BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI–
HYDERABAD CAMPUS
FIRST SEMESTER 2021-2022
COURSE HANDOUT (PART II)

11th August 2023

Course No. : **ME F216**
Course Title : **Materials Science and Engineering**
Instructor-in-Charge : **Dr. Sujith R**
Team of Instructors : **Dr. Piyush Chandra Verma, Ashish Saurabh, Vicky Lad, Lingampally Swetha, Kandula Uday Kumar Reddy, Sreejith S, M Abhinav**

1. Course Description: Introduction, structure of materials (metals, ceramics, and polymers), crystalline structure imperfections, amorphous and semi-crystalline materials, correlation of structure to properties, phase diagrams & phase transformation, solidification, diffusion and heat treatment, mechanical behaviour of material. Composites, advanced-smart materials, and functional materials, criteria for material selection, economic environmental, and societal issues. Experiments related to materials testing and characterization such as tensile, torsion, hardness, impact, non-destructive testing, XRD, SEM, etc.

Prescribed Text Book

T1. Callister William D & R. Balasubramaniam, Materials Science and Engineering, Wiley Student Edition, 7th Edition, 2007.

Reference Books

R1. George E. Dieter, Mechanical Metallurgy, SI Metric Edition McGraw Hill Book Company, London.

R2. R. A. Higgins, Applied Physical Metallurgy, Sixth edition, Viva Low priced students edition, New Delhi.

R3. V. Raghavan, Material Science and Engineering, Fifth Edition, Prentice-Hall of India Private Limited (2004).

R4. M. F. Ashby, David R H Jones, Engineering Materials I, Elsevier, 3rd edition (2005).

R5. M. F. Ashby, David R H Jones, Engineering Materials II, Elsevier, 3rd edition (2006).

Course Plan :

Lecture No.	Learning Objectives	Topics to be covered	Chapter in the Text Book
1	Introduction	Course introduction and evaluation scheme, Historical perspective, Why study materials science and engineering?	T1. Ch. 1
2	Identify the different types of atomic bonds in solids and evaluate the effect of bonding on material properties	Bonding forces and energies; Primary and Secondary bonding	T1. Ch. 2
3-4	Distinguish between crystalline and amorphous	Unit cells; Crystal structures: Metals; Density computations;	T1. Ch. 3 & Ch. 4

	materials, Identify the crystal structures and specify the Miller indices, Define isotropy and anisotropy	Crystallographic directions and planes; Crystalline and Amorphous materials; Determination of crystal structures using X-ray diffraction	
5-7	Identify the different types of defects in crystals, Differentiate between the two types of solid solutions	Point defects in metals Dislocations, Surface and Volume defects, Microscopic techniques (SEM & TEM), Grain size determination (OM), X-ray Photoelectron Spectroscopy (XPS)	T1. Ch. 5
8-9	Describe the atomic mechanisms of diffusion, Distinguish between steady-state and non-steady-state diffusion	Diffusion mechanisms; Steady-state and Non-steady state; Factors influencing diffusion	T1. Ch. 6
10-13	Identify and interpret one component and two component phase diagrams, Use the Gibbs phase rule to identify the invariant reactions, Sketch and interpret iron-carbon phase diagram	Definition and basic concepts, Phase equilibria, Unary and binary phase diagrams, Gibbs phase rule, Iron –iron carbide phase diagram, Development of microstructure in iron-carbon alloys, Influence of other alloying elements	T1. Ch. 7
14-16	Sketch and interpret the time temperature transformation diagram and continuous cooling transformation diagram, Design a heat treatment that will produce a specified microstructure, Explain the mechanism of age hardening	The kinetics of solid-state reactions, Isothermal transformation diagram, Continuous cooling transformation diagrams, Martensite structures and tempering, Heat treatments, Glass transition temperature.	T1. Ch. 8
15-17	Determine the modulus of elasticity, yield strength and toughness of various material systems, Compute impact toughness and hardness	Concepts of Stress and strain, Elastic deformation, Plastic deformation, Impact strength & Hardness, Design/Safety factors	T1. Ch. 9
18-21	Describe how plastic deformation occurs by movement of dislocations, Define slip systems, Describe and explain various strengthening mechanisms, Differentiate between hot working and cold working	Dislocations; Slip systems; deformation by twinning; strengthening mechanisms; recovery, recrystallization & grain growth	T1. Ch. 10
22-24	Differentiate between ductile and brittle fracture, Define fracture toughness, Distinguish between fatigue and creep.	Fundamentals of fracture: ductile and brittle; Principles of fracture mechanics; Fatigue: S-N Curve; Crack initiation and propagation; Generalized creep behaviour	T1. Ch. 11
25-27	Differentiate between a fibre-reinforced and a dispersion-strengthened	Particle-reinforced and fibre-reinforced composites; Mechanical properties of composites	T1. Ch. 15

	composite, Determine the longitudinal and transverse elastic modulus of long fibre composite		
28-29	Economic, Environmental and Societal Issues in Materials Science and Engineering	Economic considerations: Component design; Materials; Manufacturing techniques; Recycling issues in MSE	T1. Ch.22

Evaluation Scheme:

No.	Evaluation Component	Duration	Weightage (%)	Date & Time	Nature of Component
1	Mid-semester exam	90 min	20	14/10 - 2.00 - 3.30PM	Closed Book
2	Comprehensive exam	3 h	40	21/12 FN	Closed Book
3	Laboratory[#]	-	20		Open Book
4	Tutorial participation*	-	10		Open Book
5	Class participation*	-	10		Open Book

* Best 8 out of 10 quizzes will be considered for evaluation.

 # List of experiments (Weightage:20%)

Section A: Solid Mechanics

1. Determine the mechanical properties of steel & Al alloys by conducting uni-axial tensile tests.
2. (a) Determine the modulus of rigidity and maximum torsional shear stress by conducting torsion tests.
(b) Spring stiffness measurement (series and parallel)
3. Determine the deflection of a simply supported beam and cantilever beam.
4. Determine the buckling load of a column

Section B: Materials Science

5. Observe the microstructure of mild steel and determine its grain size by image analysis.
6. Determine the hardenability of steel by conducting the Jominy end-quench test.
7. (a) Determine the impact toughness of metals at different temperatures using the Izod test.
(b) Determine energy absorption by conducting a drop weight impact test
8. Determine the indentation hardness using Rockwell and Brinell hardness testers.

Section C: Demonstrations

10. Differentiate between ductile and brittle fractures using a scanning electron microscope.
11. Demonstration of fatigue and creep studies
12. Identification of flaws by Non-Destructive Testing methods.

Note:

1. **Chamber Consultation hour:** Friday 5 pm, E207
2. **Notices:** All notices concerning this course will be displayed on CMS.
3. **Make-up Policy**: Make-up will be granted only to genuine cases. For cases related to illness, proper documentary evidence is essential. Prior permission is necessary if the student is out of station on the test date.
4. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge
ME F216