MATERIAL SCIENCE

Aim: At the end of the course the student will have an understanding of mechanics, physical and chemical properties of materials including metals, ceramics, polymers and composites and the reasons for these properties to exist.

Module 1: Introduction (3)

Historical perspective of Materials Science. Why study properties of materials? Classification of materials. Advanced Materials, Future materials and modern materials

Module 2: Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids (5)

Atomic structure. Atomic bonding in solids, Crystal structures, Crystalline and non-crystalline materials. Miller indices. Anisotropic elasticity. Elastic behavior of composites. Structure and properties of polymers. Structure and properties of ceramics.

Module 3: Imperfections in Solids (2)

Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations

Module 4: Mechanical Properties of Metals (3)

Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors

Module 5: Diffusion (2)

Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure

Module 6: Dislocations and Strengthening Mechanisms (3)

Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion

Module 7: Phase Diagrams (4)

Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system

Module 8: Failure (5)

Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behavior. Stress and temperature effects

Module 9: Applications and Processing of Metals and Alloys (2)

Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening.

Module 10: Applications and Processing of Ceramics (1)
Types and applications of ceramics. Fabrication and processing of ceramics.

Module 11: Applications and Processing of Polymers (2)

Mechanical behavior of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing.

Module 12: Composites (1)
Particle reinforced composites. Fiber reinforced composites. Structural composites

Module 13: Corrosion and Degradation of Materials (1)

Corrosion of metals. Corrosion of ceramics. Degradation of polymers

Module 14: Electrical Properties (1)

Electrical conduction. Semi conductivity. Super conductivity. Electrical conduction in ionic ceramics and in polymers. Dielectric behavior. Ferroelectricity. Piezoelectricity

Module 15: Thermal Properties (1)

Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses

Module 16: Magnetic Properties (1)

Diamagnetism and paramagnetism. Ferromagnetism.Antiferromagnetism and ferrimagnetism. Influence of temperature on magnetic behavior. Domains and Hysteresis

Module 17: Optical Properties (1)

Basic concepts. Optical properties of metals. Optical properties of nonmetals. Application of optical phenomena.

Module 18: Economic, Environmental and Social Issues of Material Usage (2)

Economic considerations. Environmental and societal considerations. Recycling issues. Life cycle analysis and its use in design

Lecture Plan

Module	Learning Units	Hours per topic	Total Hours
1) Introduction	1. Historic perspective and Materials Science	1	3
	2. Why study properties of materials. Classification of materials	1	
	3. Advanced materials, Future materials and Modern materials	1	
2) Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids	4. Atomic Structure and atomic bonding in solids	1	5
	5. Crystal structures, Crystalline and non-crystalline materials	1	
	6. Miller indices, Anisotropic elasticity and elastic behavior of composites	1	
	7. Structure and properties of polymers	1	
	8. Structure and properties of Ceramics	1	
3) Imperfections in Solids	9. Pint defects, theoretical yield point, line defects and dislocations	1	2
	10. Interfacial defects, bulk or volume defects and atomic vibrations	1	
4) Mechanical Properties of Metals	11. Elastic deformation and plastic deformation	1	3
	12. Interpretation of tensile stress-strain curves	1	
	13. Yielding under multiaxial stress, Yield criteria and macroscopic aspects of plastic deformation and property variability and design factors	1	
5) Diffusion	14. Diffusion Mechanisms and steady state and non-steady state diffusion	1	2
	15. Factors that influence diffusion and non-equilibrium transformation and microstructure	1	
6) Dislocations and Strengthening Mechanisms	16. Dislocation and plastic deformation and mechanisms of strengthening in metals	1	3
	17. Recovery, recrystallization and grain growth	1	
	18. Strengthening by second phase particles, optimum distribution of particles and lattice resistance to dislocation motion	1	
7. Phase Diagrams	19. Equilibrium phase diagrams, Particle strengthening by precipitation and precipitation reactions	1	4
	20. Kinetics of nucleation and growth	1	
	21. The iron-carbon system, phase transformations	1	
	22. Transformation rate effects and TTT diagrams, Microstructure and property changes in iron-carbon system	1	
8. Failure	23. Fracture, ductile and brittle fracture	1	
	24. Fracture mechanics	1	
	25. Impact fracture, ductile brittle transition	1	

	26. Fatigue, crack initiation and propagation, crack propagation rate	1	5
	27. Creep, generalized creep behavior, stress and temperature effects	1	
9. Applications and Processing of Metals and Alloys	28. Types on metals and alloys, fabrication of metals, thermal processing of metals	1	2
	29. Heat treatment and precipitation hardening	1	
10. Applications and Processing of Ceramics	30. Types and applications of ceramics, fabrication and processing of ceramics	1	1
11. Applications and Processing of Polymers	31. Mechanical Behavior of polymers, Mechanisms of deformation and strengthening of polymers	1	2
	32. Crystallization, melting and glass transition, polymer types and polymer synthesis and processing	1	
12. Composites	33. Particle reinforced composites, fiber reinforced composites, structural composites	1	1
13. Corrosion and Degradation of Materials	34. Corrosion of metals, Corrosion of ceramics, Degradation of polymers	1	1
14. Electrical Properties	35. Electrical conduction, Semi conductivity, Super conductivity, Electrical conduction in ionic ceramics and in polymers, Dielectric behavior, Ferroelectricity, Piezoelectricity	2	1
15. Thermal Properties	36. Heat capacity, Thermal expansion, Thermal conductivity, Thermal stresses	1	1
16. Magnetic Properties	37. Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, and ferrimagnetism. Influence of temperature on magnetic behavior, domains and hysteresis	1	1
17. Optical Properties	38. Basic concepts, Optical properties of metals, Optical properties of nonmetals, Application of optical phenomena	1	1
18. Economic, Environmental and Social Issues of Material Usage	39. Economic considerations, Environmental and societal considerations, Recycling issues	1	2
	40. Life Cycle analysis and its use in design	1	