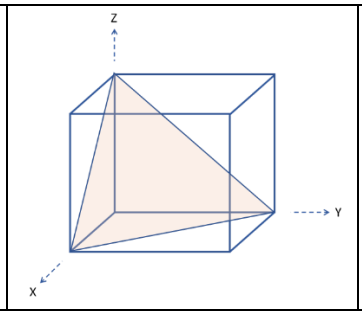
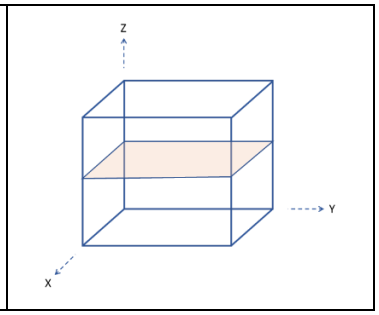
Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

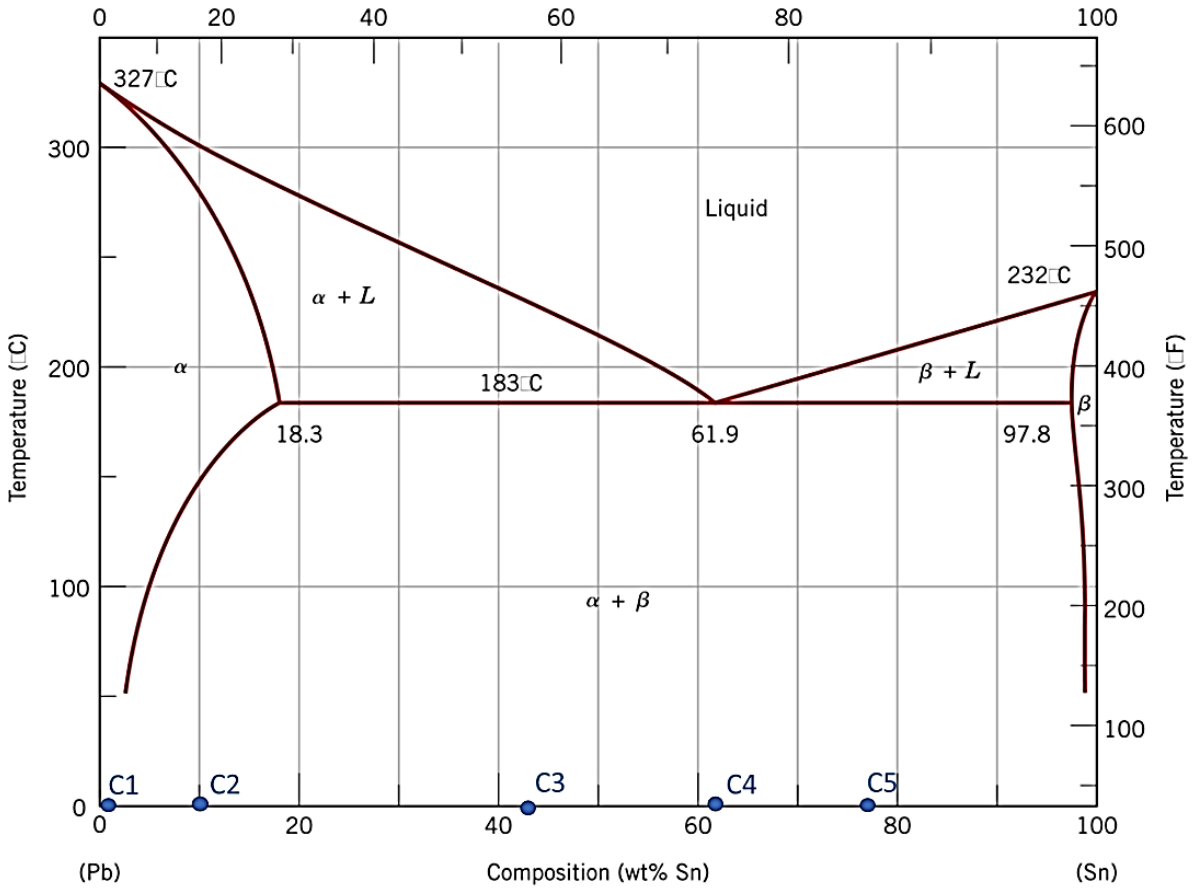
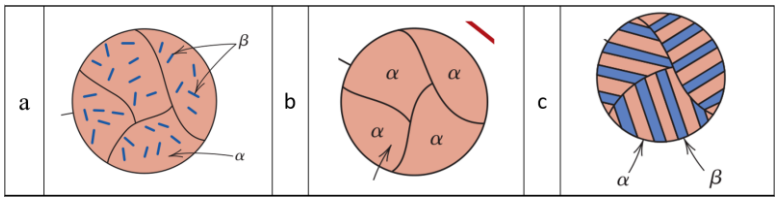
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2021

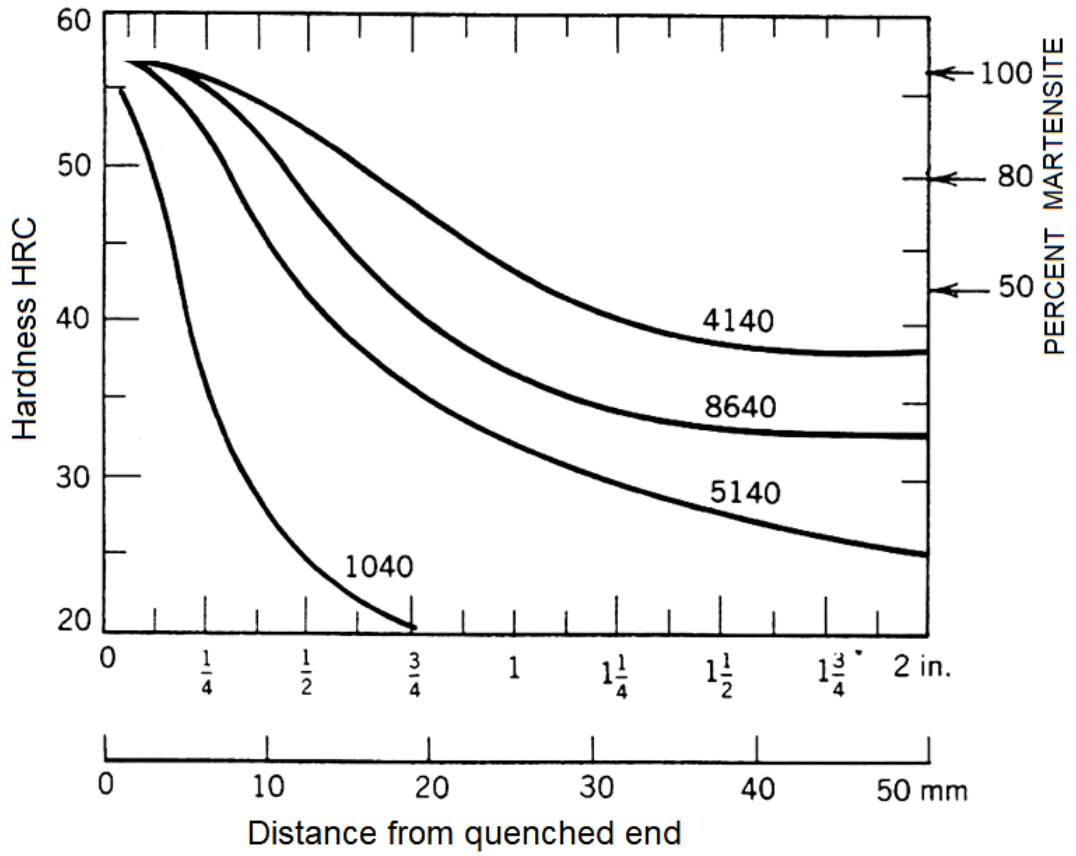
Course: Material Engineering — **Semester: III**
Program: B. Tech Mechanical — **Time 03 hrs**
Course Code: MEMA2003 — **Max. Marks: 100**

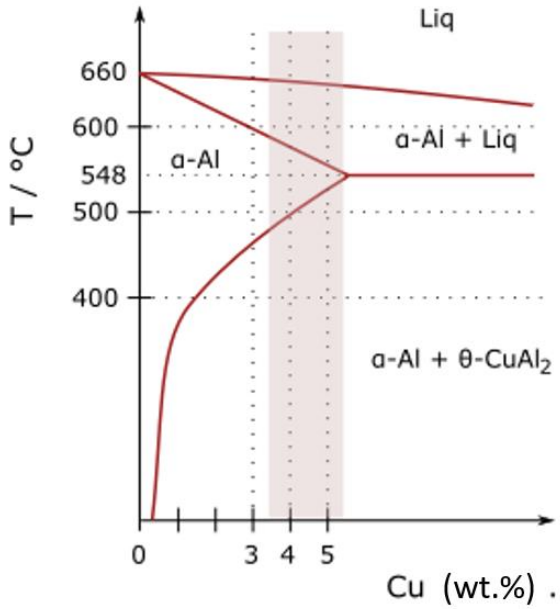
Instructions:

SECTION-A: Total 20 marks
Each question carries 4 marks

S. No.		**CO**
Q 1	Classify following materials into their class of materials (metal, alloy, polymer, ceramic, composite): a) Superalloy, b) Teflon, c) Alumina, d) Carbon fibre reinforced polymer a) _____, b) _____, c) _____, d) _____, e) _____	CO2
Q 2	True/False: a) BCC crystal structure has 3 closest packed planes. _____ b) FCC materials generally have lower strength and are more ductile as compared to BCC materials. _____ c) X-ray diffraction is used to identify the crystal structure of a material. _____ d) Fatigue failure is characterized by formation of beach marks on fracture surface. _____	CO1
Q 3	Identify **ALL the correct options** related to potential energy curve: a) At equilibrium atomic spacing, overall potential energy is minimum. b) At equilibrium atomic spacing, attractive potential energy is minimum. c) The depth of potential energy well is a measure of cohesive energy. d) At equilibrium atomic spacing, the interatomic force is zero.	CO1
Q 4	Write the miller indices of planes shown in below cubic unit cells: a  b  a) _____, b) _____	CO1

Q 5	Pb-Sn forms a eutectic phase diagram wherein α is Pb-rich and β is Sn-rich phase.  Below microstructures can correspond to different compositions: C1, C2, C3, C4 and C5 (marked in above phase diagram). Identify the compositions to which each of the following microstructure belongs:  a) _____, b) _____, c) _____	CO2
SECTION-B : Total 40 marks **Each question carries 10 marks**		
Q 6	a) List the Hume-Rothery rules which govern solubility in substitutional solid solutions. (5) b) Based on these rules, briefly discuss why Cu-Ni forms isomorphous phase diagram with 100% solid solubility, whereas Pb-Sn form a eutectic phase diagram with considerably lower solid solubility. (5)	CO1 CO2

Q 7	The graph below depicts the Jominy-end quench test results for 5 different grades of steel – 1040, 4140, 5140 and 8640. Using the graph below, measure the hardenability of each steel and arrange them in increasing order of hardenability.  	CO3
Q 8	At high temperatures, materials can undergo creep failure. Answer the following related to creep failure: a) Draw a schematic creep curve for a material and clearly mark different regions. b) Arrange the following into increasing order of creep rate and briefly discuss the reasoning: Polycrystalline material, directionally solidified material, single crystal	CO3
Q 9	a) Draw a schematic T-T-T diagram for eutectoid plain carbon steel. Answer **<u>any one of the following</u>**: b) Based on nucleation and growth phase transformation, describe the nose formation in T-T-T diagram. c) Briefly describe the differences between annealing and normalizing heat treatment processes.	CO3

SECTION-C: Total 40 marks		
Q 10	a) Draw the Fe-C diagram showing eutectoid and eutectic phase transformations. (10) Answer **any ONE of the following**: b) Show the microstructural evolution as a **hypo-eutectoid steel** is cooled from single phase austenite region to room temperature. (10) c) Show the microstructural evolution as a **hyper-eutectoid steel** is cooled from single phase austenite region to room temperature. (10) d) Show the microstructural evolution as a **eutectoid steel** is cooled from single phase austenite region to room temperature. (10)	CO1 CO3
Q 11	Al-based alloys are used extensively in vehicles for various applications. 2000 series corresponds to Al-Cu alloys and the figure below shows the phase-diagram of Al-Cu system.  **Answer the following:** a) List the two conditions that must be satisfied for any alloy to be precipitation hardened. Based on this, what composition range would be suitable for making a precipitation hardened 2000 series Al-alloy? (6) b) Take any composition from the range identified above and briefly discuss how you would carry out the precipitation hardening heat treatment. (7) c) Discuss how will you optimize the mechanical properties of this alloy by controlling ageing temperature and ageing time. (7)	CO4