Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

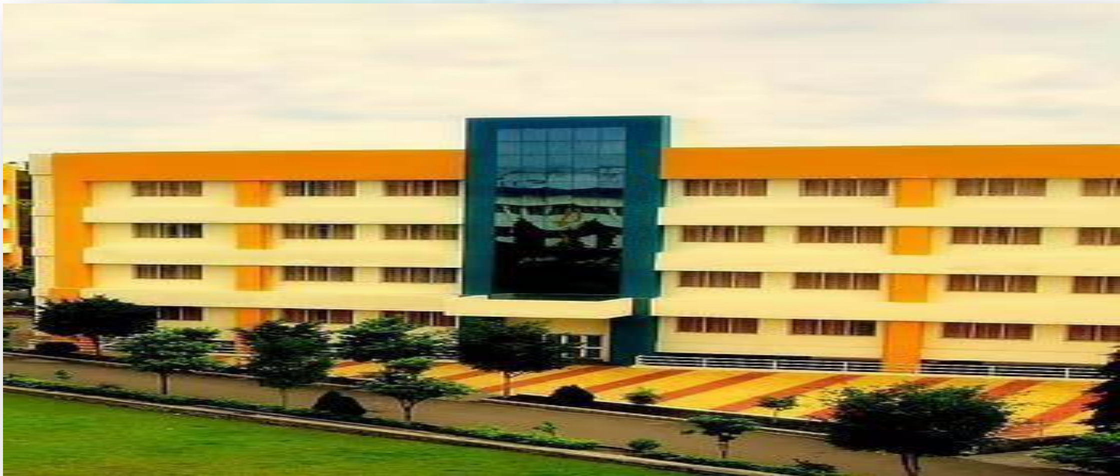
An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum Structure and Syllabus
of
M. Tech. Computational Mechanics (Mechanical Engineering)

(Approved by BoS Mechanical Engineering)

(Regulation 2024)



Effective from Academic Year 2025-26
(Updated with Minor Changes)

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. Computational Mechanics (Mechanical Engineering)

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.	Finite Element Method	MMC21PC01	11	
2.	Computational Fluid Dynamics	MMC21PC02	14	
3.	Professional Elective-I	MMC21PE01	16-21	
4.	Professional Elective-II	MMC21PE02	22-26	
5.	Finite Element Method Lab	MMC21PC03	27	
6.	Computational Fluid Dynamics Lab	MMC21PC04	28	
7.	Professional Elective-I Lab	MMC21PE03	30-32	
8.	Professional Elective-II Lab	MMC21PE04	33-38	
FY M Tech – Semester II				
9.	Numerical Analysis	MMC22PC05	40	
10.	Professional Elective III	MMC22PE05	42-45	
11.	Professional Elective IV	MMC22PE06	46-51	
12.	Numerical Analysis Lab	MMC22PC06	52	
13.	Professional Elective- III & IV Lab	MMC22PE07	53-58	
14.	Research Methodology	MMC22AE01	59	
15.	Research Internship / Field Visit based Case Study/ Experiential Learning	MMC22EL01	60-63	
16.	Research Writing	MMC22AE02	64	

Approved by Academic Council:

Chairman, Academic Council
Pimpri Chinchwad College of Engineering

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ABBREVIATION

Abbreviations	Course Full Name
PCC	Programme Core Course
PEC	Professional Elective Course
AEC	Ability Enhancement Courses
EL	Experiential Learning
MOOCs	Massive Open Online Course

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
4	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 / MOOCs	-	6	20	20	46	57.5
		Total	**20**	**20**	**20**	**20**	**20**	**20**

Curriculum Structure

CURRICULUM STRUCTURE

STRUCTURE FOR FIRST YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)
SEMESTER – I

First Year Computational Mechanics (Mechanical Engineering) (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**
MMC21PC01	Finite Element Method	3	-	-	3	3	-	-	40	60	-	-	-	100
MMC21PC02	Computational Fluid Dynamics	3	-	-	3	3	-	-	40	60	-	-	-	100
MMC21PE01	Professional Elective-I	3	-	-	3	3	-	-	40	60	-	-	-	100
MMC21PE02	Professional Elective-II	3	-	-	3	3	-	-	40	60	-	-	-	100
MMC21PC03	Finite Element Method Lab	-	2	-	2	-	4	-	-	-	25	-	25	50
MMC21PC04	Computational Fluid Dynamics Lab	-	2	-	2	-	4	-	-	-	25	-	25	50
MMC21PE03	Professional Elective-I Lab	-	2	-	2	-	4	-	-	-	50	-	-	50
MMC21PE04	Professional Elective-II Lab	-	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

Course Code	Elective-I	Course Code	Elective-II
MMC21PE01A	Applied Solid Mechanics	MMC21PE02A	Advanced Machine Design
MMC21PE01B	Advanced Thermodynamics and Combustion	MMC21PE02B	Applied Fluid Mechanics
MMC21PE01C	Artificial Intelligence For Engineers	MMC21PE02C	Data Analytics

Course Code	Elective-I	Course Code	Elective-II
MMC21PE03A	Applied Solid Mechanics Lab	MMC21PE04A	Advanced Machine Design Lab
MMC21PE03B	Advanced Thermodynamics and Combustion Lab	MMC21PE04B	Applied Fluid Mechanics Lab
MMC21PE03C	Artificial Intelligence For Engineers Lab	MMC21PE04C	Data Analytics Lab

Note: Students must select the lab of their respective opted Professional Elective courses.

STRUCTURE FOR FIRST YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)
SEMESTER – II

First Year Computational Mechanics (Mechanical Engineering) (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**
MMC22PC05	Numerical Analysis	3	-	-	3	3	-	-	40	60	-	-	-	100
MMC22PE05	Professional Elective III	2	-	-	2	2	-	-	20	30	-	-	-	50
MMC22PE06	Professional Elective IV	2	-	-	2	2	-	-	20	30	-	-	-	50
MMC22PC06	Numerical Analysis Lab	-	2	-	2	-	4	-	-	-	25	-	25	50
MMC22PE07	Professional Elective- III & IV Lab	-	2	-	2	-	4	-	-	-	50	-	-	50
MMC22AE01	Research Methodology	2	-	-	2	2	-	-	20	30	-	-	-	50
MMC22EL01	Research Internship / Field Visit based Case Study/ Experiential Learning	-	6	-	6	-	12	-	-	-	100	-	100	200
MMC22AE02	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

Course Code	**Elective-III**	**Course Code**	**Elective-IV**
MMC22PE05A	Advanced Heat and Mass Transfer	MMC22PE06A	Advance Computational Fluid Dynamics
MMC22PE05B	Optimization Techniques	MMC22PE06B	Non-linear FEM
MMC22PE05C	Computational Dynamics and Vibrations	MMC22PE06C	Fluid Structure Interaction

STRUCTURE FOR SECOND YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)
SEMESTER-III

Second Year Computational Mechanics (Mechanical Engineering) (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
MMC23EL02	MOOCs (Two Courses : Eight Week Each)	4	-	-	4	4	-	-	-	-	100	-	-	100
MMC23EL03	On Job Training / Core mini Project / Development of Experimental Setup / Community Engagement Project / Interdisciplinary Project.	-	10	-	10	-	10	-	-	-	200	-	100	300
MMC23EL04	Dissertation/Specialization Project - Phase I [Company/ In-house project]	-	6	-	6	-	6	-	-	-	100	-	100	200
Total		**4**	**16**	**-**	**20**	**4**	**16**	**-**	**-**	**-**	**400**	**-**	**200**	**600**

STRUCTURE FOR SECOND YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)
SEMESTER-IV

Second Year Computational Mechanics (Mechanical Engineering) (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
MMC24EL05	Dissertation/Specialization Project - Phase II [Company/ In-house project]	-	20	-	20	-	20	-	-	-	400	-	200	600
Total		**-**	**20**	**-**	**20**	**-**	**20**	**-**	**-**	**-**	**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. Computational Mechanics (Mechanical Engineering)			Semester: I		
Course :	Finite Element Method (PCC)			Code :	MMC21PC01	
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 at enabling 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 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 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 Kirchhoff theory and Mindlin plate element theory
4. **Derive and solve** heat and mass transfer numerical
5. **Understand** the nonlinear behavior related to geometry, material, and contact.
6. **Formulate and solve** the dynamic problems related to eigen value and Eigen vectors model

Detailed Syllabus:

Unit	Description	Duration [Hrs.]
1	**One dimensional problems** 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
2	**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
3	**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
4	**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

5.	**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**
6	**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

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. Computational Mechanics (Mechanical Engineering)**			**Semester :**		**I**
Course :	Computational Fluid Dynamics **(PCC)**			**Code :**		MMC21PC02
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	**3**	**-**	**-**	**40**	**60**	**100**

Prior knowledge of Fluid Mechanics, Thermodynamics and Heat Transfer **is essential.**

Course Objectives:

This course aims at enabling students,

1. Understand the basics of conservation laws and transport mechanisms of fluid- dynamics and numerical methods used for obtaining solution and calculation of engineering-parameters in CFD.
2. Algebraic formulation: develop the ability to do discretization by finite volume method.
3. CFD development: develop programming skills by in-house code development for conduction, convection or fluid dynamics problems.
4. CFD application and analysis: Learn to apply the code on various problems in fluid dynamics and heat-transfer; and analyze as well as discuss the results.

Course Outcomes:

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

1. **Understand** the major theories, approaches and methodologies used in CFD.
2. **Understand and Apply** finite difference methods to heat transfer problems
3. **Apply** suitable discretization technique to governing equations and convert into algebraic equations
4. **Analyze** the problem in fluid mechanics and heat transfer and mathematically model it
5. **Understand and Apply** finite volume methods to heat transfer and fluid flow problems
6. **Create** geometric model and **Solve** real life problem in an engineering domain using turbulence model

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Introduction** Introduction to CFD: Definition and significance of CFD; CFD analysis process: development, application and analysis; Essentials of Fluid-Mechanics and Heat-Transfer: Conservation and subsidiary laws, transport mechanisms, and differential formulation from the conservation laws.	**8**
2	**Mathematical Foundation and Numerical Methods** Overview of differential equations relevant to CFD ODE (IVP and BVP) and PDE, classification of PDE; Introduction to numerical methods: Finite Difference Method (FDM), Finite Volume Method (FVM), and Finite Element Method (FEM); Discretization techniques for spatial and temporal derivatives.	**8**
3	**Discretization Techniques: Finite Volume Method** Discretization Methods, Discretization procedure in Finite-volume framework. Approximation of Surface Integrals and of Volume Integrals, Implicit and explicit solution methodologies for one-dimensional and two-dimensional problems.	**8**
4	**Computational Heat Transfer and Turbulence Modeling** Applications of FVM in computational heat transfer: Applications of Finite Volume Methods: One-dimensional and two-dimensional steady and unsteady state diffusion equation, stability analysis, explicit and implicit method based solution-methodology; Introduction to turbulence modeling: Reynolds Averaged Navier-Stokes equations (RANS) Overview of one-equation and two-equation turbulence models	**7**
5.	**Numerical Solution to Navier-Stokes Equation** Finite Volume Method (FVM)-based formulation for convection-diffusion problems; Pressure correction techniques and staggered grids; Introduction to the SIMPLE algorithm for solving Navier-Stokes equations; Introduction to turbulence models, Reynolds Averaged Navier-Stokes equations (RANS), One equation model (Derivation), Characteristics of turbulence, Effect of turbulent fluctuations on mean flow.	**7**
6	**Advanced Topics in CFD** High-order discretization schemes: QUICK and TVD schemes; Overview of multiphase flow simulation; Applications of CFD in interdisciplinary fields such as aerospace, automotive, and biomedical engineering.	**7**

	Total	45

Text Books:

3. J. D. Anderson, *Computational Fluid Dynamics*, McGraw Hill, New York, 1995
4. A. Sharma, *Introduction to Computational Fluid Dynamics*, Athena Academic and John Wiley & Sons, UK, 2017.
5. T. J. Chung, *Computational Fluid Dynamics*, Cambridge University Press, 2010.

Reference Books:

3. H.K Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Longman Scientific & Technical, Harlow, 1995.
4. S.V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation, New York, 1980.
5. K. Muralidhar, and T. Sundarajan, (Editors) *Computational Fluid Flow and Heat Transfer* (2nd ed.), IIT Kanpur Series, Narosa Publishing House, New Delhi, 2003.
6. J.H. Ferziger, and M. Peric, *Computational Methods for Fluid Dynamics*, Springer Verlag, Berlin, 2002.
7. A. W. Date, *Introduction to Computational Fluid Dynamics*, Cambridge Univ. Press, USA, 2009.
8. D.C. Wilcox, *Turbulence modeling for CFD*, DCW Industries, La Canada, CA, 3rd Ed., 2006.
9. C. Hirsch, *Numerical Computation of Internal and External Flows - The Fundamentals of Computational Fluid Dynamics*, Butterworth-Heinemann, 2007
10. G. Biswas and V. Eswaran, *Turbulent Flows: Fundamentals, Experiments and Modeling*, Narosa Publishing House, 2002.

e-sources:

1. https://onlinecourses.nptel.ac.in/noc21_me126/preview
2. https://nptel.ac.in/courses/112105045
3. https://archive.nptel.ac.in/courses/112/106/112106294/

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester :**	**I**
Course :	Applied Solid Mechanics **(PEC I)**					**Code :**	MMC21PE01A
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 and Machine Design **is essential.**

Course Objectives:

This course aims at enabling 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, 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 pressurised cylinder and rotating disc.
3. **Apply** Energy methods to evaluate stresses and strains.
4. **Analyse and Determine** the Torsion and Bending of thin wall section
5. **Analyse and estimate** contact stresses in conforming and non-conforming shapes.
6. **Understand e**xperimental methods for stress evaluation estimate the same using resistance strain gauging technique and Photoelasticity technique.

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1	**Theory of Elasticity** Analysis of Stresses and Analysis of Strain. Stress Tensor, Compatibility equations in two and three dimensions, Airy's stress functions in rectangular and Polar coordinate systems.	**7**
2	**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**
3	**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**
4	**Thin wall Members:** Torsion of thin walled members of open cross section. Torsion of Multiply Connected Thin-Walled Sections Concept of shear centre in symmetrical and unsymmetrical bending, Shear centre for thin wall beam cross section, open section with one axis of symmetry.	**8**
5.	**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.	**7**
6	**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

e-sources:

1. https://archive.nptel.ac.in/courses/112/102/112102284/

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester :**	**I**	
Course :	Advanced Thermodynamics and Combustion **(PEC I)**			**Code :**	MMC21PE01B	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	**3**	**-**	**-**	**40**	**60**	**100**

Prior knowledge of Basic and Applied Thermodynamics **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Apply fundamental thermodynamic principles to analyze energy systems and processes effectively.
2. Utilize thermodynamic property relations to describe system behavior, especially in phase change and gas mixtures.
3. Analyze and optimize combustion processes for various applications.
4. Understand chemical kinetics to predict and control combustion performance and emissions.

Course Outcomes:

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

1. **Apply** the laws of thermodynamics to analyze and **Predict** the behavior of energy transfer and conversion processes in various systems.
2. **Derive and utilize** thermodynamic property relations to **Solve** problems related to phase change processes and single-phase systems.
3. **Analyze** the behavior of ideal and real gas mixtures using equations of state and thermodynamic models, and **Apply** the concepts to solve engineering problems.
4. **Evaluate** combustion processes and thermochemical reactions using fundamental principles of thermodynamics, and **Predict** the performance of combustion systems.
5. **Assess** chemical reaction kinetics and equilibrium in combustion systems, and **Analyze** the impact of reaction mechanisms on combustion efficiency.
6. **Analyze** combustion phenomena, including flame types and emissions, and **Apply** principles of combustion to optimize combustion processes in practical applications

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1	**Review of Basic Thermodynamics, Entropy and Exergy:** **Review of Basic Thermodynamics:** Temperature and zeroth law of thermodynamics Work and heat transfer — First law of thermodynamics, Heat engines and refrigerators/heat pump — Second law of thermodynamics **Entropy and Exergy:** Clausius theorem, Second law analysis and reversibility, Clausius theorem, Second law analysis and irreversibility, Entropy balance and entropy principle, Isentropic process and its application to internal reversible processes, Exergy — concepts, exergy balance, exergy destruction, Exergy analysis for closed system and control volumes, Second law efficiency	**10**
2	**Thermodynamic Property Relations:** Concepts of exact differential, Maxwell relations, Phase change processes: Clausius equation and Clausius — Clapeyron equation, Single phase systems and thermodynamic functions, Fundamental relations various thermodynamic processes, Joule — Thomson coefficient and liquefaction of gases	**7**
3	**Properties of Gas Mixture** Ideal and real gases, Equations of state, Compressibility factor, Gas mixtures and multi-component systems, Ideal gas mixtures and its thermodynamic models, Mixing analysis of thermodynamic systems	**7**
4	**Combustion and Thermochemistry** Basic terminology: Stoichiometry and equivalence ratio, Enthalpy Of, formation, Heating value and enthalpy Of combustion, Adiabatic flame, temperature First and Second law analysis for combustion models, Ficks law of diffusion and chemical equilibrium	**7**
5.	**Chemical Kinetics of combustion process** Basic terminologies, Arrhenius equation, Reaction rate coefficient, Equilibrium constants	**7**

	Fundamentals of chemical reactions, Heat of reaction mechanisms: Unimolecular and chain reaction, Chemical time scale **Thermodynamics of Reactive Systems** Chemical equilibrium and stability, Gibbs function, Chemical potential, Fugacity, Nernst equation, Affinity, Chemical and thermal analysis of reacting systems	
6	**Combustion and Flames** Laminar premixed flame, Laminar diffusion flame, Droplet evaporation and burning, Turbulent flame, Combustion processes in engines, Pollutant emissions	**7**
	Total	**45**

Text Books:

1. Y. U. Cengel and M. A. Boles, *Thermodynamics: An Engineering Approach*, Fourth Edition, Tata McGraw-Hill, New Delhi, 2003
2. R. H. Dittman and M. W. Zemansky, *Heat and Thermodynamics*, Seventh Edition, Tata McGraw-Hill, New Delhi, 2007
3. S. R. Turns, *An Introduction to Combustion: Concepts and Applications*, McGraw Hill International Edition, Singapore, 200

Reference Books:

1. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, *Principles of Engineering* Thermodynamics, Eighth Edition, Wiley, New Delhi, 2015
2. K. K. Kuo, *Principles of Combustion*, Second Edition, Wiley India Pvt. Ltd., New Delhi, 2012

e-sources:

1. https://onlinecourses.nptel.ac.in/noc22_me97/preview

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester:**		**I**
Course :	Artificial Intelligence for Engineers **(PEC I)**			**Code :**		MMC21PE01C
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	**3**	**-**	**-**	**40**	**60**	**100**

Prior knowledge of Linear Algebra, Probability, Statistics, Logical Reasoning, and Fundamentals of Mechanical Engineering **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Acquaint with fundamentals of artificial intelligence and machine learning.
2. Learn feature extraction and selection techniques for processing data set.
3. Understand basic algorithms used in classification and regression problems.
4. Familiarize with concepts of reinforced and deep learning.
5. Outline steps involved in development of machine learning model.
6. Implement and analyze machine learning model in mechanical engineering problems.

Course Outcomes:

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

1. **Demonstrate** fundamentals of artificial intelligence and machine learning.
2. **Apply** feature extraction and selection techniques.
3. **Apply** machine learning algorithms for classification and regression problems.
4. **Explain** concepts of reinforced and deep learning.
5. **Devise and develop** a machine learning model using various steps.
6. **Simulate** machine learning model in mechanical engineering problems.

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Introduction to AI:** **Overview of AI – History, AI and Data Science:** a perspective, Developments in Artificial Intelligence, Role of AI in Mechanical Engineering. **Basic search algorithms for problem solving:** Knowledge representation and reasoning, Planning, Learning, Perception, Problem solving, Pattern recognition, Neural networks Motion and manipulation.	**7**
2	**Machine Learning Foundations** **Introduction to Machine Learning,** **Types of machine learning:** Supervised learning, Unsupervised learning, Self-supervised learning, Reinforcement learning **Components of a Machine Learning Problem:** Evaluating machine-learning models: Training, validation, and test sets, Data pre-processing, feature engineering and feature learning, Over-fitting and under fitting: Reducing the network's size, adding weight, regularization, Adding dropout The universal workflow of machine learning: Defining the problem and assembling a dataset, choosing a measure of success, deciding on an evaluation protocol, Preparing your data. ML Model Development Developing: Introduction to baseline model, Customization of the baseline model, Scaling up: over fitting and under fitting, Identification of hyper-parameters and its effect	**9**
3	**Classification and Regression Models** **Classification Models -** Random Forest, Logistic regression, decision tree, Support Vector Regression, K-Nearest Neighbor (KNN), K-Means, Naive Bayes. **Regression Models -** Linear and non-linear regression, neural network regression, over fitting and underfitting. Applications of classification models in Mechanical Engineering.	**6**
4	**Introduction to Deep Learning** • What is deep learning? Artificial intelligence, machine learning, and deep learning • The mathematical building blocks of neural networks; Why deep learning? Why now? • Getting started with neural networks (Programming treatment)	**8**

	• Convolutional Neural Networks • Stochastic dynamic programming and its relationship to AI • Deep learning for various applications: Computer vision, Text and sequences	
5.	**Development of ML Model with python** • Problem identification, Steps in ML modeling (Data Collection and pre-processing, Model Selection, Model training, Model evaluation Hyperparameter Tuning, Predictions.) • Introduction to python and TensorFlow • Data & Algorithms • Supervised Learning with TensorFlow • Neural Networks and Deep Learning with TensorFlow	**7**
6	**Deep Learning and Open-Source Keras** • Introduction to Deep Learning with Keras • Keras in Action • Going beyond the Sequential model: the Keras functional API: Introduction to the • functional API, Multi-input models, Multi-output models, Layer weight sharing, • Models as layers, Wrapping up • Inspecting and monitoring deep-learning models using Keras callbacks	**8**
	Total	**45**

Text Books:

1. B Joshi, *Machine Learning and Artificial Intelligence*, Springer, 2020

Reference Books:

1. Stuart Russell, Peter Norvig, *Artificial Intelligence A Modern Approach* Pearson Series in Artifical Intelligence, 4th Ed., 2021.
2. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, MIT press, Cambridge, 2016.
3. Sandro Skansi, *Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence*, Springer , 2018.
4. Parag Kulkarni and Prachi Joshi, *Artificial Intelligence – Building Intelligent Systems*, PHI learning Pvt. Ltd., 2015.
5. Deisenroth, Faisal, Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.

e-sources:

1. https://onlinecourses.nptel.ac.in/noc22_cs24/preview
2. https://onlinecourses.nptel.ac.in/noc22_cs56/preview

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester :**	**I**	
Course :	Advanced Machine Design **(PEC II)**			**Code :**	MMC21PE02A	
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 to,

1. Make aware the students about industrial design practices.
2. 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. **Evaluate** product planning and development processes.
2. **Apply** problem-solving techniques for need identification.
3. **Demonstrate** proficiency in design and fabrication methods.
4. **Assess** reliability and strength aspects in design.
5. **Integrate** sustainability and cost considerations into design.
6. **Apply** principles of industrial design for enhanced user experience**.**

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**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**
2	**Problem Definition and Need Identification** Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing Identifying customer needs, requirements, establishing the engineering characteristics, quality function deployment, product design specification	**8**
3	**Design and Fabrication** Design for manufacture, assembly, maintenance, casting, forging	**7**
4	**Reliability and Strength** Design for Reliability, strength-based reliability, parallel and series systems, robust design	**8**
5.	**Sustainability and Cost** Design of dis-assembly, Design for reuse, Design for Environment and Design for cost and Design for Quality	**7**
6	**Industrial Design** Design for Emotion and experience, Introduction to retrofit and Eco-design, Human behavior in design	**8**
	Total	**45**

Text Books:

1. G. 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. T.T. Woodson, "*Introduction to Engineering Design*", McGraw Hill Book Company, 1966.
3. J.C. John, "*Design Methods*", Wiley Inter science, 1970.
4. A. M. Law and W. D. Kelton, "Simulation, modelling and analysis", McGraw Hill Book Company, 1991.
5. G. Pahl .and W. Beitz, "*Engineering Design–A Systematic Approac*h", Springer, 2nd Ed., 1996.

e-sources:

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester :**	**I**	
Course :	Applied Fluid Mechanics **(PEC II)**			**Code :**	MMC21PE02B	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
3	**3**	**-**	**-**	**40**	**60**	**100**

Prior knowledge of Fluid mechanics fundamentals, Basic understanding of differential equations and boundary layer theory **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Understand governing equations of fluid mechanics and its applications to flow domains.
2. Understand fundamentals of circulation and vorticity.
3. Understand and analyze laminar and turbulent boundary layer theory in various flow fields.
4. Understand and analyze the physics of flow instabilities.
5. Understand the importance of flow measurement techniques and its industrial applications.

Course Outcomes:

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

1. **Interpret and apply** governing equations to solve various the fluid flow problems.
2. **Analyze** practical fluid flow problems using potential flow theory.
3. **Apply** Laminar Boundary layer theory to engineering problems.
4. **Interprets** turbulent flows and model turbulence.
5. **Understand** flow pattern and underlying processes leading flow instability.
6. **Understand** modern experimental tools and techniques in Fluid Mechanics and would unveil fluid flow hypotheses.

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1	**Governing equations in Fluid Mechanics** Concept of continuum and definition of a fluid. Body and surface forces, stress tensor. Scalar and vector fields, Eulerian and Lagrangian description of flow ,Derivation of continuity equation and Navier-Stokes Equations using integral and differential approach; Reynolds transport theorem.	**8**
2	**Potential Flow** Kelvin's circulation theorem, Irrotational flow, Stream function-vorticity approach, Helmhotz's Vortex Theorems, Vorticity Equation in a Nonrotating Frame, Velocity Induces by a Vortex Filament: Law of Biot and Savart. Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem;	**7**
3	**Laminar Boundary layers** Boundary layer equations, flow over flat plate, Momentum integral equation for boundary layer, approximate solution methodology for boundary layer equations	**7**
4	**Turbulent Flow** Characteristics of turbulent flow, laminar turbulent transition, time mean motion and fluctuations, derivation of governing equations for turbulent flow, shear stress models, universal velocity distribution •	**7**
5.	**Introduction to Hydrodynamic stability** Linear stability of plane Poiseuille flow, Orr;Sommerfeld equation. Description of turbulent flow, velocity correlations, Reynolds stresses, Prandtl s Mixing Length Theory, Karman s velocity defect law, universal velocity distribution. Concepts of closure model, eddy viscosity models of turbulence- zero equation, one equation and two-equation models	**8**
6	**Experimental Techniques in Fluid Dynamics** Role of experiments in fluid, layout of fluid flow experiments, sources of error in experiments, data analysis, design of experiments, review of probes and transducers, Introduction to Hot wire Anemometry, Laser Doppler Velocimetry and Particle Image Velocimetry	**8**
	Total	**45**

Text Books:

1. Muralidhar and Biswas, Advanced Engineering Fluid Mechanics, Alpha Science International, 2005
2. S. K. Som, G. Biswas, S. Chakraborty, *Introduction to Fluid Mechanics and Fluid Machines*, Third Edition, Tata McGraw-Hill Education, 2013
3. Y. Cengel and J. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, Fourth Edition, Tata McGraw Hill, New Delhi, 2019.

Reference Books:

1. Frank M. White, *Fluid Mechanics*, Eighth Edition, McGraw Hill Publishing Company Ltd., 2015.
2. Irwin Shames, *Mechanics of Fluids*, McGraw Hill, 2003.
3. R.W. Fox, A.T. McDonald, *Introduction to Fluid Mechanics*, John Wiley and Sons Inc, 1985.
4. P. K. Kundu, I. M. Kohen and D. R. Dawaling, *Fluid Mechanics*, Fifth Edition, 2005

e-sources:

1. https://onlinecourses.nptel.ac.in/noc22_me102/preview

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester :**	**I**
Course :	Data Analytics **(PEC II)**					**Code :**	MMC21PE02C
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**	
3	**3**	**-**	**-**	**40**	**60**	**100**	

Prior knowledge of Fundamentals **of** Mechanical Engineering, Engineering Mathematics and Statistics, Artificial Intelligence and Machine Learning, Numerical Methods, Probability and Statistics is **essential.**

Course Objectives:

This course aims at enabling students to,

1. Explore the fundamental concept of data analytics
2. Understand the various search techniques and visualization techniques
3. Apply various machine learning techniques for data analysis.
4. Explore and apply the python package for data analytics.

Course Outcomes:

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

1. **Explain** the fundamentals of data analytics and select a suitable approach for data analytics
2. **Apply** descriptive analytics to describe and analyze the data.
3. **Select** suitable plots for the given data and draw practical interpretations.
4. **Apply** descriptive, diagnostic, predictive, and prescriptive analytics techniques to withdraw useful conclusions from the acquired data set.
5. **Explore** the data analytics techniques using various programming packages/ tools
6. **Apply** data science concepts and methods to solve problems in real-world context

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1	**Introduction** Data science and data analytics; Types of data, Data recording/ collecting; Data storing; Data pre-processing; Data describing/ visualization; Statistical modelling; Algorithmic modelling; Missing data treatment; Relationship between AI, ML, DL, and Data Science; Big data, Database system	**7**
2	**Descriptive Statistics** Universe, population, and sample, Measures of central tendency and their characteristics, outlier detection, histogram and central tendency, measures of spread, variance, percentiles, Effect of transformation of measure of spread	**7**
3	**Data Visualization** Histogram, Bar/ line chart, Box plots, swarm plot, Violin plot, faceted plot, boxen plot, leaf and stem plots, Scatter plots, Heat map, pie chart, line plot.	**7**
4	**Data Analytics Approaches** **Predictive analytics** – predictions using statistical modelling and machine learning techniques; demand forecasting; anomaly detection. **Prescriptive analytics –** process improvement decisions; supplier reviewing, maintenance scheduling **Descriptive analytics –** trends and patterns in the data, data visualization tools; **Diagnostics analytics –** root cause analysis, data mining, correlation, product quality analysis	**8**
5.	**Python for Data Analytics** Platforms; Blocks – if, for, while, etc., list, tuples, sets, dictionaries, file handling; Libraries – Numpy, Pandas, Matplotlib, Seaborn, etc. File formats – csv, tsv, json, parquet; Data visualization tools – PowerBI/ Tableau	**8**
6	**Applications** Thermal/ Heat Transfer/ HVAC/ Fluid Mechanics/ Fluid Power, Solid Mechanics/ Design, Machining/ Manufacturing, Automation and Robotics, Maintenance/ reliability/ condition monitoring, Quality Control, Materials and metallurgy, Energy Conservation and Management, Industrial Engineering, Estimation, and Management, Automotive Technology	**8**
	Total	**45**

Text Books:

1. S. L. Brunton, & J. N. Kutz, *Data-driven science and engineering*: *Machine learning*, dynamical systems, and control. Cambridge University Press, 2022.
2. P. F. Dunn, & M. P. Davis, *Measurement and data analysis for engineering and science.* CRC press, 2017.
3. S. S. Roy, P. Samui, R. Deo, & S. Ntalampiras, (Eds.), *Big data in engineering applications* (Vol. 44). Berlin/Heidelberg, Germany: Springer, 2018.

Reference Books:

1. J. A. Middleton, *Experimental Statistics and Data Analysis for Mechanical and Aerospace Engineers.* Chapman and Hall/CRC, 2021.
2. E. L. Robinson, *Data analysis for scientists and engineers*. In Data Analysis for Scientists and Engineers. Princeton University Press, 2017.
3. S. Araghinejad, *Data-driven modeling: using MATLAB® in water resources and environmental engineering* (Vol. 67). Springer Science & Business Media,2013.
4. G. Niu, *Data-driven technology for engineering systems health management*. Beijing, China: Springer, 2017.
5. Zsolt Nagy, *Artificial Intelligence and Machine Learning Fundamentals*, Packt Publishing, 2018, ISBN: 978-1-78980-165-1
6. Hastie, Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. *The elements of statistical learning: data mining, inference, and prediction. Vol. 2.* New York: springer, 2009.
7. Zaki, Mohammed J., Wagner Meira Jr, and Wagner Meira. *Data mining and analysis: fundamental concepts and algorithms*. Cambridge University Press, 2014.
8. Kumar, Zindani, Davim, *Artificial Intelligence in Mechanical and Industrial Engineering*, CRC Press, 2021.

e-sources:

1. https://padhai.onefourthlabs.in/courses/data-science

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester:	I
Course:	Finite Element Method Lab **(PCC Lab)**					Code:	MMC21PC03
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 are **is essential.**

Course Objectives:

This course aims at enabling 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 completion of this course, the students will be able to,

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.

Guidelines:

Total: **6** experiments **60 hours (10 hrs. each)**

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1.	Introduction to CAE software UI
2.	Structural Linear Analysis using 1D Element
3.	Truss Analysis using 1D Element
4.	Analysis of simple structure using 2D elements
5.	Modal Analysis using 1D and 3D Elements of any machine component
6.	Steady-state thermal, transient thermal, and thermal stress analysis
7.	Coupled thermal-structural Analysis
8.	Topology optimization
9.	Analysis of any Machine Component and Assembly using 3D Elements

Text Books:

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

Reference Books:

1. T. R. Chandrupatla and A. D. Belegunda, *Introduction to Finite Elements in Engineering*, Prentice Hall India 3rd Edition 2008.
2. J. N. Reddy, *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. Computational Mechanics (Mechanical Engineering)**			**Semester:**	**I**		
Course:	Computational Fluid Dynamics Lab (PCC Lab)			**Code:**	MMC21PC04		
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	25	25	-	50

Prior knowledge of Fluid Mechanics, Thermodynamics and Heat Transfer **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Apply Computational Fluid Dynamics (CFD) techniques in engineering problem-solving.
2. Foster critical thinking and problem-solving skills through analysis of simulation results and synthesis of optimization strategies for engineering design

Course Outcomes:

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

1. **Apply** numerical methods to solve complex engineering problems using Finite Element Analysis (FEA) and Computational Fluid Dynamics
2. **Analyze** simulation results and evaluate the accuracy and reliability of computational models
3. **Create** optimization strategies and propose innovative solutions for engineering design and analysis

Guidelines:

1. Total experiments to be conducted are Six
2. Total: 6 experiments 60 hours

Detailed Syllabus

Expt. No.	**Suggested List of Experiments**
1	**Introduction to CFD and Conservation Laws** Problem: Simulate heat conduction in a metal rod with known boundary temperatures. Determine the temperature distribution along the rod using finite difference method and compare it with analytical solution.
2	**Numerical Methods for PDEs** Problem: Model transient heat conduction in a composite material slab. Use finite volume method to solve the transient convection-diffusion equation and analyze temperature evolution over time.
3	**Finite Volume Method for Convection-Diffusion Problems** Problem: Analyze fluid flow around a circular cylinder. Implement finite volume method to solve the steady-state incompressible flow equations and compute the velocity and pressure fields around the cylinder.
4	**Turbulence Modeling** Problem: Study turbulent flow over a backward-facing step. Implement a two-equation turbulence model (e.g., k-epsilon model) to predict the turbulent flow characteristics and compare them with experimental data.
5	**Pressure Correction Techniques** Problem: Solve lid-driven cavity flow using the SIMPLE algorithm. Implement the SIMPLE algorithm to solve the Navier-Stokes equations and visualize the velocity and pressure fields inside the cavity.
6	**Implicit vs. Explicit Solution Methodologies** Problem: Compare implicit and explicit finite difference methods for solving transient diffusion equation. Implement both methods and analyze their stability and computational efficiency for different time step sizes.
7	**Finite Element Method for Structural Analysis** Problem: Perform stress analysis of a cantilever beam. Model the beam using finite element method and analyze stress distribution under applied load.
8	**Computational Heat Transfer** Problem: Simulate transient heat conduction in a composite material plate. Use finite element method to solve the transient heat conduction equation and analyze temperature distribution over time.
9	**Application of FVM in Fluid Flow** Problem: Analyze flow through a pipe network with multiple branches. Implement finite volume method to solve the flow equations and determine pressure distribution and flow rates in each branch.
10	**Optimization and Advanced Techniques** Problem: Optimize the design of a heat exchanger to maximize heat transfer efficiency. Use adjoint-based optimization method to iteratively modify the heat exchanger geometry and analyze the impact

	on heat transfer performance.

Text Books:

1. J. D. Anderson, *Computational Fluid Dynamics*, McGraw Hill, New York, 1995
2. A. Sharma, *Introduction to Computational Fluid Dynamics*, Athena Academic and John Wiley & Sons, UK, 2017.
3. T. J. Chung, *Computational Fluid Dynamics*, Cambridge University Press, 2010.

Reference Books:

1. H.K Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Longman Scientific & Technical, Harlow, 1995.
2. S.V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation, New York, 1980.
3. K. Muralidhar, and T. Sundarajan, (Editors) *Computational Fluid Flow and Heat Transfer* (2nd ed.), IIT Kanpur Series, Narosa Publishing House, New Delhi, 2003.
4. J.H. Ferziger, and M. Peric, *Computational Methods for Fluid Dynamics*, Springer Verlag, Berlin, 2002.
5. A. W. Date, *Introduction to Computational Fluid Dynamics*, Cambridge Univ. Press, USA, 2009.
6. D.C. Wilcox, *Turbulence modeling for CFD*, DCW Industries, La Canada, CA, 3rd Ed., 2006.
7. C. Hirsch, *Numerical Computation of Internal and External Flows - The Fundamentals of Computational Fluid Dynamics*, Butterworth-Heinemann, 2007
8. G. Biswas and V. Eswaran, *Turbulent Flows: Fundamentals, Experiments and Modeling*, Narosa Publishing House, 2002.

e-sources:

1. https://onlinecourses.nptel.ac.in/noc21_me126/preview
2. https://nptel.ac.in/courses/112105045
3. https://archive.nptel.ac.in/courses/112/106/112106294/

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester:	I
Course:	**Applied Solid Mechanics Lab** (Professional Elective-I Lab **(PEC-I Lab)**)					Code:	MMC21PE03A
	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
Credits	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	50	-	-	50

Important:

Prior knowledge of Physics, Engineering Mathematics, Dynamics of Machinery **is essential**

Course Objectives:

This course aims at enabling students to,

1. Obtain the results for validation and effective understanding of system by imparting students with various Vibration and Noise Analysis Techniques, interpret data and report.

Course Outcomes:

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

1. **Simulate** the problem and correlate with theoretical concepts
2. **Apply** strain gauges at appropriate locations, collect data, analyses, and interpret results.

Guidelines:

1. Total experiments to be conducted are Six
2. Total: 6 experiments 60 hours

Detailed Syllabus

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

Text Books:

1. R. G. Budyna, *Advanced Strength and Applied Stress Analysis*–s, New Delhi Tata McGraw Hill Education 2011
2. R. Huston, Harold Josephs *Practical Stress Analysis in Engineering Design*, 3rd Edition, CRC Press, 2008

Reference Books:

1. L S Srinath *Advanced mechanics of solids*, 3rd Edition Tata McGraw-Hill Publishing Company Limited 2009.

e-sources:

1. https://archive.nptel.ac.in/courses/112/102/112102284/

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester:**	**I**	
Course:	**Advanced Thermodynamics and Combustion Lab** (Professional Elective-I Lab **(PEC-I Lab))**				**Code:**	MMC21PE03B	
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Important: Students must select the lab of their respective opted Professional Elective-I course.

Prior knowledge of Basics and applied thermodynamics **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Develop proficiency in utilizing engineering software such as Engineering Equation Solver (EES) for thermodynamic analysis and visualization of complex processes.
2. Enhance understanding of advanced thermodynamic concepts through hands-on experimentation and analysis of real-world systems, such as boilers, internal combustion engines, and combustion processes.
3. Strengthen problem-solving skills by developing programs to solve generalized equations for hydrocarbon combustion and calculating theoretical air requirements for different combustion scenarios.

Course Outcomes:

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

1. **Apply** critical thinking skills to analyze thermodynamic processes and combustion phenomena encountered in the lab experiments.
2. **Demonstrate** proficiency in using specialized software tools like Engineering Equation Solver (EES) for thermodynamic analysis and data visualization.
3. **Synthesize** theoretical knowledge with practical experimentation to deepen understanding of thermodynamic principles and combustion behavior.

Guidelines: 1. Total experiments to be conducted are Six; 2. Total: 6 experiments 60 hours

Detailed Syllabus

Expt. No.	**Suggested List of Experiments**
1	Exergy analysis of simple closed system
2	Plotting enthalpy of vaporization of steam with respect to temperature using Clapeyron equation in EES software.
3	Plotting of Joule Thompson inversion curve using EES
4	Measurement of gases in exhaust of IC engine using exhaust gas analyzer
5	Boiler performance assessment
6	Plotting of adiabatic flame temperature with respect to equivalence ratio using EES software for methane combustion process
7	Plotting of Pressure-Crank angle diagram for variable compression ratio engine
8	Write a program to solve general case of any hydrocarbon C_xH_y, where x and y are input parameters. Calculate the percentage of theoretical air for any given percentages of combustion products.

Text Books:

1. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, Principles of Engineering Thermodynamics, Eighth Edition, Wiley, New Delhi, 2015
2. Y. U. Cengel and M. A. Boles, Thermodynamics: An Engineering Approach, Fourth Edition, Tata McGraw-Hill, New Delhi, 2003
3. R. H. Dittman and M. W. Zemansky, Heat and Thermodynamics, Seventh Edition, Tata McGraw-Hill, New Delhi, 2007
4. S. R. Turns, An Introduction to Combustion: Concepts and Applications, McGraw Hill International Edition, Singapore, 200
5. K. K. Kuo, Principles of Combustion, Second Edition, Wiley India Pvt. Ltd., New Delhi, 2012

Reference Books:

1. Van Wylen & Sonntag, "Thermodynamics", John Wiley and Sons Inc., U.S.A
2. Jones and Hawkings, "Engineering Thermodynamics", John Wiley and Sons Inc., U.S.A, 2004

e-sources:

1. **https://onlinecourses.nptel.ac.in/noc22_me97/preview**

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester:**	**I**	
Course:	**Artificial Intelligence for Engineers Lab** **(**Professional Elective-I Lab **(PEC-I Lab))**				**Code:**	MMC21PE03C	
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of Linear Algebra, Probability, Statistics, Logical Reasoning, Fundamentals of Mechanical Engineering **is essential**

Course Objectives:

This course aims at enabling students to,

1. Learn feature extraction and selection techniques for processing data set.
3. Understand basic algorithms used in classification and regression problems.
4. Outline steps involved in development of machine learning model.
5. Familiarize with concepts of reinforced and deep learning.
6. Implement and analyze machine learning model in mechanical engineering problems.

Course Outcomes:

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

1. **Simulate** machine learning model in mechanical engineering problems
2. **Apply** feature extraction and selection techniques.
3. **Apply** machine learning algorithms for classification and regression problems.
4. **Apply** reinforced and deep learning algorithms

Guidelines:

3. Total experiments to be conducted are Six
4. Total: 6 experiments 60 hours
5. Students need to apply the computational algorithms using suitable software / programming language.

Detailed Syllabus

Expt. No.	**Suggested List of Experiments**
1	Acquire, visualize, outlier removal and analyze the data set.
2	Extract features from a given data set and select suitable features using suitable approach and EDA
3	Classify features / develop classification model and evaluate its performance
4	Develop regression model and evaluate its performance (any one algorithm).
6	Use CNN for image classification (faulty/non faulty).
7	To use PCA for dimensionality reduction.
8	Demonstration and implementation of Shallow architecture, using Python, Tensorflow and Keras
9	Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation.
10	Build Neural Network (NN) with multilayer.

Text Books:

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

Reference Books:

1. Mohri, Rostamizdeh, Talwalkar, *Foundations of Machine Learning*, MIT Press, 2018.
2. Kumar, Zindani, Davim, *Artificial Intelligence in Mechanical and Industrial Engineering*, CRC Press, 2021.
3. Zsolt Nagy - *Artificial Intelligence and Machine Learning Fundamentals*-Apress (2018)

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester:	I	
Course:	**Advanced Machine Design Lab (**Professional Elective-II Lab **(PEC II Lab))**				Code:	MMC21PE04A	
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	50	-	-	50

Important: Students must select the lab of their respective opted Professional Elective-I course.

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

Course Objectives:

This course aims at enabling students to,

1. Understand and apply advanced principles and methodologies in machine design, including design for manufacturability, reliability, sustainability, and cost-effectiveness.
2. Equip students with the skills and knowledge necessary to analyze, simulate, and optimize machine components and systems using CAD tools, incorporating industry best practices and standards.

Course Outcomes:

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

1. **Apply** advanced principles of design, including Design for Manufacture and Assembly (DFMA), Reliability Engineering, Sustainable Manufacturing, and Industrial Design, to develop innovative engineering products.
2. **Demonstrate** proficiency in conducting market research, needs identification, concept generation, and product development processes, resulting in optimized product designs that meet customer requirements and market demands.

Guidelines:

1. Total experiments to be conducted are Six
2. Total: 6 experiments 60 hours

Detailed Syllabus

Expt. No.	Suggested List of Experiments	
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. • 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.	**60**

- 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.

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. T.T. Woodson, “*Introduction to Engineering Design*”, McGraw Hill Book Company, 1966.
3. J.C. John “*Design Methods*”, Wiley Inter science, 1970.

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester:**	**I**
Course:	**Applied Fluid Mechanics Lab** (Professional Elective-II Lab **(PEC II Lab))**					**Code:**	MMC21PE04B
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of Fluid Mechanics Basics, Aerodynamics Principles, Boundary Layer Theory, and Fluid Flow Visualization **is essential.**

Course Objectives:

1. Develop practical skills in experimental techniques and computational analysis related to fluid mechanics.
2. Gain hands-on experience in conducting experiments, analyzing fluid flow phenomena, and interpreting experimental data to understand the fundamental principles of fluid mechanics.

Course Outcomes:

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

1. **Apply** theoretical knowledge of fluid mechanics to design and conduct experiments, demonstrating comprehension and analysis skills.
2. **Evaluate** experimental results, interpret data, and draw conclusions about fluid flow phenomena, demonstrating critical thinking and problem-solving skills

Guidelines: 1. Total experiments to be conducted are Six; 2. Total 6 experiments 60 hours

Detailed Syllabus

Expt. No.	**Suggested List of Experiments**
1	**Visualization of Potential Flow:** Setup equipment for visualizing potential flow phenomena, such as flow around objects or through nozzles.; Perform experiments to observe and document different aspects of potential flow behavior, such as streamlines and flow separation.; Analyze and discuss observed flow patterns and phenomena.
2	**Wake Velocity Measurement for Flow Over Circular Cylinder:** Set up the experimental apparatus to measure wake velocities behind a circular cylinder. Conduct experiments to measure wake velocities at various distances downstream of the cylinder. Process and analyze the collected data to understand the wake characteristics and their implications.
3	**Flow Rate Measurements Using Venturi and Orifice Meters:** Set up the Venturi and orifice meters to measure flow rates in a piping system; Perform experiments to measure flow rates under different operating conditions; Analyze the data to understand the performance characteristics of the Venturi and orifice meters.
4	**Pressure and Velocity Distribution on a Circular Pipe Through ANSYS Fluent:** Set up computational models in ANSYS Fluent to simulate flow through a circular pipe. Run simulations to obtain pressure and velocity distributions along the pipe length. Analyze the simulation results to understand the flow behavior and characteristics.
5	**Wind Tunnel Study of Flow Over an Airfoil at Different Angles of Attack - Surface Pressure Measurements:** Set up the airfoil model in the wind tunnel; Conduct experiments to measure surface pressures on the airfoil at various angles of attack. Analyze the pressure distribution data to understand the aerodynamic characteristics of the airfoil.
6	**Measurements of Lift and Drag Forces of a Symmetric Aerofoil in a Low-Speed Flow:** Set up the experimental apparatus to measure lift and drag forces on the symmetric airfoil. Perform experiments to measure lift and drag forces under different flow conditions. Analyze the force measurements to understand the aerodynamic performance of the airfoil.
7	**Flow Over a Cylinder/Sphere at Different Re.No Through ANSYS Fluent:** Set up computational models in ANSYS Fluent to simulate flow over a cylinder or sphere. Run simulations to study the flow characteristics at different Reynolds numbers. Analyze the simulation results to understand the effects of Reynolds number on flow behavior.

Text Books:

1. E. Ratha Krishnan (2010). *Gas Dynamics*. 3th Edition, PHI Learning Pvt. Ltd. ISBN 9788120341975.
2. P.N. Modi, S. M. Seth. (2018). *Gas Dynamics*. 21th Edition, STANDARD BOOK HOUSE. ISBN 9788189401269.

Reference Books:

1. S. M. Yahya. *Fundamentals of Compressible flow*. 3th Edition, New Age Publishers, 1992. ISBN 8122414680.
2. Streeter, *Fluid Dynamics*. McGraw-Hill College, 1997). ISBN 9780070625372
3. Fox, McDonald, Pritchard, *Fluid Mechanic*s. 8th Edition, John Wiley Sons, Limited, 2011. ISBN 9781118961278.
4. Kundu, Cohen, Dowling. *Fluid Mechanics*. 8th Edition, John Wiley Sons, Limited, 2015. ISBN 9780124059351.
5. A. J. Raudkivi, *Advanced Fluid Mechanics*: An Introduction. Hodder Stoughton Educational, 1975. ISBN 9780713133448.

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester:**	**I**	
Course:	**Data Analytics Lab (**Professional Elective-II Lab **(PEC II Lab))**				**Code:**	MMC21PE04C	
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of basic programming concepts, data analysis techniques, and familiarity with relevant software tools (e.g., Python, MATLAB, Excel) **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Develop proficiency in data collection techniques and instrumentation relevant to computational mechanics applications.
2. Apply data analytics methods to analyze experimental data and extract insights for solving problems in computational mechanics.

Course Outcomes:

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

1. Apply data preprocessing techniques to clean and prepare experimental data for analysis
2. Utilize statistical analysis and machine learning algorithms to extract meaningful patterns and insights from experimental data.

Guidelines:

1. Total: 6 experiments 60 hours

Detailed Syllabus

Expt. No.	**Suggested List of Experiments**
1.	**Thermal/Heat Transfer:** Collect temperature and pressure data using sensors in a controlled environment. Analyze thermal conductivity of materials using data collected from experiments. Perform regression analysis on heat transfer rates under varying conditions.
2.	**Fluid Mechanics:** Conduct experiments to measure flow rates and velocities using sensors. Analyze pressure distribution in different flow scenarios using data visualization techniques. Implement data-driven models to predict fluid behavior in various systems.
3.	**Solid Mechanics/ Design** Measure strain and stress using strain gauges and load cells. Utilize data analytics to optimize structural designs based on material properties and loads. Predict mechanical behavior under different loading conditions using machine learning algorithms.
4.	**Manufacturing** Monitor machining parameters such as speed, feed rate, and tool wear during machining operations. Employ statistical process control techniques to analyze variation and optimize manufacturing processes. Predict tool life and optimize tool paths using historical data and predictive analytics
5.	**Reliability / Maintenance** Collect data on equipment performance and failures over time. Apply predictive maintenance algorithms to anticipate equipment failures and schedule maintenance activities. Analyze failure patterns and trends to improve reliability and reduce downtime.
6	**Automation and Robotics** Capture sensor data from robotic systems during operation. Develop algorithms for motion planning and trajectory optimization using data analytics. Implement machine learning models for predictive maintenance and fault detection in robotic systems.

Text Books:

1. Brunton, S. L., & Kutz, J. N. (2022*). Data-driven science and engineering: Machine learning*, dynamical systems, and control. Cambridge University Press.
2. Dunn, P. F., & Davis, M. P. (2017). *Measurement and data analysis for engineering and science*. CRC press.
3. Roy, S. S., Samui, P., Deo, R., & Ntalampiras, S. (Eds.). (2018). *Big data in engineering applications* (Vol. 44). Berlin/Heidelberg, Germany: Springer.

Reference Books:

1. Middleton, J. A. (2021). *Experimental Statistics and Data Analysis for Mechanical and Aerospace Engineers*. Chapman and Hall/CRC.
2. Brandt, S. (1970). *Statistical and computational methods* in data analysis.
3. Robinson, E. L. (2017). *Data analysis for scientists and engineers. In Data Analysis for Scientists and Engineers*. Princeton University Press.
4. Araghinejad, S. (2013). *Data-driven modeling: using MATLAB® in water resources and environmental engineering* (Vol. 67). Springer Science & Business Media.
5. Niu, G. (2017). *Data-driven technology for engineering systems health management*. Beijing, China: Springer.
6. Zsolt Nagy, "*Artificial Intelligence and Machine Learning Fundamentals*", Packt Publishing, 2018, ISBN: 978-1-78980-165-1
7. Hastie, Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. *The elements of statistical learning: data mining, inference, and predictio*n. Vol. 2. New York: springer, 2009.
8. Zaki, Mohammed J., Wagner Meira Jr, and Wagner Meira. *Data mining and analysis: fundamental concepts and algorithm*s. Cambridge University Press, 2014.
9. Kumar, Zindani, Davim, *Artificial Intelligence in Mechanical and Industrial Engineering*, CRC Press, 2021.

e-sources:

1. https://padhai.onefourthlabs.in/courses/data-science

Course Syllabus
Semester-II

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester:**	**II**
Course :	Numerical Analysis **(PCC)**					**Code :**	MMC22PC05
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**	
3	**3**	**-**	**-**	**40**	**60**	**100**	

Prior knowledge of Basic of ordinary differential equations Calculus, and Differential Equations, Linear Algebra **is essential.**

Course Objectives: This course aims at enabling students,

1. To equip students with numerical methods to solve linear and nonlinear algebraic equations

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

1. **D**escribe the fundamental concepts of error analysis in numerical methods and Apply appropriate techniques to solve algebraic equations
2. Apply numerical methods to find solutions of ordinary differential equations for engineering application problems.
3. Analyse numerical methods to find solutions of partial differential equations for complex engineering problems.
4. Compute the numerical solution by applying various integration techniques.
5. Apply various interpolation methods and regression concepts.
6. Apply statistical technique for quantitative data analysis.

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Roots of Equation and Simultaneous Equations** Introduction to numerical analysis, Significant digits, Types of errors; Stability; Accuracy; Precision; **Roots of Equation**: Bracketing method and Newton-Raphson method **Solution of simultaneous equations:** Gauss Elimination, Gauss- Seidel method, Thomas algorithm for Tri-diagonal Matrix.	**8**
2	**Ordinary Differential Equations [ODE]** Taylor series method, Euler Method, Modified Euler's method. Runge-Kutta 4th order. Simultaneous equations using Runge-Kutta 2nd order method, Convergence and numerical stability analysis.	**8**
3	**Partial Differential Equations [PDE]:** Finite difference method, Simple Laplace method, PDE's Parabolic explicit solution, Elliptic explicit solution, Bender-Smidth method, Convergence and stability analysis	**7**
4	**Numerical Integration** **Numerical Integration (1D):** Trapezoidal rule, Simpson's 1/3rdRule, Simpson's3/8thRule, Gauss Quadrature2-point and 3-point method. **Double Integration:** Trapezoidal rule, Simpson's 1/3rdRule.	**8**
5.	**Regression and Interpolation** **Regression:** Linear, non-linear, and multiple regression, Correlation: Karl Pearson's Coefficient of correlation, and Spearman's Rank correlation. **Interpolation:** Lagrange's, Divided difference, Hermite and cubic spline,	**7**
6	**Statistical Diagrams** Scattered diagram, histogram, pie charts, Violin plot, swarm plot, Pie charts, etc., and measure of association between two variables.	**7**
	Total	**45**

Text Books:

1. R. V. Dukkipati, *Applied Numerical Methods using MATLAB*, New Age International Publishers, 2020.
2. S. C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, Tata Mc-Graw Hill, 2022.

Reference Books:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, Wiley India, 2011.
2. Sheldon M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 5th Edition, Elsevier Academic Press, 2014.
3. E. Balagurusamy, *Numerical Methods*, Tata McGraw Hill, 2017.
4. M. T. Heath, *Scientific Computing - An Introductory Survey*, Revised Second Edition, SIAM, 2018.
5. Deisentoth, Faisal, Ong, *Mathematics for machine learning*, Cambridge University Press, 2020.

e-sources:

1. https://archive.nptel.ac.in/courses/111/101/111101165/
2. https://archive.nptel.ac.in/courses/111/107/111107105/

Program :	M. Tech. Computational Mechanics (Mechanical Engineering)			Semester:	II	
Course :	Advanced Heat and Mass Transfer **(PEC III)**			**Code :**	MMC22PE05A	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	**2**	**-**	**-**	**20**	**30**	**50**

Prior knowledge of Basic of ordinary differential equations Calculus, and Differential Equations, Linear Algebra **is essential.**

Course Objectives: This course aims at enabling students,

1. Understand and apply the principles of heat and mass transfer, including mathematical modeling for steady and unsteady state problems.
2. Analyze free and forced convection for internal and external flow situations.
3. Explore mechanisms and applications of pool boiling, convective boiling, film condensation, and dropwise condensation.
4. Apply radiation heat transfer concepts for enclosure analysis and design heat exchangers

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

1. **Understand** physical and mathematical aspects of heat and mass transfer.
2. **Develop** mathematical models for steady and unsteady state heat transfer problems.
3. **Analyze** free and forced convection for internal and external flow problems.
4. **Understand the mechanisms and applications** of pool boiling, convective boiling, film condensation, and dropwise condensation.
5. **Apply t**he concepts of radiation heat transfer for enclosure analysis.
6. **Design** heat exchangers

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Introduction:** Review of the fundamentals of heat transfer and modes of heat transfer. **One – Dimensional Steady State Heat Conduction:** General Heat Conduction Equation in (i) Cartesian, (ii) Polar and (iii) Spherical Coordinate Systems, Heat generation, Variable thermal conductivity, Extended surfaces –Uniform and Non-Uniform cross sections. Inverse heattransfer problems. **Steady- State Two-Dimensional Heat Conduction:** Governing equations and solutions, Use of Bessel's functions. **Transient Heat Conduction:** Lumped heat capacity system, Infinite plate of finite thickness and Semi-infinite Solid, Heisler and Grober charts for Transient Conduction.	8
2	**Forced Convection:** Conservation equations, Integral and analytical solutions, Boundary layer analogies, Internal and external flows, Laminar and turbulent flows, Empirical relations, cooling of electronic equipment. **Free convection:** Governing equations, Laminar and turbulent flows, Analytical and empirical solutions.	7
3	**Boiling and Condensation:** Pool boiling and convective boiling, Film condensation and dropwise condensation. **Thermal Radiation:** Fundamental principles, Radiation exchange between surfaces - View factor, Radiation shields, Multimode heat transfer.	8
4	**Heat Exchangers:** Types of heat exchangers, LMTD method and Effectiveness – NTU method,plate and tube heat exchangers, industrial standards for design of heat exchangers. Mass Transfer: Fick's law of diffusion, Analogy between heat transfer and mass transfer, Mass diffusion and mass convection.	7
	Total	30

Text Book

1. F. P. Incropera, and D. P. De Witt, *Fundamentals of Heat and Mass Transfer*, 5th Edition, Wiley, Indian Edition, 2018.
2. Y. A. Çengel and A. J. Ghajar, *Heat and Mass Transfer: Fundamentals and Applications*, 6th Edition McGraw-Hill Education, 2020,
3. Sadik Kakac and Yaman Yener, *Heat Conduction*, 5th Edition Taylor & Francis, 2018,.
4. W. M. Kays and M. E. Crawford, *Convective Heat and Mass Transfer*, 4th Tata McGraw Hill, 2017.

Reference Books:

1. S.M. Ghiaasiaan, *Convective Heat and Mass Transfer*, Cambridge, 2015.
2. R, M. Siegel, Pinar Menguc and J. R. Howell, *Thermal Radiation Heat Transfer*, 7^{th} Edition Taylor and Francis, 2020.
3. M.N. Ozisik, and H.R.B. Orlande, *Inverse Heat Transfer*, *Fundamentals and Applications*, Taylor and Francis, 2^{nd} Edition, 2021.

Online Sources

1. *Heat transfer* by Prof. Ganesh A. Viswanathan (IIT Bombay), NPTEL Course (Link: https://nptel.ac.in/courses/103/101/103101137/#)
2. *Convective Heat Transfer* by Prof. Saptarshi Basu (IISc Bangalore), NPTEL Course (Link: https://nptel.ac.in/courses/112/108/112108246/)
3. *Transport Processes I: Heat and Mass Transfer*, Prof. V. Kumaran (IISc Bangalore), NPTEL Course (Link: https://nptel.ac.in/courses/103/108/103108123/)

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester:**	**II**	
Course :	Optimization Techniques (PEC III)			**Code :**	MMC22PE05B	
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.**

Course Objectives:

This course aims to enable students,

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

Course Outcomes:

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

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

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1.	**Mathematical Modelling and Classical Optimization:** Need, Techniques, And Classifications of Mathematical Modelling. Applications of Optimization, Single-variable and multi-variable optimization, without constraints.	**7**
2.	**Linear Programming** Two-phase simplex method, primal and dual Simplex Method, sensitivity analysis of simplex method	**8**
3.	**Non-Linear Programming** Elimination and iterative methods for one-dimensional minimization and multi-dimensional minimization.	**8**
4.	**Modern Methods of Optimization** Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Teaching Learning Based Optimization, and Neural Networks.	**7**
	Total	**30**

Text Books:

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

Reference Books:

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

Online Sources

1. https://nptel.ac.in/courses/111105039
2. https://archive.nptel.ac.in/courses/111/105/111105039/

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester:**		**II**
Course :	Computational Dynamics and Vibration **(PEC III)**			**Code :**		MMC22PE05C
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	**2**	**-**	**-**	**20**	**30**	**50**

Prior knowledge of Basic of ordinary differential equations Calculus, and Differential Equations, Linear Algebra **is essential.**

Course Objectives:
This course aims at enabling students to,

1. Introduce fundamental concepts of vibration analysis, including single-degree-of-freedom and multi-degree-of-freedom systems and to provide an understanding of the Finite Difference Method for continuous systems.
2. Develop skills in formulating vibration problems, analyzing them and to familiarize with basic vibration analysis techniques and commercial software packages.
3. Introduce the Finite Element Method and its application in dynamic analysis and provide insights into modeling aspects for dynamic analysis using finite element techniques.
4. Introduce frequency spectrum analysis and Fourier analysis techniques and develop skills in analyzing various types of vibration signals.

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

1. **Analyze** and **Model** single-degree-of-freedom and multi-degree-of-freedom systems and will demonstrate proficiency in applying the Finite Difference
2. **Formulate** and **analyze** vibration problems effectively and will demonstrate competency in using commercial software packages for vibration analysis.
3. **Apply** the principles of the Finite Element Method and its relevance in dynamic analysis and will be capable of modeling dynamic systems using finite element techniques.
4. **Analyze** vibration signals and interpreting frequency spectra and will demonstrate the ability to apply Fourier analysis techniques to analyze vibration data effectively.

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1.	**Introduction to Single-Degree-of-Freedom System and Systems with Two or More Degrees of Freedom** Basic Concepts of Vibration, Single-Degree-of-Freedom Systems, Multi-Degree-of-Freedom Systems, Finite Difference Method for Continuous Systems (Introduction)	**8**
2.	**Vibration Modeling and Software Tools** Formulation of Vibration Problems, Basic Vibration Analysis Techniques, Introduction to Commercial Software Packages for Vibration Analysis	**7**
3.	**Finite Element Applications in Dynamics** Introduction to Finite Element Method, Application of Finite Element Method in Dynamic Analysis, Modeling Aspects for Dynamic Analysis	**8**
4.	**Vibration Signal Analysis** Introduction to Frequency Spectrum, Fourier Analysis and its Applications, Basic Signal Types and Analysis Techniques	**7**
	Total	30

Text Books:

1. Clarence W. de Silva, Computer Techniques in Vibration, CRC Press, 2016.
2. S. S. Rao (2018), *Mechanical Vibrations*, 6th Edition, Pearson, 2018.

Reference Books:

1. A.K. Chopra, Dynamics of Structures: *Theory and Applications to Earthquake Engineering*, Pearson, 2017.
2. K.J. Bathe, *Finite Element Procedures*. Prentice Hall, 2006.
3. L. Meirovitch, *Principles and Techniques of Vibrations*, Prentice Hall, 2001.
4. A.H. Nayfeh and B. Balachandran, *Applied Nonlinear Dynamics: Analytical, Computational, and Experimental Method*s. Wiley, 2008.

Online Sources

1. https://onlinecourses.nptel.ac.in/noc21_ae15/preview

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester: II**
Course :	Advance Computational Fluid Dynamics (PEC IV)				**Code :**	MMC22PE06A
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	**2**	**-**	**-**	**20**	**30**	**50**

Prior knowledge of Fluid Mechanics, Thermodynamics, Heat Transfer, Viscous Flow Theory **is essential.**

Course Objectives: This course aims at enabling students,

1. Acquaint students with Finite volume techniques to solve steady and unsteady heat conduction equations.
2. CFD development: develop programming skills by in-house code development for conduction, convection or fluid dynamics problems.
3. CFD application and analysis: Learn to apply the code on various problems in fluid dynamics and heat transfer; and analyze as well as discuss the results.

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

1. Apply finite volume method to solve steady-state 1D conduction and convection-diffusion problems.
2. Analyze solver algorithms and pressure-velocity coupling techniques used in CFD solvers.
3. Develop solutions for unsteady 1D heat conduction problems using FVM and apply suitable boundary conditions.
4. Evaluate CFD simulation reliability through error analysis, validation techniques, and grid strategies

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs.]**
1	**Finite Volume Method for Heat Conduction** Steady 1-D conduction and convection-diffusion problems; Conservativeness, Boundedness, Transportiveness; Discretization schemes: Central, Upwind, Hybrid, Power Law; Introduction to QUICK and TVD schemes).	**8**
2	**Solver Algorithms & Pressure-Velocity Coupling** Pressure-velocity coupling, staggered grids, Comparative overview of SIMPLE algorithm and its variants (SIMPLEC, SIMPLER, PISO, Coupled), Solver implementation examples	**8**
3	**Unsteady Heat Conduction & Boundary Conditions** 1-D unsteady conduction using FVM: Explicit, Crank-Nicolson, Fully Implicit; QUICK for transient problems; Essential boundary conditions (Inlet, Outlet, Wall, Pressure, Cyclic/Symmetric).	**7**
4	**Advanced Topics in CFD** Errors and uncertainty in CFD: numerical, input, model; Core concept of Verification & Validation.; Unstructured grid methods: overview of nodalization, Delaunay method); Introduction to Turbulence Modeling: LES, DNS, k-ε and k-ω	**7**
	Total	**30**

Text Books:

1. J.D Anderson (Jr), Computational Fluid Dynamics, McGraw-Hill Book Company, 2017.
2. D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, 3rd Edition, CRC Press, 2013.
3. H.K Versteeg, and W. Malalasekara, An Introduction to Computational Fluid Dynamics, Pearson Education, 2010.

Reference Books:

1. H.K. Versteeg, and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, Harlow, 1995.
2. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, New York, 1980.

3. K. Muralidhar, and T. Sundarajan, (Editors) Computational Fluid Flow and Heat Transfer (2nd ed.), IIT Kanpur Series, Narosa Publishing House, New Delhi, 2003.
4. J.H. Ferziger, and M. Peric Computational Methods for Fluid Dynamics, Springer Verlag, Berlin, 2002.
5. A. W. Date Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA, 2009.
6. D.C. Wilcox, Turbulence modeling for CFD, DCW Industries, La Canada, CA, 3rd Ed., 2006.
7. C. Hirsch, Numerical Computation of Internal and External Flows - The Fundamentals of Computational Fluid Dynamics, Butterworth-Heinemann, 2007.

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester:**	**II**	
Course :	Non-linear FEM **(PEC IV)**			**Code :**	MMC22PE06B	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	**2**	**-**	**-**	**20**	**30**	**50**

Prior knowledge of Finite Element Method, Numerical Analysis **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Understand applications of finite element procedures to nonlinear structural/solid mechanics problems.
2. Learn about different types of structural nonlinearities.
3. The formulation of finite element procedure to solve boundary value problems with nonlinearities.
4. Stress update procedures, consistent linearization and solution of discrete equilibrium equations by Newton-Raphson method.
5. Exposure to implementing algorithms in finite element codes and debugging them through example problems.

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

1. **Understand** applications of non-linear large deformations problems.
2. **Solve** one-dimensional plasticity problems.
3. **Analyze** three-dimensional nonlinear elasticity problems.
4. **Evaluate** basic concepts of continuum mechanics like deformation gradient, Cauchy stress, etc.
5. **Evaluate** Finite element formulations for finite deformation elasticity using Total Lagrangian or Updated Lagrangian

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Introduction to structural nonlinearities.** Material nonlinearity, Geometric nonlinearity, Force nonlinearity, Kinematic nonlinearity. Introduction to nonlinear problems using the classical form of the Galerkin method. Solution procedures for non-linear problems: Newton-Raphson Method, Constant stiffness iteration, Load increments, Arc-Length Method. Linearization and Directional Derivative.	**6**
2	**Material nonlinearity in general solids**. Analysis of axially loaded bars, weak form, two noded axial deformation element incremental solution using Lagrange interpolation function, One-Dimensional Plasticity, Yield criteria, State determination procedure.	**6**
3	**Material nonlinearity in general solids**. Derive the general form of the Finite element Equations for a three dimensional solid in terms of stress. General formulation for incremental stress-strain equations.	**6**
4	**Geometric nonlinearity in general solids**. Basic continuum mechanics concepts: Deformation Gradient, Green-Lagrange Strains, Cauchy and Piola-Kirchhoff Stresses, Constitutive Equations: Kirchhoff Material and compressible Neo-hookean material. Plane stress and plane strain conditions. Strain energy density functions for hyperelastic materials.	**6**
5	**Geometric nonlinearity in general solids**. Finite element formulations for finite deformation elasticity: Total Lagrangian and Updated Lagrangian, Governing differential equations and weak forms, Linearization of weak form, General form of Element Tangent Matrices, State Determination and Check for convergence.	**6**
	Total	30

Text Books:

1. J.N. Reddy, “An introduction to nonlinear Finite Element Analysis”, Oxford.
2. M. Asghar Bhatti, “Advanced Topics in Finite Element Analysis of Structures with Mathematica and MATLAB Computations”, Wiley publisher.

Reference Books:

1. T. Belythschko, W.K. Liu and B. Moran, "*Nonlinear Finite Element for Continua and Structures*", Wiley, 2000.
2. P. Wriggers, "*Nonlinear Finite Element Methods*", Springer, 2008.
3. P. K. Kythe, D. Wei, "*An Introduction to linear and nonlinear finite element analysis: a Computational Approach*", Birkhauser, 2004.
4. K. J. Bathe, "*Finite Element Procedures*", Second edition, Prentice Hall, 1996.

e-sources:

1. A. Francis, et. al, A cell based smoothed finite element method for finite elasticity, /doi.org/10.1080/15502287.2022.2030427
2. International Journal for Computational methods in engineering science and mechanics, 2022.

Program :	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester:**	**II**
Course :	Fluid Structure Interaction **(PEC IV)**				**Code :**	MMC22PE06C
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**
2	**2**	**-**	**-**	**20**	**30**	**50**

Prior knowledge of Basics of Fluid Mechanics, Solid mechanics, Structural mechanics, Thermodynamics, Heat Transfer **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Grasp the fundamentals of Fluid Structure Interaction (FSI), covering its definition, importance, and applications.
2. Understand the coupling conditions inherent in FSI, laying the foundation for analyzing complex interactions.
3. Learn Finite Element Method (FEM) techniques for solving FSI governing equations, enabling accurate simulation.
4. Comprehend linear equation solvers tailored for FSI, facilitating numerical analysis.
5. Explore real-world applications of FSI, fostering an understanding of its practical implications and future directions

Course Outcomes:

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

1. **Analyze** fluid and structural mechanics equations to understand FSI fundamentals.
2. **Evaluate** coupling conditions in FSI for predicting complex interactions.
3. **Apply** FEM techniques to accurately simulate FSI scenarios.
4. **Utilize** specialized linear equation solvers for numerical FSI analysis.
5. **Integrate** FSI principles into real-world engineering for innovative solutions.

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs]**
1	**Introduction to Fluid Structure Interaction** Introduction to FSI: Definition, significance, and applications; Governing Equations of Fluid and Structural Mechanics: Linear Stokes, steady and unsteady Navier-Stokes equations, structural dynamics equations; Classification of FSI problems: Coupled and uncoupled problems; Challenges in FSI: Numerical instability, convergence issues, and coupling strategies	**6**
2	**Fluid Dynamics and Solid Mechanics Fundamentals** Structural dynamics of continuous systems (plates and membranes), Basics of fluid dynamics and wave equations, Fluid Mechanics Fundamentals: Continuity Equation, Navier-Stokes Equations, Boundary Conditions, No-slip condition, Dirichlet and Neumann boundary conditions; Solid Mechanics Fundamentals: Stress and Strain, Constitutive Equations: Linear elasticity, nonlinear material behavior, Structural Dynamics: Equations of motion, natural frequencies, and mode shapes..	**6**
3	**Fluid-Structure Interaction Modeling** Fluid-Structure Interaction Phenomena: Fluid-elastic instability, vortex-induced vibration Mesh Generation: Structured and unstructured grids, mesh quality considerations Interface Treatment: Immersed boundary method, overset grids, body-conforming grids Coupling Strategies: Loose and strong coupling, implicit and explicit coupling methods	**6**
4	**Advanced Topics in Fluid-Structure Interaction** Coupled and Partitioned systems: Lagrangian and Eulerian formulations, Arbitrary Lagrangian Eulerian formulation; Discretization techniques for FSI equations: Time discretization, Galerkin Methods; Numerical Methods for FSI: Partitioned Methods, Monolithic Methods, Time Integration Schemes	**6**
5	**Engineering Applications** Pipes Conveying Fluid: Linear and Nonlinear Dynamics, Wave Propagation Cylindrical Shells and Prisms in Cross-Flow: Stability, Vibration, and Applications; Vortex-Induced Vibrations (VIV) and Fish Swimming Mechanics: Modeling and Analysis; Industrial Applications and Future Directions in FSI Research	**6**
	Total	30

Text Book

1. Thomas Richter, *Fluid Structure Interactions: Models, Analysis and finite elements*, Second Edition Springer, 2017, ISBN 978-3-319-63969-7
2. Rajeev Kumar Jaiman, Vaibhav Joshi, *Computational Mechanics of Fluid Structure Interaction: Computational methods for coupled fluid structure analysis*, 1st Edition, Springer, 2021, ISBN 978-981-16-5354-4
3. Yuri Bazilevs, Kenji Takizawa, Tayfun E. Tezduyar, *Computational Fluid Structure Interaction: Methods and Application*, 1st Edition, John-Wiley, 2013, ISBN: 978-0-4709- 7877-1
4. Païdoussis, M.P., Price, S.J., De Langre, E., *Fluid-structure interactions: cross-flowinduced instabilities*. Cambridge University Press 2010.

Reference Books:

1. M.P. Païdoussis, 2003. *Fluid-Structure Interactions: Slender Structures and Axial Flow*. Volume 2. Academic Press, London, UK.
2. E. H. Dowell, *A Modern Course on Aeroelasticity*, Kluwer Academic Publishers,
3. R.D. Blevins, 1990 *Flow-induced vibration*. Van Nostrand Reinhold, New York.

Online Sources

1. https://archive.nptel.ac.in/courses/114/106/114106038/

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester:**	**II**
Course:	Numerical Analysis Lab **(PCC Lab)**					**Code:**	MMC22PC06
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	25	25	-	50

Prior knowledge of System of linear equations, Partial differentiation, Problem-solving and programming **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Effective use of Numerical methods for solving complex mechanical engineering problems
2. Develop a logical solution for mechanical engineering problems.

Course Outcomes:

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

1. **Use** appropriate Numerical Methods to solve complex mechanical engineering problems.
2. **Formulate** algorithms and programming.

Guidelines:

Total: **6** experiments **60 hours (10 hrs. each)**

Detailed Syllabus

Expt. No.	**Suggested List of Experiments** (Solve any six from the list of following eight experiments)
1	To find the roots of non-linear equation using newton’s method
2	To solve the system of linear equations using gauss - elimination method
3	To solve the system of linear equations using Gauss-Seidal iteration method
4	To find numerical solution of ordinary differential equations by Runge- Kutta method
5	To find numerical solution of ordinary differential equations by Euler’s method
6	To integrate numerically using Simpson’s rules
7	To find the numerical solution of wave equation
8	To find the numerical solution of heat equation

Text Books:

1. Rao V. Dukkipati, *Applied Numerical Methods using Matlab*, New Age International Publishers, 2020.
2. Steven C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, Tata Mc-Graw Hill Publishing, 2022.

Reference Books:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, Wiley India, 2011.
2. Sheldon M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 5th Edition, Elsevier Academic Press, 2014.
3. E. Balagurusamy, *Numerical Methods*, Tata McGraw Hill, 2017.
4. M. T. Heath, *Scientific Computing - An Introductory Survey*, Revised Second Edition, SIAM, 2018.
5. Deisentoth, Faisal, Ong, *Mathematics for machine learning*, Cambridge University Press, 2020.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester:	II
Course:	Professional Elective- III & IV Lab **(PEC III &IV Lab)**					Code:	MMC22PE07
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	50	-	-	50

Instruction: Select Subject from Part A and Part B as per student's elective choices. Students must select the lab of their respective opted Professional Elective- III & IV courses.

Part A: Elective III- Advanced Heat and Mass Transfer Lab

Prior knowledge of basics of Heat transfer principles**, idea about** Computational tools (e.g., ANSYS Workbench, ANSYS Fluent), Fluid mechanics, Thermodynamics **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Develop proficiency in using computational tools such as ANSYS Workbench and ANSYS Fluent for modeling and analyzing heat transfer phenomena.
2. Gain hands-on experience in simulating and analyzing various heat transfer processes, including conduction, convection, and radiation, using computational and experimental methods.

Course Outcomes:

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

1. **Apply** advanced analytical and computational methods to solve complex heat transfer problems.
2. **Evaluate** heat exchanger performance and analyze natural convection phenomena using computational tools.

Guidelines:

Total: **3** experiments **30 hours (10 hrs. each)**

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1	Modeling Steady-State Heat Transfer in a Composite Wall with ANSYS (Steady State Thermal)
2	Performing Computational Analysis of Natural Convection Heat Transfer on a Vertical Rod Utilizing ANSYS Fluent
3	Computational Modeling of Natural Convection Heat Transfer
4	Numerical Investigation of Pin Fin Heat Transfer under Steady-State Conditions
5	Simulating Radiation and Natural Convection in ANSYS Workbench: A Practical Approach
6	CFD Simulation and Experimental Validation of Shell-and-Tube Heat Exchanger Performance

Part A: Elective III- Optimization Techniques Lab

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

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.
4. Apply modern optimization algorithms

Guidelines:

- Solve any 3 out of 7 assignments.
- Students will perform the lab assignments using any suitable software.

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1	Mathematical modelling of a real-world problem

2	Optimization of Single-variable/multi-variable problems using classical techniques
3	Solution of Linear problem using Two phase simplex method
4	Primal-dual simplex method
5	Sensitivity analysis of the linear problem
6	Optimization using non-linear methods
7	Optimization using modern methods

References:

1. A. Ghosh and A.K. Mallik, *Theory of Machines and Mechanisms*, Affiliated East-West Press, 2008.
2. S. S. Rattan, *Theory of machines*, McGraw-Hill Publications, 4th Edition, 2017.
3. A.G. Erdman and G.N. Sandor, *Mechanism Design - Analysis and Synthesis* (Vol.1and 2), Prentice Hall, 3rd Edition, 1986.
4. R.S. Hartenberg and J. Denavit, *Kinematic Synthesis of Linkages*, McGraw-Hill, 1964

Part A: Elective III- Computational Dynamics and Vibration Lab

Prior knowledge of System of linear equations, Partial differentiation, Problem-solving and programming **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Enable students to develop proficiency in computational modeling and simulation techniques for analyzing dynamic systems, focusing on vibrations and dynamic responses.
2. Foster an understanding of theoretical concepts related to dynamic systems and their practical application through hands-on exercises and projects.

Course Outcomes:

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

1. **Develop** MATLAB or Python codes to simulate the behavior of dynamic systems, including free and forced vibrations of single degree of freedom systems.
2. **Demonstrate** the ability to analyze and interpret simulation results, compare them with theoretical predictions, and apply computational techniques to solve practical engineering problems related to dynamic systems.

Guidelines:

Total: **3** experiments **30 hours (10 hrs. each)**

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1	Free Vibration/Forced Vibration Analysis of a Single Degree of Freedom System • Develop a MATLAB or Python code to simulate free vibration of a single degree of freedom system. • Use the code to simulate the natural frequency, damping ratio, and response of the system to an initial displacement or velocity. • Analyze and interpret the results.
2	Modal Analysis of a Beam • Develop a finite element model of a beam using ANSYS or any other FEA software. • Conduct modal analysis to obtain the natural frequencies and mode shapes of the beam. • Compare the results with theoretical calculations and experimental measurements.
3	Frequency Response Analysis/Time Domain Analysis of a Multi-Degree of Freedom System • Develop a MATLAB or Python code to simulate frequency response of a multi-degree of freedom system. • Use the code to simulate the response of a system with multiple degrees of freedom to a harmonic force input. • Analyze and interpret the results.
4	Dynamic Response of a Beam Under Impact Load • Develop a finite element model of a beam using ANSYS or any other FEA software.

	• Conduct a dynamic analysis to obtain the response of the beam to an impact load. • Analyze and interpret the results.

Text Books:

1. Clarence W. de Silva, *Computer Techniques in Vibration*, CRC Press, 2016.
2. Singiresu S. Rao, *Mechanical Vibrations*, 6^{th} Edition, Pearson, 2018.

Reference Books:

1. A.K. Chopra, *Dynamics of Structures: Theory and Applications to Earthquake Engineering*. Pearson, 2017.
2. K.J. Bathe, *Finite Element Procedures*. Prentice Hall, 2006.
3. L. Meirovitch, *Principles and Techniques of Vibrations*. Prentice Hall, 2001.
4. A.H. Nayfeh, & B. Balachandran, *Applied Nonlinear Dynamics: Analytical, Computational, and Experimental Methods*, Wiley, 2008.

Part B: Elective IV- Advance Computational Fluid Dynamics Lab

Prior knowledge of System of linear equations, Partial differentiation, Problem-solving and programming **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Apply advanced numerical methods and techniques to solve complex fluid dynamics problems, demonstrating proficiency in high-level simulation methodologies.
2. Analyze simulation results critically, identify areas for optimization, and develop problem-solving skills to enhance the accuracy and efficiency of computational fluid dynamics simulations.

Course Outcomes:

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

1. **Apply** Computational Fluid Dynamics (CFD) principles and techniques to solve heat conduction problems (Lab 1 and Lab 2)
2. **Demonstrate** competence in utilizing CFD software and algorithms for simulating fluid flow phenomena (Lab 3 and Lab 4)
3. **Evaluate and optimize** CFD simulations through critical analysis and problem-solving (Lab 5 and 6)

Guidelines:

1. Total experiments to be conducted are Three
2. Total: 3 experiments 30 hours

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1	**Finite Volume Method for Steady Heat Conduction:** Implement finite volume method to find steady-state temperature distribution in a 1-D metal rod with known boundary temperatures. Explore central and upwind differencing schemes.
2	**Finite Volume Method for Unsteady Heat Conduction:** Implement explicit, Crank-Nicolson, and implicit schemes to solve unsteady heat conduction in a 1-D rod with sudden temperature change. Compare accuracy and stability for different time steps.
3	**Solver Algorithms and Implementation:** Simulate steady laminar flow in a 2D lid-driven cavity using SIMPLE algorithm. Observe flow patterns and convergence behavior for different Reynolds numbers and grid resolutions.
4	**Error Analysis and Best Practices in CFD Modeling:** Conduct mesh sensitivity study for flow over a backward-facing step. Compare simulation results using different turbulence models and mesh resolutions with experimental data.
5	**Unstructured Grid Generation and Delaunay Method:** Generate unstructured mesh for NACA airfoil. Perform CFD simulation to compute lift and drag coefficients at various angles of attack. Evaluate mesh quality and convergence.
6	**Turbulence Modeling and Large Eddy Simulation:** Simulate turbulent flow in a channel using LES. Compare results with k-epsilon turbulence model to assess LES capability in capturing turbulent structures. Analyze velocity fluctuations and turbulence intensity profiles.

Text Book

2. J.D. Anderson, (Jr), *Computational Fluid Dynamics*, McGraw-Hill Book Company, 2017.
3. D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, 3rd Edition, CRC Press, 2013.

Reference Books:

1. H.K. Versteeg, and W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Longman Scientific & Technical, Harlow, 1995.
2. S.V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation, New York, 1980.
3. K. Muralidhar, and T. Sundarajan, (Editors) *Computational Fluid Flow and Heat Transfer* (2nd Edition.

Part B: Elective IV - Non-linear FEM Lab

Prior knowledge of Basics of Finite Element Method, Basic of MATLAB, Basic of ANSYS software **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Understand applications of finite element procedures to nonlinear structural/solid mechanics problems.
2. Learn about different types of structural nonlinearities.
3. The formulation of finite element procedure to solve boundary value problems with nonlinearities.
4. Stress update procedures, consistent linearization and solution of discrete equilibrium equations by Newton-Raphson method.
5. Exposure to implementing algorithms in finite element codes and debugging them through example problems.

Course Outcomes:

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

1. **Understand** applications of non-linear large deformations problems.
2. **Solve** one-dimensional plasticity problems.
3. **Analyze** three-dimensional nonlinear elasticity problems.
4. **Evaluate** basic concepts of continuum mechanics like deformation gradient, Cauchy stress, etc.
5. **Evaluate** Finite element formulations for finite deformation elasticity using Total Lagrangian or Updated Lagrangian

Guidelines:

Total: **3** experiments **30 hours (10 hrs. each)**

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1	Solve the following One-Dimension non-linear boundary value problem with three elements using Newton Raphson Method in MATLAB. $$\frac{d}{dx}(u^2 \frac{du}{dx}) + q(x) = 0; \qquad 0 < x < L$$ EBC: u(x=0) = 0. NBC: load q=4 at x=L. Plot for displacement over elements at nodes x and check the convergence with higher number of elements.
2	Compute Algorithm for State Determination with isotropic hardening using MATLAB
3	Compute using MATLAB the deformation gradient for a 1 x 1 x 1 cube that undergoes a large motion. The motion consists of a rigid – body translation by {2,1,2}, a rotation of 30^o about z-axis, and a uniform expansion of the cube to a size 1.2 x 1.2 x 1.2. With this motion the coordinates of corners of the cube in the initial and the deformed configuration are given.
4	State the inference using MATLAB for a 1 x 1 square element undergoes a translation of {1,1} and a counter clockwise rotation of $\pi/6$ radians in the x-y plane. Calculate the deformation gradient.

	Compute the Green-Lagrange strains and demonstrate that no straining occurs during rigid body motion.
5	Compute the algorithm to Linearization of the weak form using MATLAB. Compute the algorithm of Element tangent metrices using MATLAB.
6	Compute the algorithm of State determination and check for convergence using MATLAB.
7	Compute the algorithm of Compressible Neo-Hookean Material using MATLAB for large deformation problems for both plane stress and plane strain conditions.
8	Develop a Hyperelastic Material Model using MATLAB. Taking large displacements into consideration, determine deflections and stresses in the thin plate of 2X4 dim. Solve using one element with fixed at (0,0) and (0,2). Load of 50N at (4,1) and 25N at (4,2). Assume E= 1000 MPa, v=0.25 and h = 0.1.
9	Choose any Scopus journal paper on nonlinear FEM and reproduce the result and present your inferences. (Use of tools like MATLAB, ANSYS, ABAQUS, etc are allowed)
10	Choose any Scopus journal paper on nonlinear FEM and reproduce the result and present your inferences. (Use of tools like MATLAB, ANSYS, ABAQUS, etc are allowed)

Text Books:

1. J. N. Reddy, "*An introduction to nonlinear Finite Element Analysis*", Oxford.
2. M. Asghar Bhatti, "*Advanced Topics in Finite Element Analysis of Structures with Mathematica and MATLAB Computations*", Wiley publisher.

Reference Books:

1. T. Belythschko, W.K. Liu and B. Moran, "*Nonlinear Finite Element for Continua and Structures*", Wiley, 2000.
2. P. Wriggers, "*Nonlinear Finite Element Methods*", Springer, 2008.
3. P. K. Kythe, D. Wei, "*An Introduction to linear and nonlinear finite element analysis: a Computational Approach*", Birkhauser, 2004.
4. K. J. Bathe, "*Finite Element Procedures*", Second edition, Prentice Hall, 1996.

e-sources:

1. Francis, et. al, A cell based smoothed finite element method for finite elasticity, /doi.org/10.1080/15502287.2022.2030427
2. International Journal for Computational methods in engineering science and mechanics, 2022.

Part B: Elective IV - Fluid Structure Interaction Lab

Prior knowledge of: Basics of Fluid Mechanics, Solid mechanics, Structural mechanics, Thermodynamics, Heat Transfer

Course Objectives:

This course aims at enabling the students to,

1. Grasp the fundamentals of Fluid Structure Interaction (FSI), covering its definition, importance, and applications.

2. Understand the coupling conditions inherent in FSI, laying the foundation for analyzing complex interactions.
3. Learn Finite Element Method (FEM) techniques for solving FSI governing equations, enabling accurate simulation.
4. Comprehend linear equation solvers tailored for FSI, facilitating numerical analysis.
5. Explore real-world applications of FSI, fostering an understanding of its practical implications and future directions.

Course Outcomes:

1. **Analyze** fluid and structural mechanics equations to understand FSI fundamentals.
2. **Evaluate** coupling conditions in FSI for predicting complex interactions.
3. **Apply** FEM techniques to accurately simulate FSI scenarios.
4. **Utilize** specialized linear equation solvers for numerical FSI analysis.
5. **Integrate** FSI principles into real-world engineering for innovative solutions.

Guidelines:

Total: **6** experiments **60 hours (10 hrs. each)**

Detailed Syllabus

Expt. No.	Suggested List of Experiments
1	Introduction to ANSYS software to perform FSI problem.
2	Introduction to basic flow problem using ANSYS software.
3	Solve one way interaction problem using ANSYS software.
4	Solve two-way interaction problem using ANSYS software.
5	Choose any Scopus journal paper on FSI and reproduce the result and present your inferences. (Use of tools like MATLAB, ANSYS, ABAQUS, etc are allowed)

Text Book

1. Thomas Richter, *Fluid Structure Interactions: Models, Analysis and finite elements*, 2nd Edition Springer, 2017, ISBN 978-3-319-63969-7
2. Rajeev Kumar Jaiman, Vaibhav Joshi, *Computational Mechanics of Fluid Structure Interaction: Computational methods for coupled fluid structure analysis*, 1st Edition, Springer, 2021, ISBN 978-981-16-5354-4

Reference Books:

1. M.P. Païdoussis, 2003. Fluid-Structure Interactions: Slender Structures and Axial Flow. Volume 2. Academic Press, London, UK.
2. E. H. Dowell, *A Modern Course on Aeroelasticity*, Kluwer Academic Publishers,
3. R.D. Blevins, 1990 *Flow-induced vibration*. Van Nostrand Reinhold, New York.

Online Sources

4. https://archive.nptel.ac.in/courses/114/106/114106038/

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester:**	**II**
Course :	Research Methodology **(AEC)**					**Code :**	**MMC22AE01**
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**	**SA**	**Total**	
2	**2**	**-**	**-**	**20**	**30**	**50**	

Prior knowledge of project execution and seminars in undergraduate **is essential**.

Course Objectives:

This course aims at enabling students to,

1. Select and define appropriate research problem and parameters with appropriate methodology.
2. Understand statistical techniques for the specific perspective data in an appropriate manner.
3. Learn the various steps in research writing and publication process
4. 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)**
1	**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**
2	**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, and Normal Distribution.	**8**
3	**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**
4	**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. B. Ramakrishna and H. S. Anil Kumar, “Fundamentals of Intellectual Property Rights: For students, Industrialist and Patent Lawyers”, Notion Press, 2017.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)						Semester: II
Course:	Research Internship / Field Visit based Case Study/ Experiential Learning **(EL)**				Code:		MMC22EL01
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 Projects idea, Design and Simulation software and programming language **is essential**

Course Objectives:

This course will enable students to,

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.

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 4-5):** Expectation: Discussion on the problem statement and defined objectives
5.	Implementation of the problem statement: Identification of technology/methodology/algorithm, system architecture, flow diagram, mathematical modeling, front end, back end
6.	**Review-2 (Will be conducted in Week 10):** Expectations: Discussion on methodology, system architecture, implementation and partial results.
7.	**Review-3 (Will be conducted in Week 15):** Result Analysis and discussion
8.	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 4-5):** 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 10):** Expectations: Discussion on methodology, system architecture, implementation and partial results.
10.	**Review-3 (Will be conducted in Week 15):** 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 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 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. Computational Mechanics (Mechanical Engineering)**			**Semester:**	**II**		
Course:	Research Writing **(AEC)**			**Code:**	MMC22AE02		
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 **r**esearch problem formulation, Literature Review **is essential.**

Course Objectives:

This course aims at enabling students to,

1. Enhance research problem formulation and literature review skills in computational mechanics.
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 proficiency 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

Task No.	**Task to be carried out**
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. Computational Mechanics (Mechanical Engineering)**					**Semester:**	**III**
Course	Massive Open Online Course **(MOOCs)**					**Code**	MMC23EL02
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
4	4	-	-	100	-	-	100

Prior knowledge as per the MOOCs Course **is essential**

Course Objectives:

This course aims at enabling students to,

- Provide diversified knowledge and skills in a single platform
- Provide opportunity to students to explore new areas of interest
- Poster student engagement in self-learning

Course Outcomes:

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

- **Apply** diversified knowledge and skills across various domains.
- **Demonstrate** proactive engagement in self-learning initiative

Guidelines for Students:

Individual students needs 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:** A selected two course should be of Minimum 8 weeks each.

C. **Assessment of Course :**

- At the end of Course submission the MOOCs report of 10-15 Pages in hardcopy is mandatory along with certificate of completion.
- Assessment will be done through Certification exam report.
- Assessment will be done by MOOC Mentor.
- Oral and Presentation of course/ training will be taken at the end of semester

Evaluation Guidelines and Rubrics:

- MOOC Mentor will observe the progress of the student.
- 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 topic Selected	20
2	Scores of Assignments Submitted	50
3	Certification received based on examination conducted by MOOCs provider	30
Total Marks		**100**

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

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester:**	**III**
Course:	On Job Training / Core mini Project / Development of Experimental Setup / Community Engagement Project / Interdisciplinary Project **(EL)**					**Code:**	MMC23EL03
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
10	-	20	-	200	100	-	300

Prior knowledge of: Engineering Mechanics, Numerical Methods, Fluid Dynamics, Solid Mechanics Basics of Computer Programming Concepts **is essential.**

Course Objectives:

This course will enable students to,

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.

Select any one EL from the following

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.

EL: 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
7.	**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.
8.	**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
9.	**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.
10.	**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.
11.	**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.
12.	**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.	
Task No.	**Detailed Syllabus: Task to be carried out**
7.	**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.
8.	**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
9.	**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
10.	**Week 9-10:** Progress Review Conduct a review of project activities and progress to assess effectiveness and address any challenges.
11.	**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.
12.	**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 findin
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. Computational Mechanics (Mechanical Engineering)					Semester:	III
Course:	Dissertation/Specialization Project - Phase I [Company/ In-house project]					Code:	MMC23EL04
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
6	-	12	-	100	100	-	200

Prior knowledge of basics of Computational Mechanics, Mechanical system design, Analysis/ Simulation software, and any Programming language **is essential.**

Course Objectives:

This course will enable students to,

1. Plan for various activities of the major project and channelize the work towards product /process development.
2. Enable students to apply the knowledge about research design and methods to develop their project.
3. 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.
5. **Publish** quality paper in reputed journal/ present their work in reputed conferences.

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

"Knowledge Brings Freedom"

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester	IV	
Course	Dissertation/Specialization Project - Phase II [Company/ In-house project] **(EL)**				Code	MMC24EL05	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
20	-	40	-	400	200	-	600

Prior knowledge of basics of Computational Mechanics, Mechanical system design, Analysis/ Simulation software, and any Programming language **is essential.**

Course Objectives:

This course will enable students to

1. Understand the Product Development Process including budgeting.
2. Plan for various activities of the major project and channelize the work towards product development.
3. Build, design and implement real time application using available platforms.
4. 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** 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

Task 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