HÖGSKOLAN
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Institutionen för Ingenjörsvetenskap

TENTAMEN

Kurs: **Moderna tillverkningsteknologier och tillämpningar A1N**

Delkurs: *Skriftlig tentamen*
Kurskod: *VP772A*
Datum: *21 augusti 2026*

Högskolepoäng för tentamen: *4 hp*
Skrivtid: *08.15-12.30*

Ansvarig lärare: Rohollah Ghasemi

Berörda lärare: Rohollah Ghasemi, Tobias Andersson, Mahdi Eynian

Examinator: Tobias Andersson

Tillåtna Hjälpmedel: Skrivhjälpmedel och miniräknare

Anvisningar

- ☒ Alla svar ska skrivs på svarsbladet i tentamenstesen.
- ☒ Skriv namn och personnummer på samtliga inlämnade blad.
- ☒ Endast i undantagsfall görs kompletteringar på numrerade lösblad.
- ☒ Använd inte röd penna.
- ☒ Markera med kryss på omslaget vilka uppgifter som är lösta.

Poänggränser:

Betyg	**Poäng**	**Procent**
A	18 ≤ P < 20	90–100 %
B	16 ≤ P < 18	80–89 %
C	14 ≤ P < 16	70–79 %
D	12 ≤ P < 14	60–69 %
E	10 ≤ P < 12	50–59 %
F	0 ≤ P < 10	Under 50 %

Svar kan ges på svenska eller engelska! Totalt innehåller tentamen 12st frågor!

Skrivningsresultat offentliggör inom 18 arbetsdagar!

Lycka till!

Antal sidor totalt 19

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Crystal Structures

1. Crystal structure defines the properties of the materials.
   a) Differentiate between crystalline and amorphous solid structures in terms of atomic configuration. Briefly explain how the three core concepts of materials science establish a relationship that allows engineers to tailor material properties? *(1 Point)*
   b) Explain how atomic bond energy (E_0) relates directly to the macroscopic melting temperature (T_m) and modulus of elasticity (E) of a material. Compare metallic and covalent bonds in terms of directional behaviour? *(1 Point)*
   c) Why do metallic crystal structures tend to be densely packed compared to covalent structures? Identify the two common metallic crystal structures that exhibit the highest theoretical atomic packing factor (APF) and name their value? *(1 Point)*

Hardening Mechanisms

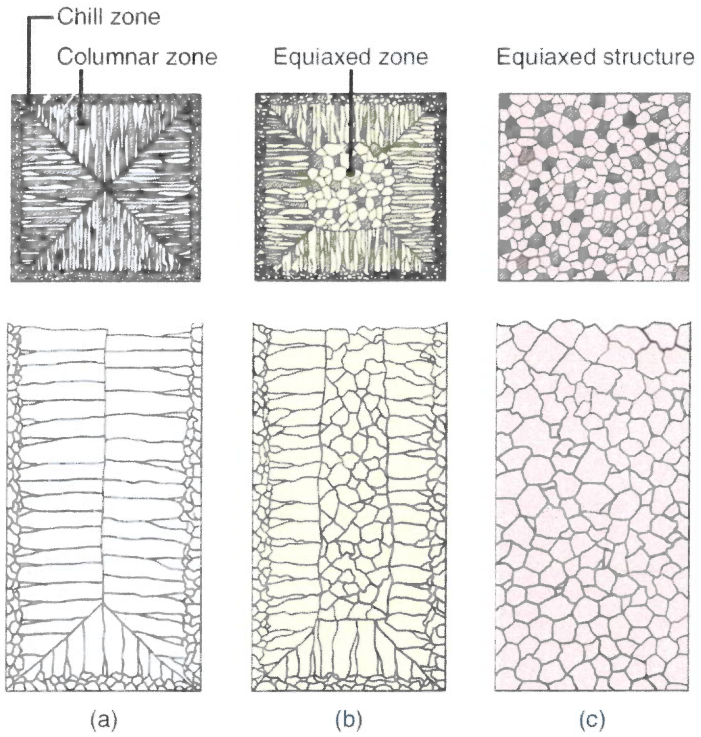
2. Explain how grain boundaries function as planar defects and describe how refining the grain size alters a metal's macroscopic yield strength? *(1.5 Point)*

Metal Casting

3. In metal casting after pouring the molten metal into a mould shaped, allowing it to harden, and removing it from the mould. Hence. the metal casting process involves three distinct stages of shrinkage during cooling: liquid shrinkage, solidification shrinkage, and solid cooling shrinkage.
   a) Explain the differences between liquid shrinkage, solidification shrinkage, and solid-state cooling shrinkage. *(0.5 Point)*
   b) Which type of shrinkage is most critical for the formation of internal cavities and porosity in castings? Explain why. *(0.5 Point)*
   c) Describe two industrial methods used to compensate for this shrinkage and improve casting quality. *(0.5 Point)*

4. Identify the primary fluid-flow phenomenon that must be minimized when designing a casting mould's gating system. Explain the consequences of failing to control this fluid behaviour on final casting quality. *(1 Point)*

5. The figure illustrates three different grain structures that can develop during the solidification of metals and alloys in a square mould: (a) pure metal, (b) solid-solution alloy, and (c) inoculated metal with a fully equiaxed grain structure.

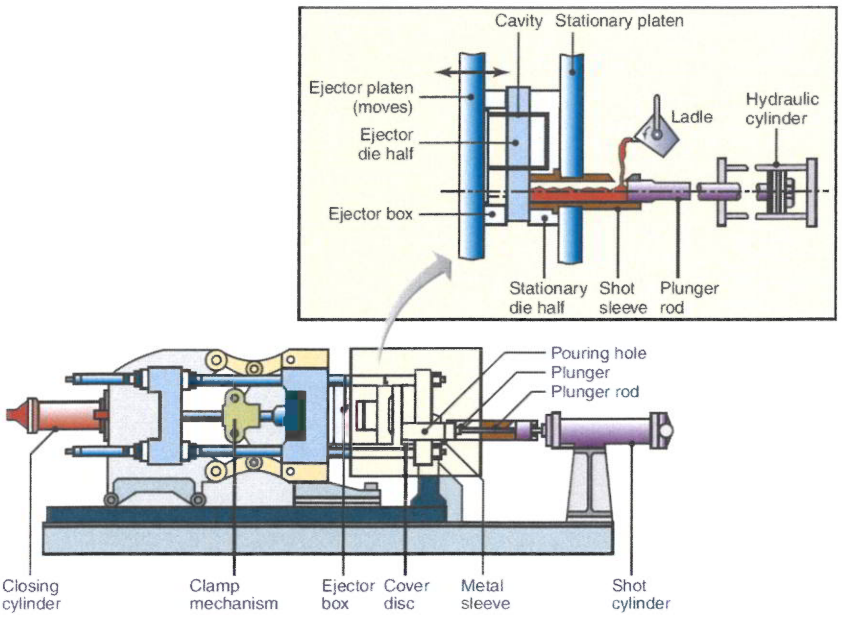


a) Identify and describe the three microstructural zones commonly observed during the solidification of cast metals (chill zone, columnar zone, and equiaxed zone). Explain how temperature gradients and nucleation conditions influence the formation of each zone? *(1 Point)*

b) Compare the solidification structures shown in Figures (a), (b), and (c). Discuss how alloy composition and the use of nucleating (grain-refining) agents affect grain morphology, mechanical properties, and the likelihood of casting defects? *(1 Point)*

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6. This image presents the operational sequences and different configurations of a process used in metal casting manufacturing technology.
   a) Describe clearly and in details the process in including both advantageous and dis advantageous? *(0,5 Point)*
   b) From a manufacturing efficiency standpoint, why might a process engineer select and prefer this method compared to the sand casting or investment casting? *(0,5 Point)*
   c) For an aluminium alloy automotive component (e.g., an engine block), with 500,000 part per year explain do you select prefer to use this method or conventional sand casting. Motivate your method selection by considering factors such as production rate, dimensional accuracy, and surface finish in your comparison? *(0,5 Point)*



Heat Treatment

7. Heat treatment is one of the important process technologies used in steel industries.
   a) Describe the structural composition of pearlite at room temperature in a hypoeutectoid (0,5 wt% carbon) steel. Explain how it forms

when cooling through the eutectoid temperature (727 °C). *(0,75 Point)*

b) What is Martensite? Explain the thermodynamic and kinetic conditions required to form it from Austenite, and describe its crystal structure. *(0,75 Point)*

8. Differentiate between Annealing and Quenching heat treatments applied to plain carbon steels in terms of process cooling rates and resulting microstructure and mechanical properties? *(1,5 Point)*

Polymer Materials

9. Abou the polymers:
   a) Compare the Thermoplastics and Thermosetting plastics regarding their molecular network structures and their response to elevated temperatures? *(1 Point)*
   b) The four primary types of polymer structure based on molecular shape are Linear, Branched, Crosslinked, and Network polymers. Neatly draw a representative 2D schematic diagram for each of these four polymer types. For each diagram, clearly indicate the main polymer chain (backbone) and, where applicable, the side branches or crosslinks. On your diagrams, clearly indicate the chemical bonding (e.g., covalent bonds, ...) *(1 Point)*

Machining

10. About machining:
    a) Describe the tool-workpiece relative movements for the following machining operations: Turning, Drilling, and Milling. Include simple sketches with your answer. *(0,75 Point)*
    b) Compare High-Speed Steel (HSS) and Cemented Carbides in terms of "Hot Hardness" and "Toughness." Why are ceramics unsuitable for interrupted cuts? *(0,75 Point)*

Laser welding

11. Laser welding is an important manufacturing technology particularly in battery application.

a) What are the two primary modes of laser welding, and how do they differ in terms of power density and energy absorption? *(0,75 Point)*
b) Draw a cross-section of a Keyhole. Label and indicate the direction of the Recoil Pressure, Buoyancy Force, and Marangoni Force for a pure metal. *(0,75 Point)*

Mechanical Testing

12. An alloy specimen with an initial cylindrical gauge diameter (d_0) of 10,0 mm and an initial gauge length (l_0) of 50,0 mm is subjected to a destructive uniaxial tensile test. During the elastic deformation regime, an applied tensile force of 15,708 N produces an axial elongation (Δl) of exactly 0,05 mm.

    As the test progresses into the plastic regime, the material reaches its maximum load capacity at an ultimate tensile engineering force of 35,343 N, right before localized necking begins. After the specimen fractures, the two pieces are fit back together, and the final fractured gauge length (l_f) is measured to be 58,5 mm.

    a) Calculate the Modulus of Elasticity (E) of this alloy. *(0,5 Point)*
    b) Calculate the Ultimate Tensile Strength (UTS) of the alloy. *(0,5 Point)*
    c) Calculate the Ductility expressed as the total percentage elongation (EL). *(0,5 Point)*

$E = \sigma / \epsilon$

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ANSWER SHEET FOR: (Name)_____

(Pers-nr)_____(Program/Independent)_____

1. (3p)	

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2. (1,5p)	

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3. (1,5p)	

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4. (1p)	

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5. (2p)	

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6. (1,5p)	

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7. (1,5p)	

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8. (1,5p)	

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9. (2p)	

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10. (1,5p)	

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11. (1,5p)	

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(Pers-nr)_____(Program/Independent)_____

12. (1,5p)	