BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani

Pilani Campus

First Semester 2018-2019
Instruction Division
Course Handout (Part II)

Date: 02/08/2018

In addition to Part I (General Handout for all courses appended to the Time Table), this portion gives further specific details regarding the course.

1. Course No. : **ME F213 & MF F213**

2. Course Title : **Materials Science and Engineering**

3. Instructor In-charge : **Sachin U Belgamwar**

Instructor : **Dr. Murali Palla**

4. Course Description

Introduction, Structure of Materials (Metal and Ceramics), Dislocations, heat treatment of steel and strengthening Mechanisms of Metals, Phase diagrams, Iron-carbide phase diagram, Phase transformation in Metals, Mechanical and thermal properties of Metals, Polymers (Structure, processes and properties), powder metallurgy.

5. Scope and Objectives

CO1. Develop familiarity with the different levels of structure (atomic, crystal, microscopic) in engineering materials and deviations from "perfect" structure (structural defects).

CO2. Understand the effects of microstructure on the mechanical properties of materials.

CO3. Understand the basis for microstructure development in materials.

CO4. Understand how materials are processed.

CO5. Selection of Materials for specific application

6. Prescribed Text Book

T1. Callister, William D., Materials Science and Engineering: An Introduction, 8th Edition, ISBN# 978-0-047-0419977, Wiley, 2010 5.

7. Reference Books

R1. William F Smith, Javad Hashmi and Ravi Prakash, Materials Science and Engineering, Fourth Edition, Tata Mcgraw Hill Education Private Limited, New Delhi.

R2. George E. Dieter, Mechanical Metallurgy, SI Metric Edition McGraw Hill Book Company, London.
R3. R A Higgins, Applied Physical Metallurgy, Sixth edition, Viva Low priced students edition, New Delhi.

8. Course Plan

Module Number	Lecture session/Tutorial Session.	Reference	Learning Out come
1. Introduction to Engineering Materials, structure and properties.	L1.1.Introduction of Engineering materials, classification into metals polymers and ceramics and their properties.	T 1.1-1.6. RL.M1LI	Identifying the relationship between the material structure and its influence on Modulus of elasticity, melting point, strength, etc.,. This is useful in selection of materials.
	L 1.2. Atomic structure, crystal structure, micro structure and macro structure of materials.	T 2.1-2.7 RL.M1l2 and M1l3..	
	T1.1. Exercise problems on structure property correlations.	T 1 and 2	
2. Basic crystalline structure of solids, miller indices for planes, directions, planer density, linear density and properties of solid influenced by crystal structure.	L2.1 Bravice lattice, unit cell, arrangement of atoms in common crystal structure	T 3.1-3.8. RL.M2.1LI	Understanding the relationship between crystal structure and property. Effect of close packed plan and direction on slip system. Deformation behaviors of different crystalline materials.
	L2.2. Miller indices for planes and directions, identification of miller plan and directions. Determination of close packed plan, close packed directions, slip system and influence of crystal structure on properties of materials	T 3.8-3.16 RL.M2l2 and M2L3	
	T2. Exercise problems on crystal structure and its influence on properties.	T 3	
3. Crystal imperfections such as Point, line, planer and volume defects. Influence of crystal defects on properties of materials.	L3.1 Classification of crystal defects, point defects, vacancies, interstitials, vacancy concentration and influence of point defect on properties of materials.	T 4.1-4.6. RL.M3.1LI	Diffusion process, grain boundary strengthening, ASTM grain size number. Effect of dislocation on formability.
	L3.2. Line defects-edge dislocation, screw dislocation, Burger vector. Influence of line defects on plastic deformation of materials and deformation by slip and Planer defects- tilt boundaries, twin boundaries, grain boundaries and surfaces. Influence of planer defect, strengthening mechanisms twinning,	T 4.6-4.11 RL.M3L2 and M3L3	
	T3. Exercise problems on crystal imperfections and its effect.	T 4	
4. Binary phase diagrams, isomorphous and eutectic systems. Cooling curves of pure	L4.1 Cooling curve of pure metal and alloys, method of arriving at phase diagram from cooling curves, Gibb's	T 9.1-9.5 RL.M4.1LI	Understanding the effect of phase diagram on microstructure and

metals, alloys, formation of phase diagram, Gibb's phase rule, lever rule and applications	phase rule and phase equilibrium.		properties of materials and importance of alloy systems.
	L4.2. Isomorphous system of phase diagram with Cu-Ni system as example, liquidus, solidus line, lever rule and determination of phases. Eutectic system with Pb-Sn system as example, eutectic, hypo eutectic, hyper eutectic phase transformations, microstructure and properties	T 9.5-9.11 RL.M4L2 and M4L3	
	T4. Exercise problems on phase diagrams.	T 9	
5. Iron and Iron carbide Phase diagram- solidification of pure iron, allotropy, invariant reactions, steel and cast iron region. Different phases of iron-carbon system and their influence on properties.	L5.1.Cooling curve of pure iron, allotropic transformations, effect of carbon. Three invariant reactions and regions	T 9.17 RL.M5.1LI	Microstructure of steel and cast iron. Influence of carbon on property of steel. Plain carbon steel and alloy steel and properties. Cast iron and it's applications.
	L5.2.Steel region of Fe-Fe_3C phase diagram, eutectoid reaction, phase transformation. Effect of Carbon on properties of steel, Plain carbon and alloy steels, their influence on microstructure and properties.	T 9.18 RL.M5L2	
	L 5.3 Cast iron region of Fe-Fe_3C phase diagram, white cast iron and it's properties, Grey, ductile and Malleable cast iron and their applications	T11.1-11.4 RL.M5L3	
	T5. Exercise problems on Iron- carbon system	T9 and T11	
6.Isothermal transformation, formation of TTT diagram, cooling rate and phase transformation, critical cooling rate, effect of alloying elements. Heat treatment of steel-Annealing, normalizing, hardening, tempering, austempering, martempering, size effect. Effect of heat treatment on microstructure and properties of steel.	L6.1. Brief introduction to solidification of pure metals, critical nucleation sites and growth, transformation rate and temperature. Analogy between liquid to solid transformation and solid to solid transformation, S curves and formation of isothermal transformation diagram, Metallic glasses.	T 10.1-10.5 RL.M6.1LI	Equilibrium and non equilibrium cooling of plain carbon steel and alloy steel and its influence on property of steel. Influence of CCT on casting, welding and other manufacturing processes. Making of tool steels. Cost associated with alloy steel and decision making.
	L6.2. Formation of TTT diagram for eutectoid steel, different phases and regions, influence of cooling rate and phase transformation, critical cooling rate and martensitic transformation.	T 10.6-10.9 RL.M6L2	
	L 6.3 Size effect, hardenability, effect of alloying elements, Austempering and martempering .	T11.8	
	T6. Exercise problems on TTT and CCT diagram.	T 110 and T11	
7. Mechanical properties of	L7.1. Stress-strain diagram of metals,	T 6.1-6.11	Understanding the

materials, tensile testing, fatigue, creep and fracture of materials.	polymers and ceramics. Engineering stress, engineering strain, elastic modulus, True stress, true strain and relations ship.	RL.M7LI	failure of materials and preventing the catastrophic failure, life estimation and residual life assessment. Historic failures and development of fracture mechanics.
	L7.2.Ductile and Brittle fracture, fractography, impact testing, ductile to brittle transition temperature and failure of materials.	T 8.1-8.6 RL.M7L2	
	L 7.3 Fatigue and creep, SN Curve, endurance limit, Types of fatigue cycle and fatigue life estimate..	T8.7-8.11 RLM7L3	
	L 7.4 Creep, typical creep curve, effect of temperature and stress on creep curve, stress rupture test and determination of creep life. LMP approach.	T8.11-T8.15 RLM7L3	
	T9 and T10- Tutorial problems on fatigue, creep and fracture.	T6,T8	
8. Structure of Ceramics, types of crystals, Determination of density. Applications and properties of Ceramics.	L 8.1Determination of coordination number AX,AmXp and AmBnXp structures of Ceramics.	T 12.1-12.3. RLM8.L1	Structure and application of ceramics. Modern ceramic materials and phase diagram.
	L8.2. Density Calculation, silicates and polymorphs of Carbon and their structure.Types and application of ceramics.	T 12.4-12.9 T 13.1-13.7 RLM8L2,3.	
	T 11. Tutorial Problems on Ceramics.	T 12,13.	
9. Structure of polymers, types, application and properties.	L 9.1Determination of coordination number AX,AmXp and AmBnXp structures of Ceramics.	T 14.1-14.7 RLM9.L1	Structure and application of polymers. Modern polymeric materials.
	L9.2 Polymeric structure, crystallinity, polymeric molecules and chemistry, determination of molecular weight. Glass transition temperature, Properties and application of polymers. Advances polymeric materials	T14.8-14.12 RL M9 L2,3	
	T 12. Tutorial Problems on polymeric materials	T 14	
10. Composite materials.	L10.1Types of composite materials, rule of mixtures and it's applications.	T 16.1-16.6 RLM10.L1	Understanding of FRP, MMCs, CMC etc., and selection for different applications and tailor made materials. FGMs and applications.
	L10.2.Control of composite properties, different types and applications, Manufacture and testing of composites	T16.7-16.1 RL10L2-L3	
	T13. Tutorial problems on Composite	T16	

	materials.		
11. Selection of Materials.	L11.1.Materials chart with properties.	T 22.1-22.6 RLM11.L1	Understanding the selection of materials using materials performance index. Life, cost and properties base selection of real time components.
	L11.2Determination of materials performance index and it's use in materials selection decision. Application of materials selection with case study.	T22.6-22.14 RLM11 L2-L3	
	T14. Tutorial problems on selection of Materials.	T22	

9. Evaluation Scheme:

Evaluation components.	Weightage	Day, Date, Session, Time
Quiz	15% (Best 04 out of 06)	will be announced in the class
Online Quiz	15%	OB (will be announced in the class room)
Mid semester examination.	90 Minutes (30%)	14/10 2:00 - 3:30 PM
Comprehensive examinations	180 Minutes (40%)	14/12 FN

After completing this course the students will be able to

1) Select suitable material for the specific application subjected to different constraints in terms of cost, availability, properties, life etc.,.
2) Understand the relationship between the structure and properties of materials.
3) Select suitable heat treatment process of steel to get the desired microstructure and property.
4) Identify the materials from its microstructure.
5) Understand the type of fracture from the fractured surface.

Closed Book Test: No reference material of any kind will be permitted inside the exam hall.

Open Book Exam: Use of any printed / written reference material (books and notebooks) will be permitted inside the exam hall. Loose sheets of paper will not be permitted. Computers of any kind will

not be allowed inside the exam hall. Use of calculators will be allowed in all exams. No exchange of any material will be allowed.

Note:

It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handout, attend lectures and the lab demonstration as per the schedule announced in Nalanda. Mid Semester Test and Comprehensive Examination according to the Evaluation Scheme given in the respective Course Handout. If the student is unable to appear for the Regular Test/Examination due to genuine exigencies, the student must refer to the procedure for applying for Make-up Test/Examination. No make up for the tutorials.

(Sachin U Belgamwar)

Instructor In charge

ME F213 & MF F213.