PMM107: MECHANICAL PROPERTIES OF MATERIALS

L	T	P	Cr
3	1	2	4.5

Course Objective(s): To understand the materials behavior under applied stress, understanding the mechanism involved in the material deformations and strengthening and the various mechanical testing methods.

Elastic Behavior of Materials: Description of stress and strain, State of stress in two and three dimensions, Stress and strain tensors, Mohr's circles of stress and strain, Hydrostatic and shear stresses, Elastic stress-strain relationship, Strain energy.

Plasticity in Materials: True stress-strain curve, Yielding criteria for materials, Anisotropy in yielding, Invariants of stress and strain, Plastic stress-strain relationship, Slip-line field theory. Instability under tensile conditions, Stress distribution at neck, Effects of strain rate and temperature on flow properties.

Plastic Deformation of Single Crystals: Stereographic projection, Concepts of lattice defects, Deformation by slip, Slip in a perfect crystal, Dislocation and slip by dislocation movement, Critical resolved shear stress for slip, Deformation of single crystals, Stacking faults and micro-strain.

Dislocation and Related Phenomena: Concepts of dislocation and classification, Burgers vector, Dislocations in face centered cubic and body centered cubic crystals, Energies of dislocations, Forces on dislocation, Forces between dislocation, Partial dislocations, Dislocation glide and climb, Slip, Dislocation intersection, Jogs, Dislocation sources (Frank-Read and grain boundary) and multiplication of dislocations, Dislocation point defect interaction and dislocation pileups, Dislocations in ceramics and glasses.

Strengthening Mechanisms in Materials: Grain boundaries, Low angle and high angle grain boundaries, Grain boundary strengthening, Yield point phenomenon, Strain aging, Solid solution hardening, Strengthening from fine particles, Strain hardening, Bauschinger effect.

Mechanical Testing: Tensile test of Metals, ceramics and polymers; Hardness testing of materials; Hardness at elevated temperature, Tension and Torsion Tests, Creep.

Laboratory Work:
To study the stress-strain curves of different metallic samples using tensometer, Deformation by creep in metals, Thermo-mechanical behaviour of rubber, Mechanical behaviour/strength of glass, Young's modulus and strength of fiber, Rockwell, Brinell hardness of metallic samples, Effect of heat treatment on yield strength and creep resistance of metallic wire, Decomposition of austenite as a function of cooling rate and the tempering the martensite as a function of temperature in 0.8% carbon steel, The precipitation hardening of Al-alloys on Isothermal aging, Grain size and microstructure changes of metallic sample(s) with respect to heat treatment and its impact on mechanical properties, Hardness of a specimen by Vicker micro hardness tester, Wear behavior of a given metallic materials.

Course Learning Outcomes (CLO):
Student will be able to:

1. Describe and predict elastic deformation in isotropic and anisotropic engineering materials;
2. Describe and predict yielding of engineering materials under uniaxial and multiaxial states of stress;
3. Describe the major microstructural-based mechanisms of strengthening in (crystalline) materials, and apply these principles to alloy and process design;
4. Identify the microstructural based dependencies of mechanical failure in engineering materials, including yielding, fracture, fatigue, and creep; and apply these principles to design and process failure-resistant materials.

Recommended Books:

1. *Dieter George E. Mechanical Metallurgy, Mc-Graw-Hill Book Company (SI ed.) (1989).*
2. *Suryanarayana C. Experimental Techniques in Materials and Mechanics, CRC Press (1980).*
3. *Roesler J. H., Harders, and Baeker M., "Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers, and Composites", Springer-Verlag, (2007).*