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)

(Course 2023)

Effective from Academic Year 2023-24

Institute Vision

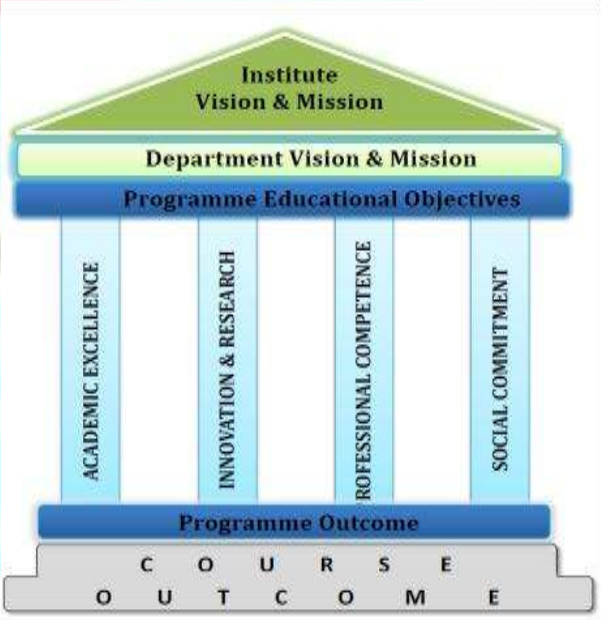
To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value Added Quality Education through a matching ecosystem for building successful careers**.**

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.

Quality Policy

We at PCCOE are committed to impart Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders. We shall strive for academic excellence, professional competence and social commitment in fine blend with innovation and research. We shall achieve this by establishing and strengthening state-of- the-art Engineering and Management Institute through continual improvement in effective implementation of Quality Management System.



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ABBREVIATIONS

Abbreviations	Course Full Name
PCC	**P**rofessional **C**ore **C**ourse
PEC	**P**rofessional **E**lective **C**ourse
OEC#	**O**pen **E**lective **C**ourse
PROJ	**Proj**ect, Mini / Minor **Proj**ects, Integrated **Proj**ects
SEM	**Sem**inar
INTR	**Inter**nship
LS	**L**ife **S**kill
AUDIT*	**A**udit **C**ourse
MO	**Massive Open Online Courses**

Note : * Indicates that these courses are at Institute level

The Course offered by the other department

Curriculum Structure

CURRICULUM STRUCTURE

STRUCTURE FOR IST YEAR

M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)

Semester I

M.Tech Structure		Semester-I	Teaching Scheme				Examination Scheme					
Course Code	**Course Type**	**Course Name**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**Total**
MMC1401	PCC	Research Methodology & IPR	3	-	3	3	20	30	50	-	-	100
MMC1402	PCC	Finite Element Methods	3	-	3	3	20	30	50	-	-	100
MMC1403	PCC	Computational Fluid Dynamics	3	-	3	3	20	30	50	-	-	100
MMC1404	PCC	Professional Core Lab- I	-	2	2	1	-	-	-	50	50	100
MMC1501	PEC	Professional Elective-I	3	-	3	3	20	30	50	-	-	100
MMC1502	PEC	Professional Elective-II	3	-	3	3	20	30	50	-	-	100
MMC1503	PEC	Professional Elective Lab-I (Elective I & II)	-	2	2	1	-	-	-	50	50	100
**	OEC	Open Elective-I	2	-	2	2	20	-	30	-	-	50
MMC1911	PCC	Skill Development Lab – I (Technical/ Software Skill)	-	2	2	1	-	-	-	50	-	50
M_2961	Audit	Audit Course – I	1	-	1	-	-	-	-	-	-	-
		Total	**18**	**6**	**24**	**20**	**120**	**150**	**280**	**150**	**100**	**800**

Abbreviation: L- Lecture; **P**- Practical; **H**- Hours; **CR**- Credits; **IE 1** – Internal Evaluation-1; **IE 2** – Internal Evaluation-II; **ETE** – End Term Examination; **TW** – Term Work; **OR** – Oral Exam

** Open Elective code will be as per course chosen

STRUCTURE FOR IST YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)

Semester II

M.Tech Structure		Semester -II	Teaching Scheme				Examination Scheme					
Course Code	**Course Type**	**Course Name**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**Total**
MMC2405	PCC	Continuum Mechanics	3	-	3	3	20	30	50	-	-	100
MMC2406	PCC	Numerical Analysis	3	-	3	3	20	30	50	-	-	100
MMC2407	PCC	Professional Core Lab- II	-	2	2	1	-	-	-	50	50	100
MMC2504	PEC	Professional Elective-III	3	-	3	3	20	30	50	-	-	100
MMC2505	PEC	Professional Elective-IV	3	-	3	3	20	30	50	-	-	100
MMC2506	PEC	Professional Elective Lab -II (Elective III and IV)	-	2	2	1	-	-	-	50	50	100
**	OEC	Open Elective –II	2	-	2	2	20	-	30	-	-	50
MMC1912	HSMC	Skill Development Lab – II (Oral & Written Communication)	-	2	2	1	-	-	-	50	-	50
MMC2701	PROJ	Integrated Mini- Project	-	6	6	3	-	50	-		50	100
M_2962	Audit	Audit Course –II	1	-	1	-	-	-	-	-	-	-
		Total	**15**	**12**	**27**	**20**	**100**	**170**	**230**	**150**	**150**	**800**

Abbreviation: L- Lecture; **P**- Practical; **H**- Hours; **CR**- Credits; **IE 1** – Internal Evaluation-1; **IE 2** – Internal Evaluation-II; **ETE** – End Term Examination; **TW** – Term Work; **OR** – Oral Exam

** Open Elective code will be as per course chosen

STRUCTURE FOR IIST YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)

SEMESTER-III

M Tech Structure		Sem – III	TEACHING SCHEME					EXAMINATION SCHEME				
Course Code	**Course Type**	**Courses**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**TOTAL**
MMC3702	PROJ	Dissertation Phase - I [Company/ In-house project]	-	20	20	10	-	-	-	100	100	200
MMC3703	SEM	Seminar	-	04	04	02	-	-	-	50	50	100
MMC3801	INTR	Internship [Company/ In-house project] /	-	04	04	02	-	-	-	100	-	100
OR												
MMC3981	MO	MOOC's / Entrepreneurship	-	04	04	02	-	-	-	100	-	100
		Total	-	**28**	**28**	**14**	-	-	-	**250**	**150**	**400**

STRUCTURE FOR IIST YEAR
M. TECH. COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)

SEMESTER-IV

M Tech Structure		Sem – IV	TEACHING SCHEME				EXAMINATION SCHEME					
Course Code	**Course Type**	**Courses**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**TOTAL**
MMC4704	PROJ	Dissertation Phase - II [Company/ In-house project]	-	24	24	12	-	-	-	200	200	400
MMC4982	MO	MOOC's	-	4	4	2	-	-	-	100	--	100
		Total	-	**28**	**28**	**14**	-	-	-	**300**	**200**	**500**

Abbreviation: L- Lecture; **P**- Practical; **H**- Hours; **CR**- Credits; **IE 1** – Internal Evaluation-1; **IE 2**– Internal Evaluation-II; **ETE** – End Term Examination; **TW** – Term Work; **OR** – Oral Exam

LIST OF ELECTIVES

	Elective-I		Elective-II
MMC1501A	Advanced Fluid Mechanics	**MMC1502A**	Optimization Techniques
MMC1501B	Battery Technologies for Electric Vehicles	**MMC1502B**	Data Analytics

	Elective-III		Elective-IV
MMC2504A	Advanced Computational Fluid Dynamics	**MMC2505A**	Artificial Intelligence and Machine Learning
MMC2504B	Computational Dynamics and Vibrations	**MMC2505B**	Additive Manufacturing Technology

LIST OF AUDIT COURSES

	SEM-I		SEM-II
M_1961A	Constitution of India	**M_2962A**	Team Building & Leadership
M_1961B	Value Education	**M_2962B**	English for Research writing
M_1961C	Stress Management	**M_2962C**	Disaster Management

LIST OF OPEN ELECTIVES

OFFERED BY COMPUTATIONAL MECHANICS (MECHANICAL ENGINEERING)

	Open Elective – I		Open Elective –II
MMC1601A	Battery Management for Electric Vehicles	**MMC2602A**	Waste Management for Smart Cities
MMC1601B	Green Technology	**MMC2602B**	Electronic Cooling
MMC1601C	System Modeling and Simulation	**MMC2602C**	Renewable Energy Sources

OFFERED BY DESIGN ENGINEERING

	Open Elective – I		Open Elective –II
MMD1601A	Advanced Materials	**MMD2602A**	Room Acoustics
MMD1601B	Optimization Methods	**MMD2602B**	Design Thinking
MMD1601C	Modeling & Simulation of Dynamic Systems	**MMD2602C**	Reliability Engineering

OFFERED BY (E&TC)- VLSI & EMBEDDED SYSTEMS

	Open Elective – I		Open Elective –II
MET1601A	Automotive Electronics & Applications	**MET2602A**	Drone Programming for Beginners
MET1601B	Industrial Drives	**MET2602B**	Instrumentation and Measurement
MET1601C	Basics of FPGA and CPLD	**MET2602C**	Microcontrollers and Microprocessors applications
MET1601D	Robotics	**MET2602D**	Electronics Implementation Platforms

OFFERED BY COMPUTER ENGINEERING

	Open Elective – I		Open Elective –II
MCE1601A	Programming with Python	**MCE2602A**	Image Processing with MATLAB
MCE1601B	Software Engineering Basics	**MCE2602B**	Linux Essentials
MCE1601C	Basics of Machine learning	**MCE2602C**	Design with UMI

OFFERED BY CIVIL- CONSTRCTION MANAGEMENT

	Open Elective – I		Open Elective –II
MCI1601A	Project Management and Finance	**MCI2602A**	Contracts, Tendering and Arbitration
MCI1601B	Green Technology	**MCI2602B**	Total Quality Management
MCI1601C	Organization Behaviour	**MCI2602C**	Operation Research

OFFERED BY INFORMATION TECHNOLOGY: ARTIFICIAL INTELLIGENCE & DATA SCIENCE

	Open Elective – I		Open Elective -II
MDS1601A	R Programming	**MDS2602A**	Python for Data Science
MDS1601B	Business Analytics	**MDS2602B**	Introduction to Neural Networks

Course Syllabus
Semester-I

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: I	
Course:	Research Methodology and IPR (PCC)				Code: MMC1401	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Project and seminars in undergraduate

Course Objectives:

1. To select and define appropriate research problem and parameters with appropriate methodology.
2. To understand statistical techniques for the specific perspective data in an appropriate manner.
3. To make predictions and decisions for the data set using open-source software.
4. To understand the mathematical modeling and its predicting capability.
5. To learn the various steps in research writing and publication process
6. To introduce fundamental aspects of Intellectual property rights

Course Outcomes:

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

1. Define a research problem and use appropriate research methodology
2. Examine data using different hypothesis tests and make conclusions about acceptance or rejection of sample data.
3. Analyze numerical data, using standard procedures of probability theory to predict the performance.
4. Develop a mathematical model and analyze the prediction capabilities
5. Write a research paper and research proposal.
6. 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.	**Applied Statistics** Measures of Variability: Standard Deviation, variance, Quartiles, Interquartile Range Inferential Statistics: Statistical Significance (p values), Pearson's r test, t- test, Chi square test, ANOVA (Analysis of variance)	8
3.	**Probability** Sampling, Types of Sampling, Probability Distribution: Binomial Distribution, Poisson Distribution, Normal Distribution, Case Study: Develop a model for Prediction and Decision Making for the data set using open-source software	8
4.	**Mathematical Modeling and prediction of performance** Types of Modeling, Types of solutions to mathematical models, Steps in Setting up a computer model to predict performance of experimental system, Validation of results, Multi- scale modeling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Sensitivity analysis.	7
5.	**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 Vs 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
6	**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	**45**

Textbooks:

1. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, 2010
2. Ramakrishna B and Anil Kumar H S., Fundamentals of IPR, Notion Press, 2016

Reference Books:

1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 2nd Edition, 1985
2. Virendra Kumar Ahuja, IPR in India, LexisNexis Butterworths Wadhwa Nagpur, 2017
3. Stuart Melville and Wayne Goddard, Research methodology: An Introduction for Science & Engineering students
4. S.D. Sharma, Operational Research, Kadar Nath Ram Nath & Co.
5. Wayne Goddard and Stuart Melville, Research Methodology: An Introduction, Juta and Company Ltd, 2004

IE Activities:

1. Write a review paper based on detailed literature survey and cheque for plagiarism.
2. Write a research proposal on your domain specific research problem.
3. Write a concept note and prepare to file an IP.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: I	
Course :	Finite Element Methods (PCC)				Code : MMC1402	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Engineering Mathematics,
b. Machine Design,
c. Strength of Material…….are essential

Course Objectives:

1. To understand the philosophy and general procedure of the Finite Element Method as applied to solid mechanics and thermal analysis problems.
2. To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
3. It provides a bridge between hand calculations based on the mechanics of materials and machine design and numerical solutions for more complex geometries and loading states.
4. To study the approximate nature of the finite element method, and convergence of results are examined.
5. It provides some experience with a commercial FEM code and some practical modelling exercises

Course Outcomes:

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

1. Apply variation methods for deriving the stiffness matrices of bar and beam element
2. Identify problems where two-dimensional methods can be applied
3. Understand the Iso-parametric Elements and Formulation of Plane Elasticity Problems
4. Create and solve the governing equations for plates using Kirchoff theory and Mindlin plate element theory
5. Evaluate non-linear problems related to geometry, material and contact.
6. Formulate and solve the dynamic problems related to eigenvalue and eigenvectors

Detailed Syllabus:

Unit	Description	Duration, (H)
1	**One dimensional problem** Finite element method, brief history, basic steps, advantages and disadvantages, weak formulation, 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. Automatic mesh generation techniques, Mesh quality checks, h & p refinements, Node Numbering scheme	8
2	**Two-Dimensional Isoperimetric Formulation** Introduction, types of 2D elements (CST, LST, QST, 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, the convergence of isoparametric elements, rate of convergence, plane elasticity problems – plane stress, plane strain and axisymmetric problems	8
3	**Isoparametric Formulation and Numerical Integration** Isoparametric formulation of 1D and 2D Elements, Subparametric, Superparametric and Isoparameetric Elements, Application of numerical integration techniques.	8
4	**Plate Theories** Thin and thick plates – Kirchhoff theory, Mindlin plate element, triangular and rectangular, conforming and nonconforming elements, degenerated shell elements, shear locking and hourglass phenomenon	7
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	7
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], Forced vibration – steady state and transient vibration analysis, modelling of damping, the mode superposition scheme, direct integration methods – implicit and explicit numerical integration	7
	Total	45

Text Books:

1. Seshu P., “Text book of Finite Element Analysis”, PHI Learning Private Ltd., New Delhi, 2010.
2. Logan D, “First course in the Finite Element Method” Cengage Learning, 2012

Reference Books:

1. Bathe K. J., “Finite Element Procedures”, Prentice-Hall of India (P) Ltd., New Delhi, 2007.
2. Cook R. D., “Finite Element Modeling for Stress Analysis”, John Wiley and Sons Inc, 1995
3. Chandrupatla T. R. and Belegunda A. D., “Introduction to Finite Elements in Engineering”, Prentice Hall India.
4. Liu G. R. and Quek S. S. “The Finite Element Method – A Practical Course”, Butterworth-Heinemann, 2003.
5. Reddy, J. N., “An Introduction to the Finite Element Method”, Tata McGraw Hill, 2003.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: I	
Course:	Computational Fluid Dynamics (PCC)				Code :MMC1403	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of: Fluid Mechanics, Thermodynamics, Heat Transfer, Viscous Flow Theory

Course Objectives:

1. Students will be able to 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
1. Understand and **Apply** finite volume methods to heat transfer and fluid flow problems
2. **Create** geometric model and Solve real life problem in an engineering domain using turbulence model.

Detailed Syllabus:

Unit	Description	Duration, (H)
1	**Introduction** Introduction to CFD: What is CFD?, Why to study 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, Brief introduction of ODE (IVP and BVP) and PDE, classification of PDE.	8
2	**Essentials of Numerical Methods** Introduction to Finite Element Method (FEM), Finite Difference Method (FDM), FDM based algebraic-formulation for 1D and 2D steady state heat conduction, iterative solution of system of linear algebraic equations, Initial and Boundary conditions, various methods to solve PDE numerically along with their advantages and disadvantages.	8
3	**Discretization Techniques: Finite Volume Method** Discretization Methods, Discretization procedure in Finite-volume framework. Approximation of Surface Integrals, Approximation of Volume Integrals, explicit based solution-methodology for 1D system, upwind schemes.	8
4	**Computational Heat-Transfer on a Cartesian-Geometry** Applications of Finite Volume Methods: One-dimensional and two-dimensional steady and unsteady state diffusion equation, steady state one-dimensional convection and diffusion, stability analysis, explicit and implicit method based solution-methodology.	7
5.	**Numerical Solution to Navier – Stokes Equation** Finite Volume Method (FVM) based algebraic-formulation for convection-diffusion problems, assessment of the central differencing scheme. Pressure correction technique, staggered grids, SIMPLE algorithm.	7
6	**Introduction to Turbulence Modeling** Introduction to turbulence models, Reynolds Averaged Navier-Stokes equations (RANS), One equation model (Derivation) and two equation model.	7
	Total	45

Text Books:

1. J. D. Anderson, Computational Fluid Dynamics, McGraw Hill, 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. Versteeg, H.K. and Malalasekera W. 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.

PROFESSIONAL CORE LAB - I						
Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester:** I	
Course:	**Professional Core Lab- I (FEM and CFD)**				**Code: MMC1404**	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**100**

Course Objectives:

This course intends to provide students the tools required to simulate, correlate and validate theoretical concepts and understand the basic principles.

Course Outcomes:

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

1. Estimate thermodynamic properties, composition of gas mixtures and adiabatic flame temperature during combustion reaction
2. Calculate lift and drag forces on bodies
3. Estimate friction factor and pressure losses in pipe flow
4. Apply measurement instrumentation in fluid flow problems

Guidelines:

1. Total experiments to be conducted are Three from Part A and Three from Part B
2. Total: 6 experiments 15 hours

Detailed Syllabus:

Part A: Finite Element Methods (ANY Three)

Expt	Description	Duration, (H)
1.	Stress analysis of 1D bar using linear and quadratic elements. Show the variation of stress and strain within the element for linear and quadratic bar element (Convergence Study)	8
2.	Modal analysis and stress analysis for 1-D beam (simply supported or cantilever beams) (Convergence Study)	
3.	Static stress concentration factor calculation for a plate with centre hole subjected to axial loading in tension using FEA software (Convergence Study)	
4.	Stress, Strain and deflection analysis of any machine component consisting of 3-D elements using FEA software. (Convergence Study)	
	Total (Any three)	**8**

Part B: Computational Fluid Dynamics (ANY Three)

Expt.	Description	Duration, (H)
1.	Geometry Creation and Meshing using any commercial CFD software, CFD modeling for internal and external flows.	**7**
2.	Laminar Pipe Flow & Turbulent Pipe Flow	
3.	Supersonic Flow over a Wedge	
4.	Compressible Flow in a Nozzle	
5.	Airfoil Analysis	
6.	Compressible Flow over a Flat Plate	
	Total (Any three)	**7**

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: I	
Course:	Advanced Fluid Mechanics (Professional Elective- I)				Code : MMC1501A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of: Fluid Mechanics, Numerical methods, Engineering mathematics, Mechanical ,measurement and instrumentation, Heat Transfer

Course Objectives: Following concepts to be taught to the students,

1. Enhanced understanding of fluid mechanics, including the equations of motion in differential form, and turbulence.
2. Understand the basic concepts in computational methods in fluid dynamics.
3. Determine the appropriate differential equations of motion, initial conditions, and boundary conditions.
4. Determine whether the flow is laminar or turbulent, and apply appropriate equations.
5. Understand the physics of boundary layer and shock waves.
6. Understand modern experimentation tools and techniques.

Course Outcomes:

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

1. Apply governing equations of fluid mechanics to fluid flow systems.
2. Analyze the laminar and turbulent fluid flow for various applications.
3. Analyze the boundary layer physics for real life applications.
4. Analyze the shock and oblique waves for various applications.
5. Understand modern experimental tools and techniques in Fluid Engineering.
6. Analyze the flow through ducts.

Detailed Syllabus:

Unit	Description	Duration, (H)
1	**Introduction:** Properties of Fluids , Fluid Statics, Fundamental Equations-Applications of Fundamental Equations, Relative Motion of Liquids. Kinematics of Fluids- Review of basics-Velocity potential, Stream function and Vorticity. General theory of Stress and Rate of Strain Fundamental Equations – Integral form Fundamental Equations – Integral form-Reynolds Transport Theorem-Applications of the Integral Form of Equations-Numerical.	8
2.	**Mechanics of Laminar and Turbulent Flow:** Introduction; Laminar and turbulent flows; viscous flow at different Reynolds number - wake frequency; laminar plane Poiseuille flow; stokes flow; flow through a concentric annulus. structure and origin of turbulent flow - Reynolds, average concept, Reynolds equation of motion; zero equation model for fully turbulent flows and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method.	8
3	**Exact and Approximate solutions of N-S Equations:** Introduction; Parallel flow past a sphere; Oseen's approximation; hydrodynamic theory of lubrication; Hele-Shaw Flow. **Boundary Layer Theory:** Introduction; Boundary layer equations; displacement and momentum thickness, shape factor; flow over a flat plate similarity transformation, integral equation for momentum and energy ; skin friction coefficient and Nusselt number; separation of boundary layer; critical Reynolds number; control of boundary layer separation.	8
4	**Flow across Normal Shock and Oblique Shock:** Basic Equations Normal Shock – Prandtl-Meyer Equation, Oblique shock-Property variation – Relations and Tables-Numericals.	7
5.	**Experimental Techniques:** Introduction; improved modeling through experiments; design of fluid flow experiments; error sources during measurement; pressure transducers; hot wire anemometer; laser - Doppler velocity meter; methods of measuring turbulence fluctuations - flow visualization techniques; wind tunnel; analysis of experimental uncertainty - types of error, estimation of uncertainty	7
6	**Flow through a constant area duct with Friction:** Flow through a constant area duct with Friction Fanno Line, Fanno Flow -Variation of Properties – Relations and Tables-Numerical. Flow through a constant area duct with Heat Transfer-Flow through a constant area duct with Heat Transfer-Rayleigh Line, Rayleigh Flow – Variation of Properties – Relations and Tables-Numerical	7
	Total	**45**

Text Books –

1. Pijush K. Kundu, Ira M. Cohen, David R Dowling, Fluid Mechanics, Academic Press, 2011.
2. S. K. Som, Gautam Biswas and Suman Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw-Hill Education

Reference Books

1. Fay, James A. *Introduction to Fluid Mechanics*. MIT Press, 1994. ISBN: 9780262061650
2. Fluid Mechanics: by F. M White, McGraw-Hill Education
3. Introduction to Fluid Mechanics by R. Fox and A. MacDonald, John Wiley and Sons
4. Tritton, D. J. Physical Fluid Dynamics. Springer, 2013. ISBN: 9780442301323.
5. Schlichting, H., and K. Gersten. Boundary Layer Theory. Springer, 2000. ISBN: 9783540662709

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: I	
Course :	Battery Technologies for Electric Vehicles (Professional Elective- I)				Code: MMC1501B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of: Basics of electronics, electrical and thermal engineering, mathematic

Course Objectives:

1. To make the learners conversant with various battery chemistries used for Electric Vehicles
2. To impart through understanding of Lithium Ion Battery
3. To understand the various battery performance parameters and testing procedures
4. To make the learners aware of thermal issues of Lithium ion battery and thermal management system
5. To understand the requirements and functioning of battery management system
6. To make the learners conversant with Equivalent Circuit Cell Modeling of Battery

Course Outcomes:

After learning the course the learners will be able to,

1. Select suitable battery for EV application
2. Compare the materials used for the components of the battery
3. Conduct tests on battery cells to determine various performance and operating parameters
4. Estimate heat generation inside battery and propose cooling strategy for the battery pack.
5. Select battery management syste, for given battery pack
6. Design and simulate battery pack for given EV

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Overview of Battery Technology of Electric vehicle (EV) :** History of Battery cells, Primary Battery, Secondary Battery, Battery terminology, Performance parameters and operating variables of Battery, Electric vehicle (EV) requirements, Battery Technologies for EV applications, Lead Acid battery, Nickel Cadmium , Nickel Metal Hydrite, Lithium Ion Batteries : Working, chemical reactions, comparison, future battery trends and challenges, Metal-Air Batteries, fuel cells , ultra capacitors	**7**
2.	**Lithium-Ion Batteries:** Introduction, Components, Functions, Cathode Materials, Anode Materials, Electrolytes: salts and solvents, separators, advantages and drawbacks, Battey cell Manufacturing: Cylindrical, prismatic and Pouch cells**,** recycling/disposal of batteries	**7**
3.	**Battery Performance and Testing:** Battery operating and performance parameters**,** Charge-discharge characteristics of batteries, Measurement of current, voltage, temperature, Estimation of SOC: Coulomb Counting method, OCV method, Estimation of SoH, Capacity, efficiency, Reasons of battery pack unbalancing, criteria for specifying a balancing set point and when to balance a battery pack, Passive balancing methods for battery packs, Active balancing methods for battery packs: capacitor-based circuits, transformer-based circuits, Estimation of available battery power using a simplified cell model	**7**
4.	**Battery Thermal Management:** Heat Generation inside battery, Thermal issues of Lithium-Ion Battery, impact of temperature on capacity, Operating temperature range, cycle life, Heat Generation inside battery, Thermal Runaway, Cooling strategies: Direct/indirect cooling, Air cooling, liquid cooling, PCM based cooling, advanced colling methods. Energy analysis and Thermal modeling	**8**
5.	**Battery Electric Management:** Primary functions of BMS, sensing voltage, current and temperature of cell and battery pack, estimation of cell SOC and battery pack SOC, Estimation of available energy and power of cell and battery pack, criteria of selection of BMS, battery pack balancing: Reasons, balancing set point and when to balance a battery pack, Passive and active balancing methods, Active balancing methods for battery packs: Capacitor-based circuits, transformer-based circuits, Estimation of available battery power using a simplified cell mode	**8**
6.	**Battery Pack Design, Modelling and simulation:** Determination of Power, Voltage, Capacity of battery pack**,** trade-off between parallel and series cell connections, parallel-cell-module (PCM), series-cell-module (SCM) **Equivalent Circuit Modelling:** Modelling OCV and SOC, voltage polarization, Warburg impedance, Estimation of Model parameter values: OCV, Columbic Efficiency, total capacity, temperature dependence of OCV, using the ECM to simulate constant voltage/ power charge/ discharge characteristics	**8**
	Total	**45**

Text Book

1. Gregory L. Plett, Battery Management Systems, Volume I: Battery Modeling, Artech House, London, 2015
2. Gregory L. Plett, Battery Management Systems Volume II, Equivalent-Circuit Methods, Artech House, London, 2015

Reference Books:

1. Gianfranco Pistoia, Boryann Liaw, Behaviour of Lithium-Ion Batteries in Electric Vehicles_ Battery 2018
2. Reiner_Korthauer, Li-I Batteries Basics and Applications, Springer International Publication, 2018
3. Jiuchun Jiang, Caiping Zhang - Fundamentals and Application of Lithium-ion Batteries in Electric Drive Vehicles-Wiley 2015.

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**					**Semester:** I		
Course:	**Optimization Techniques (Professional Elective- II)**					**Code:** MMC1502A		
Teaching Scheme				**Evaluation Scheme**				
Lecture	**Tutorial**	**Credit**	**Hours**	**IE**	**MTE**	**ETE**	**TW**	**Total**
3	-	3	3	20	30	50	-	100

Prior knowledge of:

a. Linear Algebra,
b. Probability,
c. Statistics,
d. Logical Reasoning,
e. Fundamentals of Mechanical Engineering…….are essential

Course Objectives:

1. To explain the concept of optimization and linear programming techniques to develop optimization models.
2. To introduce the concepts of constrained and unconstrained optimization techniques.
3. To familiarize students with different swarm optimization methods such as colony algorithms, and particle swarm algorithms.
4. To expose students to the concepts of evolutionary computing methods and fuzzy techniques to solve mechanical engineering applications.
5. To apply ANN and Markov models for system and process modeling and optimization
6. To introduce the concept of genetic algorithm and various advanced algorithms.

Course Outcomes:

The students will be able to,

1. Apply linear programming techniques to develop optimization model and its solution.
2. Select constrained and unconstrained optimization techniques.
3. Apply different swarm optimization techniques to solve mechanical engineering problems.
4. Develop optimization model using evolutionary computing methods and fuzzy techniques.
5. Develop ANN and Markov models for modeling systems and processes.
6. Use genetic algorithms to design and develop optimization problem in the domain of mechanical engineering.

Detailed Syllabus:

Unit	**Description**	**Duration (H)**
1	**Introduction to Optimization** Introduction and concept, Global and local optima, Mechanical engineering application, Problem formulation, Classification, Review of basic calculus concepts. **Linear Programming** – Graphical method, Simplex method, Primal and dual simplex method. Application of LPP models in design and manufacturing.	**8**
2	**Constrained optimization -** Direct methods, Penalty function methods, Steepest descent method, Engineering applications of constrained algorithms. **Unconstrained methods** - Gradient-based method, Cauchy's steepest descent method, Newton's method, and Conjugate gradient method.	**8**
3	**Swarm Intelligence and Optimization:** Concept of swarm optimization; features; types algorithms - Ant colony optimization (ACO), Particle swarm optimization (PSO), Artificial Bee colony algorithm (ABC), Other variants of swarm intelligence algorithms; Fuzzy Optimization, Parameter selection; Simulated annealing applications.	**8**
4	**Evolutionary Computing Methods** Principles of Evolutionary Processes and genetics, A history of Evolutionary computation and introduction to evolutionary algorithms, Evolutionary strategy, Evolutionary programming. **Fuzzy Systems -** Fuzzy sets, Operations, Membership functions, Fuzzy rules, and relations, Measures, Propositions, Implications, and inferences, Defuzzification techniques, Fuzzy logic controller design.	**7**
5	**Artificial Neural Network (ANN):** Concept and working of ANN, Biological and artificial neurons, ANN Architectures, Activation functions – linear, Sigmoid, Tanh, supervised and unsupervised learning, Training techniques for ANNs, Applications, advantages, and limitation. **Markov Models:** Markov decision process; Types; States of the systems; State transitions; Markov diagram; Semi-Markov chains; Hidden Markov chains; Applications in Mechanical Engineering.	**7**
6	**Genetic Algorithms (GA)** Basic Genetics, Concepts, Working Principle, Creation of Offspring, Encoding, Fitness Function, Selection Functions, Genetic Operators-Reproduction, Crossover, Mutation; Genetic Modeling, Advantages, limitations and applications, Comparison between GA and traditional algorithms	**7**
	Total	**45**

Text Books:

1. Tettamanzi Andrea, Tomassini and Marco, Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, Springer, 2001.
2. Singiresu S Rao, Engineering Optimization Theory and Practice, John Wiley & Sons, Inc, 2019
3. Ashish M. Gujarathi, B. V. Babu, "Evolutionary Computation: Techniques and Applications", CRC Press 2016.

Reference books:

1. D. K. Pratihar, Soft Computing, Narosa Publishing House, 2008.
2. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill, 2011.
3. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2010.
4. Fuzzy Logic with Engineering Application by T. J. Ross, John Wiley and Sons
5. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, John Wiley and Sons, 2001.
6. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
7. Melanic Mitchell, An Introduction to Genetic Algorithm (MIT Press), 1996.
8. Timothy J. Ross, Fuzzy Logic with Engineering Applications (Wiley), 2010.
9. Neural Networks and Learning Machines Simon Haykin (PHI).
10. Jang J.S.R, Sun C.T. and Mizutani E, "Neuro-Fuzzy and soft computing", Prentice Hall, 2008.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester: I
Course :	Data Analytics (Professional Elective- II)					Code: MMC1502B
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Fundamentals of Mechanical Engineering
b. Engineering Mathematics and Statistics
c. Artificial Intelligence and Machine Learning
d. Numerical Methods
e. Probability and Statistics…….are essential

Course Objectives:

1. To explore the fundamental concept of data analytics
2. To understand the various search techniques and visualization techniques
3. To apply various machine learning techniques for data analysis.
4. To explore and apply the python package for data analytics.

Course Outcomes:

After learning this course, the students will 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 (H)
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. 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 prediction. Vol. 2. New York: springer, 2009.
8. Zaki, Mohammed J., Wagner Meira Jr, and Wagner Meira. Data mining and analysis: fundamental concepts and algorithms. Cambridge University Press, 2014.
9. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

E-sources:

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

PROFESSIONAL ELECTIVE LAB-I (ELECTIVE I & II)						
Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester: I**	
Course :	**Professional Elective Lab-I (EL-I & EL-II)**				**Code: MMC1503**	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**50**

Guidelines:
Any one subject from Part A and Part B as per students' elective choices
Total experiments to be conducted are Three from Part A and Three from Part B
Total : 6 experiments/assignments in 12 hours

Detailed Syllabus:

Part A: Elective I- Advanced Fluid Mechanics (ANY Three)

Unit	Description	Duration, (H)
1.	Students inspecting the wind tunnel equipment and instrumentation.	**8**
2.	To study the effect of angle of attack on Lift and Drag force	
3.	To study the loss of energy in wake region behind various models (car, jeep, bus etc.) in the wind tunnel.	
4.	To visualize and plot the pattern of flow around an object in a fluid stream using Hale-Shaw apparatus	
5.	Solution of fluid flow problem using ANSYS FLUENT	
	Total	**8**

	Part A: Elective I- Battery Technologies for Electric Vehicles (ANY Three)	
1	Mathematical Modelling of LIB and simulation using suitable software	**8**
2	Thermal analysis of LIB by using CFD	
3	Case study on recent research in the field of EV Battery Technology	
4	Effect of temperature on Battery capacity, efficiency, charge/discharge characteristics, internal resistance Etc.	
5	Battery pack design for given EV application (Testing Various series parallel combinations for given application)	
	Total	**8**

Part B: Elective II- Optimization Techniques (ANY Three)

Expt	Description	Duration, (H)
1.	Linear programming	**7**
2.	Constrained/ unconstrained optimization	
3.	Ant colony optimization (ACO)/ Particle swarm optimization (PSO)/ Artificial Bee colony algorithm (ABC)	
4.	Evolutionary computing methods/ Fuzzy logic	
5.	Artificial neural network	
6.	Markov process for modeling manufacturing processes	
	Total	**7**

Part B: Elective II - Data Analytics (ANY Three)

1.	Thermal / Heat Transfer/ Fluid Mechanics	**7**
2.	Solid Mechanics/ Design	
3.	Manufacturing	
4.	Reliability / Maintenance	
5.	Automation and Robotics	
	Total	**7**

SKILL DEVELOPMENT LAB-1						
Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester: I**	
Course :	**Skill Development Lab-I (Technical and Software Skill)**				**Code:** MMC1911	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**--**	**50**

Prior knowledge of: Programming languages**,** hands on experience on commercial software like MATLAB, CATIA, 3D Experience, Ansys, Adams, etc. advisable.

Course Objectives:

The objective of this certificate curriculum is to

1. Competency building among students
2. Provide participants with a basic knowledge of CFD which will help them to work competently in both an industrial setting and in further graduate studies involving CFD and its applications.

Course Outcomes:

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

1. Enhancing skillsets of numerical analytic techniques and proficiency in applying these to solve advanced multi-disciplinary problems involving fluid mechanics and related transport process phenomena.
2. Proficiency in analyzing fluid flow problems and assessing the appropriate CFD techniques for practical applications.

Guidelines :

1. Total experiments to be conducted are Six out of eight
2. **Total : 6 experiments 15 hours**

Detailed Syllabus:

Skill Development Lab (ANY Five)

1) It is recommended to use any programming language or commercial / open-source programming tool to write the program for practicals 1 to 4. The governing equations can be coded in using suitable discretization method like **Finite Difference Method** or **Finite Volume Method**. Write any three programs from 1 to 4 practicals.
2) For practicals 5 to 8, students can use any commercial software or open-source tool like OpenFOAM. Solve any three case studies from 5 to 8 practicals using suitable CFD software tool.

Expt	Description	Duration, (H)
1	Two-dimensional steady state conduction equation.	**3**
2	Two-dimensional unsteady state conduction.	**3**
3	One-dimensional wave equation.	**3**
4	One-dimensional conduction convection problem.	**3**
5	Generate the grids for complex geometry for following cases. a) Create the structured grid for internal flows for complex geometry b) Create the unstructured grid for external flows for complex geometry	**3**
6	Numerical simulation of the flow over circular cylinder for various Reynolds number. Validation of results with published literature.	**3**
7	Suitable case study to study the boundary layer phenomena.	**3**
8	Aerodynamic analysis of an Ahmed Body	**3**
	Total	**15**

Course Syllabus
Semester-II

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester: II
Course:	Continuum Mechanics (PCC)					Code : MMC2405
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Engineering Mathematics;
b. Fluid Mechanics;
c. Heat Transfer……are essential

Course Objectives:

To introduce students with the fundamentals of continuum mechanics and demonstrate its applications

Course Outcomes:

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

1. Apply the tensor concept and tensor calculus.
2. Determine stresses and deformations in continuous materials
3. Determine strains and deformations in continuous materials
4. Formulate and solve problems of displacement and Flow.
5. Formulate and apply laws of continuum mechanics to problems
6. Model and analyse the stresses and deformations of simple geometries under an arbitrary load in liquids.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Fundamental laws of Continuum Mechanics**: Conservation of mass, conservation of linear momentum, moment of momentum, conservation of energy – First law of Thermodynamics Energy equation, Equation of state, Entropy, second law of Thermodynamics, Integral & differential approach and application to the control volume. Clausius-Duhem equality, Constitutive Equations, Thermomechanical and Mechanical Continua.	7
2.	**Fluids:** Viscous Stress Tensor, Stokesian, and Newtonian Fluid viscous flow, Navier-Stokes equation, Steady Flow, Irrotational Flow, Potential Flow, Bernoulli Equation, Kelvin's Theorem,	7
3.	**Motion and flow:** Material and spatial time derivatives - velocity and acceleration, Path lines, stream lines, Steady lines, rate of deformation, vorticity, Physical interpretation, material derivatives of volume, area and line elements	7
4.	**Tensor Analysis**: Introduction to Tensors: Vectors and second-order tensors; Tensor operation; Properties of tensors; Invariants, eigenvalues and eigenvectors of second-order tensors; Tensor fields; Differentiation of tensors; Gradient and Divergence, Daid and Daidict algebra, Isotropic Tensor, Integral Theorems of Gauss and Stokes	8
5.	**Analysis of Stress:** Body and Surface Forces, Mass Density, Cauchy stress, The Stress Tensor, Force and Moment Equilibrium; Symmetry, Stress Transformation Laws, Principle stresses and principle direction of stress, Deviatoric stresses and their directions. Octahedral Shear Stress	8
6.	**Deformation and Strain:** Lagrangian and Eulerian description, Deformation gradient, deformation tensors, finite strain tensors, stretch ratio, stretch tensor, rotation tensor, Transformation properties of strain tensor, velocity gradient, rate of deformation.	8
	Total	45

Text Books:

1. Continuum Mechanics for Engineers, T. Mase, G. Mase , CRC Press, New York 4th edition, 2020.
2. Theory and Problems in Continuum Mechanics, G Mase, McGraw Hill, Ed 2020
3. V. L. Streeter, E. B. Wylie and K. W. Bedford, "Fluid Mechanics", McGraw Hill Education India Pvt. Ltd.

Reference Books:

1. R. Chatterjee, "Mathematical Theory of Continuum Mechanics", Narosa Publishing House
2. J.N. Reddy, Principles of Continuum Mechanics, Cambridge University Press, 2010.
3. L.S. Srinath, Advanced Mechanics of Solids, 2nd Edn., TMH Publishing Co. Ltd., New Delhi, 2003
4. D. S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Academic Press, 1994.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)	Semester: II
Course:	Numerical Analysis (PCC)	Code : MMC2406

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Basic knowledge of ordinary differential equations Calculus,
b. Differential Equations,
c. Linear Algebra ……are essential

Course Objectives:

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

Course Outcomes:

After learning the course, students will be able to

1. Describe the basic concepts of error analysis in numerical methods.
2. Apply numerical methods to find solution of linear algebraic equations.
3. Apply numerical methods to find solution of non-linear algebraic equations.
4. Apply various interpolation methods and finite difference concepts.
5. Compute the numerical solution by applying various integration technique
6. Evaluate numerical solution for Initial and boundary value problems

Detailed Syllabus:

Unit	Description	Duration, (H)
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. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', Tata Mc-Graw Hill Publication, 2011.

Reference Books:

1. Erwin Kreyszig, 'Advanced Engineering Mathematics', 10th edition, Wiley India, 2011.
2. Joe D. Hoffman, 'Numerical Methods for Engineers and Scientists', 2nd edition, CRC Press, 2001
3. Sheldon M. Ross, 'Introduction to Probability and Statistics for Engineers and Scientists', 5th Edition, Elsevier Academic Press, 2014.
4. Deisentoth, Faisal, Ong, 'Mathematics for machine learning', Cambridge University Press, 2020.
5. S. D. Conte and C. de Boor, Elementary Numerical Analysis, Third Edition, Tata McGraw-Hill Education, 2005.
6. M. T. Heath, Scientific Computing - An Introductory Survey, Revised Second Edition, SIAM, 2018
7. K. E. Atkinson. An Introduction to Numerical Analysis, Second Edition, Wiley, 2004.

PROFESSIONAL CORE LAB - II						
Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**			**Semester: II**		
Course:	**Professional Core Lab-II (CM & NA)**			**Code:** MMC2407		
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**100**

Guidelines:

1. Total experiments to be conducted are Three from Part A and Three from Part B
2. Total: **6** experiments **15 hours**

Detailed Syllabus:

Part A: Core Subject 1 (ANY Three)

Expt.	Description	Duration, (H)
1.	Solve any three case studies from following list. Use of symbolic software packages like MATLAB. Hands-on practice using finite element software packages like ANSYS and ABAQUS as well as computational fluid dynamics related software such as FLUENT, Code development for problems involving 1. Solid mechanics 2. Fluid mechanics 3. Heat transfer.	**8**
	Total (Any three)	**8**

Part B: Core Subject 2 (ANY Three)

Expt.	Description	Duration, (H)
2.	Solve any three 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	**7**
	Total (Any three)	**7**

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: II	
Course:	Advanced Computational Fluid Dynamics (Professional Elective-III)				Code: MMC2504A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Fluid Mechanics,
b. Thermodynamics,
c. Heat Transfer,
d. Viscous Flow Theory……are essential

Course Objectives:

1 Aquaint 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 FVM technique to solve steady heat conduction
2. Analyze the solver algorithm nd applications
3. Apply FVM technique to solve unsteady heat conduction
4. Analyse errors and uncertainty in CFD modelling
5. Understand unstructured grid algorithms.
6. Analyse turbulence flow modelling

Detailed Syllabus:

Unit	Description	Duration, (H)
1	**Finite Volume Method for steady heat conduction** Finite volume method for Steady 1-D convection-diffusion problems, Conservativeness, Boundedness and Transportiveness, Central, Upwind, Hybrid and Power law schemes, QUICK and TVD schemes.	8
2	**Solver types and algorithm** Pressure - velocity coupling in steady flows, Staggered grid, SIMPLE algorithm, Assembly of a complete method, SIMPLER, SIMPLEC and PISO algorithms, Worked examples of the above algorithms.	8
3	**Finite Volume Method for Unsteady heat conduction** Finite volume method for 1-D unsteady heat conduction, Explicit, Crank-Nicolson and fully implicit schemes, Transient problems with QUICK, SIMPLE schemes, Implementation of boundary conditions: Inlet, Outlet, and Wall boundary conditions, Pressure boundary condition, Cyclic or Symmetric boundary condition.	8
4	**Errors and uncertainty in CFD modelling** Errors and uncertainty in CFD modelling, Numerical errors, Input uncertainty, Physical, model uncertainty, Verification and validation, Guide lines for best practices in CFD, Reporting and documentation of CFD results.	7
5	**Unstructured grid** Unstructured grid generation, Domain nodalization, Domain triangulation, Advancing front methods, The Delaunay method, The respective algorithms with examples.	7
6	**Introduction to Turbulence Modeling** Characteristics of turbulence, Effect of turbulent fluctuations on mean flow, Turbulent flow calculations, Turbulence modelling, Large Eddy Simulation, Direct Numerical Simulation.	7
	Total	45

Text Books:

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

Reference Books:

1. Hoffman, K.A., and Chiang, S.T., Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
2. Chung, T.J., Computational Fluid Dynamics, 2 nd Edition, Cambridge University Press, **2014.**

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: I	
Course :	Computational Dynamics and Vibrations (Professional Elective-III)				Code : MMC2504B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Basic Knowledge Of Calculus,
b. Differential Equations**,**
c. Linear Algebra,
d. Programming**.** ……Are Essential

Course Objectives: The students will be able to

1. To provide students with an advanced understanding of computational methods for dynamics and vibrations.
2. To introduce students to advanced computer-aided design and engineering software tools for solving complex real-world problems.
3. To develop students' ability to analyze and solve complex problems related to dynamics and vibrations using advanced computational methods.
4. To develop students' ability to analyze and solve problems related to dynamics and vibrations using computational methods.
5. To equip students with the knowledge and skills necessary for conducting research in the field of dynamics and vibrations.

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

1. Comprehend the principles of dynamic analysis and numerical integration
2. Implement numerical algorithms in programming languages such as MATLAB or Python
3. Develop mathematical models of multi-degree of freedom systems and perform modal analysis
4. Apply finite element methods to solve problems in dynamics and vibrations
5. Analyze and interpret results of computational simulations
6. Identify localized effects in many signals

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Numerical Techniques** Introduction to Single-Degree-of-Freedom System and Systems with Two or More Degrees of Freedom. Finite Difference Method for a Continuous System, Matrix Methods, Approximation Methods for the Fundamental Frequency, Finite Element method.	8
2.	**Vibration Modeling and Software Tools** Formulation, Vibration Analysis. Commercial Software Packages, basic procedure of vibration Analysis	8
3.	**Computer Analysis of Flexibly Supported Multibody Systems** Equations of Motion for the Linear Model, Linear Momentum – Force Systems, Generalization of the Equations of Moment of Momentum, Industrial Vibration Design Problem, Programming Considerations	8
4.	**Finite Element Applications in Dynamics** Problem and Element Classification, Types of Analysis, Modeling Aspects for Dynamic Analysis, Equations of Motion and Solution Methods	7
5.	**Vibration Signal Analysis** Frequency Spectrum, Signal Types, Fourier Analysis, Analysis of Random Signals	7
6.	**Wavelets — Concepts and Applications** Time – Frequency Analysis, Time-Dependent Spectra Estimation of Stochastic Processes, Random Field Simulation, System Identification, Damage Detection, Material Characterization	7
	Total	45

Text Books:

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

Reference Books:

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

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: II	
Course:	Artificial Intelligence and Machine Learning (Professional Elective-IV)				Code : MMC2505A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Linear Algebra,
b. Probability, Statistics,
c. Logical Reasoning,
d. Fundamentals of Mechanical Engineering……are essential

Course Objectives:

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. 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: The students will 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. Devise and develop a machine learning model using various steps.
5. Explain concepts of reinforced and deep learning.
6. Simulate machine learning model in mechanical engineering problems.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to AI-ML-DL:** History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning.	8
2.	**Feature Extraction and Selection** **Feature extraction:** Statistical features, Principal Component Analysis. **Feature selection:** Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering.	8
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, overfitting and underfitting. Applications of classification models in Mechanical Engineering.	8
4.	**Development of ML Model:** Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive, etc.), Hyperparameter Tuning, Predictions.	7
5.	**Reinforced and Deep Learning:** Characteristics of reinforced learning; Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Mechanical Engineering.	7
6.	**Applications:** Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms.	7
	Total	45

Text Books:

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

Reference Books:

1. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., 2015
2. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: II
Course :	Additive Manufacturing Technology (Professional Elective-IV)				Code : MMC2505B
Teaching Scheme			Evaluation Scheme		
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Prior knowledge of:

a. Materials Engineering,
b. Manufacturing Science,
c. CAD/CAM……are essential

Course Objectives:

1. To create awareness about fundamentals of AM processes, materials pre and post processing methodologies.
2. To acquaint with the generic process chain of various AM Technologies.
3. To create awareness about effect of process parameters on quality of product.

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

1. Classify, identify and justify suitable AM process.
2. Understand and apply preprocessing tools and techniques.
3. Select appropriate AM technique for product under consideration.
4. Understand and apply post processing tools and techniques.
5. Justify effect of process parameter on quality of product.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Overview of additive manufacturing:** Classification: ASTM and raw material based, Capabilities: Geometrical and Material, Applications, advantages and limitations, need and market trend.	8
2.	**Preprocessing:** Solid modelling, data formats, conversion, checking, repairing and transmission. Synergic integration technologies, Part slicing and Build Orientation, Area-filling strategies, Tool path generation,	8
3.	**Polymer based additive manufacturing processes:** Classification, Sub systems, Steriolithography (SLA), Digital light processing (DLP), Sheet lamination, Extrusion, Material Jetting, Selective LASER sintering	8
4.	**Metal based additive manufacturing processes:** Energy sources and their interactions with feedstock , Powder bed fusion, Direct energy deposition, Sheet lamination, Energy sources and their interactions with feedstock.	7
5.	**Composite AM:** Composite 3D printing, Bio 3D printing of tissues and organs, Clay and Concrete 3D printing, 3D food printing, 3D printing in space.	7
6.	**Post processing:** Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Inspection.	7
	Total	45

Text Books:

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
2. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.

Reference Books:

1. Patri K. Venuvinod and Weiyin Ma, Rapid Prototyping: Laser-based and Other Technologies, Springer, 2004.
2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
3. Rafiq Noorani, John Wiley & Sons, Rapid Prototyping: Principles and Applications in Manufacturing, 2006.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: II	
Course :	Professional Elective Lab-II (Elective III & IV)				Code : MMC2506	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	TW	PR	OR	Total
2	2	1	50	--	50	100

Guidelines :

1. **Any one subject from Part A and Part B** as per students elective choices
2. Total experiments to be conducted are Three **from Part A and Three from Part B**
3. **Total : 6 experiments 15 hours**

Detailed Syllabus:

Part A: Elective-III - Advanced Computational Fluid Dynamics (ANY Three)

Expt.	Description	Duration, (H)
1.	Numerical simulation of Flat plate boundary layer using commercial software packages	8
2.	Conjugate heat transfer analysis on graphics card	
3.	Numerical simulation of Dam break	
4.	Numerical simulation of flow through exhaust por	
5	Numerical simulation of flow over Ahmed body	
	Total	**8**

Part A: Elective-III - Computational Dynamics and Vibrations (ANY Three)

1.	**Free Vibration/Forced Vibration Analysis of a Single Degree of Freedom System** • Develop a MATLAB/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.	8
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.	
	Total	**8**

Expt.	Description	Duration, (H)
	Part A: Elective-IV - Artificial Intelligence & Machine Learning (ANY Three)	
1.	To acquire, visualize and analyze the data set (from time-domain/ frequency-domain/ etc.).	7
2.	To extract features from a given data set and select suitable features using suitable approach	
3.	To classify features/ develop classification model and evaluate its performance	
4.	To develop regression model and evaluate its performance (any one algorithm).	
5.	Machine learning model development and optimization	
	Total	**7**
	Part A: Elective-IV - Additive Manufacturing Technology (ANY Three)	
1.	Assignments on CAD Modelling for different components (Part Modeling, Assembly Modelling)	7
2.	Solid modeling of any engineering component using any 3D modeling software.	
3.	Generation of STL File, STL File Problems, STL File Manipulation (Materialize Magics & NETFAB).	
4.	Introduction to 3D Printing Software, process parameters for Additive Manufacturing Technology (CURA, GRABCAD)	
5.	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source)	
6.	Modeling of a component using 3D modelling software and development of G – Code output using any suitable Software.	
7.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes - Material to be used Plastic	
	Total	**7**

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : II	
Course :	Skill Development Lab - II (Oral & Written Communication)				Code: MMC1912	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	TW	PR	OR	Total
2	2	1	50	--	--	50

Prior knowledge of: -

Course Objectives:

1. To facilitate holistic growth
2. To make the students aware about the significance of Soft Skills and English Aptitude
3. To develop the ability of effective communication through individual and group activities
4. To expose students to right attitude and behavioural aspects and build the same through various activities

Course Outcomes:

After learning the course the students should be able to:

1. Express effectively through verbal/oral communication skills
2. Prepare for group discussions/meetings/interviews and presentations
3. Operate effectively in multi-disciplinary and heterogeneous teams through the knowledge of team work, inter personal relationships, conflict management and leadership activities

Guidelines :

1. Total experiments to be conducted are Six **out of eight**
2. **Total : 6 experiments 15 hours**

Detailed Syllabus:

Skill Development Lab (ANY Five)

Expt.	Description	Duration, (H)
1.	**Group Discussion:** Make students aware of proper and globally accepted ethical way to handle work, colleagues and clients. Develop group communication skills. Learn to speak up one's opinion in a forum. Cultivate the habit of presenting solution-driven analytical arguments making them contributors in any team.	3
2.	**Public Speaking:** Any one of the following activities may be conducted: **1. Prepared speech** (Topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver.) **2. Extempore speech** (Students deliver speeches spontaneously for 5 minutes each on a given topic)	3
3.	**Writing An Article On Any Social Issue:** Build writing skills, improve language and gain knowledge about how to write an article/ report	3
4.	**Reading and Listening skills:** The batch can be divided into pairs. Each pair will be given a article by the facilitator. Each pair would come on the stage and read aloud the article one by one. After reading by each pair, the other students would be asked questions and needful corrections in the article. The facilitator can evaluate the students for reading and listening skills.	3
5.	**Debate On Current Affairs/ Social Relevance Topics:** Cultivate the habit to present forceful arguments while respecting the opponents perspective and enhance verbal skills.	3
6.	**Telephonic etiquettes:** To teach students the skills to communicate effectively over the phone. Students will be divided into pairs. Each pair will be given different situations, such as phone call to enquire about job vacancy, scheduling a meeting with team members, phone call for requesting of urgent leave from higher authorities. Students will be given 10 min to prepare. Assessment will be done on the basis of performance during the telephone call.	3
7.	**Email etiquettes**: To provide students with an in-depth understanding of writing formal emails.	3
8.	**Mock interviews:** Guide students and conduct mock interviews	3
	Total	15

Text Books:

1. B. Mitra, Personality Development and Soft Skills
2. S. Lucas,The Art of Public Speaking

Reference Books:

1. M. Weaver, Empowering Employees Through Basic Skills
2. G. Ratigan, Aced: Superior Interview Skills to Gain an Unfair Advantage to Land Your DREAM JOB!

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester : II**	
Course :	**Integrated Mini-Project**				**Code :** MMC2701	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**IE2**	**PR**	**OR**	**Total**
6	**6**	**3**	**50**	**--**	**50**	**100**

Prior knowledge of:

a. Basics of Fluid mechanics, Heat Transfer and thermodynamics
b. Basics of MATLAB and ANSYS

Course Objectives:

1. To understand the ―Product Development Process‟ including budgeting through Mini Project.
2. To plan for various activities of the project and channelize the work.
3. To build, design and implement real time application using available platforms

Course Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute a Mini Project.
2. Design real time application
3. Prepare a technical report based on the Mini project.
4. Deliver technical seminar based on the Mini Project work carried out.
5. Understand publication and copyright process of research

Guidelines: Total: 30 h (contact) + 48 h(non-contact/implementation)

1. Individual student needs to design and demonstrate Mini-project under the guidance of allocated guide.
2. Students can choose the project considering their future implementation in Major Project in second year
3. The hardware implementation and software simulation is compulsory.
4. Mini-Project Report should be submitted as a compliance of term work associated with subject.
5. Paper publication associated with mini-project as research outcome is appreciable.
6. Mini-project work preferably should be completed in laboratory.

Detailed Syllabus:

Integrated Mini-Project

Sr. No.	**Activity**	**Duration (H)**
1.	Week 1 &2 : Mini-project guide allotment, finalization of topic and platform, Planning of the work	**8**
2.	Week 3&4: Literature review and specification and Methodology Finalization, Review 1 for finalization of topic and specification.	**8**
3.	Week 5&6 : Simulation of Idea on appropriate software tools and finalization of hardware platform	**8**
4.	Week 7 & 8 : understanding platform implementation and related software flow and execute block level design , Review 2 to understand the progress of the project	**7**
5.	Week 9 & 10: Mini Project Report writing and publication or copyright planning and execution.	**7**
6.	Week 11&12: Demonstration of Project work and Final Review for submission and term work compliances.	**7**
	Total	**45**

Course Syllabus

Semester-III

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : III	
Course :	Dissertation Phase – I [Company/ In-house project]				Code : MMC3702	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	TW	PR	OR	Total
20	20	10	100	--	100	200

Prior knowledge of:

a. Mechanical system design

Course Objectives:

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

Course Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute the major Project with appreciable research outcomes.
2. Design real time application considering immerging areas in technology
3. Prepare good quality technical report based on the project.
4. Demonstrate technical ideas and its relevance in recent technology
5. Publish good quality paper in reputed journal and present their work in reputed conferences.

Guidelines :

1. Individual student need to design and demonstrate project under the guidance of allocated guide.
2. Sponsored Project or Project Internship is acceptable considering postgraduate scope.
3. The physical / soft model and validation of results is compulsory.
4. Project Report-1 should be submitted as a compliance of term work associated with subject.
5. At least 2 paper publications are expected as research outcome of Project Stage-I (Conference or reputed journal) and 40% of planned project work should be completed for submission of Dissertation Phase-I
6. Total Duration: 150 hours are contact hours with guides and for reviews, 150 hours are expected to be spend by students to satisfy all project requirements and implementations.

Detailed Syllabus:

Integrated Mini-Project

Sr. No.	Activity	Duration, (H)
1.	Week 1, 2 and 3: Guide allotment, applying for sponsorship and project internship, finalization of topic and platform, Planning of the work.	30
2.	Week 4 & 5: Literature review, objectives and methodology Finalization, Review 1 for finalization of topic and objectives.	20
3.	Week 6, 7 & 8: understanding, analytical / numerical calculations and design of components, Review 2 to understand the progress of the project	30
4.	Week 9 & 10: preparation of the experimentation plan and measurement system for experimentation	20
5.	Week 11 & 15: Project Report writing and publication or copyright planning and execution. Demonstration of Project work and Final Review for submission and term work compliances	50
	Total	150

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : III	
Course :	Seminar				Code : MMC3703	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	PR	TW	OR	Total
4	4	2	--	50	50	100

Guidelines :

1. Individual student need to study recent topics in the field of Computational Mechanics (Mechanical Engineering) under the guidance of allocated guide.
2. Students can choose topic considering recent trends and its societal importance.
3. The extensive Literature Survey, Mathematical Modelling of particular method and valuable conclusion is expected from seminar study.
4. Seminar Report should be submitted as a compliance of term work associated with subject.
5. At least 1 review paper publication is expected as research outcome of seminar.
6. Total Duration : 30 Contact Hours and 30 Hours should be spend by students on completion of related activities and requirements.

Detailed Syllabus:

Seminar Activities

Sr. No.	Activity	Duration, (H)
1.	Week 1 to 3 : Guide allotment, finalization of topic, Planning of the work. Review-1 conduction	6
2.	Week 4 & 6: Literature review, Specification and Methodology Finalization, of detail topic.	6
3.	Week 7 & 9 : Detail Topic Mathematical model, methodology and findings Review-2 conduction	6
4.	Week 10 &15 : Comparison of detail topic with other existing methods	6
5.	Week 13 to 15: Seminar Report writing and publication or copyright planning Final Review conduction.	6
	Total	30

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : III	
Course :	Internship [Company / In-house project]				Code : MMC3801	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	IE 1	TW	OR	Total
4	4	2	--	100	--	100

Guidelines :

1. Individual student need to attempt for internship with help of PCCOE T&P cell in the field of Computational Mechanics (Mechanical Engineering) under the guidance of allocated guide.
2. If not get selected for any internships, students can choose extension of mini-project / opportunity of Entrepreneurship opportunity from PCCOE topic considering recent trends and its societal importance.
3. The idea presentation is expected from the students based on their topics.
4. Internship Report should be submitted as a compliance of term work associated with subject.
5. Total Duration: 30 Contact Hours and 30 Hours should be spend by students on completion of related activities and requirements.

Detailed Syllabus:

Internship/ Inhouse/ Entrepreneurship activity

Sr. No.	Activity	Duration, (H)
1.	Week 1 to 3 : Guide allotment, Application of internships, finalization of topic, Planning of the work. Review-1 conduction	6
2.	Week 4 to 6: Internship/ Mini-project/ Entrepreneurship activity implementation as per requirements	6
3.	Week 7 to 9 : Review-2 of Activities	6
4.	Week 10 to 11 : Interaction of Guides with Industry, Poster Presentation	6
5.	Week 12 & 15: Internship Report writing and publication or copyright planning Final Review conduction.	6
	Total	30

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : III	
Course :	MOOCs				Code : MMC3981	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	IE1	TW	OR	Total
4	4	2	--	100	--	100

Guidelines :

1. Individual student needs to register for MOOC course of their interest or Entrepreneurship related trainings.
2. Week assignment needs to be regularly completed as per requirement of course, which will be considered for internal assessment of course.
3. The certification of course or training is mandatory.
4. Oral and Presentation of course/ training will be taken at the end of semester
5. Total Duration: 30 Contact Hours and 30 Hours should be spent by students on completion of related activities and requirements.

Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester : III**	
Course :	**Entrepreneurship**				**Code : MMC3981**	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**IE1**	**TW**	**OR**	**Total**
4	4	2	--	100	--	100

Prior knowledge of:

a. Any Engineering Graduate with Innovation
b. Design thinking knowledge…….are essential

Course Objectives:

1. To acquaint with Entrepreneurial qualities.
2. To apply entrepreneurship in Engineering Courses.
3. To imbibe Entrepreneurial capabilities in engineering students.

Course Outcomes:

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

1. Motivate students to think about Entrepreneurship alternative to employment.
2. Registering students for Startup / Udyam registration of MSME.

Detailed Syllabus:

Unit	**Description**	**Duration, (H)**
1.	Introduction to Entrepreneurship and its importance	**5**
2.	Achievement Motivation. Case Studies of Indian Entrepreneurs	**5**
3.	Product Identification, Market Survey	**5**
4.	Whom to contact for what? Financial Management,	**5**
5.	Business Planning	**5**
6.	Project Report preparation	**5**
	Total	**30**

Reference Books:

1. Entrepreneurial Development by Vasant Desai, Himalaya publication
2. *Entrepreneurship Development and Small Business Enterprise*. Poornima M. Charantimath. Pearson Education India, 2005
3. *Dynamics* of *entrepreneurial development* and *management* : *Entrepreneurship, project management, finances, programmes,* and *problems.* by *Vasant Desai*.
4. *Course Material by EDII, Ahmedabad*

Experiment List: Project Report preparation for an Enterprise and Udyam Registration.2

Course Syllabus

Semester-IV

Dissertation Phase – II (Company/ In-house project)						
Program:	**M. Tech. Computational Mechanics (Mechanical Engineering)**				**Semester : IV**	
Course :	**Dissertation Phase – II [Company/ In-house project]**				**Code :** MMC4704	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
24	**24**	**12**	**200**	**--**	**200**	**400**

Prior knowledge of:

a. Basics of Heat Transfer,
b. Fluid mechanics,
c. Thermal engineering**,**
d. Basics of ANSYS,
e. MATLAB programming…….are essential

Course Objectives:

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

Course Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute the major Project with appreciable research outcomes.
2. Design real time application considering immerging areas in technology
3. Prepare good quality technical report based on the project.
4. Demonstrate technical ideas and its relevance in recent technology
5. Publish good quality paper in reputed journal and present their work in reputed conferences.

Guidelines :

1. Semester III major project is to be completed in this section under the guidance of same project guides.
2. Students need to implement the project using suitable hardware and software platforms
3. 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.
4. Total 3 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-I
5. Total Duration: 180 hours are contact hours with guides and for reviews , 180 hours are expected to be spend by students to satisfy all project requirements and implementations.

Detailed Syllabus:

Integrated Mini-Project

Sr. No.	Activity	Duration, (H)
1.	Week 1 & 2 : 60 % Work should be completed.	**30**
2.	Week 3 & 4: Software Simulation and Hardware Implementation should be completed. Review 1 conduction.	**30**
3.	Week 5 & 6 : Paper Publication should be in process or completed during this week, 80% work should be completed.	**30**
4.	Week 7 & 8 : Compliance of 100 % work. Review -2 will be conducted	**30**
5.	Week 9 & 10: Department Reviews will be conducted to check the quality of project and requirements fulfillment to permit project submission.	**30**
6.	Week 11 & 15: Project Report writing and copyright planning and execution. Demonstration of Project work and Final Research Review Committee (RRC) reviews will be conducted for submission and term work compliances	**30**
	Total	**180**

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : IV	
Course :	MOOCs/ Entrepreneurship				Code : MMC4982	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	IE1	TW	OR	Total
4	4	2	--	100	--	100

Guidelines :

1. Individual student needs to register for MOOC course of their interest or Entrepreneurship related training.
2. Week assignment needs to be regularly completed as per requirement of course, which will be considered for internal assessment of course.
3. The certification of course or training is mandatory.
4. Oral and Presentation of course/ training will be taken at the end of semester
5. Total Duration: 30 Contact Hours and 30 Hours should be spent by students on completion of related activities and requirements.

Annexure -1

Open Elective Syllabus

Program:	M. Tech. Mechanical (Design Engineering)				Semester : I	
Course :	Advanced Materials				Code: MMD1601A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Chemistry,
b. Physics,
c. Material Science,
d. Metallurgy……are essential

Course Objectives:

1. To introduce advanced and exotic materials.
2. To familiarize students with structure and properties of materials.
3. To establish significance of material selection in engineering design.
4. To explore new design opportunities.

Course Outcomes:

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

1. Student will be able to analyze of different materials in advanced engineering application.
2. Student will be able to relate structure and properties of new materials in engineering applications
3. Student will be able to evaluate and select materials for advanced engineering applications.

Detailed Syllabus:

Unit	Description	Duration, (H)
1	Advanced and exotic materials – ceramics and Plastics, Biomaterials, Aerogels, Superconductors, Carbon nano tubes	7
2	Mechanical, electrical, optical and magnetic properties of materials.	8
3	Smart materials, Piezoelectricity, Magnetostriction, smart polymers, Shape memory alloys	7
4	Introduction to nano, Nano-biomimicry, Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterizations of nanomaterials.	8
	Total	**30**

Text Books:

1. W.D. Callister Material Science and Engineering: An Introduction, Wiley publication.

Reference Books:

1. Malsch, N.H., –Biomedical Nanotechnology|, CRC Press. (2005).
2. L.F. Pease, R.M. Rose and J. Wulff, Electronic Properties (Volume IV: Structure and Properties of Materials)

Program:	M. Tech. Mechanical (Design Engineering)				Semester : I	
Course :	Optimization Methods				Code: MMD1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Engineering Mathematics

Course Objectives:

1. To introduce students to the modeling of constrained decision-making problems and optimization.
2. Provide students with the basic mathematical concepts of optimization.
3. Provide students with the modelling skills necessary to describe and formulate optimization problems.
4. Provide students with the skills necessary to solve and interpret optimization problems in engineering.

Course Outcomes:

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

1. Formulate mathematical programs in various practical systems
2. Understand basic optimization techniques
3. interpret the results of a model and present the insights (sensitivity, duality)
4. Know the limitations of different solution methodology
5. Use software to solve problems

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Classical Optimization Techniques** Introduction to Mathematical Modeling, Single variable optimization and multi variable optimization, with constraints and without constraints	7
2.	**Linear and non-Linear Programming** Simplex Methods, Elimination and iterative methods for one-dimensional minimization.	8
3.	**Simulation Modeling** Introduction, definition and types, limitations, various phases of modeling, Monte Carlo method, applications, advantages and limitations of simulation	7
4.	**Modern Methods of Optimization** Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, etc.	8
	Total	30

Text Books:

1. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons
2. Practical Optimization Methods with Mathematical Applications, M. Asghar Bhatti, Springer
3. Optimization for engineering design, K. Deb, PHI

Reference Books:

1. Topology Optimization – Theory, Methods and Applications, M. P. Bendse, Q. Sigmund
2. Evolutionary Topology Optimization of Continuum Structures, Methods and Applications, X. Huang, Y.M. Xie, Wiley
3. Structural Optimization, Raphael T. Haftka and Zafer Gurdal, Kluwer Academic Publishers
4. Mathematical Modelling, J N Kapur, New age international publication
5. Optimization concepts and applications in engineering, Belegundu, Chandrupatla, Pearson Education

Program:	M. Tech. Mechanical (Design Engineering)				Semester : I	
Course :	Modeling and Simulation of Dynamic systems				Code: MMD1601C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Engineering Mathematics

Course Objectives:

1. Students able to model any physical system for realtime applications
2. Students able to simulate any physical system for realtime applications

Course Outcomes:

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

1. Develop mathematical model for practical problem
2. Develop Bond Graph model for system
3. Apply transfer function and State space model techniques
4. Simulate the system using suitable software and Estimate parameters by optimization

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	Introduction to Modelling and Simulation, Basic systems, Introduction and Types of Mathematical modelling, Basic building blocks Mechanical, Electrical, Thermal systems.	7
2.	Bond Graph Modelling of Dynamic Systems: Representation,Elements, Single,Two and multiports Causality, Application to basic Mechanical,Electrical and Electromechanical system	8
3.	Dynamic Response and System Transfer Function: Poles, Stability Block diagram/Signal flow diagram/State Space formulation and Frequency response	7
4.	Simulation and Simulation application Parameter Estimation, System Identification and Optimization	8
	Total	**30**

Reference Books:

1. Brown, Forbes T. Engineering System Dynamics. New York, NY: CRC, 2001. ISBN: 9780824706166.

Program:	M. Tech. Mechanical (Design Engineering)				Semester : II	
Course :	Room Acoustics (Open Elective-II)				Code : MMD2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Engineering Mathematics,
b. Physics, ……are essential

Course Objectives:

The course includes sound fields in rooms with wave theoretical methods, geometrical acoustics methods Acoustical measurement techniques, sound absorption for evaluation of room acoustic quality

Course Outcomes:

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

Understand Basic principals in acoustics, measurement of sound Power and apply to analyze effectiveness in compliance to noise regulations.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Basics of acoustics –** Terminologies speed of sound, wavelength, frequency, and wave number, acoustic pressure, acoustic intensity and acoustic energy density, spherical wave, **Acoustic measurement** Directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels. Sound power measurement	7
2.	**Transmission of Sound:** changes in media with normal incidence, changes in media with oblique incidence, sound transmission through a wall, transmission loss for walls - stiffness-controlled region- mass-controlled region - damping-controlled region,	8
3.	**Sound Absorption:** General description of acoustical materials - acoustical tiles, fiberboard, resonator absorption unit absorber, carpets, acoustical plaster, resilient packing composite materials, etc. Their use, selection criteria and construction.	7
4.	**Room acoustics -** surface absorption coefficients, steady-state sound level in a room, Behaviour of sound in an enclosed space. Concept of reverberation and reverberation time effect of energy absorption in the air, noise from an adjacent room, acoustic enclosures, acoustic barriers.	8
	Total	30

Text Books:

Industrial Noise Control, Randell Barron, Marcel Dekker, Inc.

Reference Books:

Mechanical Vibrations & Noise Engineering, A.G.Ambekar, Prentice Hall of India, New-Delhi.

Program:	M. Tech. Mechanical (Design Engineering)				Semester : II	
Course :	Design Thinking (Open Elective-II)				Code: MMD2602B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:
Any Engineering Graduate

Course Objectives:
1. To acquaint with concepts of Design Thinking.
2. To apply design thinking tools in every field of Engineering.

Course Outcomes:
After learning the course, the students should be able to:
1. Use Design Thinking tools.
2. Create simple Products using design thinking tools

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	Introduction to Design thinking and its importance. Steps in Design Thinking	5
2.	Empathize Phase	5
3.	Define Phase	5
4.	Ideate Phase	5
5.	Prototype Phase	5
6.	Test Phase. One simple Product development using Design thinking tools	5
	Total	30

Reference Books:
1. Design Thinking methodology book by Emrah Yayici , Publisher Emrah Yayici, 2016
2. Designing for Growth: A design thinking toolkit for managers, Tim Ogilvie ,Columbia Business School Publishing

Program:	M. Tech. Mechanical (Design Engineering)				Semester : II	
Course :	Reliability Engineering (Open Elective-II)				Code: MMD2602C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of: Engineering Mathematics

Course Objectives:

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

Course Outcomes:

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

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

Detailed Syllabus:

Unit	Description	Duration (H)
1.	**Fundamental concepts - I** Failure density, failure rate, hazard rate, MTTF, MTBF, pdf, cdf, modes of failure, Areas of reliability, Quality and reliability assurance rules, product liability, probability distributions binomial, normal, Poisson.	7
2.	Sy**stem reliability** Series, parallel, mixed configuration, k- out of n structure, complex systems- enumeration method, conditional probability method, cut set and tie set method,	8
3.	**Redundancy** Element redundancy, unit redundancy, standby redundancy- types of stand by redundancy, parallel components single redundancy, multiple redundancy. Markov analysis.	7
4.	**System reliability Analysis** Reliability apportionment, Reliability apportionment techniques – equal apportionment, AGREE, ARINC, feasibility of objectives apportionment.	8
	Total	30

Text Books:

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

Reference Books:

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

Program:	M. Tech (E&TC)-VLSI and Embedded Systems				Semester: I	
Course:	Automotive Electronics and its Applications				Code: MET1601A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Knowledge of electronics & electrical,
b. instrumentation,
c. control systems,
d. IC engine operation, ……are essential

Course Objectives:

1. To learn and understand the various application of electronics systems and ECU in automotive.
2. To learn and understand principles and applications of sensors and actuators in automotive electronics systems.
3. To learn and understand various control systems in automotive

Course Outcomes:

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

1. Acquire an overview of automotive components, subsystems, and basics of electronic control in today's automotive industry.
2. Use and apply available automotive sensors and actuators in various electronic control systems while designing automotive system design.
3. Apply knowledge of modern technologies in automotive design.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Automotive Systems Overview:** Automotive vehicle technology, Present trends in automobiles with emphasis on increasing role of electronics and software, Overview of typical automotive subsystems and components, Body, Chassis, and Powertrain Electronics	7
2.	**Sensors and Actuators:** Basic sensor arrangement, Types of sensors such as oxygen sensors, Crank angle position sensors, Fuel metering/ vehicle speed sensors, Flow sensor, Temperature, EGO, Air mass flow sensors, Throttle position sensor, Solenoids, Stepper Motors, Relays, etc.,	8
3.	**Engine Control System:** Algorithms for engine control including open loop and closed loop control system, Electronic ignition, EGR for exhaust emission control. Look-up tables and maps, Need of maps, Procedure to generate maps, Engine calibration, Torque table, Dynamometer testing	7
4.	**Active and passive safety systems:** Body electronics including lighting control, Remote keyless entry, Immobilizers etc., Electronic instrument clusters and dashboard electronics, Antilock braking system, Electronic stability program, Air bags, Computer vision based ADAS	8
	Total	30

Text Books:

1. William B. Ribbens, –Understanding Automotive Electronics- An Engineering Perspective‖, Seventh edition, Butterworth-Heinemann Publications.
2. Ronald K. Jurgen, ―Automotive Electronics Handbook‖, Mc-Graw Hill.

Reference Books:

1. Robert Bosch,‖ Automotive Hand Book‖, Fifth edition, SAE Publications
2. Kiencke, Uwe, Nielsen & Lars, ―Automotive Control Systems for Engine, Driveline and Vehicle‖, Second edition, Springer Publication.
3. Automotive Electronics by Tom H. Denton
4. Automotive Electrical and Electronic Systems by John F. Kershaw, James D. Halderman / Pearson Education

Program:	M.Tech (E&TC)-VLSI and Embedded Systems				Semester: I	
Course:	Industrial Drives				Code: MET1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Electrical Drives,
b. Dynamics of Electrical drives,
c. Control Systems……are essential

Course Objectives:

1. To define electric drive, its parts, advantages and explain choice of electric drive.
2. To explain dynamics and modes of operation of electric drives.
3. To explain selection of motor power ratings and control of dc motor using rectifiers.
4. To explain the control of induction motor, synchronous motor and stepper motor drives.
5. To discuss typical applications electrical drives in the industry

Course Outcomes:

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

1. Analyze the performance of induction motor drives under different conditions.
2. Control induction motor, synchronous motor and stepper motor drives.
3. Suggest a suitable electrical drive for specific application in the industry
4. To analyze the performance of induction motor drives under different conditions.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Selection of Motor Power Ratings:** Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating. **Direct Current Motor Drives:** Controlled Rectifier Fed dc Drives, Single and three Phase Half and Fully Controlled Rectifier Control of dc Separately Excited Motor, Rectifier Control of dc Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited dc Motor, Chopper Control of Series Motor.	7
2.	**Induction Motor Drives:** Analysis and Performance of Three Phase Induction Motors, Analysis of Induction Motor Fed from Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.	8
3.	Voltage Source Inverter (VSI) Control, Cyclo-converter Control, Closed Loop Speed Control and Converter Rating for VSI and Cyclo-converter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.	7
4.	**Synchronous Motor Drives:** Operation from fixed frequency supply-starting, synchronous motor. Self-controlled synchronous motor drive employing load commutated thruster inverter, Permanent Magnet ac (PMAC) Motor Drives, Sinusoidal PMAC Motor Drives, Brushless dc Motor Drives. **Stepper Motor Drives:** Variable Reluctance, Permanent Magnet, Important Features of Stepper Motors, Torque Versus Stepping Rate Characteristics, Drive Circuits for Stepper Motor. **Industrial Drives:** Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools.	8
	Total	30

Text Books:

1. Gopal K Dubey , Fundamentals of the electrical drives Narosa publication
2. N. Mohan T.M. udeland & W.P.Robbins , Power Electronics converter application J.Wiley & sons
3. Vedam Suryavanshi**,** Electrical Drives Concept and application
4. B.K. Bose, Advanced power Electronics & A.C. Drives
5. S.K.Pillar, Analysis of thyristor power conditioned motors

Reference Books:

1. N.K De,P.K. Sen , Electric Drives PHI Learning 1 st Edition, 2009
2. Gobal K.Dubey, Fundamentals of Electrical Drives- Alpha Science Int. Ltd.,
3. Shepherd Hullay & Liag, Power Electronics & Motor Control -, Cambridge Univ. Press
4. Gopal K Dubey, Power Semiconductor controlled Drives, - Prentice Hall pub.
5. R. Krishnan, Electric Motor Drives–Modelling, Analysis and Control, - Pearson Education, 2003
6. P.C. Sen , Thyristorised DC Drives -, Krieger pub.
7. S.B.Dewan, G.R.Slemon & A.Stranghan; Power Semi conductor controlled Drives - John-Willey pub.

Program:	M.Tech. (E&TC)-VLSI and Embedded Systems				Semester : I	
Course :	Basic of FPGA and CPLD				Code : MET1601C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Fundamentals of digital electronics,
b. Knowledge of one hardware description language……are essential

Course Objectives:

1. To make students familiar with programmable logic devices and its architectures.
2. To understand the architecture and features of FPGA and CPLD .
3. To make the students familiar with the design process and how the design is mapped to the existing hardware in FPGA and CPLD.

Course Outcomes:

After learning the course the students should be able to:

1. To understand the depth of CPLD and FPGA architectures.
2. To design a system using FPGAs.
3. To demonstrate an understanding of interfacing of different external devices with FPGA/CPLD.
4. To apply the complete design flow of FPGA and CPLD for the specific application.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction:** Introduction to Hardware Description language, Need of Programmable logic devices, PLA PAL, CPLD, FPGA: General Architecture, features CPLD Architecture: overview, specification and applications, Features of XC9500 series of CPLD family.	7
2.	**FPGA Architecture:** Xilinx Logic Cell Array, Configurable Logic Block, I/O Block, Programmable Interconnects, Programming methods, Advanced features of Xilinx 4000 series Technology Trends: Device capacity, Utilization and Gate Density, Programming methods, General Design Flow, General Design Guidelines.	8
3.	**Interfacing with FPGA/CPLD:** The purpose of interfacing, interfacing of external devices such as WiFi Module, Bluetooth Module, GPS Module, Zigbee Module, Different types of display devices with FPGA/CPLD	7
4.	**Case Studies-FPGA/CPLD:** Xilinx Virtex-6, Spartan-6, Z-board Advanced features in FPGA based on Case studies. **Logical Design by FPGA/CPLD:** Complete design of any combinational circuit by gates, Boolean Algebra, Design of sequential circuits	8
	Total	30

Text Books:

1. P.K.Chan& S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall (Pte), 1994
2. Ronald Sass and Andrew G. Schmidt, –Embedded systems design with platform FPGAs: Principles and practices‖, Morgan Kaufmann, 2010.
3. Design manuals of Altera, Xilinx and Actel.

Reference Books:

1. S. Trimberger, Edr. Field Programmable Gate Array Technology, Kluwer Academic Publications, 1994.
2. Ronald J Tocci, Neal S. Widmer, Gregory L. Moss, –Digital Systems: Principles & Applications‖, 10th Edition, Pearson, 2009
3. J. Old Field, R. Dorf, Field Programmable Gate Arrays, John Wiley & Sons, Newyork, Reprint 2008.
4. S. Brown, R. Francis, J. Rose, Z. Vransic, Field Programmable Gate Array, BSP, 2007.
5. S. Brown and J. Rose, "Architecture of FPGAs and CPLDs: A Tutorial", IEEE Design & Test of Computers, Vol. 13, No. 2, pp. 42-57, 1996.
6. S. Brown Zvonko Vranesic – Fundamentals of Digital Logic with VHDL design, McGraw Hill – 2000

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems			Semester : I		
Course :	Robotics			Code : MET1601D		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Prior Knowledge of

a. Sensors and actuators

b. Programming language 'C', MATLAB **is essential.**

Course Objectives:

To impart knowledge on

1. Electromechanical elements of robots
2. Control system for robot automation
3. Existing robots designed for various applications

Course Outcomes:

After learning the course the students should be able to:

1. Understand kinematics, statistics and dynamic of robots
2. Apply concepts of industrial automation and communication for selection of robots
3. Select sensing and actuating elements for designing robots as per applications requirements
4. Integrate and design control system and information system for various applications.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to robotics:** Evolution of Robotics, Elements of robots; Kinematics of serial and parallel robots; Velocity and static analysis of robots; Dynamics of robots; Motion planning and control; Flexible manipulators; Wheeled mobile robots, classification of Robots	7
2.	**Advanced concepts in robotics:** Introduction to Cloud and Fog robotics; Basic concepts of industrial automation and communication protocols for PLC, DCS, SCADA systems; Introduction to Internet of Things, Protocols and real time applications.	8
3.	Sensing Elements **for robots:** Classification of Sensors, Encoders and Dead Reckoning Infrared Sensors, Ground-based RF Systems, Active Beacons, Ultrasonic Transponder Trilateration, Accelerometers, Gyroscopes, Laser Range Finder, Vision-based Sensors, Color-tracking Sensors, safety and motion sensors, Force/ Torque Sensors , Tactile Sensors, DC Motors, Controlling a DC Motor, Pulse Width Modulation, Stepper Motors, Servo Motor.	7
4.	Control System of Robots: Automatic-Feedback Control System, Control Elements, Control System Design, A Robot's System Dynamics, Sensory Feedback, Control Algorithms and Performances, Space Control, Introduction to Information System of Robots.	8
	Total	30

Text Books:

1. John J C, Introduction to Robotics: Mechanics and Control , Addison-Wesley (1989).
2. Appin Knowledge Solutions, Robotics (2007)
3. Ming Xie, Fundamentals of Robotics - Linking Perception to Action (2003)

Reference Books:

1. Thomas Bräunl, Embedded Robotics - Thomas Braunl (2006)
2. Bruno S and Sciavicco L, Robotics: Modelling, Planning and Control, Springer (2009).
3. Fu K S, Ralph G and Lee C S G, Robotics: Control Sensing. Vision, and Intelligence , Tata McGraw-Hill (1987).
4. Mukhopadhyay S, Sen S and Deb A K, Industrial Instrumentation, Control and Automation, Jaico (1999).
5. Rajkumar B and Dastjerdi A V, Internet of Things: Principles and Paradigms , Morgan Kaufmann (2016).

Program:	M.Tech (E&TC)-VLSI and Embedded Systems				Semester: II	
Course:	Drone Programming for Beginners				Code: MET2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Basic understanding of physics (Force, Velocity, Acceleration, etc),
b. Understanding of sensors and actuators,
c. Control systems,
d. Modelling Basics –MATLB & SIMULINK,
e. Programming in python……are essential

Course Objectives:

1. To understand the physics behind drones
2. To create the mathematical model of quadcopter drone from simple mathematics & Experimental data
3. To implement model into Simulink & check it against real life performance

Course Outcomes:

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

1. Identify & select different accessories of Drones as per applications
2. Establish the mathematical model & the Physics behind Quadcopter drone
3. Design Simulink model simulating the complete dynamics of quadcopter drone.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to drones:** Unmanned Aerial Systems (UAS), Basics of drones, Introduction to Drones programming and Development Tools, Current rules and regulations governing owning and operating a UAS, concerns surrounding UAS safety, security and privacy issues	7
2.	**Drone accessories and Applications:** Sensors, Motors, Propellers, Battery, Concept of propulsion, Forces working on a Flight, Principal axes and rotation of aerial systems, Stable, unstable and neutral systems, Control drone (roll, pitch and yaw), Application of drones.	8
3.	**Drone control system development in Simulink:** Control system architecture, Quadcopter with actuator & propellers functionality block, Sensing & estimation functionality block, controller functionality block, Motor mixing algorithm (RPYT) functionality block	7
4.	**Modelling, Simulation & Flight control design:** Dynamic quadcopter system Model, flight control design, 3D visualization, testing & Tuning the model, Flight operations, Applicable software for data collection, processing, and analysis	8
	Total	30

Text books:

1. John Baichtal ,Building your own drones, a beginner's guide to drones, UAVS, and ROVs"
2. Muhammad Usman , Quadcopter modelling and control with Matlab/Simulink implementation
3. Ryan Gordon , Model based design of a quadcopter
4. K.S.Fu, R.C.Gonzalez, C.G.Lee , Robotics control, sensing, vision and intelligence

Reference Books:

1. - R.K.Mittal , I.J.Nagrath,Robotics and control
2. Ben Rupert , Drones (The ultimate guide), , CreateSpace Independent Publishing Platform
3. Agam Kumar Tyagi Matlab and Simulink for engineers, , Oxford University Press, 2012

Program:	**M. Tech (E&TC)-VLSI and Embedded Systems**	**Semester:** II
Course :	**Instrumentation and Measurements**	**Code: MET2602B**

Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE 1**	**IE 2**	**ETE**	**Total**
2	**2**	**2**	**20**	**--**	**30**	**50**

Prior knowledge of:

a. Basics of sensors and Actuators,
b. Basic of Electronics,
c. Analog and Digital Systems……are essential

Course Objectives:

To impart knowledge on the following Topics -

1. Basic functional elements of instrumentation
2. Fundamentals of electrical and electronic instruments
3. Comparison between various measurement techniques
4. Various storage and display devices
5. Various transducers and the data acquisition systems

Course Outcomes:

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

1. Analyse different measuring parameters of any electronics/mechatronics system
2. Design and evaluate characteristics of different types of mechatronics/ electrical/ electronic system
3. Understand different types of wave/spectrum analyzer.
4. Interface various system components and analyse its data using data acquisition system.

Detailed Syllabus:

Unit	**Description**	**Duration, (H)**
1.	Basics of Measurements: Accuracy, Precision, resolution, reliability, repeatability, validity, Errors and their analysis, Standards of measurement. Bridge Measurement: DC bridges- wheatstone bridge, AC bridges – Kelvin, Hay, Maxwell, Schering and Wien bridges, Wagner ground Connection. Electronic Instruments for Measuring Basic Parameters: Amplified DC meter, AC Voltmeter, True- RMS responding Voltmeter, Electronic multi-meter, Digital voltmeter, Vector Voltmeter.	**7**
2.	Oscilloscopes: Cathode Ray Tube, Vertical and Horizontal Deflection Systems, Delay lines, Probes and Transducers, Specification of an Oscilloscope. Oscilloscope measurement Techniques, Special Oscilloscopes – Storage Oscilloscope, Sampling Oscilloscope. Signal Generators: Sine wave generator, Frequency – Synthesized Signal Generator, Sweep frequency Generator. Pulse and square wave generators. Function Generators.	**8**
3.	Signal Analysis: Wave Analyzer, Spectrum Analyzer. Frequency Counters: Simple Frequency Counter; Measurement errors; extending frequency range of counters Transducers: Types, Strain Gages, Displacement Transducers	**7**
4.	Digital Data Acquisition System: Interfacing transducers to Electronics Control and Measuring System. Instrumentation Amplifier, Isolation Amplifier. An Introduction to Computer-Controlled Test Systems.IEEE-488 GPIB Bus	**8**
	Total	**30**

Text Books:

1. Albert D.Helstrick and William D.Cooper, Pearson Education , Modern Electronics Instrumentation & Measurement Techniques, . Selected portion from Ch.1, 5-13.
2. Joshph J.Carr ,Elements of Electronics Instrumentation and Measurement-3rd Edition.Pearson Education. Selected portion from Ch.1,2,4,7,8,9,13,14,18,23 and 25.

Reference Books:

1. Electronics Instruments and Instrumentation Technology – Anand, PHI
2. Doebelin, E.O., Measurement systems, McGraw Hill, Fourth edition, Singapore, 1990.

Program:	M.Tech (E&TC)-VLSI and Embedded Systems	Semester : II
Course :	Microcontrollers and Microprocessors Applications	Code : MET2602C

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Digital Electronics

Course Objectives:

1. To explain architecture and features of typical Microcontroller.
2. To make students understand need of microcontrollers in real life applications.
3. To explore interfacing of real-world peripheral devices, various hardware and software tools for developing applications.
4. To explain the architecture and programmer's model of advanced processor and microcontroller
5. To acquaint the learner with application instruction set and logic to build assembly language programs.

Course Outcomes:

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

1. Learn importance of microcontroller and microprocessor in designing embedded application
2. To apply the programming skills to develop real-life embedded application.
3. Learn use of hardware and software tools.
4. Develop interfacing to real world devices.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to single chip Microcontrollers:** Intel MCS-51 family features, 8051/8031-architecture, 8051 assembly language programming, addressing modes, Programming interrupts, timers and serial communication	7
2.	**Microcontrollers and system design:** Assembly vs High-Level language programming, System Development Environment: assembler, compiler and integrated development environment, Debugging and Simulation, system design with 8051.	8
3.	**System level interfacing design;** Advanced Microprocessor Architectures- 286, 486, Pentium; Introduction to RISC processors; ARM microcontrollers; Embedded system design methodologies, embedded controller design for communication, digital control.	7
4.	**Microcontroller & Processors Applications:** Interfacing with display devices, Sensors, actuators, and memory devices. Case Study on real time embedded system.	8
	Total	30

Text Books:

1. BarryB Brey, The intel microprocessor: architecture, programming and interfacing, Prentice hall of India, New Delhi, 2003.ISBN-0138027455, 4th Edition
2. Mohammad Ali Mazidi and Janice Gillispie Maszidi –The 8051 Microcontroller and Embedded Systems| Pearson education, 2003, ISBN- 9788131710265, 2nd Edition

Reference Books:

1. Chris H. Pappas, William H. Murray, ―80386 Microprocessor Handbooks|, McGraw-Hill Osborne Media, ISBN-10: 0078812429, 13: 978-0078812422.
3. Walter A. Triebel, ―The 80386Dx Microprocessor: Hardware|, Software, and Interfacing, Pearson, Education, ISBN: 0137877307, 9780137877300.
4. Mohammad Rafiquzzaman, ―Microprocessors: Theory and Applications: Intel and Motorola", Prentice Hall, ISBN: -10:0966498011, 13:978:0966498011.
2. K. Bhurchandi, A. Ray, ―Advanced Microprocessors and Peripherals, McGraw Hill Education, Third Edition, ISBN: 978-1-25-900613-5

Program:	M. Tech (E&TC)- VLSI & Embedded Systems				Semester: II	
Course:	Electronics Implementation Platform				Code: MET2602D	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Knowledge of C language,
b. Python,
c. Electronic circuits. ……are essential

Course Objectives:

1. Explain about the Arduino, Raspberry Pi, PLDs and all other associated platforms
2. Understand of the importance of micro controllers and computers in science and technology.
3. Discuss basic programming and structures required for basic operation of the platform,
4. Describe how to recognize functions, operations and syntax of Python, C and C++

Course Outcomes:

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

1. Apply logical thinking and problem-solving skills with Arduino platform.
2. Acquire knowledge about Raspberry pi for implementation of applications
3. Understand Digital Signal processing implantation basics
4. Understanding rapid prototyping using PLDs.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	Arduino: A open-sourceHardware, Working, Interfacing, Coding basics and small applications and Debugging.	7
2.	Raspberry pi : Working, Interfacing, Coding basics and small applications and Debugging.	8
3.	DSP processor for Real time Video and Inage Processing. : Working, Interfacing, Coding basics and small applications and Debugging.	7
4.	Programmable Logic devices: FPGA: Working, Interfacing, Coding basics and small applications and Debugging.	8
	Total	30

Text Books:

1. Ryan Turner,Arduino Programming: The Ultimate Beginner's & Intermediate Guide to Learn Arduino Programming Step by Step, 2019
2. Derek Molloy Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux 1st Edition,2006
3. Avtar Singh , Digital Signal Processing Implementations : Using DSP Microprocessors (with examples from TMS320C54XX),2003
4. Roger Woods, John McAllister, Ying Yi, Gaye Lightbody, FPGA- based Implementation of Signal Processing Systems, Second Edition, 2017

Reference Books:

1. Mark TorvaldsARDUINO - ARDUINO PROGRAMMING - ARDUINO FOR BEGINNERS, Second Edition June 7, 2018
2. Eben Upton Raspberry Pi User Guide 4th Edition 2019
3. Sen M. Kuo ,Real-Time Digital Signal Processing, : Implementations, Application and Experiments with the TMS320C55X, 2001
4. Cem Unsalan, Bora Tar ,Digital System Design with FPGA: Implementation Using Verilog andx VHDL , 2017

Program:	M.Tech (Computer Engineering)				Semester : I	
Course :	Programming with Python				Code: MCE1601A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of: .

a. Basics of Programming

Course Objectives:

1. To acquire knowledge in Python and R programming
2. To develop Python programs with conditionals and loops and data structures
3. Acquire skills to apply data analysis methods to a problem

Course Outcomes:

After learning the course the students should be able to:

1. Describe the Numbers, Math functions, Strings, List, Tuples and Dictionaries in Python
2. Interpret Object oriented programming in Python
3. Apply a solution clearly and accurately in a program using Python.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to Python Programming:** Python Introduction, Installing and setting Python environment in Windows and Linux, basics of Python interpreter, Execution of python program, Editor for Python code, syntax, variable, Data types. Flow control if if else, for, while, range() function, continue, pass, break. Strings: Sequence operations, String Methods.	7
2.	**Lists:** Basic Operations, List slices,list methods,list and strings **Dictionaries:** looping and dictionaries, dictionaries & lists. **Tuples and Files :** reading and writing Functions: Definition, Call, Arguments ,Input output file handling.	8
3.	**Object Oriented Programming** features in Python: Classes, Objects, Inheritance,Errors and Exceptions: try, except and else statements, Exception Objects, Regular expressions.	7
4.	**Numpy and Matplotlib** :Array operations, Numpy Side Effects, 2D Numpy Arrays , Numpy Basic Statistics. Matplotlib: Introduction, Simple plots, Line API, Legend API, Figures, Subplots. **Pandas:** Look Ups, Selections and Indexing, Filling Methods, Series operation, Handling NaN values, Mapping, Data Frames, Reading Files, Plotting, Joins, Correlation, Histograms, Rolling calculation.	8
	Total	30

Text Books:

1. Allen B Downey, ―Think PYTHON‖, O_Rielly, ISBN: 13:978-93-5023-863-9, 4th Indian Reprint 2015
2. Peng, Roger D and Elizabeth Matsui, ―The Art of Data Science." A Guide for Anyone Who Works with Data. Skybrude Consulting 200 (2015): 162

Reference Books:

1. Zed A. Shaw,Learn Python the Hard Way

Program:	M.Tech (Computer Engineering)				Semester : I	
Course :	Software Engineering Basics				Code : MCE1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:- None

Course Objectives:

1. To learn and understand the principles of Software Engineering
2. To be acquainted with methods of capturing, specifying, visualizing and analyzing software requirements.
3. To apply Design and Testing principles to S/W project development.
4. To understand project management through life cycle of the project.
5. To understand software quality attributes.

Course Outcomes:

After learning the course the students should be able to:

1. Decide on a process model for a developing a software project
2. Classify software applications and Identify unique features of various domains
3. Design test cases of a software system.
4. Understand basics of IT Project management.
5. Plan, schedule and execute a project considering the risk management.
6. Apply quality attributes in software development life cycle.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to Software Engineering and Software Process Models:** Software Engineering Fundamentals: Nature of Software, Software Engineering Principles, The Software Process, Software Myths. Process Models :A Generic Process Model, Prescriptive Process Models: The Waterfall, Incremental Process(RAD), Evolutionary Process, Unified Process, Concurrent. Advanced Process Models & Tools: Agile software development: Agile methods, Plan-driven and agile development.	7
2.	**Software Requirements Engineering and Analysis:** Requirements Engineering: User and system requirements, Functional and non-functional requirements, Types & Metrics, A spiral view of the requirements engineering process. Software Requirements Specification (SRS): The software requirements Specification document, The structure of SRS, Ways of writing a SRS, Requirements elicitation & Analysis: Process, Requirements validation, Requirements management.	8
3.	**Design Engineering:** Design Process & quality, Design Concepts, The design Model, Pattern-based Software Design. Architectural Design :Design Decisions, Views, Patterns, Application Architectures, Modeling Component level Design: component, Designing class based components, conducting component-level design, User Interface Design: The golden rules, Interface Design steps & Analysis, Design Evaluation	7
4.	**Project Risk Management:** Risk Analysis & Management: Reactive versus Proactive Risk Strategies, Software Risks, Risk Identification, Risk Projection, Risk Refinement, Risk Mitigation, Risks Monitoring and Management, The RMMM plan for case study project	8
	Total	30

Text Books:

1. Roger Pressman, ―Software Engineering: A Practitioner _s Approach‖, McGraw Hill, ISBN 0–07–337597
2. Ian Sommerville, ― Software Engineering‖, Addison and Wesley, ISBN 0-13-703515-2

Reference Books:

1. Carlo Ghezzi, ―Fundamentals of Software Engineering", Prentice Hall India, ISBN-10: 0133056996
2. Rajib Mall, ―Fundamentals of Software Engineering‖, Prentice Hall India, ISBN-13: 978- 8120348981
3. Pankaj Jalote, ―An Integrated Approach to Software Engineering‖, Springer, ISBN 13: 9788173192715.
4. S K Chang, ―Handbook of Software Engineering and Knowledge Engineering‖, World Scientific, Vol I, II, ISBN: 978-981-02-4973-1
5. Tom Halt, ―Handbook of Software Engineering‖, Clanye International, ISBN10: 1632402939
6. Christine Bresnahan, Richard Blum –Linux command line and Shell Scripting Bible -Weilly , ISBN-978-0-470-25128-7

Program:	M.Tech (Computer Engineering)				Semester : I	
Course :	Basics of Machine Learning				Code : MCE1601C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Linear Algebra, Statistics, Probability and Calculus
b. Basic Programming Skills……are essential

Course Objectives:

1. To master the concepts of supervised and unsupervised learning, recommendation engine, and time series modeling
2. To gain practical knowledge over principles, algorithms, and applications of Machine Learning through a hands-on approach and to validate Machine Learning models and decode various accuracy metrics. Improve the final models using another set of optimization algorithms, which include Boosting & Bagging techniques
3. To acquire thorough knowledge of the statistical and heuristic aspects of Machine Learning and To comprehend the theoretical concepts and how they relate to the practical aspects of Machine Learning.
4. 4.To implement models such as support vector machines, kernel SVM, naive Bayes, decision tree classifier, random forest classifier, logistic regression, K-means clustering

Course Outcomes:

After learning the course the students should be able to:

1. Understand machine learning techniques and computing environment that are suitable for the applications under consideration.
2. Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.
3. Develop scaling up machine learning techniques and associated computing techniques and technologies for various applications.
4. Implement various ways of selecting suitable model parameters for different machine learning techniques.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Foundations for Machine Learning [ML]:** ML Techniques overview: Supervised; Unsupervised, Reinforcement Learning,Validation Techniques (Cross-Validations)**;**Feature Reduction/Dimensionality reduction;Principal components analysis (Eigen values, Eigen vectors, Orthogonality)	7
2.	**Clustering:** Distance measures;Different clustering methods (Distance, Density, Hierarchical); Iterative distance-based clustering; Dealing with continuous, categorical values in K-Means; Constructing a hierarchical cluster; K-Medoids, k-Mode and density-based clustering; Measures of quality of clustering	8
3.	**Classification: Naïve Bayes Classifier** Model Assumptions; Probability estimation; Required data processing; M-estimates;, Feature selection: Mutual information;Classifier **K-Nearest Neighbors:** K-Nearest Neighbor algorithm; Aspects to consider while designing K-Nearest Neighbor Support Vector Machines;SVM for classification and regression problems.	7
4.	**Association Rule mining:** The applications of Association Rule Mining: Market Basket, Recommendation Engines, etc. ; A mathematical model for association analysis; Large item sets; Association Rules; Apriori: Constructs large item sets with mini sup by iterations; Interestingness of discovered association rules; Application examples; Association analysis vs. classification ; FP-trees **Research Aspects: Application of ML in various domains**-Research Paper Publication in Quality Indexed International Journals/ Conferences;Practical Implementation of Industry Projects/Applications**;** IPR	8
	Total	30

Text Books:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.
2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.

Reference Books:

1. Ethem Alpaydin, Introduction to Machine Learning

Program:	M.Tech (Computer Engineering)				Semester : II	
Course :	Image Processing with MATLAB				Code: MCE2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Programming Basics

Course Objectives:

1. Develop an overview of the field of image processing.
2. Cover the basic theory and algorithms that are widely used in digital image processing.
3. Develop hands-on experience in using computers to process images.
4. Familiarize with MATLAB Image Processing Toolbox Course

Course Outcomes:

1. After learning the course the students should be able to:
2. Understand the need for image transforms different types of image transforms and their properties. 2: Learn different techniques employed for the enhancement of images.
3. Understand the need for image compression and to learn the spatial and frequency domain techniques of image compression.
4. Learn different feature extraction techniques for image analysis and recognition.
5. Develop any image processing application.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction:** What is image processing?, What are the fundamental issues? , What is the role of perception? Image sampling and quantization, Basic relationship between pixels, MATLAB orientations. **Image Transformations** Discrete Fourier transform, Properties of 2D DFT, FFT, Convolution, Correlation, Discrete cosine transform, Discrete Wavelet transform.	7
2.	**Image Enhancement Techniques** Spatial Domain Techniques: Basic gray level transformations, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters, Sharpening filters. Frequency Domain Techniques: Frequency domain filtering, Image smoothing and Image sharpening using frequency domain filters.	8
3.	**Color image processing:** Color fundamentals, Color models, Color transformation, Smoothing and Sharpening **Image Compression:** Fundamentals, Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression, Huffman coding, Arithmetic coding, Golomb coding, LZW coding, Block transform coding, Run-length coding, JPEG Lossless predictive coding, Lossy predictive coding, Wavelet coding.	7
4.	**Morphological Image processing:** Basics, Erosion, Dilation, Opening, Closing, Hit-or-Miss transform, Boundary Detection, Hole filling, Connected components, Convex hull, Thinning, Thickening, Skeletons, Pruning. **Image Segmentation and Representation:** Point, Line and Edge detection, Edge linking and Boundary detection, Thresholding, Basic global tresholding, Otsu's method, Region based segmentation, Use of motion in segmentation	8
	Total	**30**

Text Books:

1. R. C.Gonzalez, R.E.Woods,‖ Digital Image processing‖, Pearson edition, Inc3/e,2008.
2. A.K.Jain,‖ Fundamentals of Digital Image Processing‖, PHI,1995

Reference Books:

1. J.C. Russ,‖ The Image Processing Handbook‖, (5/e), CRC, 2006
2. R.C.Gonzalez & R.E. Woods; –Digital Image Processing with MATLAB‖, Prentice Hall, 2003
3.W. K. Pratt, *Digital Image Processing*, John Wiley & Sons, 2006.
4.S. Ahmed, *Image Processing*, McGraw -Hill, 1994.
5.S. J. Solari, *Digital Video and Audio Compression*, McGraw-Hill, 1997

Program:	M.Tech (Computer Engineering)				Semester : II	
Course :	Linux Essentials				Code: MCE2602B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

Course Objectives:

1. To acquire knowledge of basic Linux OS, commands, and terminologies
2. To develop programs using Shell scripting
3. To acquire skills related to Linux file system

Course Outcomes:

After learning the course the students should be able to:

1. Use common and simple Linux commands
2. Demonstrate programming ability using Unix Shell
3. Develop collaboratively using GIT and write research-papers using LaTex
4. Apply a solution clearly and accurately in Linux environment

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to Linux:**Linux introduction; Understanding philosophy of Linux; Understanding Software Licensing and Linux Distributions; Architecture of Linux OS; Installation of Linux OS (direct and using virtual machine); Using common Linux programs: Linux desktop environment, working with different productivity software; Understanding and managing hardware: CPU, Disk issues, Device drivers, Display etc.;	7
2.	**Basic Commands and Shell Scripting:** Introduction to Linux commands, concept of shell, shell variables,getcwd() and pwd; Introduction to shell programming features: Variables declaration & scope,test, return value of a program, if-else and useful examples, for andwhile loop, switch case; Shell functions, pipe and redirection, wildcards, escape characters; Awk script: Environment andworkflow, syntax, variables, operators, regular expressions, arrays, control flows, loops,functions, output redirections	8
3.	**Linux File System and Networking:** File System - Manipulating Files: creating, deleting, copying, moving, renamingetc; Using absolute and relative path; Manipulating Directories: Creating, Deleting and Managing; Basic File and Directory commands; Understanding Linux file system; Networking - Understanding network features; Configuring a network connection; Testing a network connection;	7
4.	**Essential System Administration** **Users and Group Management:** Users and Group management: Creation, Updating, Deletion of user and group; Commands –shadow, useradd, usermod, userdel, groupadd, groupmod, groupdeletc; Managing ownership and permission. **Process and PackageManagement:** Understanding package management,package management commands like rpm, yum, apt; Understanding Process hierarchy and identifying running processes; Log files. **Or** **Introduction to GIT and LaTEX:** LaTEX:Basic syntax, compiling and creating documents; Document structure including sections and paragraphs; Adding Images, Table ofcontents, Source code, graphs; Adding references, and Bibliography; Installation and Hands-on of LaTEX. GIT: Creating a project using GIT locally, add, commit; Branch and Merge; Cloning a remote repo, working with a remote repo; Working on a project in a distributed fashion; Hands-on of GIT.	8
	Total	**30**

Text Books:

1. Christine Bresnahan, Richard Blum ―Linux Essentials, Sybex, ISBN 9781119092063
2. Sumitava Das, Unix Concepts and Applications, Tata-McGraw Hill, ISBN 0-07-063546-3

Reference Books:

Christine Bresnahan, Richard Blum –Linux command line and Shell Scripting Bible -Weilly , ISBN-978-0- 470-25128-7

Program:	M.Tech (Computer Engineering)				Semester : II	
Course :	Design with UML				Code: MCE2602C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. .Basic understanding of computer programming and related programming paradigms.

Course Objectives:

1. To introduce the concept of Object-oriented design
2. To understand and differentiate Unified Process from other approaches
3. To design static and dynamic UML diagrams

Course Outcomes:

After learning the course the students should be able to:

1. Understand Basic features and elements of the object-oriented approach
2. Identify, analyze, and model structural and behavioral concepts of the system.
3. Apply the concepts of architectural design for deploying the code for software.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	Introduction to UML: Importance of modeling, principles of modeling, object-oriented modeling, conceptual model of the UML, Architecture, Software Development Life Cycle	7
2.	Basic Structural Modeling: Classes, Relationships, common Mechanisms, and diagrams. Advanced Structural Modeling: Advanced classes, advanced relationships, Interfaces, Types and Roles, Packages. Class & Object Diagrams	8
3.	Basic and Advanced Behavioral Modeling: Interactions, Interaction diagrams. Use cases, Use case Diagrams, Activity Diagrams. Advanced Behavioral Modeling Events and signals, state machines, processes and Threads, time and space, state chart diagrams.	7
4.	Architectural Modeling: Component, Deployment, Component diagrams and Deployment diagrams. Common modeling techniques	8
	Total	**30**

Text Books:

1. Grady Booch, - The unified modeling language user guide. Pearson Education India, ISBN: 0-201-57168
2. James Rumbaugh. Micheal Blaha- Object-Oriented Modeling and Design with UML: Pearson Education India, ISBN-13: 978-0130159205

Reference Books:

2. Charles Ritcher - Designing Flexible Object-Oriented systems with UML. New Riders Publishing.
3. Jackson, Burd Thomson - Object Oriented Analysis & Design. Thomson Course Technology.
4. Mike O'Docherty - Object-Oriented Analysis and Design: using UML. Wiley Publication
5. Joseph Schmuilers - Teach Yourself UML in 24 Hours. Sams publishing.

Program:	M. Tech. (Civil) Construction Management				Semester : I	
Course :	Project Management and Finance (OE 1)				Code : MCI1601A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Basics of Management,
b. Basics of Finance……are essential

Course Objectives:

After Completing this course, student will have adequate background to

1. To demonstrate knowledge and understanding of engineering and management principles.
2. To function effectively as an individual, and as a member or leader in diverse teams.
3. To understand the concepts of finance and accounts carried out in project management.

Course Outcomes:

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

1. Study the current market trends and choose projects.
2. Prepare project feasibility reports.
3. Ability to implement the project effectively meeting government norms and conditions.
4. Ability to understand the role and responsibility of the Professional Engineer.
5. Ability to choose projects which benefit the society and organization.

Detailed Syllabus:

Unit	Description	Duration, (H)
1	**Introduction to Management** What is Management? It's Need ,Importance & Purpose, Evolution of Managements thought, Different Schools/ approaches to Management: Behavioral, Quantitative, Systems, Contingency Approach	7
2.	**Project Implementation, Monitoring and Control** Project representation: Role of project managers, relevance with objective of organization, preliminary manipulations, Basic Scheduling concepts: Resource levelling, Resource allocation, Setting a base line, Project management information system: Importance of contracts in projects: Team work in Project Management: Formation of Effective terms.	8
3.	**Organizing** Organizing as a Management process, Principles of Organization, Different Structures of organizations such as line, Line & Staff, Functional, Matrix or project Organization: Characteristics, Features, their Merits and Limitation, Ownerships of Organization: Sole Proprietorship, Partnership, Private Ltd., Public Ltd., Introduction to Organizational climate, Decision Making, Group Decision Making, Staffing: What is Staffing? Steps involved in Staffing, Recruitment, Staffing, Performance Appraisal Development	8
4.	**Financial Statements and Their Analysis** Understanding of Financial Statements and Their Analysis, Like Balance Sheet, Profit & Loss Account, Ratio Analysis, Fund Flow Analysis, Statement of Changes In Financial Position.	7
	Total	30

Text Books:

1. Project Management Institute A Guide to the Project Management Body of Knowledge PMBOK Guide (Sixth Edition), Sept 2017.
2. James C.Van Horne, Fundamentals of Financial Management, Person Education 2004.
3. Khanna, R.B.,Project Management, PHI 2011.

Reference Books:

4. Kuster J., Huber, E., Lippmann, R., Schmid, A., Schneider, E., Witschi, U., Wust, R. Project Management Handbook, 2015.
5. Prasanna Chandra, Financial Management, Tata McGraw-Hill, 2008.
6. Carl S. Warren, James M. Reeve, Jonathan Duchac.
7. Financial and Managerial Accounting, 2016
8. Paneer Selvam, R., and Senthilkumar, P., Project Management, PHI, 2011.

Program:	M. Tech. (Civil) Construction Management				Semester : I	
Course :	Green Technology				Code : MCI1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:

a. Environmental study and Types of pollution

Course Objectives:

After Completing this course, student will have adequate background to understand and solve the problem involving:

1. To learn about Global warming and its effect
2. To demonstrate knowledge in the reduction of global warming.
3. To learn the control measures of carbon emission and accumulation.
4. To learn high tech measures for Reducing Carbon Emissions.

Course Outcomes:

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

1. Study the effects of Global warming
2. Implement the concept of reduction of global warming
3. Understand the remedial action for the carbon emission and accumulation.
4. Apply high tech measures for Reducing Carbon Emissions.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Global Warming and its effect:-** Introduction and physical definition of global warming, the New Carbon Problem: Accumulation, Long Half-Life, Heating Potential, Carbon Emission Factors, Carbon Absorption in Nature, The Global Emission Situation and its effect in India, The Kyoto and Other Protocols and its view in India, Effect of climate change and its impact. **Planning for the Future to reduce global warming:-** Steps taken to Control Carbon Emissions universally, Use of Promotional and Punitive Mechanisms for Reducing Carbon in Atmosphere, The General Approach in Planning for the Future, Developing Countrywide Adaptive Measures for Safety of Local People, Developing Mitigative Measures for Global Reduction of Carbon, India's National Action Plan on Climate Change (NAPCC) till date, National Mission for a Green India, The MRV Debate.	7
2.	**Opportunities in Control of Carbon Emissions and Accumulation:-** Essential Steps for Control of Carbon Emissions and Accumulation, Procedure to develop own Priorities and Business Opportunities in India for control of carbon emissions and accumulation, Needs a Mix of Green and Traditional Power Sources in India, A Logical Approach for Carbon Reduction, Need in India —More Forests, Less Deforestation and payment rates procedure for controlling carbon emissions and its Promotional Mechanisms at India. **Green Technologies for Energy Production:-** Various Technologies Available for Energy Production, Cost Comparison of a Few Typical Systems for Power Generation, Sources of Energy Production Already in Use, Alternative Methods Ready for Use, Green Technologies Needing some Prior R&D Work.	8
3.	**Green Technologies for Personal and Citywide Application :-** Measures to be taken for Green city, Carbon Emission Reduction at Personal Level, Carbon Emission Reduction at Local Authority and Citywide Level, Carbon Emissions from Imports. **Green Technologies for Specific Applications:-** Promotion of 'Green' Buildings, Guidelines, The Energy Conservation Building Code (ECBC), Green Hotels and Hospitals, Green Technologies for Transport, Green Roads, Ports and Harbors, Industries, Carbon, Carbon Emissions from a Few Selected Industries in India, The Changing Scenario in Cities, Need for Wider Application to Town Planning and Area Re- Development Projects ,'Green' Infrastructure for Municipal Services, Bringing up Indian Villages, Green Services for Crematoria, Spreading Message to all Stakeholders.	7
4.	**Some High-tech Measures for Reducing Carbon Emissions :-** Use of Solar Power with Satellite-Based Systems ,Use of Carbon Capture and Storage (Sequestration) ,Microorganisms, A Quick SWOT Analysis. **Recommended Plan of Action :-** India's National Action Plan Take Us to a Low-Carbon Path, The Missions Help Develop Awareness, Few case studies on Projects undertaken by Various Countries, Adaptive Measures Essential for Indian People to Cope with Climate Change	8
	Total	30

Text Books:

1. Green Technologies, Soli J. Arceivala, Mc Graw Hill Education.

Reference Books

1. Green Technologies and Environmental Sustainability edited by Ritu Singh, Sanjeev Kumar
2. http://cpcbenvis.nic.in/greentechnology.html

Program:	M. Tech. (Civil) Construction Management				Semester: I	
Course:	Organization Behaviour (OE I)				Code: MCI1601C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE -1	IE-2	ETE	Total
2	2	2	2	-	30	50

Prior knowledge of:

a. Knowledge of different types of Organisations structures.

Course Objective: To introduce the students with various features of Microsoft Project.

Course Outcomes: At the end of the course, students will be able to understand

1. Understand important and organisation culture of OB for organisation.
2. Apply different learning theories of learning to organisation.
3. Appraise group behaviour, leadership skills, power and politics in organisation.
4. Relate to organisation culture, climate and work stress.

Detailed Syllabus:

Unit	Description	Duration (H)
1.	**Introduction to OB**: Disciplines contributing to OB, Need and Importance of OB, Challenges and Opportunity for OB, OB model, Approaches to Organizational Behaviour, Inherited characteristics, Learning, theories of learning, reinforcement.	7
2.	**Motivation and behavior in group and team work**: Motivation at work; theories of motivations, motivation from concept to applications, Designing motivating jobs, Group Decision Making, Differences Between Groups and Teams, Types of Teams, Creating Effective Teams	8
3.	**Leadership, Power and Politics:** Trait Theories, behavioural Theories, Contingency Theories, Authentic Leadership: Ethics and Trust, A Definition of Power, Bases of Power, Power Tactics, Causes and Consequences of Political behaviour	7
4.	**Organization culture, climate and stress management:** signifance of culture in organization, creating sustainable cultures, Creating a Positive Organizational Culture, Creating a Culture for Change, Work Stress and Its Management, Case studies of OD intervention sin mega-construction projects.	8
	Total	**30**

Reference Books:

1. Gregery Moorhead, Ricky W. Griffin, Organizational Behaviour: Managing People and Organizations, 3rd Edition, Houghton Miffin Company, 2000
2. Stephen, P Robbins, Organizational Behaviour, 9th edition, Pearson Education Asia, New Delhi, 2001
3. Wendell L French, Cecil H. Bell, Jr., Organization Development: Behavioural Science Interventions for Organization Improvement, 6th edition, Pearson Education Asia, New Delhi, 2001.
4. Jit. S. Chander, Organizational Behaviour, 3rd edition, Vikas Publishing House Pvt. Ltd.,, New Delhi, 2005.

Program:	M. Tech. (Construction Management)				Semester : II	
Course :	Contracts, Tendering & Arbitration				Code : MCI2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of: None

Course Objectives:

1. To equipped with knowledge of contracts system.
2. To study principles and specifications for making tender documents
3. To learn basic principles of Arbitration in the context of various construction aspects.

Course Outcomes:

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

1. Adopting the ethical knowledge for making construction contracts & Tenders.
2. Prepare Tendering documents as per conditions of contract.
3. Exhibit concept of Arbitration to resolution of disputes in construction projects.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Construction Contracts:** Indian Contract Act (1872): Definition of the contract as per the ACT. Valid, Voidable, Void contracts, Objectives of the act. Introduction: To law, Indian legal system, Laws governing structure & Working of Construction Organization Firms, Laws of Tort.	7
2.	**Construction Contract Documents:** Evaluation of contract documents, need for documents, present stage of national and international contract documents, types of construction contracts, roles and functions of parties to the contract. Contract Formation.	8
3.	**Stages in Contracting:** Preparation of tender documents estimating, pre - qualification, bid evaluation, award of contract, project financing and contract payments, contracts close out and completion.	7
4.	**Arbitration:** Comparison of Actions and Laws - Agreements, subject matter-Violations- Appointment of Arbitrators-Conditions of Arbitrations-Powers and duties of	8
	Total	30

Text Books:

1. Civil Engineering Contracts and Estimates - B.S.Patil – Universities Press- 2006 Edition,reprinted in 2009.
2. The Indian Contract Act (9 of 1872), 1872- Bare Act- 2006 edition, Professional Book Publishers.
3. The Arbitration and Conciliation Act,(1996), 1996 (26 of 1996)- 2006 Edition, Professional Book Publisher.

Reference Books:

1. Law of contract Part I and Part II, Dr. R.K. Bangia- 2005 Edition, Allahabad Law Agency.
2. Arbitration, Conciliation and Alternative Dispute Resolution Systems- Dr. S.R. Myneni- 2004 Edition, reprinted in 2005- Asia Law House Publishers.
3. The Workmen_s Compensation Act, 1923 (8 of 1923) Bare Act- 2005- Professional Book Publishers.
4. Standard General Conditions for Domestic Contracts- 2001 Ministry Of Statistics and Program Implementation, Government of India.
5. FIDIC Document (1999).
6. Dispute Resolution Board foundation manual-www.drbf.org. 30 Edition

Program:	M. Tech. (Civil) Construction Management				Semester : II	
Course :	Total Quality Management				Code : MCI2602B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Prior knowledge of:
TQM & MIS at UG Level ,
Awareness of Quality Construction Aspects

Course Objectives:
1. To **understand** the need of QM in construction and **apply** necessary tools to achieve
2. To **apply** necessary trainings for the effective utilization of resources
3. To **apply** effectively the eight principles of ISO for quality processes in construction
4. To **apply** Six Sigma tool for TQM in construction project

Course Outcomes:
After learning the course, the engineers should be able to:
1. Understand and apply the TQM phylosophy in construction
2. Able to use effectively QC tools.
3. Apply ISO principles for effective Quality processes in construction
4. Able to apply Six Sigma effectively.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Concepts of Quality** A) Definition of quality as given by Deming, Juran, Crosby, difference between Quality control, Quality Assurance (QA/QC). Total quality control (TQC) and Total Quality Management (TQM), Need for TQM in construction industry. Organization necessary for implementation of quality, Quality manual-Contents, data required, preparation, responsibility matrix, monitoring for quality-PDCA Cycle. Quality aspects in every phase in the life cycle of Construction project.	7
2.	**Quality Control Tools** Histogram, Pareto diagram, Fish-bone diagram, Quality control chart-Testing required for quality control of construction material used in RCC Work- destructive and Non destructive Test (NDT). Statistical Quality Control-Necessity, Benchmarking.	8
3.	**Study of ISO 9004- Quality System Standards.** Purpose of ISO Standards. Difference between ISO 9001 and ISO 9004. Certification process for ISO 9001. Certification bodies involved. Eight Principles of ISO-Basic meaning, applying these principles for an effective quality process in the organization. Management support and commitment necessary for achieving implementation for quality system standards. **Development** of quality circles, quality inspection team, inspection reports, monitoring and control, 360_ feedback for quality.	8
4.	**A) Six Sigma** Definition of six sigma, evolution – Historical aspects, probability distribution Six sigma ratings, Six sigma training, six sigma as an effective tool in TQM. **B) Application of Six Sigma** i) RCC Work in building (ii) Assessment of overall construction process from concept to completion of a construction project.	7
	Total	30

Text Books:
1. Quality Control and Total Quality Management by P.L.Jain- Tata McGraw Hill Publ.Company Ltd 2.
2. Total Engineering Quality Management – Sunil Sharma – Macmillan India Ltd.
3. 3.Total Project Management – The Indian Context - P.K.Joy Macmillan India Ltd.

Reference Books:
1. International Standards Organization – ISO 9001 and ISO 9004
2. Mantri Handbook – A to Z of Construction – Mantri Publications
3. Juran_s Quality Handbook – Joseph M. Juran, A. Blanton. Godfrey – Mcgraw Hill International Edition (1998)
4. Management Information Systems – Gordon B. Davis, Margrethe H. Olson – Tata McGraw Hill Publ. Co.

Program:	M. Tech. (Civil Engineering)	Semester : II
Course :	Operations Research	Code : MCI2602C

Teaching Scheme			Evaluation Scheme			
Lecture	Hour s	Credit	IE 1	IE2	ETE	Tota l
2	2	2	20	-	30	50

Prior knowledge of:

a. Applied Mathematics Including Calculus and Linear Algebra,
b. Calculus-Based Probability/Statistics……are essential

Course Objectives: This course aims at enabling students,

1. To familiarize with concepts and techniques of Linear and Nonlinear Programming Problems.
2. To derive feasible and optimal solution for Transportation and Assignment Problem.
3. To apply various methods to select and execute various optimal strategies using decision theory.
4. To construct network diagrams with single and three time estimates of activities involved in the project.

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

1. Model and solve Linear and Nonlinear Programming Problems.
2. Model & Solve profit maximization Transportation and Assignment Problem.
3. Apply various methods to select and execute various optimal strategies using decision theory.
4. Calculate Project schedule and expected completion time for the project.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction to Operations Research** Introduction, operations research approach to problem solving, Models and Modelling in operations research, Advantages, Methods for solving operations research models, Methodology of operations research, Advantages. **Linear Programming** Introduction, Structure of Linear programming Model, Advantages, Limitations, Assumptions and Applications of Linear programming, Guidelines for Model Formulation, Solving Linear programming problems using Graphical Method and Simplex Method	7
2.	**Transportation and Assignment Problems** Mathematical Models of Transportation Problem, The Transportation Algorithm, Methods for Finding Initial Solution, Test for Optimality. Mathematical Models of Assignment Problem, Solution Methods of Assignment Problem.	8
3.	**Decision Theory and Games Theory** Steps of Decision-Making Process, Types of Decision- Making Environment, DecisionMaking Under Uncertainty, Games Theory: Introduction, Two Person Zero Sum Games, Pure Strategies (Minimax and Maximin Principles): Games with Saddle Point, Mixed Strategies: Games without Saddle Point, The Rules of Dominance, Solution Methods of Games without Saddle Point.	7
4.	**Project Management** Introduction, Basic Difference between PERT and CPM, Phases of Project Management, PERT/CPM Network Components and Precedence Relationships, Critical Path Analysis. Project scheduling with uncertain activity times, Estimation of project completion time.	8
	Total	30

Text Books:

1. J K Sharma, "Operations Research: Theory and Applications" , Trinity Press 5th Edition ISBN No. 9789350593363.
2. Frederick S. Hillier, Gerald Lieberman, "Introduction to Operations Research, McGraw Hill", 6th Edition ISBN No.0071139893.

Reference Books:

1. Gerald Lieberman, "Operations Research: An Introduction", PHI, 9th Edition, ISBN No. 978- 9332518223.
2. Gupta Prem Kumar and Hira D.S, "Problems in Operations Research", S. Chand, ISBN No.978- 8121909686.
3. Wayne L. Winston, "Operations Research Applications and Algorithms", Cengage Learning, 4th Edition, 1987
4. P Sankara Iyer, "Operations Research", Sigma Series, TMH, 1st Edition, ISBN No.978-0070669024.

Program:	M. Tech. (Artificial Intelligence and Data Science)				Semester : I	
Course :	R Programming (OE I)				Code :MDS1601A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	-	30	50

Prior knowledge of:

a. Knowledge of Statistics in Mathematics

b. Prior Knowledge of any programming……are essential

Course Objectives:

1. To use R and R Studio Environment
2. To understand different data types and control structures in R
3. To interface R with other languages.
4. To understand the use of R for Big Data analytics.

Course Outcomes:

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

1. Explain the basics in R programming in terms of constructs, control statements, string functions.
2. Apply the use of R for Big Data analytics.
3. Learn to apply R programming for Text processing.
4. Able to appreciate and apply the R programming from a statistical perspective.

Detailed Syllabus:

Unit	Description	Duration (H.)
1.	**Getting Started with R Programming:** Introduction to the R-Studio, user-interface, Basic commands, Data Structures in R,Reading data into R Subsetting	7
2.	**Matrices, Arrays And Lists:** Creating matrices ,Matrix operations ,Applying Functions to Matrix Rows and Columns, Adding and deleting rows and columns, Vector/Matrix Distinction, Avoiding Dimension Reduction, Higher Dimensional arrays, Lists, Creating lists, General list operations,– Accessing list components and values, Applying functions to lists, Recursive lists	8
3.	**Data Frames:** Creating Data Frames, Matrix-like operations in frames, Merging Data Frames, Applying functions to Data frames, Factors and Tables: factors and levels, Common functions used with factors, Working with tables, Other factors and table related functions, Control statements: Arithmetic and Boolean operators and values, Default values for arguments, Returning Boolean values, Environment and Scope issues: Writing Upstairs – Recursion ,Replacement functions, Tools for composing function code, Math and Simulations in R	8
4.	**Interfacing:** Interfacing R to other languages, Parallel R, Basic Statistics, Linear Model, GeneralizedLinear models, Non-linear models, Time Series and Auto-correlation – Clustering	7
	Total	**30**

Text Books:

1. Mark Gardener, " Beginning R – The Statistical Programming Language", Wiley,2013
2. Norman Matloff , "The Art of R Programming: A Tour of Statistical Software Design", No Starch Press,2011

Reference Books:

1. Jared P. Lander, "R for Everyone: Advanced Analytics and Graphics", Addison-Wesley Data & AnalyticsSeries, 2013
2. Robert Knell, "Introductory R: A Beginner's Guide to Data Visualization, Statistical Analysis and Programming in R", Amazon Digital South Asia Services Inc,2013.

Program:	M. Tech. (Artificial Intelligence and Data Science)	Semester : I
Course :	Business Analytics (OE I)	Code :MDS1601B

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	-	30	50

Prior knowledge of:

a. Machine Learning
b. Data Science……are essential

Course Objectives:

1. Understand the different basic concept / fundamentals of business statistics
2. Understand the concept of Probability and its usage in various business applications.
3. Understand the practical application of Descriptive and Inferential Statistics concepts and their uses forBusiness Analytics.
4. Evaluate different data analytics tools.

Course Outcomes:

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

1. Gaining Knowledge of basic concept / fundamentals of business analytics.
2. Evaluating basic concepts of probability and perform probability theoretical distributions.
3. To perform practical application by taking managerial decision and evaluating the Concept of Business Analytics.
4. Evaluate different tools.

Detailed Syllabus:

Unit	Description	Duration (H)
1.	**Introduction** What is business analytics?, Business Analytics process: problem framing, Data modeling, model building, Deployment, Different types of business analytics, application of business analytics, current trends, roles within data analytics team.	**8**
2.	**Analytics Techniques** Optimization techniques: Linear Programming, Goal Programming, Integer Programming, Non – linear programming, Predictive modelling :- regression, multiple linear regression for predictive analysis, logistic regression, linear discriminate analysis, Data Mining: Introduction to supervised and unsupervised learning, clustering	**8**
3.	**Probability Theory & Distribution** Probability: Theory of Probability, Addition and Multiplication Law, Baye's Theorem Probability Theoretical Distributions: Concept and application of Binomial; Poisson and Normal distributions. Concept of Business Analytics- Meaning types and application of Business Analytics, Use of Spread Sheet to analyze data-Descriptive analytics and Predictive analytics	**8**
4.	**Data analytics tools** Data Visualization using Tableau/Python/R/SQL. Case study.	**6**
	Total	**30**

Text Books:

1. R.N. Prasad , Seema Acharya, "Fundamentals of business analytics", Wiley

Reference Books:

1. James Evans, Business Analytics, 2nd Edition, Pearson

Program:	M. Tech. (Artificial Intelligence and Data Science)			Semester	II
Course :	Python for Data Science (OE II)			Code :	MDS2602A
Teaching Scheme			Evaluation Scheme		
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	-	30	50

Prior knowledge of: 1. Python basics ; 2.Statistical and numerical methods

Course Objectives:

1. Apply various Python data structures to effectively manage various types of data.
2. Explore various steps of data science pipeline with role of Python
3. Design applications applying various operations for data cleansing and transformation.
4. Use various data visualization tools for effective interpretations and insights of data.

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

1. Gain an in-depth understanding of data science processes and the basics of statistics.
2. Explain the essential concepts of Python programming.
3. Perform high-level mathematical computations.
4. Perform data analysis and manipulation.

Detailed Syllabus:

Unit	Description	Duration (H)
1.	**Overview of Python and Data Structures:** Basics of Python including data types, variables, expressions, objects and functions.Python data structures including String, Array, List, Tuple, Set, Dictionary and operations them	**6**
2.	**Data Science and Python:** Discovering the match between data science and python: Outlining the core competencies of a data scientist, Linking data science, big data, and AI, Understanding the role of programming, Creating the Data Science Pipeline, Preparing the data, Performing exploratory data analysis, Learning from data, Visualizing, Obtaining insights and data products, Understanding Python's Role in Data Science, Introducing Python's Capabilities and Wonders: Why Python?, Grasping Python's Core Philosophy, Contributing to data science, Discovering present and future development goals, Working with Python, Getting a taste of the language, Understanding the need for indentation, Working at the command line or in the IDE, Performing Rapid Prototyping and Experimentation, Considering Speed of Execution, Visualizing Power, Using the Python Ecosystem for Data Science, Accessing scientific tools using SciPy, Performing fundamental scientific computing using NumPy, Performing data analysis using pandas, Implementing machine learning using Scikit-learn, Going for deep learning with Keras and TensorFlow, Plotting the data using matplotlib, Creating graphs with NetworkX, Parsing HTML documents using Beautiful Soup.	**9**
3.	**Data Visualization:** Visualizing Information: Starting with a Graph, Defining the plot, Drawing multiple lines and plots, Saving your work to disk, Setting the Axis, Ticks, Grids, Getting the axes, Formatting the axes, Adding grids, Defining the Line Appearance, Working with line style, Using colors, Adding markers, Using Labels, Annotations, and Legends, Adding labels, Annotating the chart, Creating a legend.	**7**
4.	**Data Wrangling:** Wrangling Data: Playing with Scikit-learn, Understanding classes in Scikit-learn, Defining applications for data science, Performing the Hashing Trick, Using hash functions, Demonstrating the hashing trick, Working with deterministic selection, Considering Timing and Performance, Benchmarkin, with,timeit, Working with the memory profiler, Running in Parallel on Multiple Cores, Performing multicore parallelism, Demonstrating multiprocessing.	**8**
	Total	**30**

Text Book

1. Python for data science for dummies 2nd Edition, John Paul Mueller, Luca Massaron, Wiley
2. Programming through Python, M. T. Savaliya, R**. K. Maurya**, G. M. Magar, STAREDU Solutions
3. Pandas for everyone :Python Data Analysis, Daniel Y. Chen, Pearson

Reference Book

1. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools Davy Cielen, ArnoD.B. Meysman, Mohamed Ali

Program:	M. Tech. (Artificial Intelligence & Data Science)				Semester : II	
Course :	Introduction to Neural Networks				Code : MDS2602B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	-	30	50

a. Prerequisite:

b. Linear Algebra

c. Mathematics……are essential

Course Objectives:

1. The main objective of this course is to provide the student with a basic understanding of neural networks fundamentals
2. Program the related algorithms and Design the required and related systems

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

1. Demonstrate ANN structure and activation Functions
2. Define foundations and learning mechanisms and state-space concepts
3. Identify structure and learning of perceptions
4. Explain Feed forward, multi-layer feed forward networks and Back propagation algorithms
5. Analyze Radial Basis Function Networks, Regularization and RBF networks
6. Explain the Self Organizing Map

Detailed Syllabus:

Unit	Description	Duration (H)
1.	**Introduction to Neural Networks:** Introduction and ANN Structure, Biological neurons and artificial neurons. Model of an ANN. Activation functions used in ANNs. Typical classes of network architectures.	6
2.	**Mathematical Foundation** Mathematical Foundations and Learning mechanisms. Re-visiting vector and matrix algebra, State-space concepts, Concepts of optimization, and Error-correction learning. Memory-based learning, Hebbian learning. Competitive learning.	8
3.	**Perceptrons** Single-layer perceptrons, Structure and learning of perceptrons, Pattern classifier, introduction and Bayes' classifiers, Perceptron as a pattern classifier, Perceptron convergence. Limitations of a perceptrons.	7
4.	**Feed Forward and Backpropagation NN:** Feed forward ANN, Structures of Multi-layer feed forward networks. Back propagation algorithm, Back propagation - training and convergence, Functional approximation with back propagation. Practical and design issues of back propagation learning	9
	Total	30

Text Books:

1. Introduction to Artificial Neural Systems, Jacek Zurada, West Publishing Company
2. Simon Haykin, "Neural Networks: A comprehensive foundation", Second Edition, Pearson Education Asia.
3. Satish Kumar, "Neural Networks: A classroom approach", Tata McGraw Hill, 2004

Reference Books:

1. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996
2. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

MOOC Courses-

1. Deep Learning Part-I, Swayam Prof.Mitesh M. Khapra
2. Neural Networks and Deep Learning, Coursera, Andrew Ng
3. Deep Learning for Computer Vision, Prof. Vineeth N Balasubramanian

Annexure-II

Audit Courses

Program:	**M.Tech Mechanical (Computational Mechanics (Mechanical engineering)**					**Semester:** I and II
Course :	**Audit Courses (Semester I and II)**					**Code:** M_1961 and M_2962
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE1**	**IE2**	**ETE**	**Total**
1	**1**	**--**	**--**	**--**	**--**	**--**

Guidelines:

1. The audit courses are common to all M. Tech programs
2. Students can select any audit course from list of audit courses for Semester I and II
3. These are non-credit courses but mandatory to comply the submission of the semester.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester : I
Course :	Constitution of India					Code : M_1961A
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Course Objectives:

1. To understand the constitution and the centre-state relations and functioning
2. To understand the rules and regulations under which public and private sector work
3. To understand E-governance through computers and knowledge of cyber laws

Course Outcomes:

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

1. Work cohesively without violating the rules and regulations of the constitution
2. Understanding and application of E-governance for suitable projects

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	Introduction to Constitution of India; Salient Features of the Constitution; Fundamental Rights and Fundamental Duties; Directive Principles of State Policy Role of Public Sector Undertakings in economic development; Need for Reformed Engineering Serving at the Union and State level	6
2.	E-Governance and Role of engineers in E-Governance; Finance Commission and Centre-State Relations; Role of I.T. professionals in Judiciary; Cyber laws in India	6
	Total	12

Text Books:

1. Brij Kishore Sharma: An Introduction to the Constitution of India, Eighth Edition. PHI Learning, 2011
2. C.S.Prabhu: E-Governance, Concepts and Case Studies

Reference Books:

1. Dr J N Pandey : Constitutional Law of India
2. https://www.meity.gov.in/divisions/national-e-governance-plan
2. https://www.meity.gov.in/DeitY_e-book/e-gov_policy/download/Policy%20Document.pdf
3. http://www.iibf.org.in/documents/cyber-laws-chapter-in-legal-aspects-book.pdf

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester : I	
Course :	Value Education				Code : M_1961B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Course Objectives:

1. To identify and develop Attitude and Core Faith values
2. To expose students to Family Relations
3. To enable student to understand Creative Thinking and Problem solving
4. To enable students to understand Humanistic Education.

Course Outcomes:

After learning the course the students should be able to:

1. Change in awareness levels, knowledge and understanding of student
2. Change in attitudes / behavior of students with regards to their education improved teamwork, institutional leadership and other life skills
3. Improvement in social health and attitude.

Detailed Syllabus:

Unit	Description	Duration, (H)
1	Why Human Relations are so important? Understanding Behavior, Human Relations, and Performance, Personality, Stress, Learning, and Perception, Attitudes, Self-Concept, Natural acceptance of human values, and Ethics, Dealing with Conflict, Leading and Trust	6
2	Justice in Humankind, Nurturing and Exploitation, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics	6
	Total	12

Text Books:

1. A Foundation Course in Human Values and Professional Ethics‖ R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi and Teacher's Manual, R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi

Reference Books:

1. Human Relations in Organizations Applications and Skill Building‖ Robart Lussier, eighth edition, McGraw-Hill (2014).
2. Atkinson and Hilgard‘s, –Introduction to psychology‖ Nolen-Hoeksema, S., Fredrickson, B. L., Loftus, G. R., & Lutz, C., Cengage Learning EME.

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)					Semester : I
Course :	Stress Management					Code : M_1961C
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Course Objectives:

1. To overcome stress
2. To achieve overall health of body and mind
3. To learn to achieve the highest goal happily
4. To become a person with stable mind, pleasing personality and determination

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	Definitions of Eight parts of Yog. (Ashtanga) Yam and Niyam. Do`s and Don't's in life.	6
2.	Pranayam Regularization of breathing techniques and its effects- Types of pranayama Approach to day to day work and duties, wisdom	6
	Total	12

Text Books:

1. Yogic Asanas for Group Tarining-Part-I : Janardan Swami Yogabhyasi Mandal, Nagpur

Reference Books:

1. Swami Vivekananda, Rajayoga or conquering the Internal Nature, Advaita Ashrama (Publication Department), Kolkata
2. Wendelin Küpers, David J. Pauleen, A Handbook of Practical Wisdom Leadership, Organization and Integral Business Practice, 2016
3. A Foundation Course in Human Values and Professional Ethics Presenting a Universal Approach to Value Education - Through Self-exploration

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)				Semester: II	
Course:	Team Building & Leadership				Code: M_2962A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Course Objectives:

1. Develop and strengthen interpersonal skills
2. Become familiar with and discuss different leadership models.
3. Familiarize students with the characteristics of team building.

Course Outcomes:

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

1. Use leadership and teamwork knowledge to develop projects.
2. To develop the capacity to work collaboratively in a team

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Leadership:** Will and motivation, Personal leadership, self-knowledge, and self- control, using power responsibly and respectfully: the leader as a team-builder, Ability to plan future actions and transmit that vision to others. Taking the initiative and stimulate others. What the word ‒leader‖ means, Types of leadership, Traditional, legal, and legitimate leader. Categories: autocratic, democratic, charismatic, paternalistic, authentic, spiritual, dictatorial, etc	6
2.	**Team work** Why is teamwork important? The evolution from group to team: development stages. Advantages and disadvantages of teamwork. How to determine roles in a team. Traditional vs. virtuoso teams, forming effective and balanced teams, Strengthening teams within the organization. Creating a friendly and collaborative environment. Strategies to develop the team‘s mission, vision, values, and objectives. Shared objectives vs. personal motivation. Distinguishing purpose and tasks in the team. Encouraging participation. Creating team identity, creating high-performing teams.	6
	Total	12

Text Books

1. Stephen Covey, The Seven Habits of Highly Effective People, Free Press, 1989.
2. Ronald A. Heifetz, Leadership without Easy Answers, Belknap Press, 1994.
3. Michael E. Porter, Competitive Strategy, Free Press, 1980.

Reference Books:

1. John Kotter, Leading Change: Why Transformation Efforts Fail,
2. Ikujiro Nonaka, The Knowledge-Creating Company
3. Michael West, The Secrets of Successful Team Management, Chap. 2, ‒Self-Management,‖ pgs. 32-61

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)	Semester : II
Course :	English For Research Paper Writing	Code : M_2962B

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
1	1	-	--	--	--	--

Course Objectives:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

Course Outcomes:

After learning the course the students should be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Detailed Syllabus:

Unit	Description	Duration, (H)
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness, Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	6
2	key skills are needed when writing a Title, Abstract, Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	6
	Total	**12**

Text Books:

1. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
3. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

Program:	M. Tech. Computational Mechanics (Mechanical Engineering)	Semester : II
Course :	Disaster Management	Code : M_2962C

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
1	1	-	--	--	--	--

Course Objectives:

1. To orient engineers about various natural and manmade disasters.
2. To teach the concept of Disaster management and measures to be taken at different stages of disaster management.
3. To provide insight about global, national and regional level scenario of disaster management.

Course Outcomes:

After learning the course the students should be able to:

1. Learn different disasters and measures to reduce the risk due to these disasters.
2. Learn institutional frame work for disaster management at national as well as global level.

Detailed Syllabus:

Unit	Description	Duration, (H)
1.	**Introduction** – Hazard and Disaster. Concepts of Hazard, Vulnerability, Risks. Different Types of Disaster : A) Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc B) Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures(Building and Bridge), War & Terrorism etc. Slow Disasters (famine, draught, epidemics) and Rapid Onset Disasters(Air Crash, tidal waves, Tsunami) Causes, effects and practical examples for all disasters.	6
2.	**Natural disasters**- Earthquakes, Tsunami, Floods, Drought, Landslides, Cyclones and Volcanic eruptions. Their case studies. Coastal disasters. Coastal regulation Zone. **Disaster Prevention and Mitigation**. Refugee operations during disasters, Human Resettlement and Rehabilitation issues during and after disasters, Inter-sectoral coordination during disasters, Models in Disasters. **Disaster Management** : Role of Government, International and NGO Bodies. Role of IT in Disaster Preparedness Role of Engineers on Disaster Management.	6
	Total	12

Text Books:

1. Disaster Administration and Management, Text & Case studies- SL Goel-Deep and Deep Publications
2. Disaster Management- G.K Ghosh-A.P.H. Publishing Corporation
3. Disaster management – S.K.Singh, S.C. Kundu, Shobha Singh A – 119, William Publications, New Delhi.
4. Disaster Management – Vinod K Sharma- IIPA, New Delhi,1995
5. Encyclopedia of Disaster Management- Goel S.L. - Deep and Deep Publications, New Delhi, 2006.

Reference Books:

1. Pandey, M., 2014. Disaster Management, Wiley India Pvt. Ltd., 240p.
2. Tushar Bhattacharya, Disaster Science and Management, McGraw Hill Education (India) Pvt. Ltd
3. Jagbir Singh, Disaster, Management: Future Challenges and Opportunities, K W Publishers Pvt. Ltd.
4. J.P. Singhal, Disaster Management, Laxmi Publications
5. C. K. Rajan, Navale Pandharinath, Earth and Atmospheric Disaster Management : Nature and Manmade, B S Publication
6. Shailesh Shukla, Shamna Hussain, Biodiversity, Environment and Disaster Management, Unique Publications