(T) **Roll No. ....**

PAPER ID—21187

Bachelor of Technology (Mechanical Engineering), Bachelor of Technology (Robotics and Automation)

EXAMINATION, 2025

(Second Semester)

MATERIAL SCIENCE

Time : 3 *Hours* *Maximum Marks* : 70

Before answering the question-paper candidates should ensure that they have been supplied to correct and complete question-paper. No complaint, in this regard, will be entertained after the examination.

Note : Attempt *Five* questions in all. Unit I is compulsory and attempt any *four* questions from Unit II. All questions carry equal marks.

Unit I

1. (a) Define a unit cell in the context of crystal structure and briefly explain its significance in material science.

   (b) Define slip systems in crystalline materials. How do slip systems contribute to plastic deformation, and what factors do influence the critically resolved shear stress ?

   (c) Discuss the significance of the yield strength of a material. How does it relate to the onset of plastic deformation during mechanical loading ?

   (d) Describe Griffith's criterion for brittle fracture. What role does the critical crack length play in this criterion ?

(e) Define eutectic, peritectic, peritectoid, and monotectic reactions in the context of phase diagrams. Provide a brief description of each reaction.

(f) Briefly explain the term 'maraging' in maraging steels.

(g) Briefly explain the significance of adding tin to copper to form bronze. **7×2=14**

Unit II

2. (a) Define a unit cell in crystallography. How does the choice of unit cell affect the description of a crystal structure ? 7

(b) Compare and contrast the crystal structures of metals and ceramics. What are the key differences in their atomic arrangements and bonding types ? 7

3. (a) Explain Young's modulus and its significance in material science. How is it determined experimentally, and what does it represent in terms of a material's response to tensile or compressive loading ? 7

(b) Differentiate between true and engineering stress-strain curves. What factors contribute to the differences between these two representations, and why is each curve useful in materials testing ? 7

4. (a) Explain the differences between ductile and brittle failure mechanisms in materials. How do these failure modes manifest in materials under different loading conditions ? 7

(b) Compare and contrast the Tresca and Von-Mises yield criteria. What are the assumptions and limitations of each criterion in predicting material failure ? 7

5. (a) Define alloys and explain the difference between substitutional and interstitial solid solutions. What factors determine whether an alloy forms a substitutional or interstitial solid solution ? 7

(b) Interpret binary phase diagrams, including the identification of phases, phase boundaries, and phase transformations. How does the composition of an alloy influence its phase diagram and microstructure ? 7

6. (a) Define heat treatment and explain its significance in modifying the microstructure and properties of steel. What are the primary objectives of heat treatment processes ? 7

(b) Compare and contrast the processes of annealing, tempering, normalizing, and spheroidizing in steel heat treatment. How do these processes differ in terms of temperature, cooling rate and resulting microstructure ? 7

7. (a) Explain the process of alloying in steel and its significance in enhancing the properties of the material. What are the common alloying elements added to steel, and how do they influence its mechanical properties ? 7

(b) Describe the properties of stainless steel and its applications in engineering. What makes stainless steel resistant to corrosion and how does its microstructure contribute to its mechanical strength and toughness ? 7

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PAPER ID—21187

B.Tech. EXAMINATION, 2024

(Second Semester)

MECHANICAL ENGINEERING

Material Science

Time : 3 Hours *Maximum Marks : 70*

Before answering the question-paper candidates should ensure that they have been supplied to correct and complete question-paper. No complaint, in this regard, will be entertained after the examination.

Note : Attempt *Five* questions in all. Unit I is compulsory. Attempt any *four* questions from Unit II with no internal choice.

Unit I

1. (a) Define interfacial defects in solids and give examples of such defects. Discuss their implications for material properties and behavior.

   (b) Define tensile testing and explain its significance in determining material properties. What parameters are typically measured during a tensile test ?

   (c) Define alloys and provide examples. Differentiate between substitutional and interstitial solid solutions in alloys.

   (d) Define annealing and explain its purpose in the heat treatment of steel.

   (e) Explain the difference between carburizing and nitriding processes in the context of surface hardening of steel.

(f) Discuss the advantages and limitations of vacuum and plasma hardening methods for steel.

(g) Name one alloying element commonly found in tool steels that contributes to their high hardness and wear resistance.

2×7=14

Unit II

2. (a) Discuss the concept of dislocation slip and its role in plastic deformation of metals. How does the concept of slip systems relate to the motion of dislocations ? 7

(b) What are the various types of point defects in crystalline solids ? How do vacancies and interstitials influence material properties such as diffusion and electrical conductivity ? 7

3. (a) Discuss the concept of the generalized Hooke's law and its application in describing the linear elastic behavior of materials. What are the assumptions underlying this law, and how does it relate stress to strain ? 7

(b) Compare and contrast resilience and toughness as measures of a material's ability to withstand deformation. How do they differ in terms of the energy absorbed before fracture ? 7

4. (a) Introduce the Stress Intensity Factor (SIF) approach in fracture mechanics. How does the SIF concept relate to crack propagation and fracture toughness in materials ? 7

(b) Define high cycle fatigue and explain the Stress-life approach for fatigue analysis. What is the S-N curve, and how is it used to characterize the fatigue behavior of materials ? 7

5. (a) Analyze the iron-iron carbide phase diagram and identify the phases present at various compositions and temperatures. How does the phase diagram explain the microstructural evolution of iron-carbon alloys during cooling ? 7

(b) Define the TTT curve and explain its importance in heat treatment processes for steel. How does the TTT curve provide information about the kinetics of phase transformations and the resulting microstructure ? 7

6. (a) Explain the principles and applications of case hardening techniques such as carburizing, nitriding, cyaniding, and carbo-nitriding. How do these processes modify the surface properties of steel while maintaining a core with desirable mechanical properties ? 7

(b) Discuss the principles and applications of flame and induction hardening, vacuum, and plasma hardening techniques. How do these methods provide precise control over the heat treatment process and produce uniform and hardened surfaces on steel components ? 7

7. (a) Discuss the properties and applications of grey cast iron. What makes grey cast iron suitable for applications such as engine blocks, brake rotors, and pipes ? 7

(b) Explain the properties and applications of white cast iron. How does the microstructure of white cast iron contribute to its hardness and wear resistance ? 7