

**MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR**  
**DEPARTMENT OF MECHANICAL ENGINEERING**

**B.Tech. (Mechanical Engineering)**  
**Semester VIII**

**Syllabus**

DUGC Convener

Curriculum Committee Convener  
Date:

SUGB Chairman

<b>UG/PG</b>	<b>Department: ME</b>
<b>Course Code: ME-412</b>	<b>Course Name: Robotics</b>
<b>Credit: 4</b>	<b>L-T-P: 3-1-0</b>
<b>Syllabus</b>	
<p>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 &amp; Notations Description of links &amp; 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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p><b>Text Book:</b></p> <ol style="list-style-type: none"> <li>1. Mittal R. K. &amp;Nagrath I. J., “Robotics and Control”, TMH, 2003 (Reprint 2007 or later).</li> <li>2. Groover, M. P., et al., “Industrial Robotics”, MGHISE, 1986</li> <li>3. Fu, K. S., et al., Robotic: Control, Sensing, Vision &amp; Intelligence, MGHISE, 1987.</li> <li>4. Robert J., Schilling, <i>Fundamentals of Robotics: Analysis and Control</i>, Prentice Hall, NJ, 2002.</li> </ol>	

<b>UG/PG : UG</b>	<b>Department: Mechanical Engineering</b>
<b>Course Code: MET-425</b>	<b>Course Name: Tool Engineering</b>
<b>Credit:4</b>	<b>L-T-P:3-1-0</b>
<b>Syllabus</b>	
<p><b>1. Introduction to Tool design</b>  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</p>	
<p><b>2. Design of cutting Tools</b>  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</p>	
<p><b>3. Design of Jigs and Fixtures</b>  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.</p>	
<p><b>4. Design of Forming Tools</b>  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.</p>	
<p><b>5. Tool Design for CNC machine tools</b>  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</p>	
<p><b>Books:</b></p> <p>1. Cyrll Donaldson, George H.LeCain, V.C. Goold, “Tool Design”, Tata McGraw Hill Publishing Company Ltd., 2000.</p>	

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

DUGC Convener

Curriculum Committee Convener  
Date:

SUGB Chairman

<b>UG/PG : UG</b>	<b>Department: Mechanical Engineering</b>
<b>Course Code: MET-426</b>	<b>Course Name: Mechatronic Design</b>
<b>Credit:4</b>	<b>L-T-P:3-1-0</b>
<b>Syllabus</b>	
<p>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.</p>	
<b>Books:</b>	
<ol style="list-style-type: none"> <li>1. Cochran, Era and Cadwallender, "Analysis and design of Dynamic Systems", Addison-Wesley, 1997.</li> <li>2. Tomkinson, D. And Horne, J. Longman, "Mechatronics Engineering", McGraw Hill, 1996.</li> <li>3. Bolton, W., " Mechatronics", Pearson.</li> </ol>	

<b>UG/PG : UG</b>	<b>Department: Mechanical Engineering</b>
<b>Course Code: MET-427</b>	<b>Course Name: Composite Materials Manufacturing</b>
<b>Credit:4</b>	<b>L-T-P:3-1-0</b>
<b>Syllabus</b>	
<p><b>Unit-1 Introduction:</b> 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</p> <p><b>Unit-2 Various types of composites:</b> 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 &amp; limitations of Composites</p> <p><b>Unit-3 Fabrication methods:</b> Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament winding, 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</p> <p><b>Unit-4 Testing of Composites:</b> Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.</p> <p><b>Books:</b></p> <ol style="list-style-type: none"> <li>1. Materials characterization, Vol. 10, ASM hand book</li> <li>2. Mechanical Metallurgy by G. Dieter Mc-Graw Hill</li> <li>3. Thermal Analysis of Materials by R.F. Speyer, Marcel Decker</li> <li>4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall India</li> </ol>	

<b>UG</b>	<b>Department: Mechanical Engineering</b>
<b>Course Code: MET-428</b>	<b>Course Name: Six Sigma</b>
<b>Credit:4</b>	<b>L-T-P:3-1-0</b>
<b>Syllabus</b>	
<p>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&amp;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</p>	
<b>Reference Books</b>	
Henderson, G. R. (2007), Six Sigma Quality Improvement with MINITAB, Wiley	

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

### 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



<b>UG/PG : UG</b>	<b>Department: Mechanical Engineering</b>
<b>Course Code:</b>	<b>Course Name:Smart Materials</b>
<b>Credit:4</b>	<b>L-T-P:3-1-0</b>
<b>Syllabus</b>	
<p><b>Unit-1 Introduction:</b> 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</p> <p><b>Unit-2 Various types of composites:</b> 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 &amp; limitations of Composites</p> <p><b>Unit-3 Fabrication methods:</b> Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament winding, 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</p> <p><b>Unit-4 Testing of Composites:</b> Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.</p> <p><b>Books:</b></p> <ol style="list-style-type: none"> <li>1. Materials characterization, Vol. 10, ASM hand book</li> <li>2. Mechanical Metallurgy by G. Dieter Mc-Graw Hill</li> <li>3. Thermal Analysis of Materials by R.F. Speyer, Marcel Decker</li> <li>4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall of India</li> </ol>	

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

### 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, 2<sup>nd</sup> ed., CRC Press, 2006
5. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006.

<b>UG/PG : UG</b>	<b>Department: Mechanical Engineering</b>
<b>Course Code:</b>	<b>Course Name:Fracture Mechanics</b>
<b>Credit: 4</b>	<b>L-T-P: 3-1-0</b>
<b>Pre-requisite course: Mechanics of Solid/Adv. Mech. of Solids</b>	
<b>Syllabus</b>	
<p>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.</p> <p>Stress intensity factor (SIF): Linear elastic fracture mechanics (LEFM), Stress and displacement fields in isotropic elastic materials, Elementary properties of complex variables</p> <p>SIF of more complex cases: Application of the principle of superposition, Crack in a plate of finite dimensions, Edge cracks, Embedded cracks, Relation between <math>G_I</math> and <math>K_I</math></p> <p>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.</p> <p>Elastic plastic analysis through J-Integral: Relevance and scope, Definition of J-Integral, Path independence, Stress-strain relation.</p> <p>Crack tip opening displacement (CTOD): Relationship between CTOD, <math>K_I</math> and <math>G_I</math> for small scale yielding, Equivalence between CTOD and J.</p> <p>Test methods <math>K_{IC}</math> test techniques, Test methods to determine <math>J_{IC}</math>, Test methods to determine <math>G_{IC}</math> and <math>G_{IIC}</math>, Determination of critical CTOD.</p> <p>Fatigue failure: Terminology, S-N curve, Crack initiation, Crack propagation, Effect of an overload, Crack closure, Variable amplitude fatigue load.</p> <p>Mixed mode crack initiation and growth: Fracture surface, Mixed mode crack propagation criteria, Crack growth.</p> <p>Crack detection through NDT: Visual, LPI, Magnetic Methods, Radiography, Ultrasonics</p>	
<b>Books:</b>	
<ol style="list-style-type: none"> <li>1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.</li> <li>2. T.L . Anderson, Fracture Mechanics - Fundamental s and Applications, 3rd Edition, Taylor and Francis Group, 2005.</li> <li>3. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic, Publishers, Dordrecht , 1986.</li> </ol>	