MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech. (Mechanical Engineering)
Semester VIII

Syllabus

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Date:

UG/PG	Department: ME
Course Code: ME-412	Course Name: Robotics
Credit: 4	L-T-P: 3-1-0

Syllabus

Automation and Robotics, Robot Anatomy – Links, Joints and Joint Notation scheme, Degrees of Freedom (DOF), Required DOF in a Manipulator, Precision of Movement, The kinematic Modeling of Manipulator, Direct kinematics model mechanical structure & Notations Description of links & Joints, The Inverse kinematics manipulator: workspace, solvability of inverse kinematic model. Solution technique, closed form solutions. Types of end-effector, methods of holding, Mechanical grippers, Mechanisms for grippers.

Differential kinematics, linear and angular velocity of a Rigid Body, Relationship between Transformation matrix and angular velocity, mapping velocity vectors, velocity propagation along links. Manipulator Jacobian, Jacobian Inverse, Jacobian singularities, Static Analysis. Jacobian, Examples.

Lagrangian Mechanics, Lagrange – Euler formulation - Velocity of a point on the manipulator, The inertia tensor, The kinetic energy, the potential energy. Equations of Motions, the Lagrangian-Euler (LE) Dynamic model algorithm. Examples on Dynamic modeling.

Control of movements of mechanical joints, control sequence, n-joints manipulator control system, system performance, control system with damping, control strategy, Architecture of control systems.

Robot Programming issues, optimization position definitions, interpolation language command, data object command, motion commands, gripper command, tool commands, sensors command, other command, Writing programs for different tasks.

Text Book:

1. Mittal R. K. &Nagrath I. J., "Robotics and Control", TMH, 2003 (Reprint 2007 or later).
2. Groover, M. P., et al., "Industrial Robotics", MGHISE, 1986
3. Fu, K. S., et al., Robotic: Control, Sensing, Vision & Intelligence, MGHISE, 1987.
4. Robert J., Schilling, *Fundamentals of Robotics: Analysis and Control*, Prentice Hall, NJ, 2002.

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Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code: MET-425	Course Name:Tool Engineering
Credit:4	L-T-P:3-1-0

Syllabus

1. Introduction to Tool design

Introduction –Tool Engineering – Tool Classifications– Tool Design Objectives – Tool Design in manufacturing- Challenges and requirements- Standards in tool design-Tool drawings -Surface finish – Fits and Tolerances - Tooling Materials- Ferrous and Non ferrous Tooling Materials- Carbides, Ceramics and Diamond -Non metallic tool materials- Designing with relation to heat treatment

2. Design of cutting Tools

Mechanics of Metal cutting –Oblique and orthogonal cutting- Chip formation and shear angle - Single-point cutting tools – Milling cutters – Hole making cutting tools- Broaching Tools - Design of Form relieved and profile relieved cutters-Design of gear and thread milling cutters

3. Design of Jigs and Fixtures

Introduction – Fixed Gages – Gage Tolerances –selection of material for Gages – Indicating Gages – Automatic gages – Principles of location – Locating methods and devices – Principles of clamping – Drill jigs – Chip formation in drilling – General considerations in the design of drill jigs – Drill bushings – Methods of construction –Thrust and Turning Moments in drilling - Drill jigs and modern manufacturing- Types of Fixtures – Vise Fixtures – Milling Fixtures – Boring Fixtures – Broaching Fixtures – Lathe Fixtures – Grinding Fixtures – Modular Fixtures – Cutting Force Calculations.

4. Design of Forming Tools

Types of Sheet Metal Dies –Method of Die operation–Clearance and cutting force calculations- Blanking and Piercing die design – Pilots – Strippers and pressure pads- Presswork materials – Strip layout – Short-run tooling for Piercing – Bending dies – Forming dies – Drawing dies-Design and drafting. Design of Bulk forming dies and moulds for metals and plastics.

5. Tool Design for CNC machine tools

Introduction –Tooling requirements for Numerical control systems – Fixture design for CNC machine tools- Sub plate and tombstone fixtures-Universal fixtures– Cutting tools– Tool holding methods– Automatic tool changers and tool positioners – Tool presetting– General explanation of the Brown and Sharp machine

Books:

1. Cyrll Donaldson, George H.LeCain, V.C. Goold, “Tool Design”, Tata McGraw Hill Publishing Company Ltd., 2000.

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2. E.G.Hoffman," Jig and Fixture Design", Thomson Asia Pvt Ltd, Singapore, 2004
3. Venkataraman K., "Design of Jigs, Fixtures and Presstools", TMH, 2005
4. Haslehurst M., "Manufacturing Technology", The ELBS, 1978

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Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code: MET-426	Course Name:Mechatronic Design
Credit:4	L-T-P:3-1-0

Syllabus

Introduction to system concepts: analysis of systems and design of systems. Definitions of mechatronics, the mechatronic design process, mechatronic systems and components. Modeling of lumped mechanical, electrical, thermal and fluid systems. Systems with mixed disciplines; mechanical equivalents for magnetic and electrostatic elements, strategy for electromechanical design. Amplifiers, actuators, controls and sensors with mixed disciplines. Design-oriented approach to Microsystems; design of cantilever devices, torsion bar devices and diaphragm devices. Design of robot hand, design of insulin dispenser and design of auto focus for camera.

Books:

1. Cochin, Era and Cadwallender, "Analysis and design of Dynamic Systems", Addison-Wesley, 1997.
2. Tomkinson, D. And Horne, J. Longman, "Mechatronics Engineering", McGraw Hill, 1996.
3. Bolton, W., " Mechatronics", Pearson.

DUGC Convener Curriculum Committee Convener SUGB Chairman

Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code: MET-427	Course Name: Composite Materials Manufacturing
Credit:4	L-T-P:3-1-0

Syllabus

Unit-1 Introduction: Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential

Unit-2 Various types of composites: Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites

Unit-3 Fabrication methods: Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pltrusion, pre-peg layer, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films

Unit-4 Testing of Composites: Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.

Books:

1. Materials characterization, Vol. 10, ASM hand book
2. Mechanical Metallurgy by G. Dieter Mc-Graw Hill
3. Thermal Analysis of Materials by R.F. Speyer, Marcel Decker
4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall India

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Date:

UG	Department: Mechanical Engineering
Course Code: MET-428	Course Name: Six Sigma
Credit:4	L-T-P:3-1-0

Syllabus

Introduction to six sigma, Indicators of requirement of Six sigma, Elements of six sigma, Six sigma process – Define phase, Six sigma tools (QFD, SIPOC) – Define phase, Six sigma process – Measure phase, Six sigma tools (CTQ tree, Process capability calculation, Measurement system analysis using gauge R&R) – Measure phase, Six sigma process – analyse phase, Six sigma tools (Histogram, box plot, control chart, scatter chart, fish bone diagram, pareto analysis chart, interrelations diagram) – analyse phase, Six sigma special tools (Regression analysis, Hypothesis testing, ANOVA, Multivariate analysis), Six sigma – process improvement, Six sigma tools (Affinity diagram, FMEA, DOE), Six sigma process – control phase, Six sigma tools (Value stream mapping, control charts, TPM, Poka – yoke), Implementing six sigma

Reference Books

Henderson, G. R. (2007), Six Sigma Quality Improvement with MINITAB, Wiley

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Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code: MET-429	Course Name: Special Course in manufacturing
Credit:4	L-T-P:3-1-0

Syllabus

1) Casting of the engine block – conventional and expendable pattern.
2) Casting of the cylinder heads, forging of crankshaft, connecting rod and gudgeon pins.
3) Casting of piston, upset forging of valves, piston ring manufacturing & engine bearing manufacturing.
4) Manufacturing of friction plates, manufacturing of composite friction lining, casting of gear box casting, precision forging of gears.
5) Continuous casting of propeller shaft, forging of rear axles, casting of rear axle casting, wheels, brake drum.
6) Tyre manufacturing.
7) Thermoforming, hydro forming & press forming, welding of body panels.
8) Injection moulding of instrument panel.
9) Metal/polmer/metal panel, adhesive & sealants.
10) Leaf spring manufacturing.
11) Chemical vapour deposition and physical vapour deposition.
12) Spraying, plating and painting in paint booth.
13) Starter motor and alternator.
14) Regulator, battery, lamps, control switches and electronic gauges.

Books:

1) Heldt P M "HIGH SPEED COMBUSTION ENGINE " , Oxford HBH publishing Co.. Calcutta 1996.
2) Philip F Ostwald and jairomunuz," Manufacturing processes and systems", john Walley& Sons, New York, 1998.
3) Kalpakjian,"Manufacturing engineering and technology", Pearson Education, 2005

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Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code:	**Course Name:Smart Materials**
Credit:4	**L-T-P:3-1-0**

Syllabus

Unit-1 Introduction: Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential

Unit-2 Various types of composites: Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites

Unit-3 Fabrication methods: Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pltrusion, pre-peg layer, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films

Unit-4 Testing of Composites: Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.

Books:

1. Materials characterization, Vol. 10, ASM hand book
2. Mechanical Metallurgy by G. Dieter Mc-Graw Hill
3. Thermal Analysis of Materials by R.F. Speyer, Marcel Decker
4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall of India

DUGC Convener Curriculum Committee Convener SUGB Chairman

Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code: MET-430	Course Name:Composite Materials and Mechanic
Credit:4	L-T-P:3-1-0
Pre-requisite course: Mechanics of Solid/Adv. Mech. of Solids	

Syllabus

Introduction to Composite Materials Constituents, Material forms Processing, Applications Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.

Lamina Constitutive Equations:Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.

Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure

Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies

Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations. Orthotropic Lamina - special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates - Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates

Books:

1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
2. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
3. Hyer, M.W., "Stress Analysis of Fiber-Reinforced Composite Materials", McGraw-Hill, 1998.
4. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006
5. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006.

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Date:

UG/PG : UG	Department: Mechanical Engineering
Course Code:	Course Name:Fracture Mechanics
Credit: 4	L-T-P: 3-1-0
Pre-requisite course: Mechanics of Solid/Adv. Mech. of Solids	

Syllabus

Introduction: Kinds of failure and history Conventional failure criteria, Characteristic brittle failures, Griffith's work, Fracture mechanics, Dilemma of Griffith, Surface energy, Griffith's realization, Griffith's analysis, Mathematical formulation, Thin plate vs thick plate Critical energy release rate.

Stress intensity factor (SIF): Linear elastic fracture mechanics (LEFM), Stress and displacement fields in isotropic elastic materials, Elementary properties of complex variables

SIF of more complex cases: Application of the principle of superposition, Crack in a plate of finite dimensions, Edge cracks, Embedded cracks, Relation between G_I and K_I

Anelastic deformation at the crack Tip: Further Investigation at the crack tip, Approximate shape and size of the plastic zone, Effective crack length, Effect of plate thickness.

Elastic plastic analysis through J-Integral: Relevance and scope, Definition of J-Integral, Path independence, Stress-strain relation.

Crack tip opening displacement (CTOD): Relationship between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J.

Test methods K_{IC} test techniques, Test methods to determine J_{IC}, Test methods to determine G_{IC} and G_{IIC}, Determination of critical CTOD.

Fatigue failure: Terminology, S-N curve, Crack initiation, Crack propagation, Effect of an overload, Crack closure, Variable amplitude fatigue load.

Mixed mode crack initiation and growth: Fracture surface, Mixed mode crack propagation criteria, Crack growth.

Crack detection through NDT: Visual, LPI, Magnetic Methods, Radiography, Ultrasonics

Books:

1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
2. T .L . Anderson, Fracture Mechanics - Fundamental s and Applications, 3rd
3. Edition, Taylor and Francis Group, 2005.
4. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic, Publishers, Dordrecht , 1986.

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Date:

UG/PG	Department: ME
Course Code: MET422	Course Name: Computational Fluid Dynamics
Credit: 4	L-T-P: 3-1-0-4

Syllabus

Introduction to CFD: methods of prediction ,potential and limitation of CFD; Review of numerical techniques: Solution of IVP and BVP, Euler method ,Runge-Kutta method, accuracy and errors, solution of linear algebraic equations, convergence; Mathematics of physical model :conservation law, classification of PDE's, initial and boundary conditions ,coordinate systems; Discretization methods; Method of weighted residuals, finite difference method (FDM), finite volume method(FVM), implicit and explicit schemes, consistency, stability and convergence; Modelling of diffusion problems: Numerical solution of one dimensional steady state heat conduction, unsteady heat conduction, Crank-Nicolson scheme, ADI scheme, heat conduction in multidimensional cases; Modelling of convection diffusion problems: One dimensional convection-diffusion using central difference scheme, upwind scheme, transportive property, numerical diffusion (artificial viscosity), higher order schemes; Modelling fluid flow: Discretization of incompressible Navier Stokes equations, vorticity and pressure based methods, staggered and collocated grid; Modelling multiphase problems: Fixed grid and moving grid methods, enthalpy based method for melting and solidification, VOF method for two phase flows

Prerequisites / Recommended Background:

1. Basic programming skills (FORTRAN, C, MATLAB etc.)
2. Basic Fluid Mechanics/Heat Transfer/Transport Phenomena
3. Applied Mathematics

Textbook(s):

1. W Malalasekera. An introduction to computational fluid dynamics: the finite volume method. Pearson Prentice Hall, 2007
2. Suhas Patankar. Numerical heat transfer and fluid flow. CRC press, 1980

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Date:

UG/PG	Department: ME
Course Code: MET411	Course Name: FINITE ELEMENT METHODS
Credit: 3	L-T-P: 3-0-0

Introduction to FEM: History and basic concepts of FEM, Integral Formulations and Variational Methods: Weighted integral forms.

One Dimensional Problems: Finite Element Modeling, Coordinates and Shape Functions, Galerkin's approach, Assembly of the Global stiffness Matrix and Load Vector, Treatment of Boundary Conditions – Elimination Approach, Penalty Approach, Quadratic Shape Functions, Temperature Effects. Plane Trusses: Local and Global Coordinate System, Element Stiffness Matrix, Stress Calculations, Temperature Effects. Beams and Frames: Finite Element Formulation using Potential Energy Approach and Galerkin's Approach, Load Vector, Boundary Conditions, Shear Force and Bending Moment, Beams on Elastic Supports, Plane Frames

Two Dimensional Problems: Constant Strain Triangle Element:, Potential Energy Approach, Element Stiffness Matrix, Force Terms, Galerkin's Approach, Stress Calculations, Temperature Effects. Axisymmetric Solids Subjected to Axisymmetric Loading: Formulation, Potential Energy Approach, Body Force, Rotating Flywheel, Surface Traction, Galerkin's Approach, Stress Calculations, and Temperature Effects.

Isoparametric Formulation and Numerical Integration: Four nodded quadrilateral, Numerical Integration, Higher Order Elements. Dynamic Considerations: Formulation, Element Mass Matrix, Eigenvalue and Eigenvector evaluation, Determination of Critical Speeds, Guyan Reduction, Rigid Body Modes.

Textbook(s)/Reference book(s)

1. *The Finite Element Method: Its Basis & Fundamentals*, Zienkiewicz.O.C, Taylor.R.L,&Zhu,J.Z, , India published by Elsevier India Pvt. Ltd., New Delhi.,2013
2. *Textbook of Finite element Analysis*, P. Seshu , PHI, Eighteenth Printing, 2019
3. *Introduction To Finite Element Method*, J. N. Reddy, McGraw Hill, 2020
4. *A First Course in the Finite Element Method*, Daryl L Logan, CL Engineering, 2016

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