Jharkhand University of Technology

Ranchi

Master of Technology in

Machine Design

Course Structure & Syllabus

Department of Mechanical Engineering

December 2021

(With effect from Academic Year 2021-22)

Course Structure
Specialization – Machine Design
Semester I

S.No	Course code	course	Subject	Credits
1	MD1101	Core -I	Advance Stress Analysis	3
2	MD1102	Core II	Advance Vibrations and Acoustics	3
3	1 .MD1103 2. MD1104 3. MD1105 4. MD1106 5. MD1107	Programme Elective -I	1 Advance Finite Element Method 2. Advance Metallurgy 3. Advance Mathematical Methods in Engineering 4. Fatigue Fracture and Failure Analysis 5. Modeling and Simulation	3
4	1.MD1108 2.MD1109 3.MD 1110 4.MD1111 5.MD1112	Programme Elective -II	1. Advance Machine Design 2. Design for Manufacturing and Assembly 3. Analysis and Design of Mechanical System 4. Advance Mechanics of Solid 5. Engineering Design	3
5	1. MD 1113 2.MD 1114 3. MD 1115 4. MD 1116 5. MD 1117	Programme Elective -III	1. Advance Engineering Materials 2. Mechanics of Composite Materials 3. Analysis and Synthesis of Mechanism 4. Theory and Design of Turbomachine 5. Advanced Mechanism	3
6	MD 1201	Lab I	Thermal Engineering Lab -I	2
7	MD 1202	Lab II	Thermal Engineering Lab -II	2
8	RMC 1101	Common Paper	Research Methodology &IPR	2
9	**A10001**	**Audit -I**	English for research paper writing	-
	A10002		Professional ethics	
	A10003		Constitution of India	
	A10004		Stress management by yoga	
			Total Credit	**21**

Course Structure
Specialization – Machine Design
Semester II

S.No	Course code	course	Subject	Credits
1	MD2101	Core -III	Finite Elements Method	3
2	MD2102	Core IV	Computer Aided Design	3
3	1.MD 2103 2. MD2104 3. MD2105 4. MD 2106 5. MD2107	Programme Elective -IV	1. Tribology in Design 2. Robotics 3. Fracture Mechanics 4. Mechanical Behavior of Materials 5. Advance Composites	3
4	1. MD 2108 2. MD2109 3. MD2110 4. MD2111 5. MD2112	Programme Elective -V	1. Multi body Dyanimics 2. Condition based Monitoring 3. Optimization Techniques in Design 4. Design for Manufacturing and Assembly 5. Mechatronics	3
5	1.MD 2113 2.MD 2114 3. MD 2115 4.MD 2116 5.MD 2117 6.MD 2118	Open Elective -I	1.Business Analytic 2.Industrial Safety 3.Operational Research 4.Cost Management of Engineering Project 5.Composite Materials 6.Waste to energy	3
6	MD2201	Lab III	Finite Elements Method Lab -III	2
7	MD 2202	Lab IV	Computer Design Lab -IV	2
8	MD 2203	Core	Mini Project	2
9	**A20001** **A20002** **A20003** **A20004**	**Audit -II**	Disaster management Value education Soft skills Personality development through life enlightenment skills	-
			Total Credit	**21**

Specialization – Machine Design

Semester III

S.No.	Course Code	Course	Subject	Credits
1	MD 3201	DISSERTATION Phase 1	PROJECT - I	10
			Total Credit	**10**

Specialization – Machine Design

Semester IV

S.No.	Course Code	Course	Subject	Credits
1	MD 4201	DISSERTATION Phase II	PROJECT -II	16
			Total Credit	**16**

MD1101	Core I	Advance Stress Analysis	3

Syllabus

Module 1-Theory of Elasticity

Analysis ofstress, Analysis ofstain, Elasticityproblemsintwodimensionandthreedimensions, Mohr'scircleforthreedimensionalstresses.Stresstensor,Air'sstressfunctioninrectangularand polarcoordinates.

Module 2-EnergyMethods

Energy method for analysisofstress,strainand deflection The three theorem's-theoremofvirtual work, theoremof least work, Castiglioni's theorem, Rayleigh Ritz method, Galekin'smethod, Elastic behaviour of anisotropic materials like fibrein forced composites.

Module 3-TheoryofTorsion

Torsion of prismaticbars of solid section and thin walled section. Analogies fortorsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion ofconical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are preventedfromwarping,Torsionofnoncircularshaft.

Module 4-UnsymmetricalBendingandShearCentre

Concept ofshearcenterinsymmetricalandunsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear centerforthin wall beam cross section, open section with oneaxis of symmetry,generalopensection,and closedsection.

Module 5-PressurizedCylindersandRotatingDisks, Contactstresses

Governingequations,stressinthickwalledcylinderunderinternalandexternalpressure,shrinkfitcompound cylinders,stressesinrotatingflatsolid disk,flatdiskwithcentralhole,diskwith variable thickness,disk of uniform strength, Plasticactionin thick walled cylinders and rotating disc. Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area.Introduction to Analysis of flow-speed impact.

References:

1. Sadd, MartinH., Elasticity: Theory, applications and Numeric, Academic Press
2. Boresi,A.P.andK.P.Chong,ElasticityinEngineeringMechanics,SecondEdition, JohnWiley&Sons
3. Budynas,R.G.AdvancestrengthandAppliedStressAnalysis,SecondEdition,WCB/ McGrawHill1999
4. Dally,J.W.andW.F.Riley,ExperimentalStressAnalysis,McGrawHillInternational, ThirdEdition,1991
5. TheoryofElasticity–TimoshenkoandGoodier,McGrawHill

MD1102	Core - II	Advanced Vibrations and Acoustics	3

Syllabus

Module 1

Transient Vibrations, Response ofasingle degree offreedomsystemto stepandany arbitrary excitation, convolution (Duhamel's) integral, impulse response function.

Module 2

Multidegree of freedom systems, Free,damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors,normal modes and their properties, mode summation method,use of Lagrange'sequations to derive the equations of motion.

Module 3

ContinuousSystems,NaturalVibrationsofbeams–Differentialequationofmotion, solution bythe method ofseparation ofvariables, frequency parameter, natural frequencies and mode shapes, forced vibration of simply supported beam subjected to concentrated harmonic force at apoint, Modesummation method, discretized models ofcontinuous systems and their solutions using Rayleigh–Ritzmethod

Module 4

VibrationControl,Methodsof vibrationcontrol,principleof superposition,Numericaland computer methods in vibrations: Rayleigh, Rayleigh- Ritz and Dunkerley's methods, matrix iteration method for Eigen-value calculations, Holzer's method,

Module 5

Plane acoustic waves, Sound speed, characteristic acoustic impedance of elastic media, sound intensity,dBscale,Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns, Symmetric Spherical waves, near and far fields, simple models of sound sources, sound power, determination of sound power and intensity levels at a point due to a simple source. Psychoacoustics, Speech, mechanism of hearing, thresholds of the ear – sound intensity and frequency, loudness, equalloudness levels, loudness, pitch and timbre,beats,masking by pure tones,masking by noise.

References:

1. ThomsonW.T.,"TheoryofVibrationswithapplications",GeorgeAllenandUnwhLtd.London,1981.
2. S.S.Rao,Addison,"MechanicalVibrations",WesleyPublishingCo.,1990.
3. LeonardMeirovitch,"Fundamentalsofvibrations",McGrawHillInternationalEdition.
4. S.Timoshenko,"VibrationproblemsinEngineering",Wiley,1974.
5. Lawrence.KinslerandAustinR.Frey,"Fundamentalsofacoustics",WileyEasternLtd.,1987.

MD1103	Programme Elective -I	Advance Finite Element Method	3

SyllabusContents

Module 1

ReviewoflinearFEA:

FE formulation of 1Dbar, 3Dlinearelastic continuum, 2Dplane strain,plane stress, and axis-symmetric elements; Iso-parametric mapping; numerica lintegration.

Module 2

FE formulation for 1Dplasticity :Elastic-perfectly plastic material; Isotropic and kinematic hardening; Integration algorithms for 1D plasticity; FEformulation; Newton-Raphson method for solving nonlinear equilibrium equations;1Dvisco-plasticity and integration algorithm.

Module 3

Continuum theories of plasticity: Review of tensor algebra; Yield condition, flow rule, and hardening rules; loading and unloading conditions; Drucker's stability postulates; Convexity and normality; J2 flow theory of plasticity and visco-plasticity, Gurson model.

Module 4

FEprocedures for 2D and 3Dplasticity: Integration algorithms forrate-independent plasticity—explicit forward Euler and implicit backward Euler; Return mapping algorithm; visco-plasticity; FE formulation; Consistent linearization; Algorithmic and consistenttangent modulii; Treatment of incompressible deformation (Locking);B-barmethod.

Module 5

FE procedures for large deformation problems:

Continuummechanics—deformation gradient, polarde composition, Green-Lagrange strain,rate of deformation, Cauchystress, P-Kstresses, Balancelaws; Principle of objectivity and isotropy; Constitutive equations for hyperelasticity;Neo-Hookean model; FE formulation—Total Lagrangian and updated Lagrangian descriptions; Tangent Stiffness Matrix. Introduction to finite strain plasticity. Contact Problems, Condition of impenetrability; Gap elements for modelling contact; Tangent stiffness matrix and force vectors for 2D frictionless contact problems.

References:

1) K.J.Bathe,FiniteElementProcedures,Prentice-HallofIndiaPrivateLimited,NewDelhi,1996
2) J.C.SimoandT.J.R.Hughes,ComputationalInelasticity,Springer-VerlagNewYork,Inc., NewYork,1998
3) O.C.ZienkiewiczandR.L.Taylor,FiniteElementMethod:Volume2SolidMechanics,FifthEdition,Butterworth-Heinemann,Oxford,00
4) T.BelytschkoandW.K.LiuandB.Moran,NonlinearFiniteElementsforContinuaandStructures,JohnWiley&SonsLtd.,England,00
5) D.R.J.OwenandE.Hinton,FiniteElementsinPlasticity:TheoryandPractice,PineridgePressLtd.

MD1104	Programme Elective -I	Advance Metallurgy	3

SyllabusContents:

Module 1

Aspects of Physical Metallurgy: Crystalstructure, systems, and Barvialattices,Indexing of lattice planes (Miller's Indices), Indexing of lattice directions, Co-ordination Number (Ligency), Densitycalculations and imperfections in crystals.

Module 2

Study of Equilibrium diagrams for Fe-C systems, Cu –Bronzealloys i.e. Cu:Zn, Cu:Sn, Cu:Al, etc.,Developments in metallic materials like HSLA state, maraging steels,dual-phase steels, creep resisting steels,materials for high and low-temperature applications, Nimerics,Inconels, Haste Alloysetc.,Al,Nialloys,Ti,Mg alloys.

Module 3

HeatTreatmentofNonferrousalloys,HeatTreatmentofToolsteels.

Module 4

Orthodental materials, Biomaterials, Prosthetic materials, Nanomaterials, super conducting materials,sports materials.

Module 5

Composites, ceramics, cermets, shape memory alloys their manufacturing techniques, Advantagesandlimitations.Surfacecoatingsandtheirtribological aspects.PVD,CVD,IVDionimplantationmethod.

ReferenceBooks:

1. Engineering Metallurgy,R.A.Higgins,VivaBooksPvt.Ltd.
2. Elements of Material Science and Engineering, Lawrence H.,Van Vlack Addison-Wesley Publishing Company
3. Principles of Material Science and Engineering,William F.Smith,McGraw-Hill BookCo.
4. Material Science,R.B.Gupta,Satya Publications, NewDelhi.
5. A Text-Book of Material Science and Metallurgy,O.P.Khanna,Dhanpat Raiand Sons,NewDelhi.

MD1105	Programme Elective I	Advance Mathematical Methods in Engineering	3

Syllabus

Module 1: Introduction to Probability Theory:
Probability Theory and Sampling Distributions. Basic probability theory along with examples. Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance.Some sampling distributions like 2, t, F.

Module 2:Testing of Statistical Hypothesis:
Testing a statistical hypothesis, tests on a single sample and two samples concerning means and variances.ANOVA: One–way, Two – way with/without interactions.

Module 3:Ordinary Differential Equations:
Ordinary linear differential equations solvable by direct solution methods; solvable nonlinear ODE's;

Module 4:
Partial Differential Equations and Concepts in Solution to Boundary Value Problems:
First and second-order partial differential equations; canonical forms

Module 5:
Major Equation Types Encountered in Engineering and Physical Sciences
Solution methods for the wave equation, D'Alembert solution, potential equation, properties of harmonic functions, maximum principle, solution by the variable separation method

Reference Books:

1. Ronald E, Walpole, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists (8th Edition), Pearson Prentice Hall, 07 (for Units I & II)
2. J. B. Doshi, Differential Equations for Scientists and Engineers, Narosa, New Delhi
3. Douglas C. Montgomery, Design and Analysis of Experiments (7th Edition), Wiley Student Edition, 09.
4. S. P. Gupta, Statistical Methods, S. Chand & Sons, 37th revised edition, 08
5. William W.Hines, Douglas C. Montgomery, David M. Goldsman, Probability and Statistics for Engineering, (4th Edition), Willey Student edition, 06.

MD1106	Programme Elective -I	Fatigue Fracture and Failure Analysis	3

Unit-1 Fundamental of failure: Introduction to failure, Importance of failure analysis and its relationship to material selection, the fundamental cause of failure, kind of failure, material failure mode and their identification, theories of failure.

Unit-2 Introduction to fatigue failure: Fatigue failure, cause of fatigue failure, stress cycles, S-N curve, endurance limit, the effect of mean stress on fatigue, the effect of stress concentration, Goodman, Gerber and Soderberg relations, and diagrams.

Unit-3 Fundamentals of fracture: Definition, Types of fracture, ductile and brittle fracture, ductile-to-brittle transition, the theoretical cohesive strength of metals, distinguishing features and mechanisms of the fundamental fracture modes, Griffith theory of brittle fracture.

Unit-4 Physical aspects of fatigue: Phase in fatigue life-crack initiation-crack growth-Final fracture-Dislocations-Fatigue fracture surfaces, micro mechanisms of fatigue crack initiation and growth, mechanism of striation formation.

Unit-5 Practical aspect of fatigue failure: Introduction to various tests and characterization of fatigue failure, Fatigue test, microfractographic features of fatigue failure, analysis of fatigue failure, different case studies in the analysis of fatigue failure, remedies of fatigue failure.

Reference Books:

1. Dislocations and Mechanical behavior of Materials by M. N. Shetty, PHI
2. Mechanical Metallurgy by George E. Dieter, Mc Graw Hill
3. Element of fracture mechanics by Prasant Kumar, Mc Graw Hill

MD1107	Programme Elective -I	Modeling and Simulation	3

Module 1

INTRODUCTION Simulation: a tool, advantages,and disadvantages of simulation, areas of application, systems and system environment, components of a system, discrete and continuous systems,discreteeventsystemsimulation. GENERAL PRINCIPLESConcepts indiscrete event simulation, timeadvance algorithm, manual simulationusingeventscheduling,basic properties, andoperations.

Module 2

MODELS IN SIMULATION: Terminology and concepts, statistical models: queuing systems; inventorysystems;reliabilityandmaintainability,limiteddata,discretedistributions:Bernoullidistributio n; Bionomialdistribution; Geometric distribution, continuous distribution: Uniform distribution; Exponentialdistribution; Gammadistribution; Normaldistribution; Weibulldistribution; TriangularDistribution;Lognormaldistribution, Poisson process,

Module 3

QUEUEING MODELS: Characteristics ofqueuingsystems,thecallingpopulation,systemcapacity, arrivalprocess,servicemechanism,queuingnotations,long-runmeasuresofperformanceof queuing systems, server utilization in G/G/1/∞/∞ queues, server utilization in G/G/C/∞/∞ queues, server utilization, andsystemperformance,costsinqueuingproblems,Larkovianmodels.

Module 4

RANDOMNUMBERGENERATION: Propertiesof randomnumbers,Pseudo-randomnumbers, techniques of generating andomnumbers,tests of random numbers.

RANDOM VARIATEGENERATION: Inverse transform technique, Direct transformation for the Normal and Lognormal distribution,Convolution Method,Acceptancerejection technique.

Module 5

INPUT MODELLINGAND VALIDATION: Steps inthedevelopment of the model, data collection, Distribution identification,Parameter estimation,Goodnessof Fit Tests,selecting input models without data,verification, and validation of simulation models.

Reference Books:

1. SimulationModellingandAnalysisbyLawandKelton,McGrawHill,1991
2. SimulationModelDesign&executionbyFishwich,PrenticeHall,1995
3. DiscreteeventsystemsimulationbyBanks,Carson,Nelson, andNicol

MD1108	Programme Elective -II	Advanced Machine Design	3

Syllabus:

Module 1
Development processes and organizations, Product Planning

Module 2
Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing

Module 3
Design for manufacture, assembly, maintenance, casting, forging,

Module 4
Design for Reliability, strength-based reliability, parallel and series systems, robust design,

Module 5
Industrial design: Design for Emotion and experience, Introduction to retrofit and Eco-design, Human behavior in design,Rapid Prototyping

Reference Books:

1.George E Dieter, "Engineering Design", McGraw Hill Company.
2.Prashant Kumar, "Product Design, Creativity, Concepts, and Usability", Eastern Economy Edition, PHI New Delhi. 12
3.Woodson T.T., "Introduction to Engineering Design", McGraw Hill Book Company, 1966.
4.John J.C. "Design Methods", Wiley Inter-Science, 1970.
5.Averill M. Law and W. David Kelton "Simulation, modeling and analysis", McGraw Hill Book company, 1991.

MD1109	Programme Elective -II	Design for Manufacturing and Assembly	3

Syllabus :

Module 1

Introduction Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design, Selection of Materials and Shapes

Module 2

Properties of Engineering Materials, Selection of Materials – I, Selection of Materials – II, Case Studies – I, Selection of Shapes, Co-selection of Materials and Shapes, Case Studies – II,

Module 3

Selection of ManufacturingProcesses, Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes, Design for Machining, Design for Powder Metallurgy,Design for Polymer Processing, Co- selection of Materials and Processes, Case-Studies – III

Module 4

Design for Assembly, Review of Assembly Processes, Design for Welding – I, Design for Welding – II, Design for Brazing and Soldering, Design for Adhesive Bonding, Design for Joining of Polymers, Design for Heat Treatment, Case-Studies - IV

Module 5

Design for Reliability, Failure Mode and Effect Analysis and Quality, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization,

Reference Books:

1. M F Ashby and K Johnson, Materials and Design - the art and science of material selection inproduct design, Butterworth-Heinemann, 03.
2. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 00.
3. M F Ashby, Material Selection in Mechanical Design, Butterworth-Heinemann, 1999.
4. T H Courtney, Mechanical Behavior of Materials, McGraw Hill, NY, 00.
5. KG Swift and J D Booker, Process selection: from design to manufacture, London: Arnold,1997.

MD1110	Programme Elective -II	Analysis and Design of Mechanical System	3

Module 1

AnalysisVsDesign: Basicconcept,PhasesinDesignProcessesCharacteristicsofMechanicaldesign,Considerations in design, Formulations of the mechanical design problem, Modelling of mechanical systems:Physicaland Mathematical Models,Identification of variables and parameters, Numerical simulations.**Failure Analysis:** Theories of failure (MNS, MSS, DET),Coulomb-Mohr Theory, Prevention of failures,Understanding failures under Static loading.

Module 2

DynamicLoadingAndItsBehavior: Fatiguestrength,S-Ncurve,Goodman,Gerber and Soderberg relations, modified Goodman.**Introduction to Kinematics:** Analysis and Design of Mechanisms, Mechanisms, and machines, Mobility of mechanisms,four-barchain,Inversions:Single slider crank chain,double slider crank chain.

Module 3

Graphical LinkageSynthesis: Two-position synthesis forrocker output, Three-position synthesis, Position synthesis for more than three positions (four and sixbar quick return),Coupler curves,Exact and approximate straight-line mechanisms. **Analytical Linkage Synthesis:**Two-position synthesis for rocker output,Comparison of analytical and graphical two-position synthesis,three-position syntheses.

Module 3

Velocity and Acceleration Analysis: Instant centers of velocity, the velocity of slip, Analytical solutions for velocity analysis, Coriolis Acceleration. **CAM Design:**SVAJ diagrams,Double and singled wellcam design. **Design of Gears and Bearings:** Interferenceingears,Differential gear train,Rolling contact, Sliding contact.

Module 5

BALANCING: Primary balancing(Balancingof the rotating system),Secondary balancing, balancing for two-cylinderengine,multi cylinderengine, 4cylinder 4stroke engine, 6cylinder engine,V-engine. **Surface Failures:**Adhesive, Abrasive, Corrosive,Surface fatigue.

Analysis And Synthesis Of IC Engine Components: Machine tool and IC engine components, Engine Dynamics, Casestudies.

Reference Books:

1.KinematicsandDynamicsofMachinery-RL.Norton,TataMcGrawHill,2009
2.MachineDesignanIntegratedApproach-RL.Norton,Pearson,2004
3.MechanicalEngineeringDesign-Shigleyetal.,TataMcGrawHill,2011

MD1111	Programme Elective -II	Advanced Mechanics of Solids	3

Module 1

Analysis of Stress: Introduction, Body Force, surface force and stress vector, The state of stress at a point, Normal, Shear and Rectangular stress components, Stress components on an arbitrary plane, Equality of cross shears, A more general theorem, Principal stresses, Stress invariants, Principal planes, cubic equations, The state of stress referred to principal axes, Octahedral stresses, the state of pure shear, The plane state of stress, Differential equations of equilibrium, Equations of equilibrium in cylindrical coordinates,

Module 2

Analysis of Strain: Introduction, Deformations in the neighborhood of a point, Change in length of a linear element, Change in length of a linear element-linear components, The state of strain at a point, Interpretation of shear strain components, Cubical dilatation, the angle between two line elements, Principal axes of strain and principal strains, Plane state of strain, Plane strains in polar coordinates, Compatibility conditions.

Module 3

Stress-Strain Relations for Linearly Elastic Solids: Introduction, generalized statement of Hooke's law, Stress-strain relations for isotropic materials, Modulus of rigidity, bulk modulus, Young's modulus, and poison's ratio, Relation between the elastic constants, Displacement equations of equilibrium. Theories of Failure: Significance of the theories of failure, Factor of safety in design, Ideally plastic solid

Module 4

Energy Methods: Hooke's law and the principle of superposition, Work done by forces and elastic strain energy stored, Maxwell-Betti-Rayleigh Reciprocal theorem, Begg'sDeformeter, First theorem of Castigliano, Theorem of virtual work, Kirchhoff's theorem.

Module 5

Bending of Beams: Straight beams and asymmetrical bending, Bending of curved beams.

Torsion &Axisymmetric Problems: Torsional of general prismatic bars-solid sections, Torsion of circular, Thick-walled cylinder subjected to internal and external pressures-lames-problems, Stresses in composite tubes, Thermal Stresses.

Reference Books:

1. Irving H. Shames, Mechanics of Deformable Solids, Krieger Pub Co, 2008.
2. L.S. Srinath, Advanced Mechanics of Solids, 3rd Edition,TMH, 2009.

MD1112	Programme Elective -II	Engineering Design	3

Module 1

Introduction: Considerations of a Good Design, Design Process, Concurrent and Computer-aided engineering concepts, Design codes and Standards, Design Review and societal considerations.

Module 2

Need Identification and gathering information: Evaluating Customer requirements and Benchmarking, Product Design Specification, Information sources, Copyright, Expert systems.

Module 3

Concept Generation and Evaluation: Creativity and Problem solving, Theory of Inventive Problem solving, Conceptual Decomposition and Axiomatic Design, Decision concept evaluation and decision making.

Module 4

Embodiment Design Introduction, Product Architecture, Configuration and Parametric design Concepts, Industrial Design, Ergonomics and Design for Environment, Modelling and Simulation for the engineering design process, Material selection and detailed design.

Module 5

Team Work and Ethics in engineering design: Team formation, functioning, discharge, team dynamics, Ethical issues considered during the engineering design process.

Reference Books:

1. Engineering Design 3rd Ed., George E Dieter, McGraw Hill 2001.
2. Engineering Design Principles, Ken Hurst, Elsevier, 1999.
3. Engineering Design 3rd Ed. Pahl, W Beitz J Feldhusun, K G Grote Springer 2007

MD1113	Programme Elective -III	Advanced Engineering Materials	3

Module1

Introduction,AtomicStructure,InteratomicBonding, andStructureofCrystallineSolids:
Historical perspectiveof Materials Science. Why studyproperties of materials? Classification ofmaterials. Advanced Materials, Future materials,and modern materials, Atomicstructure. Atomic bonding insolids, Crystalstructures, Crystalline and nanocrystallinematerials. Millerindices. Anisotropicelasticity.Elasticbehaviourofcomposites.Structureandpropertiesofpolymers.Structure andpropertiesofceramics.

Module 2

ImperfectionsinSolidsandMechanicalPropertiesofMetals,Diffusion,Dislocations, andStrengtheningMechanisms:
Point defects. Theoretical yieldpoint. Line defectsand dislocations. Interfacial defects. Bulk orvolumedefects.Atomicvibrations;Elasticdeformation.Plastic deformation. Interpretationoftensile stress-straincurvesYieldingundermulti-axialstress.Yieldcriteriaandmacroscopicaspectsofplastic deformation.Propertyvariabilityand designfactors, Diffusion mechanisms. Steadyand non-steady state diffusion.Factors that influence diffusion.Non-equilibrium transformation andmicrostructure, Dislocation,andplastic deformation. Mechanisms ofstrengthening in metals. Recovery, recrystallization, and grain growth.Strengthening by second phase particles.Optimum distributionof particles.Latticeresistancetodislocationmotion.

Module3

Phase Diagrams: Equilibrium phasediagrams. Particle strengthening by precipitation. Precipitationreactions. Kinetics ofnucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure andproperty changes iniron-carbonsystem**Failure:**Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiationand propagation. Crack propagation rate. Creep. Generalized creep behaviour.Stress and temperatur e effects.

Module 4

Applications andProcessing of Metals and Alloys, Polymers, Ceramics, and composites:
Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Fabrication and processing of ceramics, Mechanical behaviour of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing,Particlere in forced composites. Fibrere in forced composites. Structural composites

Module5

Electrical,Thermal,Opticaland MagneticPropertiesandeconomicConsiderations: Electrical conduction. Semiconductivity. Superconductivity. Electrical conduction in ionic ceramics and in

polymers. Dielectric behaviour. Ferroelectricity. Piezoelectricity Heat capacity. Thermal expansion. Thermal conductivity.Thermal stresses Diamagnetism and Paramagnetism. Ferromagnetism. Anti ferromagnetism and ferrimagnetism. Influence of temperatureon magnetic behaviour. Domains and Hysteresis, Basic concepts. Optical properties of metals.Optical properties of non-metals. Application of optical phenomena. Economic, Environmental and Social Issues of Material Usage- Economic considerations. Environmental and societal considerations. Recyclingissues. Life cycle analysis and its use in design.

Reference Books:

1. MaterialsScienceandEngineering,WilliamD.Callister,Jr,JohnWiley&sons,07
2. ModernPhysicalMetallurgyandMaterialEngineering,Science,Process,application, Smallman R.E.,BishopRJ,ButterworthHeinemann,SixthEd.,1999.

MD1114	Programme Elective -III	Mechanics of Composite Materials	3

Module 1 Introduction:

Definition and characteristics,Overviewof advantageandlimitationsof compositematerials, Significanceandobjectivesofcompositematerials,Scienceandtechnology,currentstatus ,andfuture prospectus.

Module2: BasicConceptsandCharacteristics:

Structural performance of conventional material,Geometric and physical definition, Material response, Classification of composite materials, Scaleof analysis; Micromechanics, Basiclamina properties, Constituent materials, and properties, Properties of typical composite materials

Module3: ElasticBehaviorofUnidirectionalLamina:

Stress-strain relations, Relation between mathematical and engineering constants, the transformation of stress,strain ,and elasticparameters

Micromechanics offailure; failure mechanisms, Macro-mechanical strength parameters, Macro-mechanicalfailuretheories,Applicabilityofvariousfailuretheories

Module4:ElasticBehaviorof Laminate:

Basic assumptions, Strain-displacement relations,Stress- strainrelation of the layer within alaminate, Force and moment resultant,General load-deformation relations,Analysis of different types of laminates

Module5: StressandFailureAnalysisofLaminates:

Types of failures,Stress analysis, and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure;Progressive and ultimat elaminate failure,Design methodology for structural composite materials.

Reference Books:

1. Isaac M.Daniels, OriIshai, "Engineering MechaincsofCompositeMaterials", OxfordUniversityPress,1994.
2. BhagwanD.Agarwal,LawrenceJ.Broutman,"AnalysisandPerformanceoffibercomposites",JohnWi leyandSons,Inc.1990.
3. Mathews,F.L.andRawlings,R.D.,"CompositeMaterials:EngineeringandScience", CRC Press,BocaRaton,03.
4. MadhujitMukhopadhyay,"MechanicsofCompositeMaterialsandStructures",UniversityPress,04.
5. MazumdarS.K.,"ComposaiteManufacturing–Materials,ProductandProcessingEngineering", CRCPress,BocaRaton,02.

MD1115	Programme Elective -III	Analysis and Synthesis of Mechanisms	3

Module 1

Basic Concepts;Definitions and assumptions;planar and spatial mechanisms; kinematic pairs; Degree of freedom;equivalent mechanisms; Kinematic Analysis of Planar Mechanisms.Reviewof graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanisms,velocity-acceleration, analysis of complex mechanisms by the normal acceleration, and auxiliary-point methods.

Module 2

Curvature Theory:Fixed and moving centrodes, inflection circle, Euler-Savaryequation, Bobillier constructions,cubic of stationary curvature, Ball'spoint,Applications in dwell mechanisms.

Module 3

Kinematic Synthesisof planar mechanisms, accuracy (precision) points, Chebesychevspacing, types oferrors, Graphical synthesis for function generation and rigid bodyguidance with two, three,and four accuracy points using pole method, centre ,and circle point curves, Analytical synthesis of four-barand slider-crankmechanisms.

Module 4

Freudenstein'sequation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-barfor prescribed angular velocities and accelerations using complex numbers, three accuracy point synthesisusing complex numbers.

Module 5

Coupler Curves: Equation of couplercurve, Robert-Chebychevtheorem, double points,and symmetry. Kinematic Analysis of Spatial Mechanisms, Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

Reference Books:

1. R.S. HartenbergandJ. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill, NewYork,1980.
2. RobertL.Nortan,"DesignofMachinery',TataMcGrawHillEdition
3. Hamilton H.Mabie,"Mechanisms and Dynamics of Machinery",JohnWileyand Sons NewYork
4. S.B.Tuttle,"MechanismsforEngineeringDesign"JohnWileyandSonsNewYork
5. A.GhoshandA.K. Mallik, "TheoryofMachinesand Mechanisms", Affiliated East-WestPress,NewDelhi,1988.

MD1116	Programme Elective -III	Theory and Design of Turbomachines	3

Module 1

Energy interchange in fluid machinery, momentum principle, streamline theory, momentum, and circulation.

Module 2

Theory of centrifugal impeller for an incompressible fluid, velocity triangle – impeller for approach, and prerotation vortex theory.

Module 3

Blower casing volute, vaned and vaneless diffuser, thermodynamics ofturbo blowers. Dimensionless characteristic ofturboblowers.

Module 4

Axial Flow Compressors. Two dimensional Cascade: Theoretical analysis of performance and experimental works. Howell's and Cartter's correlations for low speed. Effect of Reynolds and Mach numbers. Pitch line design of axial flow compressor. Radial equilibrium. Calculation of losses and stage efficiencies.

Module 5

Stresses in the discs and blades - interstage traversing, measurements of total and static pressures and vane angles.

Transonic and supersonic compressors. Industrial Steam Turbines. Type of Industrial Steam Turbines.

Reference Books:

1. Turbines Fans and Compressors S.M. Yahya
2. A Practical Guide to Steam Turbine Technology - Heinz P. Bloch

MD1117	Programme Elective -III	Advance Mechanisms	3

Module1

Introductiontokinematics,typesofmechanism,kinematicssynthesis,scienceofrelativemotion,tasks ofkinematicsynthesiswithpracticalapplications,Degreeof freedom,class-I,class-IIchain,Harding's notation,Grashofcriterion,Grubler'scriterion.

Module 2

Introduction to position generation problem,concept of pole,two & three-position generation synthesis, pole triangle,Relationship between moving & fixed pivots, Fourposition generation, opposite pole quadrilateral, centerpoint&circle point curve, Burmester'spoint.

Module 3

Matrixmethod for position generation problem, rotation matrix, displacement matrix. Introduction to function eneration problem, coordination ofinput-output link motion,relative pole technique, inversion technique,overlay technique,graphical synthesis of quick return mechanisms for optimum transmission angle.

Module 4

Types of errors, accuracy point schebyshev's spacing, and Freudenstein equation. Introduction to path generation problem, synthesis for path generation with and without prescribed timing using graphical method.Couplercurves,cognatelinkages,Robert'slawof cognate linkages.

Module 5

Complex number method for path generation problem 3 precision point.Synthesis for infinitesimally separatedposition, the concept of polodeandcentrod, Euler'ssavery equation, inflection circle, Bobbilier and Hartman's construction. Optimal synthesis of planer mechanisms, least square method. Introduction to spatial mechanisms,D-Hnotations,Introduction to kinematic analysis of robot arms.

ReferenceBooks:

1. TadD.C,"Appliedlinkagesynthesis",AddisonWesleypublication,1964.
2. SandorG.N.,Erdman,A.G,"Advancedmechanismdesign",PrenticeHallInc,1984
3. SuhC.H.,RadcliffC.W,"Kinematicsandmechanismsdesign",JohnWiley&Sons.,1978.

MD1201	**Lab I**	**Thermal Engineering Lab -I**	**2**

Syllabus:

Thelab practice consists of experiments, tutorials and assignments decided by the coursesupervisors of the program core courses and program specific elective courses.

MD1202	**Lab II**	**Thermal Engineering Lab -II**	**2**

MD 1202 Lab–I I

The lab practice consists of experiments,tutorials and assignments decided by the course supervisors of theprogram core courses and program specific elective course

Compulsory Paper: Research Methodology and IPR (RMC 1101)

Syllabus:

Module 1:
Meaning of research problem, Sources of research problem, Criteria Characteristics of agood research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Module 2:
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Module 3:
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 4:
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 5:
New Developments in IPR: Administration of Patent System. New developments in IPR;IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Reference Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.

MD2101	Core III	Finite Element Method	3

Syllabus

Module 1

Introduction, Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear, etc,

Module 2

Differential equation as the starting point for FEM, steps in finite element method,discretization, types of elements used, Shape functions, Linear Elements, Local andGlobal coordinates, Coordinate transformation and Gauss-Legendre scheme ofnumerical integration, Nodal degrees of freedom,

Module 3

Finite element formulation, variational, weighted residual, and virtual work methods.

Module 4

1-D and 2-D problems from Structural Mechanics – Bar, Beam, Plane stress ,and planestrain problems, Axisymmetric problems – Axi-symmetric forces and geometry,

Module 5

computer implementation, higher-order elements, iso-parametric formulation,Eigen-value problems, Natural vibration of bars and beams, Methods to find eigenvalues and eigenvectors.

Reference Books:

1. Chandrupatla and Belegundu "Introduction to Finite Elements in Engineering", Prentice-Hall of India Pvt. Ltd. New Delhi, Ed.4, 11.
2. Logan Deryl L., "A First Course in Finite Element Method", Thomson Brook/Cole,5th Ed. 12
3. Cook R.D. "Concepts and applications of finite element analysis" Wiley, New York, 4th Ed. 02.
4. Reddy J N, "Finite element Method", Tata McGraw Hill Publishing Co Ltd, New Delhi, 3rd Ed.,

5 Bathe K.J., Cliffs, N.J. "Finite Element Procedures in Engineering Analysis", PHI Learning, Eastern Economy Editions, 09.

MD2102	Core IV	Computer-Aided Design	3

Syllabus

Module 1:
CAD Hardwareand Software, Types of systems and system considerations, input and outputdevices,hardwareintegrationandnetworking,hardwaretrends,Softwaremodules.

Module2:
Computer Communications, Principle of networking, classification networks, network wring,methods,transmissionmedia,andinterfaces,network operatingsystems.

Modules 3:
ComputerGraphicsIntroduction,transformationof geometricmodels:translation,scaling, reflection, rotation, homogeneous representation, concatenated transformations; mappings of geometricmodels,translationalmappingrotationalmapping,generalmapping,mappingsaschanges ofcoordinatesystem;inversetransformationsandmapping.

Module 4:
Projections ofgeometric models, orthographic projections, Geometric Modeling, curverepresentation:Parametricrepresentationofanalyticcurves,parametricrepresentationofsynthetic curves,curvemanipulations.Surfacepresentation.

Module 5:
Fundamentalsofsolidmodeling,boundaryrepresentation(B-rep),ConstructiveSolidGeometry (CSF), sweep representation, Analytic Solid Modeling(ASM), other representations; solidmanipulations,solid modelling based applications: mass properties calculations, mechanical tolerancing,etc.Finite Element Modeling and Analysis, Finite Element Analysis, finite element modeling, mesh generation mesh requirements, semiautomatic methods, fully automatic methods,design and engineering applications,System Simulation, Need of simulation,areasof applications, when the simulation is appropriate tool/not appropriate, the concept of a system,components of asystem,discreteandcontinuoussystems, model of a system,types of models,types of simulation approaches.

Reference Books:
1.IbrahbimZeid,"CAD/CAMTheoryandPractice".
2.JimBrowne,"ComputerAidedEngineeringandDesign".
3.P.Radhakrishnan/V.Raju/S.Subramanyam,"CAD/CAM/CIM".
4.P.N.Rao,"CAD/CAMprinciplesandapplications",TataMcraw-Hill,02.
5.Rogers/Adams,"MathematicalElementsforComputerGraphics".

MD2103	Programme Elective IV	Tribology in Design	3

Syllabus:

Module1:
Friction, theories of friction, Friction control, Surface texture andmeasurement, the genesis of friction, instabilities and stick-slipmotion.

Module2:
Wear,types of wear, theories of wear, wear prevention.

Module3:
Tribological properties of bearing materials and lubricants.

Module4:
Lubrication, Reynolds'sequation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders,infinitely long and infinitelyshort(narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff's solution), FiniteBearings,Design of hydrodynamic journal bearings

Module5:
Hydrostatic, squeeze film Circular and rectangular flat plates,variable and alternating loads, piston pin lubrications, application to journal bearings.Elastohydro dynamic lubrication– pressure viscosity term in Reynolds's equation, Hertz' theory, Ertel-Grubinequation, lubrication of spheres, gear teeth and rolling element bearings, Air lubricatedbearings,Tiltingpad bearings.

Reference Books:

1. Cameron,"BasicLubricationTheory",EllisHorwoodLtd,1981.
2. PrinciplesinTribology,EditedbyJ.Halling,1975
3. Fundamentals of FluidFilm Lubrication – B. J. Hamrock, McGraw Hill International,1994
4. D.D.Fuller,"Theory andPracticeofLubricationforEngineers",JohnWileyandSons,1984.
5.FundamentalsofFrictionandwearofMaterials"AmericanSocietyofMetals.
6. IntroductiontoTribologyofBearings–B.C.Majumdar,A.H.Wheeler&co.pvt.Ltd1985.

MD2104	Programme Elective IV	Robotics	3

Syllabus:

Module1:Introduction:
Basic Conceptssuch as Definition, three laws, DOF, Misunderstood devices,etc., Elements ofRobotic Systemsi.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, etc. Automation -Concept, Need, Automation inProduction System, Principles andStrategies ofAutomation, Basic ElementsofanAutomated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.

Module2:RobotGrippers:
Types of Grippers, Design aspect for the gripper, Force analysis for various basic gripper systems. Sensors for Robots:-Characteristics of sensing devices, Selections ofsensors, Classification,and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.

Module3:Drivesandcontrolsystems:
Typesof Drives,Actuatorsanditsselectionwhiledesigningarobotsystem.Typesof transmission systems,Control Systems -Typesof Controllers, Introduction to closed loop control Control Technologies in Automation:-Industrial Control Systems, Process Industries VersesDiscrete- Manufacturing Industries, Continuous Verses Discrete Control, Computer Process ,and its Forms. Control System Components such as Sensors, Actuators and others.

Module 4: Kinematics:
Transformation matrices and their arithmetic, link and joint description, Denavit–Hartenbergparameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods. Velocities and Static forces in manipulators:-Jacobians, singularities, staticforces,Jacobianin force domain. Dynamics:-Introduction to Dynamics,Trajectory generations.

Module5:MachineVisionSystem:
MachineVisionSystem:Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation. Robot Programming:- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAYcommands, subroutines, Programming Languages: Introduction to various types such as RAIL and VALII etc, Features of type and development of languages for recent robot systems.

Modeling and Simulation for manufacturing Plant Automation: Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation.

Artificial Intelligence:-Introduction to Artificial Intelligence, AItechniques,Need and application of AI.Other Topics in Robotics:-Socio-Economic aspect of robotisation.Economicalaspectsfor robot design,Safety for robot and associated mass,NewTrends & recent updates in robotics.

Reference Books:

1. JohnJ.Craig,IntroductiontoRobotics(MechanicsandControl),Addison-Wesley, 2nd Edition,04
2. Mikell P. Groover et. Al., IndustrialRobotics: Technology, Programming and Applications,McGraw–HillInternational,1986.
3. ShimonY.Nof,HandbookofIndustrialRobotics,JohnWileyCo,01.
4. Automation,ProductionSystemsandComputerIntegratedManufacturing,M.P.Groover, PearsonEducation.
5. IndustrialAutomation:W.P.David,JohnWiley andSons.

MD2105	Programme Elective IV	Fracture Mechanics	3

Syllabus

Module 1

Modes of fracture failure, Brittle and ductile fracture,

Module 2

Energy release rate: crack resistance, stable and unstable crack growth.

Module 3

Stress intensity factor: Stress and displacement fields, edge cracks, embedded cracks.

Module 4

Crack tip plasticity: Shape and size of the plastic zone, effective crack length, the effect of plate thickness, Crack tip opening displacement, J-integral Fatigue failure: Crack propagation, effect of an overload, crack closure, variable amplitude fatigue load.

Module 5

Test methods for determining critical energy release rate, critical stress intensity factor Environment-assisted cracking. Dynamic mode cracks initiation and growth, various crack detection techniques.

Reference Books:

1. Brook D, “Elementary engineering fracture mechanics”.
2. Liebowitz H., “Fracture” Volume I to VII.
3. A Nadai, W. S. Hemp, “Theory of flow and fracture of solids”, McGraw Hill Book Company, 1950.

MD2106	Programme Elective IV	Mechanical Behaviour of Materials	3

Syllabus:

Module 1

Introduction:Overviewofthecourse,examinationandevaluationpatterns,historyandIntroductiontoMechanicalbehaviourofMaterials.

Module 2

Fundamental concepts: Mechanical properties ofmaterials, stressandstrain, Mohr's strain circle, Elasticity,plasticity,TensileTesting,stress-straincurveforductile,brittleandpolymermaterials, Bridgmancorrection,Othertestsofplasticbehavior.

Module 3

Strainhardening: Strainhardening ofmetals,StrainrateandTemperature dependence, Hardening mechanismsinmetals-strainhardening,solidsolutionstrengthening,dynamicstrainageing.

Module 4

Fatigue,FractureandCreepmechanisms: S-Ncurves,effectofmeanstress,stressconcentration, design estimates, cyclic stress-strain behavior, Ductility andFracture, slipsystem, Griffithstheory, Orowantheory,theoreticalfracturestrength, Irwin'sfractureanalysis, fracturemechanicsindesign,Creepmechanisms, the temperaturedependenceofcreep.

Module 5

Mechanicalbehaviourofothermaterials:Mechanical behaviour ofceramics,glasses,polymers, andComposites:FRPandMMC,Materialcharacterizationusingopticalmicroscopyand SEM.

Reference Books:

1.GeorgeE.Dieter,MechanicalMetallurgy,McGrawHill,2ndEd,2005.
2.HellanK,IntroductiontoFractureMechanics,McGrawHill,2002.
3.J.E.Dorn,Mechanicalbehaviourofmaterialsatelevatedtemperatures,McGrawHill,2000.

MD2107	Programme Elective IV	Advance Composite	3

Syllabus:

Module 1

Introduction: Overview of the course,examination and evaluation patterns,history and basic concept of composites.

Module 2

Fundamentalconcepts: Definition and Classification of Composites, MMC, PMC, CMC.Reinforcing fibres-Natural fibres(cellulose, jute,coiretc),boron, carbon, ceramicglass, aramids, polyethylene (UHMWPE), polybenzthiazoles etc. Particulate fillers-importance of particle shape and size. Matrix resins-thermoplastics and thermosetting matrix resins.Coupling agents-surface treatment offillers and fibres, significance of interfacein composites. Nanocomposites, short and continuous fiberrein forced composites,critical fibre length,and anisotropic behaviour.

Module 3

Engineeringmechanicsanalysisanddesign:conceptsof isotropyvs. anisotropy,composite micromechanics (effective stiffness/ strength predictions, load-transfer mechanisms), Classical Lamination Plate theory(CLPT).

Fabricationtechniques:pultrusion,filament winding, prepreg technology,injection and compression moulding,bag moulding,resin transfermoulding,reaction injection moulding.

Module 4

Properties andperformance of composites: Properties and microstructure of high-strength fibermaterials(glass,carbon,polymer,ceramicfibers) and matrix materials (polymer, metal,ceramic,and carbon matrices). Specific strength and stiffness of high-performance composites. Rule of mixtures. Stress,straintrans formations.

Module 5

Failure criteria: Hygrothermal stresses, bending of composite plates, analysis of sandwich plates, buckling analysis of laminated composite plates, inter-laminar stresses,FirstOrderShearDeformation Theory(FSDT).Application**s:** Industrial,aerospace,automobile,householdetc.

Reference Books:

1.StevenL.Donaldson,ASMHandbookCompositesVolume21,2001.
2.KrishanK.Chawla,CompositeMaterials,ScienceandEngineering,Springer,2001.
3.SureshG.Advani,E.MuratSozer,ProcessModellinginCompositesManufacturing,2ndEd.CRC Press,2009

MD2108	Programme Elective V	Multi-body Dynamics	3

Syllabus:

Module 1.Introduction:
The method of constraints for planar kinematic analysis. Revolute, prismatic, gear, and cam pairs are considered together with other 2 degrees-of-freedom types of constraints.
Basic principles for the analysis of multi-body systems:The automatic assembly of the systems of equations for position, velocity and acceleration analysis. Iterative solution of systems of non linear equations. Geometry of masses. The principle of virtual work and Lagrange's equations.

Module 2.Dynamics of Planar Systems:
Dynamics of planar systems. Systematic computation and assembly of mass matrix. Computation of planar generalized forces for external forces and for actuator-spring-damper element. Simple applications of inverse and forward dynamic analysis. Numerical integration of first-order initial- value problems. The method of Baumgarte for the solution of mixed differential-algebraic equations of motion. The use of coordinates partitioning, QR and SVD decomposition for the orthogonalization of constraints.

Module 3.Kinematics of rigid bodies in space:
Reference frames for the location of a body in space. Euler angles and Euler parameters. The formula of Rodrigues. Screw motion in space. Velocity, acceleration and angular velocity. Relationship between the angular velocity vector and the time derivatives of Euler parameters.

Module 4.Kinematic analysis of spatial systems:Basic kinematic constraints. Joint definition frames. The constraints required for the description in space of common kinematic pairs (revolute, prismatic, cylindrical, spherical). Equations of motion of constrained spatial systems.

Module 5.Computation of Forces:
Computation of spatial generalized forces for external forces and for actuator-spring-damper element. Computation of reaction forces from Lagrange's multi- pliers.

Reference Books:

1. Wittenburg, J., Dynamics of Systems of Rigid Bodies, B.G. Teubner, Stuttgart, 1977.
2. Kane, T.R, Levinson, D.A., Dynamics: Theory and Applications, McGraw-Hill Book Co., 1985.
3. Nikravesh, P.E., Computer Aided Analysis of Mechanical Systems, Prentice-Hall Inc., Englewood Cliffs, NJ, 1988.
4. Roberson, R.E., Schwertassek, R., Dynamics of Multibody Systems, Springer-Verlag, Berlin, 1988.
5. Haug, E.J., Computer-Aided Kinematics and Dynamics of Mechanical Systems-Basic Methods, Allyn and Bacon, 1989.

MD2109	Programme Elective V	Condition Based Monitoring	3

Syllabus:

Module 1.
The basic idea of health monitoring and condition monitoring of structures and machines. Some basic techniques.

Module 2.
Basics of signal processing: Study of periodic and random signals, probability distribution, statistical properties, auto and cross correlation and power spectral density functions of commonly found systems, spectral analysis.

Module 3.
Fourier transform: the basic idea of Fourier transform, interpretation and application to real signals. Response of linear systems to stationary random signals: FRFs, resonant frequencies, modes of vibration,

Module 4.
Introduction to vibration-based monitoring, Machinery condition monitoring by vibration analysis: Use and selection of measurements, analysis procedures and instruments,

Module 5.
Typical applications of condition monitoring using vibration analysis to rotating machines, Some other health monitoring techniques, acoustic emission, oil debris and temperature analysis, Applications.

Reference Books:

1. M.Adams, Rotating machinery analysis - from analysis to troubleshooting, Marcel Dekker, New York.
2. Cornelius SchefferPareshGirdhar, Practical Machinery Vibration Analysis and Predictive Maintenance, Newnes, 1st Edition, 04.

MD2110	Programme Elective V	Optimization Techniques in Design	3

Syllabus :

Module 1:
Introduction to optimization, classification of optimisation problems, classical optimization techniques.

Module 2:
Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,

Module 3:
Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods,

Module 4:
Geometric programming, Optimum design of mechanical elements like beams, columns,gears, shafts, etc.

Module 5:
Introduction to Genetic Algorithms, Operators, applications to engineering optimization problems.

Reference Books:

1. S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York, 1985.
2. R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
3. J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
4. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi,
5. L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.

MD2111	Programme Elective V	Design for Manufacture and Assembly	3

Syllabus:

Module 1.Design for manufacturing:
Reduce the cost of manufacturing process, understanding the process and constraints, standard components and process, consider the impact of DFM decisions and other factors.

Module 2.Design consideration in metal casting:
Mold and Gating System Design,Directional Solidification, and Troubleshooting.

Module 3. Design for welding:
selection of materials for joining, welding defects, minimize the residual streses etc. Design for forging and sheet metal and powder metal process.

Module 4. Selection of materials:
choice of materials, organizing material and processes.

Module 5.Design for assembly and automation:

Application of Design for manufacture and assembly with selection of materials and ranking of processes like casting, injection moulding, sheet metal working, die casting, powder metal process, investment casting and hot forging, Design for assembly and automation.

Reference Books:

1. George E. Dieter, Engineering Design - A Material Processing Approach, 2nd Edition, McGraw Hill International, 2001.
2. Geoffrey Boothroyd, Peter Dewhurst, Product Design for Manufacture and Assembly, 3rd Edition, CRC Press, 2010.

MD2112	Programme Elective V	Mechatronics	3

Module 1.Introduction:
Overview of the course, Examination and Evaluation patterns, History of Mechatronics,Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing.

Module 2. Sensors:
classification of sensors basic working principles, Displacement Sensor - Linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders. Strain gauges. Force/Torque – Load cells. Temperature – Thermocouple, Bimetallic Strips, Thermistor, RTD Accelerometers, Velocity sensors – Tachometers, Proximity and Range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, Hall Effect sensor, inductive proximity switch. Light sensors – Photodiodes, phototransistors, Flow sensors – Ultrasonic sensor, laser Doppler anemometer tactile sensors – PVDF tactile sensor, micro-switch and reed switch Piezoelectric sensors, vision sensor.

Actuators: Electrical Actuators : Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys.

Module 3.Basic System Models & Analysis:
Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems. Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems.

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Module 4. Controllers:
Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

PLC Programming: PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

Case studies of Mechatronics systems: Pick and place robot, Bar code, Engine Management system, Washing machine etc.

Module 5. Robotics:

Introduction to Robotics, Robot anatomy physical configurations, Manipulator, Kinematics, Technical features. Programming of Mobile robot, robot programming language, end effecters, work cell design.

Reference Books:

1. W. Bolton, "Mechatronics", 5th edition, Addison Wesley Longman Ltd, 2010
2. DevdasShetty& Richard Kolk "Mechatronics System Design", 3rd ed. PWS Publishing, 2009.
3. Alciatore David G &Histand Michael B, "Introduction to Mechatronics and Measurement System4th ed, Tata McGraw Hill, 2006.
4. Saeed B Niku, "Introduction to Robotics: Analysis, Systems, Applications ", 2nd edition, PearsonEducation India, PHI, 2003.

MD2113	Open Elective 1	Business Analytics	3

Syllabus:

Module 1.

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Module 2.

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Module 3.

Organization Structures of Business analytics, Team management, Management Issues, DesigningInformation Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Module 4.

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models,Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Module 5.

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Reference Books:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G.
2. Schniederjans, Christopher M. Starkey, Pearson FT Press.
3. Business Analytics by James Evans, persons Education.

MD2114	Open Elective 1	Industrial Safety	3

Syllabus:

Module 1.
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Module 2.
Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Module 3. Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv.Gravit y lubrication, v.Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Module 4. Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Module 5.Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference Books:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

MD2115	**Open Elective 1**	**Operations Research**	**3**

Syllabus:

Module 1.
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Module 2.
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplexmethod - sensitivity analysis - parametric programming

Module 3.
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Module 4.
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Module 5.
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Reference Books:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009

MD2116	Open Elective 1	Cost Management of Engineering Projects	3

Syllabus:

Module 1
Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Module 2
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non- technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Module 3

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints.

Module 4.
Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Module 5.
Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Reference Books:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

MD2117	Open Elective 1	Composite Materials	3

Syllabus:

Module 1.
INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

Module 2.
REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

Module 3.
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

Module 4.
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

Module 5.
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Reference Books:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications ,Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

MD2118	**Open Elective 1**	**Waste to Energy**	**3**

Syllabus:

Module 1.
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Module 2.
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Module 3.
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Module 4.
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Module 5.
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Reference Books:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

MD2201	**Lab III**	**Finite Elements Methods Lab III**	**2**

The lab practice consists of experiments,tutorials and assignments decided by the course supervisors of the program core courses and program specificelective course.

MD2202	**Lab IV**	**Computer Design Lab IV**	**2**

The lab practice consists of experiments,tutorials and assignments decided by the course supervisors of the program core courses and program specific elective course.

MD2203	**Lab**	**Mini Project**	**2**

Guideline:

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.