professional Elective-I)				**Code :**	**MMD21PE01D**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	3	-	-	40	60	100

Prior basic knowledge of

a. Engineering Mechanics
b. Material science,
c. Fluid mechanics is essential.

Course Objectives: This course aims at enabling students,

1. Gain a deep understanding of friction, wear, lubrication, and surface characterization techniques, and their practical applications in engineering design.
2. Develop the ability to analyze friction and wear mechanisms, lubrication principles, and surface characteristics to assess their impact on mechanical systems' tribological behavior.
3. Acquire proficiency in applying tribological principles to design mechanical systems, including selecting suitable components, lubricants, and surface treatments to optimize performance and reliability.

Course Outcomes: After learning the course, the students should be able to:

1. **Understand** tribological principles, including the definition, historical development, and significance of tribology in design engineering.
2. **Evaluate** the mechanisms of friction and various types of wear, identifying factors influencing friction and wear in different materials.
3. **Compare** Lubrication Principles and Techniques to reduce friction and wear, selecting appropriate lubricants, and designing lubrication systems for different applications.
4. **Apply** surface characterization techniques to analyze surface topography, roughness, and adhesion, with practical applications in design engineering.
5. **Design** mechanical systems with optimized tribological performance, and addressing challenges in diverse engineering applications.
6. **Investigate** advanced applications of tribology in various domains, identifying tribological challenges and opportunities for future research and innovation.

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Introduction to Tribology** Definition and Scope of Tribology, Historical Development of Tribology, Importance of Tribology in Design Engineering, Tribological Interfaces and Their Significance, Basic Concepts: Friction, Wear, and Lubrication	7
II.	**Friction and Wear Mechanisms** Mechanisms of Friction: Adhesion, Deformation, Interlocking, Types of Wear: Abrasive, Adhesive, Erosive, Fatigue, Factors Influencing Friction and Wear, Case studies and applications.	7
III.	**Lubrication Principles and Techniques** Role of Lubrication in Reducing Friction and Wear, Types of Lubricants: Oils, Greases, Solid Lubricants, Lubrication Regimes: Boundary, Mixed, Hydrodynamic, Lubricant Additives and Their Functions, Case studies and applications	8
IV.	**Surface Characterization Techniques** Introduction to Surface Topography and Roughness, Surface Characterization Techniques: Profilometry, Microscopy (SEM, AFM), Quantitative Parameters for Surface Characterization, Case Studies and Practical Examples.	7

V.	**Bearing Selection and Tribological Systems** Sliding-element bearings: Reynold's equation and its significance, hydrostatic bearing, thrust bearings, journal bearings, etc. Selection Criteria for Bearings in Design Applications, Tribological Aspects of Gears, Case Studies on Bearing and Tribological System Failures, Case studies and applications	8
VI.	**Tribology in Advanced Design Applications** Tribological Considerations in Automotive Design, Aerospace Applications of Tribology, Tribology in Biomedical Engineering, Tribological Challenges in Renewable Energy Systems, Nanotribology, Future Directions and Research Opportunities, Case studies and applications	8
	Total	**45**

Text Books:

1. Ian M. Hutchings, "Engineering Tribology," Butterworth-Heinemann, 2015.
2. Bharat Bhushan, "Introduction to Tribology," John Wiley & Sons, 2013.
3. T. A. Stolarski, P. A. Cawley, and M. M. Stack, "Tribology in Machine Design," Butterworth-Heinemann, 1999.

Reference Books:

1. Y. H. Chen and G. W. Blau, "Elastohydrodynamic Lubrication for Line and Point Contacts: Asymptotic and Numerical Approaches," Cambridge University Press, 2013.
2. Michael M. Khonsari, "Applied Tribology (Bearing Design and Lubrication)," John Wiley & Sons, 2001.
3. Michael J. Neale (Editor), "Tribology Handbook," CRC Press, 1995.

e-sources:

1. https://nptel.ac.in/courses/112102015
2. https://archive.nptel.ac.in/courses/112/102/112102014/#

Program :	**M. Tech. Mechanical Engineering Design**			**Semester: I**		
Course :	**Mechanics of Composites** (Professional Elective-II)			**Code :**		**MMD21PE02A**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	3	-	-	40	60	100

Prior knowledge of
Material behavior **is essential.**

Course Objectives:
This course aims to enable students,
1. Understand the concept of combining the different materials on a macroscopic level.
2. Learn different relationships between the elastic constants to predict the behavior of composite lamina.
3. Learn Predicting the behavior of the composite lamina using rule of mixture.
4. Develop strategies for predicting behavior of composite laminate.

Course Outcomes:
After learning the course, the students should be able to:
1. **Develop** the equations for behavior prediction of composite lamina.
2. **Develop** Choose the appropriate type of composite for the given application.
3. **Estimate** of Elastic constants based on the volume fraction.
4. **Determine** the strength of laminate.

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Introduction to composite materials** Definition, Classification, Types of reinforcement and matrix materials, Selection of composite material type for applications, Comparison of composite and conventional materials.	6
II.	**Metal Matrix Composite and Polymer Matrix Composites**	7
III.	**Macro-mechanics of composite lamina** Stress-strain relationship, Elastic modulus, strength, and stiffness properties, Anisotropic and orthotropic behavior of composite lamina.	9
IV.	**Micro-mechanics of composite lamina** Representative volume element, Rule of mixture, Fiber and matrix interactions, Effects of fiber orientation and volume fraction on the properties of composite materials	8
V.	**Laminate analysis and Design** Classical laminate theory, Stress-strain transformations, Failure criteria for laminated composites, Design considerations and optimizing techniques.	8
VI.	**Joining methods and their design approaches** Mechanical Fastening, Adhesively bonded joints, Behavior of these joints under axial loadings.	7
	Total	**45**

Text Books:
1. Mechanics of Composites Autar K Kaw, CRC Press, Second edition, 2006
2. Mechanics of Composite materials, Robert M Jones, Taylor and Fransis, 1999

Reference Books:
1. Engineering Mechanics of Composite Materials, Isaac Danial Ori Ishai, Oxford University Press (1994)

Program :	M. Tech. Mechanical Engineering Design			Semester: I		
Course :	**Computer Aided Design** (Professional Elective-II)			Code :	MMD21PE02B	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
3	3	-	-	40	60	100

Prior knowledge of
Mathematics **is essential.**

Course Objectives:
This course aims to enable students,
1. To represent the design concepts using Wireframe modeling, surface modeling, and Solid modeling.
2. To transform the models.

Course Outcomes:
After learning the course, the students should be able to:
1. **Perform** transformations and mapping of models.
2. **Apply** parametric curves to wireframe modeling.
3. **Apply** synthetic curves to wireframe modeling.
4. **Develop** a surface model using parametric surfaces.
5. **Develop** a surface model using synthetic surfaces
6. **Develop** a solid model

Detailed Syllabus:

Unit	Description	Duration (H)
I.	**Geometric Transformations** Homogeneous transformations: translation, scaling, mirror, rotation, shearing in 2D and 3D. Mapping of models. Orthographic and perspective projections.	7
II.	**Wireframe modeling Parametric Curves:** Mathematical representation of curves, wireframe models using parametric curves: Lines, Circle, Ellipse, parabola and hyperbola	7
III.	**Wireframe modeling Synthetic Curves:** Hermit Cubic Spline. Bezier Curve, B-Splines and NURBS. Mathematical representation of Projection Of Point on Curve, Curve-Curve Intersection.	8
IV.	**Surfaces Modeling Parametric surfaces:** Mathematical representation of surfaces, Parametric representation of surfaces: plane surface, ruled surface, surface of revolution, Tabulated surface. Principal curvatures, Curve-Surface Intersection, Surface-Surface Intersection, Projection Of Curves On Surfaces, Projection Of Surface On Surfaces	7
V.	**Surface Modeling Synthetic surfaces:** Hermite Bicubic surface, Bezier surface, B-Spline surface, COONs surface, Blending of surfaces. Surface manipulation - Displaying, Segmentation, Trimming, Intersection.	8
VI.	**Solid Modeling** Solid representation, Concept of Topology, Boundary Representations (B-Rep), Constructive Solid Geometry, Feature Based Modeling, Drawings, Extrusion, Revolve, Shell, Draft, Patterning, Surface and Solid Boolean Operations.	8
	Total	**45**

Text Books:
1. Rogers & Adams, Mathematical Elements for Computer graphics, Tata McGraw –Hill, New Delhi, 2nd Edition, 2002
2. Donald Hearn and M. Pauline Baker, Computer Graphics, Eastern Economy Edition- Prentice Hall, 3rd Edition, 1986

Reference Books:
1. Computer graphics, Schaum Series, McGraw Hill, 2nd Ed, 2000
2. Computer graphics- Foley Van Dam, Addison-Wesley, 2nd edition, 1996
3. Rooney, J. and Steadman, P., Principles of Computer Aided Design, Prentice Hall.
4. Kuang-Hua Chang, Product Design Modeling using CAD/CAE - The Computer-Aided
5. Engineering Design Series, Elsevier Inc., 2014
6. Computer Aided Engineering Design, by Anupam Saxena and Birendra Sahay ISBN-13: 978-1402025556.

Program:	M. Tech. Mechanical Engineering Design			Semester: I		
Course :	Fatigue and Fracture Analysis (Professional Elective-II)			Code :		MMD21PE02C
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
3	3	-	-	40	60	100

Prior knowledge of: Machine Design, Engineering Metallurgy, Material Science is essential

Course Objectives:

1. To assess fatigue life at different loading conditions
2. To make aware of the analysis of Fracture Mechanics of mechanical components

Course Outcomes: After learning the course, the students should be able to:

1. **Analyze** components under multi-axial loading, and **interpret** load spectra and cycle counting methods using both stress and strain-based approaches.
2. **Apply** ASTM standards for specimen preparation and testing procedures in fatigue analysis by using data acquisition systems.
3. **Evaluate** the effects of vibration, corrosion, and temperature variations on the fatigue performance of welded and structural components.
4. **Apply** linear elastic fracture mechanics to predict brittle fracture.
5. **Evaluate** Crack resistance and energy release rate for crack criticality
6. **Apply** the relationship between crack tip opening displacement and SIF to ductile and brittle materials

Detailed Syllabus

Unit	Description	Duration (H)
I.	**Fatigue Mechanics** Time varying uniaxial, biaxial and multiaxial loading of components, load spectra, cycle counting, fatigue damage theories of crack initiation, stress based and strain based approach	8
II.	**Fatigue Testing** Data acquisition and instrumentation, classical methods of fatigue testing, ASTM standards - specimen preparation, procedure	6
III.	**Special Cases in Fatigue** Fatigue analysis in frequency domain, vibration fatigue, fatigue of welded structure, corrosion fatigue, high temperature and low temperature fatigue	8
IV.	**Linear Elastic Fracture Mechanics** Mechanisms of fracture, initiation of fracture and crack propagation, stress and energy criteria and fracture - effects of geometry, Inglis theory of stress, energy concept – Griffith theory of fracture, energy balance during crack growth, modes of loading,	8
V.	**Stress Intensity factors** – Concept, calculation for center crack, single edge crack, double edge crack, round hole with crack, superposition of stress intensity factors, leak before break (LBB) criterion	8
VI.	**Elastic – Plastic Fracture Mechanics** Introduction, crack tip stress state, Irwin's approximation, Dugdale's approximation, crack opening displacement, shape of the plastic zone – von Mises and Tresca yielding criteria,	7
	Total	**45**

Text Books:

1. Fatigue Testing and Analysis – Theory and Practice, YUNG-LI LEE, Elsevier
2. Fatigue of Structures and Materials, Japp Schijve, Kluwer Academic
3. Metal Fatigue in Engineering, Ali Fatemi, Wiley-Interscience
4. Elements of Fracture Mechanics, Prashant Kumar, Mc Graw Hill Education

Reference Books:

1. Metal Fatigue Analysis Handbook, YUNG-LI LEE, Elsevier
2. Design & Analysis of Fatigue Resistant Welded Structure, Dieter Radaj, Woodhead Publishing
3. Fracture Mechanics Anderson T.L., CRC Press
4. Fracture Mechanics, Nestor Perez, , Kluwer Academic Publishers
5. Fracture Mechanics – An Introduction, Gdoutos E. E., , Springer
6. Nonlinear Fracture Mechanics for Engineers, Ashok Saxena, , CRC Press
7. Deformation and Fracture Mechanics of Engineering Materials, Hertzberg, R. W., John Wiley & Sons, Inc.

Program:	M. Tech. Mechanical Engineering Design				Semester: I	
Course:	**Advanced Machine Design** (Professional Elective-II)				Code:	MMD21PE02D
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
3	3	-	-	40	60	100

Prior knowledge of Advanced Stress Analysis, Engineering Design, manufacturing Processes is essential

Course Objectives:

This course aims at enabling students,

1. To make aware the students about industrial design practices.
2. To enable the students to identify, define and solve real-life engineering problems.

Course Outcomes:

After learning the course, the students should be able to:

1. **Realize** that creativity, manufacturability, assembly, maintainability, emotions, and reliability are also important aspects of design other than finding dimensions and stresses in the highly competitive, dynamic, and customer-centered market.
2. **Demonstrate** the ability to identify the needs of the customer and **convert** them into technical specifications of a product.
3. **Select** appropriate design requirements as per the manufacturing process and maintenance.
4. **Design** the components considering strength-based reliability
5. **Demonstrate and implement** sustainability in design.
6. **Conceptualize** industrial design.

Detailed Syllabus:

Unit	Description	Duration (H)
I.	**Development processes and organizations, Product Planning** Introduction to engineering design, Product development process, Product and process cycles, organization for design and product development, technological innovation	7
II.	**Problem Definition and Need Identification** Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing. Identifying customer needs and requirements, establishing the engineering characteristics, quality function deployment, product design specification	8
III.	**Design and Fabrication** Design for manufacture, assembly, maintenance, casting, forging	7
IV.	**Reliability and Strength** Design for Reliability, strength-based reliability, parallel and series systems, robust design	8
V.	**Sustainability and Cost** Design of dis-assembly, Design for reuse, Design for Environment and Design for cost and Design for Quality	7
VI.	**Industrial Design** Design for Emotion and experience, Introduction to retrofit and Eco-design, Human behavior in design	8
	Total	**45**

Text Books:

1. George E Dieter, “Engineering Design”, McGraw Hill Company, 2000

Reference Books:

1. Prashant Kumar, “Product Design, Creativity, Concepts and Usability”, Eastern Economy Edition, PHI New Delhi. 2012
2. Woodson T.T., “Introduction to Engineering Design”, McGraw Hill Book Company, 1966.
3. John J.C. “Design Methods”, Wiley Inter science, 1970.
4. Averill M. Law and W. David Kelton, “Simulation, modeling and analysis”, McGraw Hill Book Company, 1991.
5. Pahl, G.andW.Beitz, “Engineering Design–A Systematic Approach”, Springer, 2nd Ed., 1996.
6. Product Design and Development Karl T. Ulrich, Steven Eppinger

Program:	M. Tech. Mechanical Engineering Design					Semester: I	
Course :	**Stress Analysis** Professional Core Lab					Code :	MMD21PC03
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	25	25	-	50

Prior knowledge of Physics, Engineering Mathematics, Machine Design is essential

Course Objectives:

To impart students with various Vibration and Noise Analysis Techniques, interpret data, and report to obtain the results for validation and effective understanding of the system.

Course Outcomes:

After learning the course, the students should be able to:

1. **Simulate** the problem and correlate it with theoretical concepts.
2. **Analyse** simulation result and the impact of assumptions on it..
3. **Interpret** results of photoelasticity techniques.
4. **Apply** strain gauges at appropriate locations, collect data, analyse and interpret results.

Detailed Syllabus:

Stress Analysis (Any Six)

Expt. No.	Description	Duration (H)
1.	Analytical and Numerical Evaluation of Stresses on plate with hole and correlate with theoretical model developed for solution	10
2.	Analytical and Numerical Evaluation of Stresses on Thin Tube Subjected to Torsion	10
3.	Contact stress analysis using FEM software and correlate with a theoretical model developed for a solution.	10
4.	Evaluation of Shear Centre location for thin section beam. (Box, L-section, C-section)	10
5.	Stain gauge mounting and Measurement of strain in cantilever beam using strain gauges	10
6.	Calibration of the photo-elastic constant	10
7.	Evaluation of Stresses using Photo-elasticity Technique	10
8.	Stress analysis of rotating disc (solid / hollow discs) using FEA software, Compare with theoretical model results.	10
9.	Analysis of thin Arch / Rings using energy methods	10
	Total	**60**

Text Books:

1. Advanced Strength and Applied Stress Analysis–Richard G. Budynas, McGrawHill
2. Ronald Huston, Harold Josephs Practical Stress Analysis in Engineering Design

Reference Books:

1. Advanced Strength and Applied Stress Analysis–Richard G. Budynas, McGrawHill
2. L S Srinath Advanced mechanics of solids

Program:	M. Tech. Mechanical Engineering Design					Semester : I	
Course :	Finite Element Method Professional Core Lab					Code :	MMD21PC04
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	25	25	-	50

Prior knowledge of Computer-Aided Design, Engineering Mathematics, Machine Design, and Strength of Material is essential.

Course Objectives:

This course aims to enable students to,

1. Gain proficiency in using industry-standard finite element analysis software to model and analyze engineering problems, including structural and thermal simulations.
2. Learn how to create accurate and efficient finite element models by selecting appropriate element types, meshing strategies, and boundary conditions based on engineering principles and problem requirements.
3. Acquire skills to perform static and dynamic analyses, linear material behavior simulations, eigenvalue analyses, Heat and mass transfer, and transient response simulations using FEM
4. Enhance problem-solving skills by applying FEM to real-world engineering problems across various disciplines such as structural mechanics, heat transfer problems

Course Outcomes:

After taking the course,

1. **Analyse and solve** real-life engineering problems using commercially available CAE Software.
2. **Solve** 1D,2D, and 3D FEA problems for displacement, strain, stress, Temperature, and mode shapes.

Detailed Syllabus:

Stress Analysis (Any Six)

Expt.	Description	Duration (H)
1.	Introduction to CAE software UI	10
2.	Structural Linear Analysis using 1D Element	10
3.	Truss Analysis using 1D Element	10
4.	Analysis of simple structure using 2D elements	10
5.	Modal Analysis using 1D and 3D Elements of any machine component	10
6.	Steady-state thermal, transient thermal, and thermal stress analysis	10
7.	Coupled thermal-structural Analysis	10
8.	Topology optimization	10
9.	Analysis of any Machine Component and Assembly using 3D Elements	10
	Total	**60**

Text Books:

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008
2. Seshu P., ―Text book of Finite Element Analysis, PHI Learning Private Ltd., New Delhi, 3rd Edition 2019.
3. Logan D, ―First course in the Finite Element Method, Cengage Learning, 6th Edition 2016

Reference Books:

1. Chandrupatla T. R. and Belegunda A. D., ―Introduction to Finite Elements in Engineering, Prentice Hall India 3rd Edition 2008.
2. Reddy, J. N., ―An Introduction to The Finite Element Method, Tata McGraw Hill, 3rd Edition 2017.

e-sources:

1. https://onlinecourses.nptel.ac.in/noc22_me43/preview [NPTEL COURSE]
2. https://nptel.ac.in/courses/112104193 [NPTEL COURSE]

Program:	**M. Tech. Mechanical Engineering Design**					**Semester : I**	
Course :	**Advanced Vibrations and Acoustics** Professional Elective Lab – I					**Code :**	**MMD21PE03A**
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Pre-requisite:

a. Physics
b. Engineering Mathematics
c. Dynamics of Machinery……are essential

Course Objectives:

To impart students with various Vibration and Noise Analysis Techniques, interpret data and report, to obtain the results for validation and effective understanding of system.

Course Outcomes:

After learning the course, the students should be able to:

1. **Collect** data using different instruments and analyze it for identification of sources of noise and vibrations.
2. **Apply** Vibration measurement techniques and Analyse, model, and measure using modern tools and techniques.
3. **Apply and analyze** effectiveness in compliance to noise / vibration regulations.

Detailed Syllabus:

Advanced Vibrations and Acoustics (ANY Six)

Expt.	**Description**	**Duration (H)**
1.	Case Study on - Time domain and Frequency domain analysis of signals / experimental modal analysis / machine conditioning and monitoring / fault diagnosis	10
2.	Simulation study using finite element Analysis Tool on a. Modal analysis b. Harmonic analysis c. Transient analysis	10
3.	Modal Analysis with Impact Hammer Test	10
4.	Electro Dynamic Shaker to Obtain Natural Frequency and Dynamic Studies of a Cantilever Beam.	10
5.	Case study Analysis machine noise signature and analyze effectiveness in compliance to noise regulations.	10
6.	Study of vibration characteristics of bearings / Fan Experimental analysis of – a. Faulty bearing OR b. Unbalanced rotor	10
7.	Natural frequencies and mode shapes of multiple degrees of freedom problem using a suitable software/ write a MATLAB CODE	10
8.	Sound Field Calculations and Analysis of a Diesel Generator with Enclosure / Compressor / Electric Motor	10
9.	Environmental Noise Assessment	10
	Total	**60**

Text Books:

1. Mechanical Vibrations, S. S. Rao, Pearson Education, Delhi
2. Industrial Noise Control, Randell Barron, Marcel Dekker, Inc.

Reference Books:

1. Machinery Condition Monitoring: Principles and Practices, A. R. Mohanty, CRC Press, 2014
2. Vibration and Acoustic: Measurement and Signal Analysis, C. Sujatha, Tata McGraw Hill Education Pvt. Ltd

Program:	**M. Tech. Mechanical Engineering Design**					**Semester: I**	
Course:	**Mechanical Behavior of Materials** Professional Elective Lab – I					**Code:**	**MMD21PE03B**
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of Strength of materials **is essential.**

Course Objectives:

This course is to provide students the tools required for Simulate correlate and validate theoretical concepts and understand the principles.

Course Outcomes:

After learning the course the students should be able to:

1. **Interpret** the performance the mechanical behavior of material under different loading conditions.
2. **Simulate** the problem and correlate with theoretical concepts
3. Collect data, **analyse, interpret and report** the results.

Detailed Syllabus

Expt. No.	**Suggested List of Experiments (ANY Six)**	**Duration (H)**
1.	Elasto-plastic analysis of a tensile test specimen using FEM software	10
2.	Elasto-plastic analysis of a Compression test specimen using FEM software	10
3.	Determination of full range stress strain curve for mild steel and aluminum specimen as per ASTM -E8M	10
4.	Determination of full range stress strain curve for Austenitic stainless steel specimen as per ASTM -E8M	10
5.	Experimental verification of Three point bending test	10
6.	Tensile test for polymer and polymer composite	10
7.	Impact test for plastic	10
8.	Numerical analysis of wire drawing/forging with any suitable material using FEA	10
9.	Establishing flow curve using hardness test (Meyer's Hardness)	10
	Total	**60**

References:

1. Mechanical Behaviour of Materials, W.F.Hosford, Cambridge University Press, 2005
2. Mechanical Metallurgy, George E. Dieter, McGraw Hill Book Company, 1988

Program:	**M. Tech. Mechanical Engineering Design**					**Semester: I**	
Course:	**Analysis and Synthesis of Mechanisms** Professional Elective Lab - I					**Code:**	**MMD21PE03C**
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of Velocity and Acceleration analysis of mechanisms **is essential.**

Course Objectives:

This course aims to enable students,

1. To analyse the simple and complex mechanisms
2. To analytically and graphically synthesize mechanisms

Course Outcomes:

After completion of this course, the students will be able to,

1. **Kinematically analyze** the velocity and acceleration of Simple and Complex Mechanisms
2. **Analyse** curvature of simple planar mechanism
3. **Graphically** synthesize planar mechanism
4. **Analytically** synthesize planar mechanism

Guidelines:

- Students will perform the lab assignments using any suitable software.
- Graphical assigned will be on an A2 size sheet.

Detailed Syllabus

Expt. No.	**Suggested List of Experiments (ANY Six)**	**Duration (H)**
1.	Kinematic analysis of Simple Mechanism	10
2.	Kinematic analysis of Complex Mechanism	10
3.	Curvature analysis of Simple Planar Mechanism	10
4.	Graphical Synthesis of Path Generating Mechanism	10
5.	Graphical Synthesis of Function Generating Mechanism	10
6.	Graphical Synthesis of Rigid Body Guiding Mechanism	10
7.	Analytical Synthesis of Path Generating Mechanism	10
8.	Analytical Synthesis of Function Generating Mechanism	10
9.	Analytical Synthesis of Rigid Body Guiding Mechanism	10
	Total	**60**

References:

1. Theory of Machines and Mechanisms, A. Ghosh and A.K. Mallik, Affiliated East-West Press.
2. Theory of machines – S. S. Rattan McGraw-Hill Publications
3. Mechanism Design - Analysis and Synthesis (Vol.1and 2), A.G. Erdman and G.N. Sandor, Prentice Hall.
4. Kinematic Synthesis of Linkages, R.S. Hartenberg and J. Denavit, McGraw-Hill

Program :	**M. Tech. Mechanical Engineering Design**			**Semester: I**			
Course :	**Tribology in Design** Professional Elective Lab - I			**Code :**			**MMD21PE03D**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior basic knowledge of

a. Engineering Mechanics,
b. Material science,
c. Fluid mechanics is **essential.**

Course Objectives:

This course aims at enabling students,

1. To enhance practical skills in analyzing friction and wear characteristics across a range of materials under different environmental conditions, employing specialized wear and friction monitoring equipment.
2. To learn the formulation of lubricants with customized attributes by using additive packages and understanding different ASTM standards in tribological assessments.
3. To acquire expertise in innovation in Tribological Engineering, employing predictive models and machine learning algorithms for enhanced understanding and problem-solving.

Course Outcomes:

After learning the course, the students should be able to:

1. **Develop** proficiency in analyzing friction and wear behaviors of diverse materials under varying conditions using wear and friction monitoring apparatus.
2. **Formulate** lubricants with tailored properties through additive packages and understanding ASTM standards for tribological testing.
3. **Develop** proficiency in utilizing experimental data for advancing Tribological Engineering through predictive models and machine learning algorithms.
4. **Evaluate** feature extraction, selection, and application of data-driven models for predicting friction, wear, lubricant performance, coating effectiveness, and surface engineering optimization.

Detailed Syllabus:

Labs	**Description**	**Duration (H)**
	Part A (Any 3)	
1	To Formulate various grades of oils and greases using additives packages.	10
2	● To study different ASTM standards used in tribology testings. ● To study the variation of viscosity of lubricants with temperature. ● To study the nature of surfaces (grain structure) and surface characterization of wear components.	10
3	Experimental analysis on friction and wear properties of a specimen (metallic/polymeric/ceramic surfaces) using wear and friction monitoring apparatus under dry and wet sliding conditions.	10
4	To evaluate the effect of temperature, speed and load on the friction and wear performance of composite materials using high temperature pin/ball on disc tester.	10
	Part B (Any 3)	
1	Role of Experiments in Data-Enabled Tribological Engineering. ● Feature Extraction and Selection ● Introduction to machine learning algorithms ● Regression and classification algorithms for tribological modeling.	10
2	Predictive Models for friction and wear prediction ● Deep Learning for Tribological Engineering ● Data-Driven Models for Friction Prediction ● Data-Driven Models for Wear Prediction	10
3	Predictive Models for lubricant film formation and tribocorrosion ● Data-Driven Models for Lubricant Optimization ● Data-Driven Models for Tribofilm Formation ● Data-Driven Models for Tribocorrosion Prediction	10

4	Predictive Models for coating and surface engineering ● Prediction of coating and surface treatment performance ● Optimization of surface engineering processes using machine learning ● Uncertainty Quantification and Sensitivity Analysis	10
	Total	**60**

Text Books:

1. M.C. Oliver and G. Tabor “Experimental Techniques in Tribology” Elsevier, 1977
2. Ian Hutchings ”Tribology: Friction and Wear of Engineering Materials” Butterworth-Heinemann, 1992

Reference Books:

1. Bharat Bhushan “Introduction to Tribology” John Wiley & Sons, 2013
2. George E. Totten and Hong Liang ”Handbook of Lubrication and Tribology, Volume I: Application and Maintenance, CRC Press, 2011
3. P.J. Blau “Experimental Methods in Tribology” Society of Automotive Engineers Inc. 2004
4. T. A. Stolarski, P. A. Cawley, and M. M. Stack, "Tribology in Machine Design," Butterworth-Heinemann, 1999.
5. Michael J. Neale (Editor), "Tribology Handbook," CRC Press, 1995.

e-sources:

1. https://nptel.ac.in/courses/112102015
2. https://archive.nptel.ac.in/courses/112/102/112102014/#
3. https://onlinecourses.nptel.ac.in/noc24_me75/preview

Program:	**M. Tech. Mechanical Engineering Design**					**Semester: I**	
Course:	**Mechanics of Composites** Professional Elective Lab - II					**Code:**	**MMD21PE04A**
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	100

Prior knowledge of
Basics of material behavior **is essential.**

Course Objectives:

1. To provide the students with knowledge of behavior analysis techniques
2. To equip students with the skills necessary to predict the behavior of composite materials.

Course Outcomes:
After completion of this course, the students will be able to,

1. **Identify** the root cause of failure in the past disasters.
2. **Suggest** the failure prevention measures
3. **Predict** the failure of components/ system.

Detailed Syllabus

Expt. No.	**Suggested List of Experiments (ANY 6 Experiments)**	Duration (H)
1.	Determine the strength and stiffness of composite laminate	10
2.	Study the effect of fiber orientation on the behavior of composite laminate.	10
3.	Study the effect of volume fraction on the behavior of composite laminate using rule of mixture.	10
4.	Identify the best volume fraction and fiber orientation to develop a composite laminate and determine its behavior.	10
5.	Develop and test three composite laminates made out of different constituents	10
6.	Compare the behavior and identify the parameters influencing the behavior of the composite laminates	10
7.	Degrade the composite laminates (exposed to moisture) and determine the behavior of composite laminates	10
8.	Treat the natural fibers and determine the effect on the behavior of composite material.	10
9.	Develop a biodegradable hybrid composite.	10
10.	Develop a simulation model and compare the simulation and experimental results for any experiments number 1 to 9.	10
	Total	**60**

References:

1. Mechanics of Composites, Autar K Kaw, CRC Press, 2006

Program:	**M. Tech. Mechanical Engineering Design**					**Semester: I**	
Course:	**Computer Aided Design** Professional Elective Lab – II					**Code:**	**MMD21PE04B**
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of
Mathematics **is essential.**

Course Objectives:
This course aims to enable students,
1. To represent the design concepts using Wireframe modeling, Surfaces Modeling, and Solid Modeling.
2. To transform the models.

Course Outcomes:
After completion of this course, the students will be able to,
1. **Develop** a code for transformations and mapping of models.
2. **Develop** a code for wireframe modeling and represent it graphically.
3. **Develop** a code for surface modeling and represent it graphically.
4. **Compare** different solid modeling techniques for a given a real life component.

Guidelines:
- Students will perform the lab assignments using any suitable software.
- Graphical assigned will be on an A2 size sheet.

Detailed Syllabus:
- Any six experiments out of nine.
- Use suitable modeling software to validate the results.

Expt. No.	**Suggested List of Experiments**	**Duration (H)**
1.	Geometric Transformations of 2D objects: translation, scaling, mirror, rotation, shearing	10
2.	Geometric Transformations of 3D objects: translation, scaling, mirror, rotation	10
3.	Orthographic and perspective projections.	10
4.	Modeling using Parametric Curves	10
5.	Modeling using Synthetic Curves	10
6.	Modeling using Parametric surfaces	10
7.	Modeling using Synthetic surfaces	10
8.	Projection of surfaces	10
9.	Solid modelling	10
	Total	**60**

References:

1. Theory of Machines and Mechanisms, A. Ghosh and A.K. Mallik, Affiliated East-West Press.
2. Theory of machines – S. S. Rattan McGraw-Hill Publications
3. Mechanism Design - Analysis and Synthesis (Vol.1and 2), A.G. Erdman and G.N. Sandor, Prentice Hall.
4. Kinematic Synthesis of Linkages, R.S. Hartenberg and J. Denavit, McGraw-Hill

Program:	**M. Tech. Mechanical Engineering Design**					**Semester: I**	
Course:	**Fatigue and Fracture Analysis** Professional Elective Lab – II					**Code:**	MMD21PE04C
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of Material Science is essential.

Course Objectives:

This course is to provide students with the tools required to Simulate, correlate, and validate theoretical concepts and understand the principles.

Course Outcomes:

After learning the course the students should be able to:

1. **Evaluate** stress due to fatigue and fracture
2. **Simulate** crack behavior for fracture mechanics

Detailed Syllabus

Expt. No.	**Suggested List of Experiments (ANY Six)**	**Duration (H)**
1.	Case Studies based on Rain Flow Counting Technique	10
2.	Fatigue Analysis using Stress Based Fatigue Analysis	10
3.	Strain Based Fatigue Analysis	10
4.	FEA Simulation of fatigue / Fracture problem	10
5.	Crack tip stresses using Photoelasticity	10
6.	Numerical technique for SIF computation	10
7.	Computation of SERR using VCCT/J-Integral method using FEA software	10
8.	Crack tip plastic zone shape using MATLab	10
9.	Phase field models for fracture and fatigue	10
10.	Crack evaluation under applied load (Center crack/Edge crack) in a finite plate	10
11.	Stress Analysis using Image Processing	**60**

References:

1. Mechanical Behaviour of Materials, W.F.Hosford, Cambridge University Press, 2005
2. Mechanical Metallurgy, George E. Dieter, McGraw Hill Book Company, 1988

Program:	M. Tech. Mechanical Engineering Design					Semester: I	
Course:	**Advanced Machine Design** Lab Professional Elective – II					Code:	MMD21PE04D
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	50	-	-	50

Prior knowledge of

a. Advanced Stress Analysis
b. Engineering Design
c. Manufacturing Processes is essential

Course Objectives:

This course aims at,

1. Developing structured approach integrating DFMA, Reliability Engineering, Sustainable Manufacturing, and Industrial Design for product development.
2. Equipping students with skills for market research, analysis, and defining product specifications based on market needs.
3. Encouraging creativity in generating and evaluating product concepts for technical and market viability.
4. Providing knowledge and tools for detailed product design, CAD modeling, and enhancing reliability and compliance.
5. Analyzing manufacturing processes, minimize costs, and design products for sustainability and environmental impact reduction.
6. Collaborating with industrial designers, conduct user research, and integrate user-centered design principles for enhanced usability and satisfaction.

Course Outcomes:

After learning the course, the students should be able to:

1. Construct a comprehensive product planning and development process integrating DFMA, reliability engineering, sustainable manufacturing, and industrial design principles.
2. Conduct thorough market research, analyze market trends, competitor products, and customer feedback, and define product specifications based on market requirements.
3. Generate multiple product concepts, evaluate them against predefined criteria, and select the most promising concept based on technical, economic, and market factors.
4. Develop detailed product design specifications, utilize CAD software to create 3D models and simulations, and implement design modifications to improve system reliability, robustness, and regulatory compliance.
5. Analyze manufacturing and assembly processes; identify opportunities for design simplification and standardization, conduct life cycle assessments (LCAs), and design products for sustainability by minimizing environmental impact.
6. Collaborate with industrial designers, conduct user research and usability testing, and integrate user-centered design principles to optimize usability and enhance user satisfaction in product design.

Detailed Syllabus:

Expt.	Description	Duration (H)
1.	**Integrated Design Assignment: Product Development and Optimization** **Objective:** To develop a comprehensive product planning and development process for a new engineering product while integrating principles of Design for Manufacture and Assembly (DFMA), Reliability Engineering, Sustainable Manufacturing, and Industrial Design to optimize the product's design and enhance user experience. **Tasks:** **A] Market Research and Needs Identification (10 hours):** • Conduct extensive market research to identify potential product opportunities and customer needs. • Analyze market trends, competitor products, and customer feedback to gain insights into market demands. • Define product specifications and establish engineering characteristics based on market requirements and feasibility studies. **B] Concept Generation and Evaluation (10 hours):** • Generate multiple product concepts using creative brainstorming techniques and concept generation tools.	60

	• Evaluate each concept against predefined criteria such as feasibility, market potential, and alignment with customer needs. • Select the most promising concept based on a comprehensive evaluation of technical, economic, and market factors. **C] Product Design and Development (15 hours):** • Develop a detailed product design specification, including functional requirements, performance targets, and regulatory compliance. • Utilize CAD software to create 3D models and simulations of the product design, incorporating DFMA principles to optimize for manufacturing and assembly. • Implement design modifications to improve system reliability and robustness, including redundancy, fault tolerance, and error-proofing mechanisms. **D] Manufacturing Optimization and Sustainable Design (15 hours):** • Analyze the manufacturing and assembly processes involved in producing the product. • Identify opportunities for design simplification, standardization, and component consolidation to minimize manufacturing costs and assembly time. • Conduct a life cycle assessment (LCA) to quantify the environmental footprint of the product and identify opportunities for material substitution, waste reduction, and energy efficiency improvements. **E] Industrial Design and User Experience (10 hours):** • Collaborate with industrial designers to develop conceptual designs that balance functional requirements with ergonomic considerations and aesthetic appeal. • Conduct user research and usability testing to understand user needs, preferences, and pain points related to the product. • Integrate user-centered design principles into the product design to optimize usability and enhance user satisfaction. **Deliverables:** • A comprehensive product development process document outlining the steps followed, from market research to product launch. • CAD models and simulations demonstrating the optimized product design for manufacturing and assembly. • A sustainability report detailing the environmental impact reduction achieved through sustainable design initiatives. • Industrial design sketches, renderings, and user interface designs showcasing the product's aesthetic appeal and user-centric features. **Instructions to Students:** • This assignment is to be completed individually within a timeframe of 60 hours. • Allocate time wisely to ensure each task is completed thoroughly and on schedule. • Utilize appropriate research methods, tools, and techniques to gather data and analyze information effectively. • Apply theoretical concepts learned in class to practical design scenarios, incorporating DFMA, reliability engineering, sustainable manufacturing, and industrial design principles into the product development process. • Document each step of the product development process, including research findings, design iterations, and decision-making rationale. ***Prepare a final report summarizing the product development process, including*** • CAD models, simulations, sustainability analysis, and industrial design concepts. • Be prepared to present your findings and insights to the class, highlighting key design decisions, challenges, and recommendations for future improvements. **Note:** Collaboration with peers is encouraged for brainstorming and idea generation; however, each student must complete their own assignment and submit individual reports.	
	Total	**60**

Text Books:

1. George E Dieter, “Engineering Design”, McGraw Hill Company, 2000

Reference Books:

1. Prashant Kumar, “Product Design, Creativity, Concepts and Usability”, Eastern Economy Edition, PHI New Delhi. 2012
2. Woodson T.T., “Introduction to Engineering Design”, McGraw Hill Book Company, 1966.
3. John J.C. “Design Methods”, Wiley Inter science, 1970.

Course Syllabus

Semester-II

Program:	**M. Tech. Mechanical Engineering Design**				**Semester: II**	
Course:	**Optimization Techniques**				**Code:**	**MMD22PC05**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	3	-	-	40	60	100

Prior knowledge of Engineering Mathematics is essential.

Course Objectives:

This course aims to enable students,

1. To mathematically model the engineering problems.
2. To solve optimization problems using classical methods.
3. To solve linear and non-linear problems.
4. To apply modern methods of optimization.
5. Simulate mathematical model

Course Outcomes:

After learning the course, the students should be able to:

1. **Formulate** mathematical model of real-world programs
2. **Apply** classical optimization techniques
3. **Interpret** the results of linear model and present the insights (sensitivity, duality).
4. **Solve** Non-linear programming problems.
5. **Compare** the modern optimization methods.
6. **Simulate** the solution for uncertainty

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Mathematical Modeling and Optimization of Engineering Problems:** Need, Techniques, And Classifications of Mathematical Modeling. Applications of Optimization, Statement of Optimization Problem Classification of Optimization Problems.	7
II.	**Classical Optimization Techniques** Single-variable optimization and multi-variable optimization, with constraints and without constraints	7
III.	**Linear Programming** Two-phase simplex method, primal and dual Simplex Method, sensitivity analysis of simplex method	8
IV.	**Non-Linear Programming** Elimination and iterative methods for one-dimensional minimization and multi dimension minimization.	7
V.	**Modern Methods of Optimization** Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Teaching Learning Based Optimization, and Neural Networks.	8
VI.	**Simulation Modeling** Introduction, definition and types, limitations, various phases of modeling, Monte Carlo method, applications, advantages and limitations of simulation	8
	Total	**45**

Text Books:

1. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons
2. Optimization for engineering design, K. Deb, PHI

Reference Books:

1. Practical Optimization Methods with Mathematical Applications, M. Asghar Bhatti, Springer
2. Topology Optimization – Theory, Methods and Applications, M. P. Bendsoe, Q. Sigmund
3. Mathematical Modeling, J N Kapur, New Age international publication
4. Optimization concepts and applications in engineering, Belegundu, Chandrupatla, Pearson Education

Program:	**M. Tech. Mechanical Engineering Design**				**Semester : II**	
Course :	**Vehicle Dynamics** (Professional Elective-III)				**Code :**	**MMD22PE05A**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of:

a. Theory of Machine and Mechanism
b. Automobile Engineering,
c. Mechanical Vibration is essential

Course Objectives:

1. To acquaint with vehicle design parameters & vehicle dynamic behavior
2. To develop an ability to evaluate the performance of vehicle
3. To make aware the students about the road dynamics of vehicle

Course Outcomes:

After learning the course, the students will be able to:

1. **Analyze** motion equations and **evaluate** maximum tractive effort under varying conditions, enabling accurate prediction of vehicle performance parameters.
2. **Evaluate** the braking characteristics of vehicles under diverse load conditions and **formulate** strategies to enhance braking performance and vehicle safety**.**
3. **Analyze** the road holding and directional stability of two axel vehicle and interpret behavior of vehicle at different steering inputs.
4. **Analyze** the ride characteristic of quarter car model of an automobile with different road excitations. in terms of human response

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I	**Basics of Vehicle Dynamics and Performance characteristics of road vehicles** Introduction to tyre mechanics and vehicle tyre model, ISO and SAE vehicle coordinate system, Equation of motion and maximum tractive effort, Aerodynamic forces and moments, Prediction of vehicle performance, acceleration time and distance, gradeability.	8
II	**Braking Characteristics** Braking characteristics of a two-axle vehicle, Braking efficiency and stopping distance, Antilock brake system, Traction control systems	7
III	**Handling characteristics of vehicle** Steady-state handling characteristics of a two-axle vehicle, Steady-state response to steering input, Testing of handling characteristics, Transient response characteristics, Directional stability	7
IV	**Vehicle ride characteristics** Human response to vibration, Vehicle ride models - two-degree-of-freedom vehicle model for sprung and un-sprung mass, Numerical methods for determining the response of a quarter-car model to irregular surface profile excitation, Two-degree-of-freedom vehicle model for pitch and bounce, Active and semi-active suspension,	8
	Total	**30**

Text Books:

1. Vehicle Dynamics Theory and Application, Raza N. Jazar. Springer International Edition
2. Rajesh Rajamani, Vehicle Dynamics & control, Springer.

Reference Books:

1. Road Vehicle Dynamics – Problems & Solutions, Rao & Dukkipati, SAE,
2. Theory of Ground Vehicles, J.Y. Wong, John Wiley & Sons,
3. Fundamentals of Vehicle Dynamics, T.D. Gillespie, SAE
4. Garrett T K, Newton K and Steeds W, "Motor Vehicle", Butter Worths & Co., Publishers Ltd., New Delhi, 2001.
5. Vittore Cossalter, Motorcycle Dynamics, 2nd Edition, Publisher: LULU.com
6. Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE

Program:	**M. Tech. Mechanical Engineering Design**			**Semester: II**		
Course:	**Multi Body Dynamics** (Professional Elective-III)			**Code:**		**MMD22PE05B**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of Theory of Machines, Engineering Mathematics is essential.

Course Objective:

This course aims to enable students,

1. To Kinematically and dynamically analyze planar and rigid bodies

Course Outcomes:

After learning the course, the students should be able to:

1. **Derive** equations of motion for interconnected bodies in multi-body systems with three-dimensional motion.
2. **Compute** forces acting on interconnected bodies.
3. **Simulate and analyze** all types of static and dynamic behaviors of the multi-body systems, including the kinetic-static analysis.

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Basic principles for analysis of multi-body systems** The constraints for planar kinematic analysis. Revolute, prismatic, gear and cam pairs. The automatic assembly of the systems of equations for position, velocity and acceleration analysis. Iterative solution of systems of non-linear equations.	7
II.	**Computation of Forces** The geometry of masses, computation and assembly of the mass matrix. Computation of planar generalized forces for external forces and actuator-spring-damper element. Computation of spatial generalized forces from external forces.	8
III.	**Kinematics of rigid bodies in space** Reference frames for the location of a body in space. Euler angles and Euler parameters. Screw motion in space. Velocity, acceleration and angular velocity. Relationship between the angular velocity vector and the time derivatives of Euler parameters. The constraints required for the description in the space of common kinematic pairs (revolute, prismatic, cylindrical, and spherical).	8
IV.	**Dynamics of Planar Systems** Dynamics of planar systems, Simple applications of inverse and forward dynamic analysis.	7
	Total	**30**

Text Books:

1. Nikravesh, P.E., Computer Aided Analysis of Mechanical Systems, Prentice-Hall Inc., Englewood Cliffs, NJ, 1988
2. Wittenburg, J., Dynamics of Systems of Rigid Bodies, B.G. Teubner, Stuttgart, 1977

Reference Books:

1. Kane, T.R, Levinson, D.A., Dynamics: Theory and Applications, McGraw-Hill Book Co., 1985.
2. Roberson, R.E., Schwertassek, R., Dynamics of Multibody Systems, Springer-Verlag, Berlin, 1988.
3. Haug, E.J., Computer-Aided Kinematics and Dynamics of Mechanical Systems-Basic Methods, Allyn and Bacon, 1989.
4. Huston, R.L., Multibody Dynamics, Butterworth-Heinemann, 1990.
5. Schielen, W. ed., Multibody Systems Handbook, Springer-Verlag, Berlin, 1990.
6. de Jalo n, J.C., Bayo, E., Kinematic and Dynamic Simulation of Multibody Systems, Springer-Verlag, 1994.
7. Shabana, A.A., Computational Dynamics, John Wiley & Sons, 1994.

e-sources:

Program :	**M. Tech. Mechanical Engineering Design**			**Semester: II**		
Course :	**Mechatronics and Control Systems** (Professional Elective-III)			**Code :**	**MMD22PE05C**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of

a. Engineering Mathematics
b. Basic Electrical and Electronics
c. Mechatronics is **essential.**

Course Objectives:

This course aims at enabling students to,

1. Study mathematical models that describe mechanical and electromechanical systems.
2. Investigate the impact of system parameters on the stability of systems
3. Understand the control systems and its response in the time domain.
4. Understand the control systems and its response in the frequency domain.

Course Outcomes:

After learning the course, the students should be able to:

1. **Analyze** mathematical models using transfer function and state space modeling approaches.
2. **Analyze** the effect of system parameters on the stability of the system.
3. **Develop** control systems in the time domain to achieve desired system performance.
4. **Develop** control systems in the frequency domain to achieve desired system performance.

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Mathematical Modeling of Dynamic Systems** Classification of modeling, Modeling of Mechanical and Electro-mechanical systems, Transfer function, State space modeling, Block diagram representation and reduction	7
II.	**Stability analysis of Dynamic Systems** Poles and Zeros, System response of second order system, Transient response specifications, Absolute and relative stability, System Stability analysis: Poles and Zeros, Lyapunov's Criterion and Routh Hurwitz Criterion	8
III.	**Control in Time Domain** Introduction to open loop and closed loop control, Conversion of transfer function to state space. Controllability and observability of system, Full state feedback / Pole placement technique.	7
IV.	**Control in Frequency Domain** Frequency response of system, Bode plot to determine Phase margin and gain margin, PID control system design and tuning PID parameters based on transient and frequency response	8
	Total	**30**

Text Books:

1. Measurement and Instrumentation – Theory and Application, Alan Morris and Reza Langari, Elsevier,3rd Ed,2020.
2. Introduction to Mechatronics and Measurement Systems, Alciatore and Histand, Mc-Graw Hill, 5th Ed, 2019.
3. Control Systems Engineering, Norman S Nise, John Wiley & Sons,6th Ed.,2011.

Reference Books:

1. Mechatronics – Principles, concepts and applications, Mahalik, Tata Mc-Graw Hill Publication, New Delhi, 2003.
2. Process control instrumentation technology, Curtis D. Johnson, Pearson/Prentice Hall, 8th Ed.2016.
3. Mechatronics: Integrated Mechanical Electronic Systems, K.P. Ramachandran and G.K.Vijayaraghavan, John Wiley & Sons, 2008.

Program :	**M. Tech. Mechanical Engineering Design**			**Semester: II**		
Course :	**Systems Engineering** (Professional Elective-III)			**Code :**		**MMD22PE05D**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of

a. Familiarity with CAD software
b. Basic programming skills such as MATLAB, Python is essential

Course Objectives:

Students will be:

1. Introduced to the fundamental principles and methodologies of Systems Engineering and their relevance to Mechanical Design Engineering.
2. Equipped with the necessary skills to model, analyze, and optimize mechanical systems using Systems Engineering techniques.
3. Familiarized with advanced concepts such as systems integration, design optimization, and lifecycle management in the context of mechanical design projects.
4. Exposed to emerging trends and technologies in Systems Engineering for Mechanical Design and prepare them for industry-relevant applications.

Course Outcomes:

The students will be able to:

1. **Apply** systems thinking concepts to analyse and solve complex problems in Mechanical Design Engineering**.**
2. **Develop** mathematical models of mechanical systems and analyse their behaviour using simulation techniques.
3. **Integrate** multidisciplinary aspects into mechanical design projects using Systems Engineering principles.

Integrate Systems Engineering principles seamlessly into mechanical design projects for efficient problem-solving and collaboration.

Detailed Syllabus

Unit	**Description**	**Duration (H)**
1.	**Unit 1: Introduction to Systems Engineering** Overview of Systems Engineering, Historical background and evolution, Importance of Systems Engineering in Mechanical Design, Systems thinking and its application in mechanical engineering, Introduction to Systems Engineering methodologies and frameworks.	8
2.	**Fundamentals of System Modeling and Analysis** Basic concepts of system modeling, Types of systems and their characteristics, Introduction to mathematical modeling techniques in mechanical systems, System analysis methods: Simulation, optimization, sensitivity analysis, Integration of systems engineering principles in mechanical design projects.	8
3.	**Systems Integration and Design Optimization** Principles of systems integration in mechanical design, Multidisciplinary design optimization (MDO) techniques, Role of systems engineering in design optimization, Optimization algorithms and their applications in mechanical systems, Design for reliability, maintainability, and sustainability.	7
4.	**Advanced Topics in Systems Engineering for Mechanical Design** (7 hours) Advanced modeling techniques: Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), etc., Introduction to Model-Based Systems Engineering (MBSE), Lifecycle management in mechanical design projects, Emerging trends and technologies in systems engineering for mechanical design.	7
	Total	**30**

Text Books:

1. "Systems Engineering: Principles and Practice" by Norman S. Nise (3rd Edition, 2020)
2. "The Art of Systems Architecting" by Eberhardt Rechtin and Mark W. Maier (3rd Edition, 2010)
3. "Discrete-Event System Simulation" by Jerry Banks, John S. Carson II, Barry L. Nelson, and David M. Nicol (5th Edition, 2009)
4. "Engineering Systems: Meeting Human Needs in a Complex Technological World" by Olivier de Weck, Daniel Roos, and Christopher L. Magee (1st Edition, 2011)

Reference Books:

1. Systems Engineering & Analysis, Benjamin S Blanchard and Wolter J Fabrycky, 5th edition, 2010.
2. Thinking in Systems A Primer, Donella H Meadows 1st edition 2008

Program :	**M. Tech. Mechanical Engineering Design**				**Semester: II**	
Course :	**Reliability in Engineering Design** (Professional Elective-IV)				**Code :**	**MMD22PE06A**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of Engineering Mathematics is essential is essential.

Course Objectives:

1. To perform reliability engineering analysis.
2. To compute reliability engineering parameters and estimates for applications in mechanical devices and manufacturing environments.

Course Outcomes:

After learning the course, the students should be able to:

1. **Identify** the possible faults in systems and their impacts on the overall system reliability.
2. **Develop** fault trees for a sub-system and apply various reliability models on fault analysis.
3. **Evaluate** maintenance schedules and assess the corresponding risk with appropriate techniques and tools.

Detailed Syllabus

Unit	**Description**	**Duration (H)**
I.	**Fundamental concepts** Failure density, failure rate, hazard rate, MTTF, MTBF, maintainability, availability, pdf, cdf, Life characteristic phases, modes of failure, Areas of reliability. Quality and reliability assurance rules, product liability, probability distributions binomial, normal, Poisson, lognormal, Weibull, exponential, standard deviation, variance, skewness coefficient	8
II.	**System reliability** Series, parallel, mixed configuration, k- out of n structure, complex systems- enumeration method, conditional probability method, cut set and tie set method.	8
III.	**System reliability Analysis** Reliability apportionment, Reliability apportionment techniques – equal apportionment, AGREE, ARINC, feasibility of objectives apportionment.	7
IV.	**Failure Mode, Effects and Criticality Analysis** Failure mode effects analysis, severity/criticality analysis, FMECA examples, RPN, Ishikawa diagram for failure representation, fault tree construction.	7
	Total	**30**

Text Books:

1. L.S. Srinath, Concepts of Reliability Engg., Affiliated East-Wast Press (P) Ltd., 1985.
2. E. Balagurusmy, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1984.

Reference Books:

1. A.K. Govil, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1983.
2. B.S. Dhillion, C. Singh, Engineering Reliability, John Wiley & Sons, 1980.
3. M.L. Shooman, Probabilistic, Reliability, McGraw-Hill Book Co., 1968.
4. P.D.T. Conor, Practical Reliability Engg., John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, Reliability in Engineering Design, John Wiley & Sons, 1977.
6. A.Birolini , Reliability Engineering, Theory and Practice, Third Edition, Springer, 1999

e-sources:

1. NPTEL course on reliability

Program:	**M. Tech. Mechanical Engineering Design**			**Semester: II**		
Course:	**Robotics (Professional Elective-IV)**			**Code:**	**MMD22PE06B**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of

a. Theory of Machines
b. Mechatronics
c. Basics of Electrical and Electronics Engineering is **essential.**

Course Objectives:

This course aims to enable students,

1. To perform Direct and Inverse kinematics
2. To analyse the velocity and static force of the robot

Course Outcomes:

After learning the course, the students should be able to:

1. **Solve** homogeneous transformations.
2. **Analyze** the Forward and Inverse kinematics of a robot
3. **Analyze** the Velocity and Static force of a robot
4. **Analyze** the Dynamics of a robot

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Kinematic representation:** Homogeneous transformations. Representation of joints and links of a robot using Denavit-Hartenberg parameters.	7
II.	**Kinematics of Robot:** Forward and inverse kinematics of robots.	8
III.	**Statics of a robot:** Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians, Singularity analysis for manipulators.	8
IV.	**Dynamics of robots:** Mass and inertia of links, the Lagrangian formulation for equations of motion for serial manipulators. Simulation (direct and inverse) of dynamic equations of motion.	7
	Total	**30**

Text Books:

1. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
2. S. K. Saha, Introduction to Robotics, Second Edition, McGraw Hill Education, 2014

Reference Books:

1. K.S. Fu, R.C. Gonzales, C.S.G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987.
2. S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
3. Mathia, Robotics for Electronics Manufacturing, Cambridge Uni. Press, India
4. A Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2013.
5. R K Mittal & I J Nagrath, Robotics and Control, McGraw Hill Publication, 2015

Program :	**M. Tech. Mechanical Engineering Design**			**Semester: II**		
Course :	**Failure Analysis and Prevention** (Professional Elective-IV)			**Code :**	**MMD22PE06C**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of

a. Material behavior,
b. Manufacturing processes **is essential.**

Course Objectives:

This course aims at enabling students,

1. **Understand** the concept of failure and its significance in various domains.
2. Learn different methodologies for failure analysis.
3. **Identify** root cause of failures using investigative techniques.
4. **Develop** strategies for preventing failures in systems and processes.

Course Outcomes:

After learning the course, the students should be able to:

1. Identify and Explain various failure modes
2. Apply the industrial engineering tools for failure analysis
3. Analyze the failure and prepare failure report
4. Suggest the remedies to avoid the failures.

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Introduction to Failure Analysis** Need and scope of failure analysis and prevention, Engineering disasters and understanding failures, Fundamental sources of failures. Deficient design, Imperfections in base metals, Improper Manufacturing, Poor assembly, service and maintenance	6
II.	**Industrial engineering tools for failure analysis** Pareto diagram, Fishbone diagram and FMEA, FMEA, Fault tree analysis, Reliability,	7
III.	**General procedure of failure analysis** Background information collection, Preliminary examination, NDT for failure analysis, Destructive testing, DT, selection, preservation, cleaning & sectioning of samples, Macroscopy of fracture surfaces, Microscopy of fracture surfaces, Metallography of failed components, Determination of type of fracture, Application of fracture mechanics, Simulated test and analysis of evidences/results	9
IV.	**Preventive Measures and Risk Mitigation** Design for reliability and robustness, quality control and assurance techniques, maintenance and inspection protocols, failure forecasting and early warning systems, lessons learned from past failures	8
	Total	**30**

Text Books:

1. Failure Analysis and Prevention, Edited by Aidy Ali, InTech Publishers, http://dx.doi.org/10.5772/65149

Reference Books:

1. ASM HANDBOOK Failure Analysis and Prevention (2021 Edition)
2. Root Cause Failure Analysis, R. Keith Mobley, Butterworth-Heinemann, 15 Apr 1999
3. Failure Analysis of Engineering Materials, Charles R. Brooks, Ashok Choudhury, McGraw Hill Professional, 21 Sept 2001
4. Machinery Failure Analysis and Troubleshooting Practical Machinery Management for Process Plants, Heinz P. Bloch, Fred K. Geitner, Volume 2, Fourth Edition,
5. Fracture Mechanics Fundamentals and Applications, Fourth Edition, By Ted L. Anderson (2017)

e-sources:

1. NPTEL :: Mechanical Engineering - NOC:Failure Analysis and Prevention

Program:	**M. Tech. Mechanical Engineering Design**				**Semester: II**	
Course:	**Design of Material Handling Equipment** (Professional Elective-IV)				**Code:**	**MMD22PE06D**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	2	-	-	20	30	50

Prior knowledge of Theory of Machines, Machine Design is essential

Course Objectives: This course aims at enabling students,

1. To realize the importance of materials in both in product and service
2. Understand the benefit of an efficient material handling system
3. Identify and select various types of material handling equipment
4. Design of material handling systems for a variety of scenarios pertaining to the manufacturing and service industry

Course Outcomes:

After learning the course, the students should be able to:

1. **Identify** the use and importance of material handling in various industries
2. **Design** the EOT cranes with consideration of safety, efficiency, and automation integration in material handling processes.
3. **Design** the load-lifting attachments and auxiliary equipment
4. **Design** the bulk material handling equipment

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
I.	**Selection of Material handling system** Principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, classification of material handling equipment, Choice of material handling equipment, factors affecting for selection, general analysis procedures, basic analytical techniques, the unit load concept	7
II.	**Design of electric overhead travelling cranes** Electric overhead travelling crane - essential parts, design parameters, structural considerations, end carriages, long and cross travel mechanisms, brakes, motor selection, safety arrangements, electrical control system	8
III.	**Load lifting attachments** Load chains and types of ropes used in material handling system, forged standard and Ramshorn hooks, crane grabs and clamps; grab buckets; electromagnet; drums, sheaves, sprockets	7
IV.	**Study of bulk material handling systems** Design consideration for conveyor belts, Objectives of storage; bulk material handling; gravity flow of solids through slides and chutes; storage in bins and hoppers; screw conveyor, vibratory conveyor, pneumatic & hydraulic conveyor (classification, types, principles of operation)	8
	Total	**30**

Text Books:

2. N. Rudenko, ‘Materials Handling Equipment’, Peace Publishers, 1970
3. J. Fruchtbaum, ‘Bulk Materials Handling Handbook’, Springer New York, NY, 2013
4. R. B.Chowdary and G. R. N. Tagore, ‘Material Handling Equipments’, Khannna Publishers, 2003
5. J. M. Apple,’ Material Handling Systems Design’, John-Wiley and Sons, 1977
6. J. R. Immer, ‘Materials Handling’, McGraw Hill, 1953

Reference Books:

4. K. C. Arora, V. V. Shinde, ‘Aspects of Materials Handling’, Laxmi Publications, 2011
5. P.S.G. Tech., “Design Data Book”, Kalaikathir Achchagam, Coimbatore, 2016
6. Colin Hardi, ‘Material Handling in Machine shop’, Machinery Publication Co. Ltd, 1970
7. M. P. Nexandrn, ‘Material Handling Equipment’, MIR Publication, 1981
8. C. R. Cock, J. Mason, ‘Bulk Solid Handling’, Leonard Hill Publication Co. Ltd., 1987

e-sources:

1. https://archive.nptel.ac.in/courses/113/105/113105104/

Program:	M. Tech. Mechanical Engineering Design					Semester: II	
Course:	Professional Core Lab: Optimization Techniques Lab					Code:	MMD22PC06
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	25	25	-	50

Prior knowledge of Engineering Mathematics **is** essential.

Course Objectives:

This course aims to enable students,

1. to formulate mathematically the real-life problems
2. to solve the mathematical models using classical and modern optimization methods
3. To simulate the solution.

Course Outcomes:

After completion of this course, the students will be able to,

1. **Represent** a real-life problem as a mathematical model.
2. **Optimize** the problem using classical optimization techniques.
3. **Determine** the dual of a primal linear problem and **Perform** sensitivity analysis of the solution of a simplex method.
4. **Apply** non lienar optimization techniques
5. **Apply** modern optimization algorithms
6. **Apply** the Monte Carlo Simulation technique.

Guidelines:

- Solve any 6 out of 9 assignments.
- Students will perform the lab assignments using any suitable software.

Detailed Syllabus

Expt. No.	Suggested List of Experiments	Duration (H)
1.	Mathematical modeling of a real-world problem	10
2.	Optimization of Single-variable/multi-variable problems using classical techniques	10
3.	Solution of Linear problem using Two phase simplex method	10
4.	Primal-dual simplex method	10
5.	Sensitivity analysis of the linear problem	10
6.	Optimization using non-linear methods	10
7.	Optimization using modern methods	10
8.	Optimization using modern methods	10
9.	Simulation of a real world problem using Monte Carlo Simulation Method.	10
	Total	**60**

References:

1. Theory of Machines and Mechanisms, A. Ghosh and A.K. Mallik, Affiliated East-West Press.
2. Theory of machines – S. S. Rattan McGraw-Hill Publications
3. Mechanism Design - Analysis and Synthesis (Vol.1and 2), A.G. Erdman and G.N. Sandor, Prentice Hall.
4. Kinematic Synthesis of Linkages, R.S. Hartenberg and J. Denavit, McGraw-Hill

Program:	M. Tech. Mechanical Engineering Design					Semester : II	
Course :	Professional Elective Lab III (Elective III & Elective IV)					Code :	MMD22PE07
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	50	-	-	50

Detailed Syllabus:

Part A: Elective III – Vehicle Dynamics (ANY Three)

Prior knowledge of:

Course Objectives:

This course is to provide students the tools required for Simulate correlate and validate theoretical concepts and understand the principles.

Course Outcomes:

After learning the course, the students should be able to:

1. **Interpret** the performance behavior of car model.
2. **Simulate** the problem and correlate with theoretical concepts
3. Collect data, **analyse, interpret and report** the results.

Expt.	Description	Duration, (H)
1.	Road holding characteristics of vehicle and its control	10
2.	Analysis and optimal control of quarter car ride model	10
3.	ABS or Power-steering for handling analysis	10
4.	To simulate and understand behavior of sprung / un-sprung mass & lumped mass system MBD software	10
5.	Analysis of tyre behavior for vehicle dynamics stability	10
	Total	**30**

Reference Books:

1. Road Vehicle Dynamics – Problems & Solutions, Rao & Dukkipati, SAE,
2. Theory of Ground Vehicles, J.Y. Wong, John Wiley & Sons,
3. Fundamentals of Vehicle Dynamics, T.D. Gillespie, SAE
4. Garrett T K, Newton K and Steeds W, "Motor Vehicle", Butter Worths & Co., Publishers Ltd., New Delhi, 2001.
5. Vittore Cossalter, Motorcycle Dynamics, 2nd Edition, Publisher: LULU.com
6. Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE
7. Vehicle Dynamics Theory and Application, Raza N. Jazar. Springer International Edition
8. Rajesh Rajamani, Vehicle Dynamics & control, Springer.

Part A: Elective III- Multi-body Dynamics (ANY Three)

Prior knowledge of

Theory of Machines, Engineering Mathematics is essential.

Course Objective:

This course aims to enable students,

1. To Kinematically and dynamically analyze planar and rigid bodies

Course Outcomes:

After completion of this course, the students will be able to,

1. Kinematically analyse planar bodies.
2. Dynamically analyse planar bodies.
3. Kinematically analyse spatial bodies.

Guidelines: Students will use suitable software to write the programs.

Expt.	Description	Duration, (H)
1.	Velocity and acceleration analysis of planar systems	10
2.	Kinematic analysis of rigid bodies	10
3.	Kinematic analysis of spatial systems	10
4.	Dynamic analysis of planar systems	10
5.	Constraint analysis for planar kinematic analysis for revolute, prismatic, gear and cam pairs	10
	Total	**30**

References:

1. Nikravesh, P.E., Computer Aided Analysis of Mechanical Systems, Prentice-Hall Inc., Englewood Cliffs, NJ, 1988
2. Shabana, A.A., Computational Dynamics, John Wiley & Sons, 1994
3. Haug, E.J., Computer-Aided Kinematics and Dynamics of Mechanical Systems-Basic Methods, Allyn and Bacon,1989.

Part A: Elective III- Mechatronics and Control Systems (ANY Three)

Prior knowledge of

a. Engineering Mathematics
b. Basic Electrical and Electronics
c. Mechatronics…..are essential.

Course Objectives:

This course aims at enabling students to,

1. Study mathematical models that describe mechanical and electromechanical systems.
2. Investigate the impact of system parameters on the stability of systems
3. Understand the control systems and its response in the time domain.
4. Understand the control systems and its response in the frequency domain.

Course Outcomes:

After learning the course, the students should be able to:

1. **Analyze** mathematical models using transfer function and state space modeling approaches.
2. **Analyze** the effect of system parameters on the stability of the system.
3. **Develop** control systems in the time domain to achieve desired system performance.
4. **Develop** control systems in the frequency domain to achieve desired system performance.

Expt.	Description	Duration, (H)
1.	Interfacing of any sensor / actuator with Arduino	10
2.	Interfacing of any sensor with DAQ	10
3.	Modeling and Analysis in time domain: State Space Modeling of MIMO / SISO System using MATLAB /Simulink.	10
4.	Modeling and analysis in frequency domain: Transfer Function Modeling of MIMO/SISO System using MATLAB / Simulink	10
5.	Design of full state feedback controller / PID controller (software based)	10
6.	Study the effect of system parameters on stability of the mechanical system by using MATLAB / Simulink.	10
	Total	**30**

Text Books:

1. Measurement and Instrumentation – Theory and Application, Alan Morris and Reza Langari, Elsevier,3rd Ed,2020.
2. Introduction to Mechatronics and Measurement Systems, Alciatore and Histand, Mc-Graw Hill, 5th Ed, 2019.
3. Control Systems Engineering, Norman S Nise, John Wiley & Sons,6th Ed.,2011

Reference Books:

1. Mechatronics – Principles, concepts and applications, Mahalik, Tata Mc-Graw Hill Publication, New Delhi, 2003.
2. Process control instrumentation technology, Curtis D. Johnson, Pearson/Prentice Hall, 8th Ed.2016.
3. Mechatronics: Integrated Mechanical Electronic Systems, K.P. Ramachandran and G.K. Vijayaraghavan, John Wiley & Sons, 2008.

Part A: Elective III- Systems Engineering (ANY Three from Experiment number 2 to 8)

Prior knowledge of

a. Mathematical analysis and problem-solving
b. Familiarity with engineering software tools for simulation and analysis (e.g., MATLAB, Simulink)……..are essential

Course Objectives:

1. To introduce students to practical aspects of systems engineering methodologies and techniques.
2. To develop skills in analyzing system behavior, identifying failure modes, and assessing system reliability.
3. To provide hands-on experience in conducting experiments related to systems engineering principles.
4. To enhance students' problem-solving abilities and critical thinking skills in the context of system design and analysis.

Course Outcomes:

The students will be able to:
1. **Apply** systems engineering principles to analyze and optimize system performance.
2. **Gain** proficiency in conducting experiments to assess system reliability and robustness**.**
3. **Develop** the ability to identify and mitigate potential failure modes in complex engineering systems.
4. **Demonstrate** competence in interpreting experimental results and making informed decisions in system design and optimization.

Expt.	Description	Duration, (H)
1.	Systems Thinking Analysis (Mandatory)	10
2.	Modeling of Mechanical Systems	10
3.	Simulation of Mechanical Systems	10
4.	System Integration and Architecture Development	10
5.	Requirement Management and Traceability	10
6.	Trade-off Analysis	10
7.	Failure Mode and Effects Analysis (FMEA)	10
8.	System Reliability and Robustness Testing	**30**
	Total	

Text Books:
1. "Introduction to Systems Engineering" by Andrew P. Sage and William B. Rouse, 2nd Edition, Wiley, 2009.
2. "Systems Engineering: Principles and Practice" by Alexander Kossiakoff, William N. Sweet, Sam Seymour, and Steven M. Biemer, Wiley, 2011.

Reference Books:
1. "Engineering Systems Integration: Theory, Metrics, and Methods" by Gary A. Ford, CRC Press, 2009.
2. "Systems Engineering: Coping with Complexity" by Charles S. Wasson, Wiley, 2006.
3. "System Engineering Analysis, Design, and Development: Concepts, Principles, and Practices" by Charles S. Wasson, Wiley, 2015.

Part B: Elective IV- Reliability in Engineering Design (ANY Three)

Prior knowledge of
Engineering Mathematics is essential **is essential.**

Course Objectives:
1. To impart a basic understanding of probability, statistical techniques used in reliability engineering.
2. To familiarize students with methods used for system reliability modeling and allocation.
3. To be able to select system reliability, maintainability, availability for modeling.

Course Outcomes:
After learning the course, the students should be able to:
1. **Use** the probability distributions for analyzing components and systems.
2. **Select** a suitable method for system reliability modeling and reliability allocation.
3. **Apply** the FMEA at different stages of the product life cycle

Expt.	Description	Duration, (H)
1.	Characteristics of Binomial and Poisson distributions	10
2.	Characteristics of Normal and Log-Normal distributions	10
3.	Determination of MTTF for series and parallel systems	10
4.	Evaluation of basic probability indices for series and parallel systems	10
5.	Markov Analysis of system	10
6.	Reliability allocation to system	10
7.	Failure mode effects analysis, severity / criticality	10
	Total	**30**

Text Books:
1. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.

Part B: Elective IV - Robotics (ANY Three)

Prior knowledge of
Theory of Machines, Matrices is essential.

Course Objectives:
This course aims to enable students,
1. To perform Direct and Inverse kinematics

2. To analyse the velocity and static force of the robot

Course Outcomes:

After completion of this course, the students will be able to,

1. **Analyze** the Forward and Inverse kinematics of a robot
2. **Analyze** the Velocity and Static force of a robot
3. **Analyze** the Dynamics of a robot

Expt.	Description	Duration, (H)
1.	Forward kinematic analysis of a robot	10
2.	Inverse kinematic analysis of a robot	10
3.	Velocity analysis of a robot	10
4.	Static Force analysis of a robot	10
5.	Dynamic analysis of a robot	10
	Total	**30**

References:

1. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
2. S. K. Saha, Introduction to Robotics, Second Edition, McGraw Hill Education, 2014
3. R K Mittal & I J Nagrath, Robotics and Control, McGraw Hill Publication, 2015

Part B: Elective IV – Failure Analysis and Prevention (ANY Three)

Prior knowledge of

1. Basics of material behavior
2. Basic design, manufacture, quality control **is essential.**

Course Objectives:

1. To provide the students with knowledge of Failure analysis techniques.
2. To equip students with the skills necessary to identify the root cause of failure and corrective actions.

Course Outcomes:

After completion of this course, the students will be able to,

1. **Identify** the root cause of failure.
2. **Suggest** the failure prevention measures.
3. **Predict** the failure of components/systems.

Expt.	Description	Duration, (H)
1.	Case study of disasters including the failure analysis using fault tree analysis.	10
2.	Case study of FMEA.	10
3.	Case study of failure analysis based on actual failed component study using various techniques such as NDT, DT, and macroscopic analysis.	10
4.	Case study of failure analysis using microscopic analysis.	10
5.	Failure analysis of fractured component.	10
6.	Case study of failure analysis and suggesting the failure preventive measures.	10
	Total	**30**

References:

1. ASM HANDBOOK Failure Analysis and Prevention (2021 Edition)
2. Disasters case reports.

Part B: Elective IV- Design of Material Handling Equipment (ANY Three)

Prior knowledge of

a. Theory of Machines
b. Engineering mechanics
c. Machine Design……..are essential

Course Objectives:

This course aims at enabling students,

1. Understand the principles and importance of material handling in various industries
2. Analyze safety protocols and regulations associated with material handling systems
3. Identify different types of material handling equipment and their respective applications.
4. Design of material handling systems

Course Outcomes:

After learning the course, the students should be able to:

1. **Analyze** the use and importance of different material handling equipment through case studies, identifying the most efficient solutions for specific applications.

2. **Investigate** the stability factors affecting material handling equipment, and learn methods to enhance their operational safety and efficiency.
3. **Design** a material handling equipment that optimizes efficiency and material flow within a material handling system.

Expt.	Description	Duration, (H)
1.	Case studies based on use and importance of different material handling equipment.	10
2.	Safety in material handling system.	10
3.	Design of electric overhead crane for material handling application	10
4.	Design of forged standard hook for real-life application	10
5.	Design of conveyor belt for material handling applications	10
	Total	**30**

Program:	M. Tech. Mechanical Engineering Design			Semester : II		
Course :	Research Methodology			Code :	MMD22AE01	
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks		
	Lecture	Practical	Tutorial	FA	SA	Total
2	2	-	-	20	30	50

Prior knowledge of Project and seminars in undergraduate is essential.

Course Objectives:

1. To select and define appropriate research problem and parameters with appropriate methodology.
2. To understand statistical techniques for the specific perspective data in an appropriate manner.
3. To learn the various steps in research writing and publication process
4. To introduce fundamental aspects of Intellectual property rights

Course Outcomes:

After learning the course, the students should be able to:

1. **Define** a research problem and use appropriate research methodology
2. **Examine** data using different hypothesis tests and make conclusions about acceptance or rejection of sample data.
3. **Write** a research paper and research proposal.
4. **Write** a concept note and prepare to file an IP.

Detailed Syllabus:

Unit	Description	Duration (H)
I.	**Research Problem and Research Design** Objectives, Motivation, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Criteria of Good Research Definition and Feasibility study of research problem, Sources of research problem, Meaning of Hypothesis, Characteristics of Hypothesis, Errors in selecting a research problem, Concept & need of research design	**8**
II.	**Quantitative Methodology** Applied introduction to quantitative methodology, Measures of Variability: Standard Deviation, variance, Quartiles, Interquartile Range. Inferential Statistics: Statistical inference and significance (p values), Pearson's r test, t- test, Chi square test, ANOVA (Analysis of variance). Correlation, and regression analysis: - Sampling, Types of Sampling, Probability Distribution: Binomial Distribution, Poisson Distribution, Normal Distribution.	**8**
III.	**Research Report writing and Publication** Research Report: Dissemination of research findings, outline and structure of research report, different steps and precautions while writing research report, methods and significance of referencing. Publishing Research work: Selection of suitable journal for publishing research work, Open access V/s Subscription Journals, Identifying indexing of selected journals, Impact factor of the journal, structure of research paper, Check for plagiarism of the article, Research paper submission and review process.	**7**
IV.	**Intellectual property Rights** Definition of IPR, Classification of IP, Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents. Prior Art Search, Patentability Criteria, Patent Filing Procedure, Forms and Fees, Case Study of Patent, Copyright.	**7**
	Total	**30**

Textbooks:

1. Ranjit Kumar, "Research Methodology: A Step-by-Step Guide for Beginners", SAGE Publications, 4th Ed., 2023.
2. Ramakrishna B and Anil Kumar H S., "Fundamentals of Intellectual Property Rights: For students, Industrialist and Patent Lawyers", Notion Press, 2017.

Reference Books:

1. Umesh Kumar B. Dubey, D. P. Kothari, “Research Methodology: Techniques and Trends”, CRC Press, 2022.
2. C. George Thomas. “Research Methodology And Scientific Writing”, Springer, 2021.
3. Virendra Kumar Ahuja, IPR in India, LexisNexis Butterworths Wadhwa Nagpur, 2017
4. Vivien Irish, “Intellectual Property Rights for Engineers”, The Institution of Engineering and Technology, UK, 2005.
5. S.D. Sharma, “Operational Research (Theory methods and applications)”, Kadar Nath Ram Nath & Co, 2020.

Program:	M. Tech. Mechanical Engineering Design					Semester: II	
Course	Research Internship / Field Visit based Case Study/ Experiential Learning (EL)					Code:	MMD22EL01
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
6	-	12	-	100	100	-	200

Prior knowledge of Research project ideas, Design and Simulation software and programming language is essential

Course Objectives:

This course will enable students

1. Engage students in practical research projects/ field visits/ experiential learning topics to apply theoretical knowledge effectively and analyze real-world applications.
2. Develop critical thinking, problem-solving skills, and enhance understanding of engineering principles.

Course Outcomes:

After learning the course, the students will be able to:

1. **Apply** theoretical knowledge gained in the Research Internship/ Field Visit Case Study/ Experiential Learning activities to practical research projects and real-world engineering challenges.
2. **Develop** advanced problem-solving skills, critical thinking abilities, and a deep understanding of engineering principles

Research Internship

Guidelines:

1. Individual student need to attempt for research internship under the guidance of allocated supervisor.
2. Prior approval from the program coordinator is required for research internships, field visits, or experiential learning activities to ensure alignment with program objectives and learning outcomes.
3. Student can do research internship in the industry / institute under guidance of allocated supervisor.
4. Student doing research internship in the industry can work on the problem statement provided by the industry. For student doing internship in the institute, supervisor will assign a research task (problem statement) Student is supposed to provide a feasible solution to the assigned problem statement.
5. Student will synthesize research findings by drafting a research report.
6. Students are required to maintain detailed records of their activities in project diary for tasks performed, data collected, observations made, and any challenges encountered during the internship or field visit.
7. Three reviews will be scheduled to assess progress of the research work. Review-I: Student will present current state of the art of the literature for the assigned research task.
   Review-II: Explanation of the partial results obtained.
   Review-III: Demonstration and explanation of the work carried during internship is expected.
8. Student is supposed to submit research internship report as a compliance of term work associated with subject.
9. Student should try to publish the results in the reputed journal or register a patent/ Copyright.

Assignment No.	Detailed Syllabus: Suggested List of Assignments
1.	Assignment of research task • Presentation of domain knowledge in the interested area of research • Guide allotment • Assignment of research task by supervisor
2.	Finalize problem statement and define objectives
3.	Conducting critical literature review: Selection of appropriate research papers Critical reading and thinking Comparative analysis of the papers Finding a research Gap
4.	Review-1 (Will be conducted in Week 4-5): Expectation: Discussion on the problem statement and defined objectives
6.	Implementation of the problem statement: Identification of technology/methodology/algorithm, system architecture, flow diagram, mathematical modeling, front end, back end
7.	Review-2 (Will be conducted in Week 10): Expectations: Discussion on methodology, system architecture, implementation and partial results.
9.	Review-3 (Will be conducted in Week 15): Result Analysis and discussion

10.	Write a research paper/funding proposal/patent draft. Software for paper formatting like LaTeX/MS Office etc can be used Citing styles and tools such as Google scholar, Mendley etc Reference Management Software like Zotero/Mendeley

Field Visit based Case Study (EL)

Guidelines:

1. Supervisor Guidance: Each student will undertake a field visit based case study under the supervision of an assigned faculty member.
2. Program Coordinator Approval: Prior approval from the program coordinator is necessary to ensure the alignment of field visit activities with course objectives and learning outcomes.
3. Internship Locations: Students can conduct their field visits in industry / institutes, with guidance from their allocated supervisor.
4. Industry Problem Statements: Students conducting field visits in industry settings will work on problem statements provided by the industry.
5. Institute Research Tasks: For visits to institutes, supervisors will assign research tasks, such as problem statements or components of funding proposals.
6. Solution Proposal: Students must propose feasible solutions to the assigned problem statements based on their case study findings.
7. Research Report: Synthesize case study findings into a comprehensive research report, documenting activities, data collected, observations, and challenges encountered during the field visit.
8. Review Sessions: Three review sessions will be conducted to assess progress:
9. Review-I: Present the state of the art literature relevant to the assigned research task.
10. Review-II: Explain partial results obtained during the field visit.
11. Review-III: Demonstrate and explain the work conducted during the field visit.
12. Report Submission: Submit a field visit based case study report as a requirement for course completion.
13. Publication or Patent: Encourage students to publish their findings in reputed journals or register patents based on their case study results.

Task No.	Detailed Syllabus: Task to be carried out
1.	Assignment of research task • Presentation of domain knowledge in the interested area of research • Guide allotment • Assignment of research task by supervisor
2.	Finalize problem statement and define objectives
3.	Conducting critical literature review: Selection of appropriate research papers Critical reading and thinking Comparative analysis of the papers Finding a research Gap
4.	Review-1 (Will be conducted in Week 5-6): Expectation: Discussion on the problem statement and defined objectives
6.	Data Collection: Techniques of data collection. Sources used for Data collection, creation and publishing own Data Sets if required
7.	Implementation of the problem statement: Identification of technology/methodology/algorithm, system architecture, flow diagram, mathematical modeling, front end, back end
9.	Review-2 (Will be conducted in Week 11): Expectations: Discussion on methodology, system architecture, implementation and partial results.
10.	Result Analysis and discussion
11.	Write a research paper/funding proposal/patent draft. Software for paper formatting like LaTeX/MS Office etc can be used Citing styles and tools such as Google scholar, Mendley etc Reference Management Software like Zotero/Mendeley

Experiential Learning (EL)

Guidelines:

1. Supervisor Guidance: Each student will undertake experiential learning activities under the guidance of an allocated supervisor.
2. Program Coordinator Approval: Prior approval from the program coordinator is necessary for experiential learning activities to ensure alignment with course objectives and learning outcomes.
3. Internship Locations: Students can engage in experiential learning activities in industry settings or at top 50 NIRF institutes, under the guidance of their allocated supervisor.
4. Industry Problem Statements: Students participating in industry-based experiential learning can work on problem statements provided by the industry.
5. Institute Research Tasks: For students engaged in institute-based activities, supervisors will assign research tasks or components of funding proposals.
6. Feasible Solutions: Students must provide feasible solutions to the assigned problem statements based on their experiential learning activities.
7. Research Report: Synthesize findings from experiential learning activities into a comprehensive research report, documenting activities, data collected, observations, and challenges encountered.
8. Progress Reviews: Three progress reviews will be conducted to assess student progress:
9. Review-I: Present the current state of the art literature relevant to the assigned research task.
10. Review-II: Explain partial results obtained during the experiential learning activities.
11. Review-III: Demonstrate and explain the work conducted during the experiential learning activities.
12. Report Submission: Submit an experiential learning report as a requirement for course completion.
13. Publication or Patent: Encourage students to publish their findings in reputed journals or register patents based on their experiential learning results.

Task No.	Detailed Syllabus: Task to be carried out
1.	Assignment of research task • Presentation of domain knowledge in the area of interest for experiential learning. • Allocation of supervisor to guide students.
2.	**Problem Definition:** Finalize problem statement and define objectives for the experiential learning project.
3.	Conduct critical literature review: Select appropriate research materials from the authenticate sources. Engage in critical reading and comparative analysis. Identify research gaps relevant to the experiential learning project
4.	Review-1 (Will be conducted in Week 5-6): Expectation: Discussion on the problem statement and defined objectives
6.	Implementation of the problem statement: Identification of technology/methodology/algorithm, system architecture, flow diagram, mathematical modeling, front end, back end
7.	Review-2 (Will be conducted in Week 11): Expectations: Discussion on methodology, system architecture, implementation and partial results.
9.	Result Analysis and discussion Analyze results obtained from the implementation phase. Engage in discussions regarding the implications and significance of the findings
10.	Write a research paper, funding proposal, or patent draft based on the experiential learning project: Use appropriate software for paper formatting (e.g., LaTeX, MS Office). Apply citing styles and tools such as Google Scholar, Mendeley, etc. Manage references using reference management software like Zotero or Mendeley.

Program:	M. Tech. Mechanical Engineering Design					Semester: II	
Course:	Research Writing					Code:	MMD22AE02
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
1	-	2	-	50	-	-	50

Prior knowledge of
basic idea and purpose of research problem formulation,
Literature Review, Paper Writing Tools is essential.

Course Objectives:

1. Enhance research problem formulation and literature review skills.
2. Equip students with proficiency in using paper writing tools and presenting research findings effectively.

Course Outcomes:

After completion of this course, the students will be able to,

1. **Synthesize** well-defined research problems, showcasing understanding and innovation.
2. **Evaluate** existing research through comprehensive literature surveys, critical analysis, and gap identification for original contributions.
3. **Apply** effective utilization of paper writing tools for proper organization, formatting, and citation practices in research papers and presentations.

Guidelines:

1. Ensure clarity, relevance, and originality in articulating research problems, demonstrating a deep understanding of the research domain.
2. Conduct a comprehensive literature review, critically analyzing relevant literature to identify research gaps and synthesize key findings, while contextualizing the research problem within existing literature.
3. Demonstrate proficiency in using paper writing tools such as Latex, Mendeley, and TypeSet, ensuring effective organization, formatting, and adherence to proper citation and referencing practices.
4. Effectively communicate research findings through presentations at reputable conferences and aim for publication in esteemed journals.
5. Evaluate the quality of work based on research problem formulation, literature survey, and paper presentation. Assess technical profiIEncy in paper writing tools and presentation skills. Monitor the status of papers for journal publication.
6. Adhere to submission deadlines for assignments, research papers, and conference abstracts. Failure to present at a conference or publish a journal paper without valid reasons may result in course failure. Uphold academic integrity by avoiding plagiarism and adhering to citation and referencing standards.

Detailed Syllabus

Expt. No.	Suggested List of Experiments (Solve any six from the list of following eight experiments)
1.	Generate and refine research problem statements through group discussions and individual work.
2.	Conduct literature searches, critically analyze key papers, and identify research gaps.
3.	Attend workshops on using Latex, Mendeley, and TypeSet, and complete assignments using these tools.
4.	Participate in presentation skills workshops and practice sessions for effective communication.
5.	Engage in peer review sessions and receive feedback from instructors to improve work quality.
6.	Revise and finalize research papers Submission of assignments and papers and presentations based on feedback received.

Course Syllabus

Semester-III

Program:	M. Tech. Mechanical Engineering Design			Semester: III	
Course	Massive Open Online Course (MOOC)			Code	MMD23EL02
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme	
	Lecture	Practical	Tutorial	TW	Total
4	4	-	-	100	100

Course Objectives:

1. To provide diversified knowledge and skills in a single platform
2. To provide an opportunity for students to explore new areas of interest
3. To foster student engagement in self-learning

Course Outcomes:

After learning the course, the students will be able to:

1. **Acquire** knowledge about various technical domains.
2. **Apply** domain experiences in solving real life problems.
3. **Analyze** the new state- of- art for life-long learning.

Guidelines for Students:

Individual students need to register for MOOC courses of their interest.

A. Selection of Course:

- Students can select any MOOC Course from an Online Certification provider with guidance from MOOC Mentor.
- The selected course should not be from courses offered in the program curriculum earlier at UG and PG level.
- The selected MOOC course should be approved by the Department.
- The selected course should be from NPTEL/ Coursera / Udemy/Any foreign University approved course.
- Certification and Grade report is mandatory for the course to be selected.

B. Duration of Course: Select any two courses of minimum 8 weeks duration.

C. Assessment of Course:

- At the end of the semester, MOOC reports of 10-15 Pages each in hardcopy are mandatory, along with the certificate of completion.
- Assessment will be done on the basis of the MOOC Certification exam along with Oral and Presentation at the end of the semester.

Evaluation Guidelines and Rubrics:

- Students will be evaluated progressively for a total 100 Marks. (i.e. 70 Marks Progressive and 30 Marks Completion of Certificate)

Sr. No.	Rubrics	Marks
1	Presentation of the Selected topic	20
2	Scores of Assignments Submitted	50
3	Certification received based on the examination conducted by MOOCs provider	30
Total Marks		**100**

The **30** marks will be based on Certification Completion.

Program:	M. Tech. Mechanical Engineering Design					Semester: III	
Course	On Job Training / Core mini Project / Development of Experimental Setup / Community Engagement Project / Interdisciplinary Project					Code:	MMD23EL03
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
10	-	20	-	200	100	-	300

Prior knowledge of:

a. Basics of Computer Programming Concepts
b. Knowledge about internship area and program in which internship is interested
c. Project Management
d. Research Methodology
e. Experimental Design is essential.

Course Objectives:

This course will enable students

1. Apply engineering principles to real-world scenarios in relevant industries or research institutions, demonstrating practical application and problem-solving skills.
2. Develop project management and research methodology skills through hands-on experience under faculty guidance.

Course Outcomes:

After learning the course, the students will be able to:

1. **Analyze and solve** real-world engineering problems effectively.
2. **Apply** core technical or interdisciplinary theoretical concepts to practical scenarios through hands-on project-based work.

EL: On Job Training

Guidelines:

1. Project Proposal Submission: Submit a detailed proposal outlining the chosen activity, including objectives, methodology, timeline, and expected outcomes. Obtain approval from the course coordinator or faculty advisor before starting the OJT.
2. Supervision: Be assigned a faculty supervisor for guidance and support throughout the project duration. Schedule regular meetings with the supervisor to track progress and address any issues.
3. Idea Presentation: Present ideas based on chosen topics to faculty members as part of the internship or entrepreneurship opportunity.
4. Progress Reports: Submit progress reports at specified intervals, detailing completed work, challenges faced, and plans for the next phase. These reports will be evaluated by the supervisor to ensure timely progress.
5. Final Report and Presentation: Prepare a comprehensive final report documenting the work, including literature review, methodology, results, and conclusions. Deliver a presentation summarizing findings to a panel of faculty members at the end of the project.
6. Internship Report Submission: Submit the internship report as a requirement for the course. Also, provide internship details and certificate to the course coordinator for credit. Additionally, submit a working project demonstrating acquired skills if permitted by the industry

Task No.	Detailed Syllabus: Task to be carried out
1.	Week 1 - 2: Guide Allotment and On Job Training Application Students are assigned a faculty guide to oversee their training. They apply for on job training opportunities relevant to their field of study. Students present their domain knowledge to the faculty in their chosen area of on job training.
2.	Week 3 - 4: Topic Finalization and Planning Students finalize the topic or project scope for their on job training activity. They develop a detailed plan outlining objectives, methodology, and timeline for their work. A preliminary review is conducted to assess the feasibility and adequacy of the proposed plan.
3.	Week 5 - 8: On Job Training Activity Implementation Students begin implementing their on job training activities as per the requirements. They engage in practical work, gaining hands-on experience in their chosen field.
4.	Week 9 - 10: Review of Activities A mid-term review is conducted to evaluate the progress of the on job training activities. Students reflect on their achievements and address any challenges or deviations from the initial plan.
5.	Week 11 - 12: Interaction with Industry and Presentation

	Faculty guides interact with industry experts to gather feedback on students' work. Students prepare and deliver a poster presentation to showcase their activities and findings.
6.	Week 13 - 15: On Job Training Report Writing and Final Review Students write a comprehensive report documenting their on job training experience, including project details, outcomes, and learnings. They may explore options for publication or copyright planning for their work. Final review is conducted to evaluate the overall performance and outcomes of the On Job Training course.

L: Core mini Project

Guidelines:

1. Project Proposal Submission: Submit a detailed proposal outlining the chosen project activity, including objectives, methodology, timeline, and expected outcomes. Obtain approval from the course coordinator or faculty advisor before commencing the project.
2. Supervision: Be assigned a faculty supervisor who will provide guidance and support throughout the project duration. Schedule regular meetings with the supervisor to track progress and address any issues.
3. Idea Presentation: Present project ideas to faculty members as part of the project initiation process, ensuring alignment with course objectives and feasibility.
4. Progress Reports: Submit progress reports at specified intervals, detailing completed work, challenges faced, and plans for the next phase. These reports will be evaluated by the supervisor to ensure timely progress.
5. Final Report and Presentation: Prepare a comprehensive final report documenting the project work, including literature review, methodology, results, and conclusions. Deliver a presentation summarizing findings to a panel of faculty members at the end of the project.
6. Project Completion and Documentation: Submit the completed project along with all relevant documentation, including the final report, to the course coordinator for evaluation.

Task No.	Detailed Syllabus: Task to be carried out
1.	Week 1 - 2: Guide Allotment and Topic Selection Students are assigned a faculty guide to mentor them throughout the project. They explore potential project topics and select one aligned with their interests and expertise.
2.	Week 3 - 4: Project Planning and Review-1 Students finalize the project topic and outline project objectives and methodology. They conduct an initial review (Review-1) to ensure the project plan is comprehensive and feasible
3.	Week 5 - 8: Project Implementation Students begin implementing their project, following the planned methodology. They collect data, perform analyses, and develop solutions as per project requirements.
4.	Week 9 - 10: Mid-term Review-2 A mid-term review (Review-2) is conducted to evaluate project progress and address any challenges. Students reflect on their accomplishments and make adjustments to their project plan if necessary.
5.	Week 11 - 12: Interaction with Industry and Poster Presentation Faculty guides facilitate interactions with industry experts to gather feedback on project progress. Students prepare and deliver a poster presentation summarizing their project findings and progress.
6.	Week 13 - 15: Project Report Writing and Final Review Students compile their project findings, analyses, and conclusions into a comprehensive project report. They may explore options for publication or copyright planning for their project work. Final review is conducted to assess the overall project outcomes and student performance.

EL: Development of Experimental Setup

Guidelines:

1. Project Proposal Submission: Submit a detailed proposal outlining the planned experimental setup, including objectives, methodology, timeline, and expected outcomes. Obtain approval from the course coordinator or faculty advisor before beginning the project.
2. Supervision: Be assigned a faculty supervisor who will offer guidance and support throughout the project duration. Schedule regular meetings with the supervisor to discuss progress, address challenges, and ensure alignment with course objectives.
3. Idea Presentation: Present the proposed experimental setup to faculty members for feedback and approval, ensuring feasibility and alignment with course objectives.
4. Progress Reports: Submit progress reports at designated intervals, providing updates on completed work, encountered challenges, and plans for the next phase. These reports will be reviewed by the supervisor to monitor progress and offer guidance.

5. Final Report and Presentation: Prepare a comprehensive final report documenting the development of the experimental setup, including details on design, construction, instrumentation, and validation. Deliver a presentation summarizing the setup's features, functionality, and validation process to a panel of faculty members at the end of the course.
6. Project Completion and Documentation: Submit the completed experimental setup along with all relevant documentation, including design drawings, construction plans, instrument specifications, and validation data, to the course coordinator for evaluation.

Task No.	Detailed Syllabus: Task to be carried out
1.	Week 1 - 2: Guide Allotment and Topic Exploration Students are assigned a faculty guide to oversee their project. They explore potential topics for developing experimental setups and present their domain knowledge in their chosen area.
2.	Week 3 - 4: Topic Finalization and Planning and Review I Students finalize the topic for their experimental setup project. They develop a detailed plan outlining the objectives, methodology, and required resources for their project. Review-1 is conducted to assess the feasibility and adequacy of the proposed plan
3.	Week 5 - 8: Experimental Setup Development Students begin developing their experimental setups according to the planned methodology. They acquire necessary components, design prototypes, and conduct initial tests to ensure functionality.
4.	Week 9 - 10: Mid-term Review A mid-term review is conducted to evaluate the progress of the experimental setup development. Students present their progress and address any challenges or modifications needed to their plan
5.	Week 11 - 12: Interaction with Industry and Poster Presentation Faculty guides facilitate interactions with industry experts to gather feedback on the experimental setup design. Students prepare and deliver a poster presentation showcasing their setup's design and progress
6.	Week 13 - 15: Experimental Setup Documentation and Final Review Students document their experimental setup development process, including design specifications, test results, and modifications made. They explore options for publication or copyright planning for their work. Final review is conducted to evaluate the overall performance and outcomes of the Development of Experimental Setup course.

EL: Community Engagement Project

Guidelines:

1. Project Identification: Identify a community or organization to collaborate with and select a societal challenge to address.
2. Community Engagement Plan: Develop a detailed plan outlining objectives, methodologies, and expected outcomes of the community engagement project.
3. Stakeholder Collaboration: Engage with community members and relevant stakeholders to ensure alignment of project goals and objectives.
4. Implementation and Progress Tracking: Execute the community engagement project according to the established plan and regularly monitor progress.
5. Reporting and Feedback: Provide regular progress reports to stakeholders, highlighting achievements, challenges, and proposed solutions.
6. Final Evaluation and Presentation: Prepare a comprehensive final report documenting project activities, outcomes, and lessons learned. Deliver a presentation summarizing project findings and impact to stakeholders and faculty members.
7. Duration: The course duration is 300 contact hours, with students expected to dedicate additional time to project-related activities and requirements.

Detailed Syllabus: Community Engagement Project

Task No.	Task to be carried out
1.	Week 1-2: Community Identification and Engagement Identify and engage with a local community or organization to understand their needs and challenges. Present domain knowledge relevant to the community's interests and challenges.

2.	Week 3-4: Project Planning and Topic Finalization :Review I Finalize the project topic based on the identified community needs and interests. Develop a detailed plan for project implementation, including objectives, methodologies, and timeline
3.	Week 5-8: Project Implementation Execute the community engagement project according to the established plan. Implement activities such as workshops, surveys, or events to address community needs and foster engagement
4.	Week 9-10: Progress Review Conduct a review of project activities and progress to assess effectiveness and address any challenges.
5.	Week 11-12: Stakeholder Interaction and Presentation Engage with community stakeholders and industry experts to gather feedback and insights. Prepare and deliver a poster presentation summarizing project activities and outcomes.
6.	Week 13-15: Project Documentation and Final Review Write the internship report documenting project details, including objectives, methodologies, results, and conclusions. Plan for publication or copyright of project outcomes. Conduct a final review to evaluate project success and lessons learned.

EL: Interdisciplinary Project

Guidelines:

1. Project Proposal Submission: Submit a detailed proposal outlining the chosen interdisciplinary project, including objectives, methodology, timeline, and expected outcomes. Obtain approval from the course coordinator or faculty advisor before commencing the project.
2. Supervision: Be assigned a faculty supervisor who will provide guidance and support throughout the project duration. Schedule regular meetings with the supervisor to track progress and address any issues.
3. Idea Presentation: Present project ideas based on interdisciplinary integration to faculty members as part of the project initiation process.
4. Progress Reports: Submit progress reports at specified intervals, detailing completed work, challenges faced, and plans for the next phase. These reports will be evaluated by the supervisor to ensure timely progress.
5. Final Report and Presentation: Prepare a comprehensive final report documenting the interdisciplinary project work, including literature review, methodology, results, and conclusions. Deliver a presentation summarizing findings to a panel of faculty members at the end of the project.
6. Project Completion and Documentation: Submit the completed interdisciplinary project along with all relevant documentation, including the final report, to the course coordinator for evaluation.

Task No.	**Detailed Syllabus: Task to be carried out**
1.	Week 1-2: Guide Allotment and Topic Exploration Students are assigned faculty guides and explore potential interdisciplinary project topics. They present their domain knowledge relevant to the chosen area of interdisciplinary integration.
2.	Week 3-4: Topic Finalization and Planning (Review I) Finalize the interdisciplinary project topic and develop a comprehensive plan for project execution. Conduct Review-1 to discuss the chosen topic and project plan.
3.	Week 5-8: Project Implementation Implement the interdisciplinary project according to the established plan, incorporating elements from multiple fields. Engage in internship or entrepreneurship activities as per project requirements.
4.	Week 9-10: Progress Review Conduct Review-2 to evaluate progress, address any challenges, and refine project strategies if needed.
5.	Week 11-12: Industry Interaction and Presentation Interact with industry experts to gather insights and feedback on the interdisciplinary project. Prepare and deliver a poster presentation showcasing project progress and finding
6.	Week 13-15: Project Reporting and Final Review Write the interdisciplinary project report, including literature review, methodology, results, and conclusions. Submit the report for publication or copyright planning and conduct the Final Review to assess project outcomes and learning achievements..

Program:	**M. Tech. Mechanical Engineering Design**				**Semester: III**		
Course:	**Dissertation/Specialization Project - Phase I [Company/ In-house project]**				**Code** :		**MMD23EL04**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
6	-	12	-	100	100	-	200

Prior knowledge of:

a. Basic knowledge of Mechanism and Machine Design,
b. Mechanical system design,
c. Basics of Analysis software,
d. MATLAB programming is essential

Course Objectives:

This course will enable students

1. To plan for various activities of the major project and channelize the work towards product /process development.
2. To enable students to apply the knowledge about research design and methods to develop their project.
3. To inculcate research culture in students for their technical growth and lifelong learning.

Course Outcomes:

After learning the course, the students will be able to:

1. **Understand, plan and execute** an original Project work with appreciable research outcomes.
2. **Integrate** theory and practice in relation to the identified area of study.
3. **Demonstrate** research skills in the chosen area of study.
4. Prepare quality technical report based on the project work.

Guidelines:

1. Students should get the approval of authorities for dissertation title.
2. Sponsored Project Internship is acceptable considering postgraduate scope.
3. Students shall conduct a comprehensive review of relevant literature and research in the chosen field. Critically analyze existing work and identify gaps, controversies, or areas needing further exploration.
4. Students shall provide an overview of the research problem, its significance, and the objectives of the study. Briefly discuss the background literature and highlight the gap your research aims to address.
5. Students shall describe the research Aim, Objectives, methodology and expected outcomes or contributions of the research
6. Individual student need to design and demonstrate project under the guidance of allocated guide.
7. Project Report-1should be submitted as a compliance of term work associated with the subject.
8. 40% of planned project work should be completed for submission of Dissertation Phase-I.

Detailed Syllabus

Task No.	**Description**
1.	Week 1-3: Initial Planning and Preparation Allocate guides to students and facilitate the process of applying for sponsorship and project internships. Finalize project topics and platforms, and develop a detailed work plan.
2.	Week 4-6: Literature Review and Methodology Finalization Conduct a thorough literature review relevant to the project. Finalize specifications and methodologies for the project. Conduct Review-1 to finalize the project topic and specifications.
3.	Week 7-9: Platform Understanding and Design Execution Gain understanding of the platform for implementation and related software flow. Execute block-level design based on the project requirements. Conduct Review-2 to assess project progress.
4.	Week 10-11: Simulation and Hardware Finalization Simulate the proposed methodology using appropriate software tools. Finalize the hardware platform for project implementation.
5.	Week 12-15: Project Report Writing and Finalization Dedicate time to writing the project report and planning for copyright execution. Demonstrate the project work and undergo Final Review to ensure compliance with term work requirements before submission.

Course Syllabus

Semester-IV

Program:	M. Tech. Mechanical Engineering Design					Semester: IV	
Course	Dissertation/Specialization Project - Phase II [Company/ In-house project]					Code:	MMD24EL05
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
20	-	40	-	400	200	-	600

Prior knowledge of:

a. Basic knowledge of Mechanism and Machine Design,
b. Mechanical system design,
c. Basics of Analysis software,
d. MATLAB programming is essential

Course Objectives:

This course will enable students

1. To understand the Product Development Process including budgeting.
2. To plan for various activities of the major project and channelize the work towards product development.
3. To build, design and implement real time application using available platforms.
4. To inculcate research culture in students for their technical growth.

Course Outcomes:

After learning the course, the students will be able to:

1. **Understand, plan and execute** an original Project work with appreciable research outcomes.
2. **Integrate** theory and practice in relation to the identified area of study.
3. **Demonstrate** research skills in the chosen area of study.
4. Prepare good quality technical report based on the project.
5. Publish good quality paper in reputed journal and present their work in reputed conferences

Guidelines:

1. Semester III major project is continued to be completed in this section under the guidance of allocated project guide.
2. Summarize the research problem, objectives, and methodology from Phase I, noting any adjustments based on feedback.
3. Detail the steps taken to implement your proposed solution or research methodology.
4. Describe the experiments or studies conducted, including setup, data collection methods, and variables investigated.
5. Present the results in a clear and organized manner, analyzing the data for meaningful insights.
6. Interpret the results within existing literature and theoretical frameworks.
7. Summarize key findings and their implications, reflecting on contributions to the field and future research directions.
8. Reflect on the research experience, discussing challenges, lessons learned, and changes in understanding or approach.
9. Final Project Report including all process of project should be submitted as a compliance of term work associated with subject and permission to appear for examination.
10. Total 2 Paper publications are expected as research outcome of Project Stage-I and II (Conference or reputed journal) and 100% of planned project work should be completed for submission of Dissertation Phase-II .

Detailed Syllabus

Assignment No.	Description
1.	Week 1-2: Progress Monitoring Ensure that at least 60% of the project work is completed during this period. Regularly monitor progress and address any issues that may arise.
2.	Week 3-4: Software Simulation and Hardware Implementation Complete software simulations and hardware implementations as per project requirements. Conduct Review-1 to evaluate the progress and discuss any challenges faced.
3.	Week 5-7: Paper Publication Process Initiate or complete the process of paper publication related to the project. Aim to accomplish at least 80% of the project work during this phase..
4.	Week 8-10: Project Completion and Review Ensure that all project work is completed, reaching 100% compliance. Conduct Review-2 to assess project progress and ensure alignment with objectives.

5.	Week 11-12: Department Reviews Schedule department reviews to evaluate the quality of the project and assess fulfillment of requirements. Make necessary adjustments based on feedback received during reviews.
6.	Week 13-15: Project Report Writing and Final Review Dedicate time to writing the project report and planning for copyright execution. Conduct a demonstration of the project work and undergo Final Research Review Committee (RRC) reviews for submission and compliance with term work requirements