

Ph.D. Qualifying Examination

Materials Science

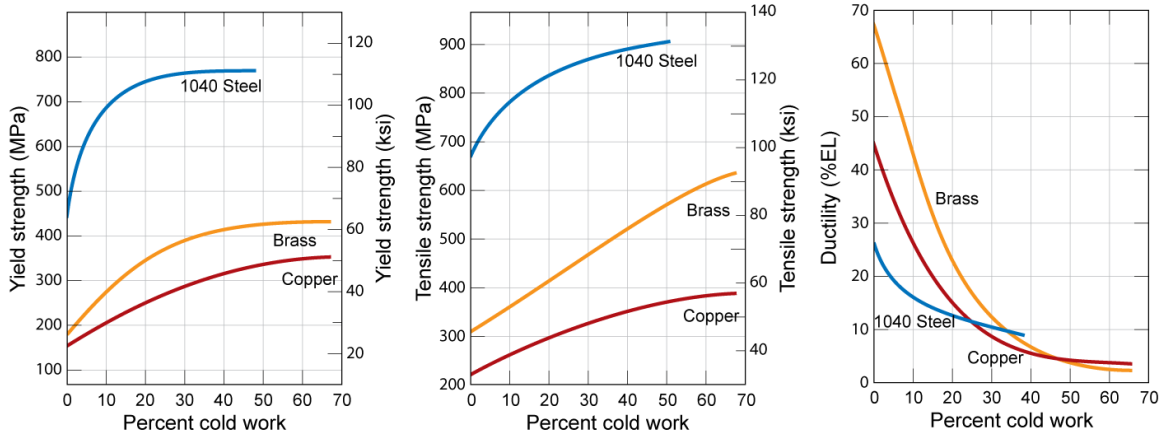
Summer 2025

Notes:

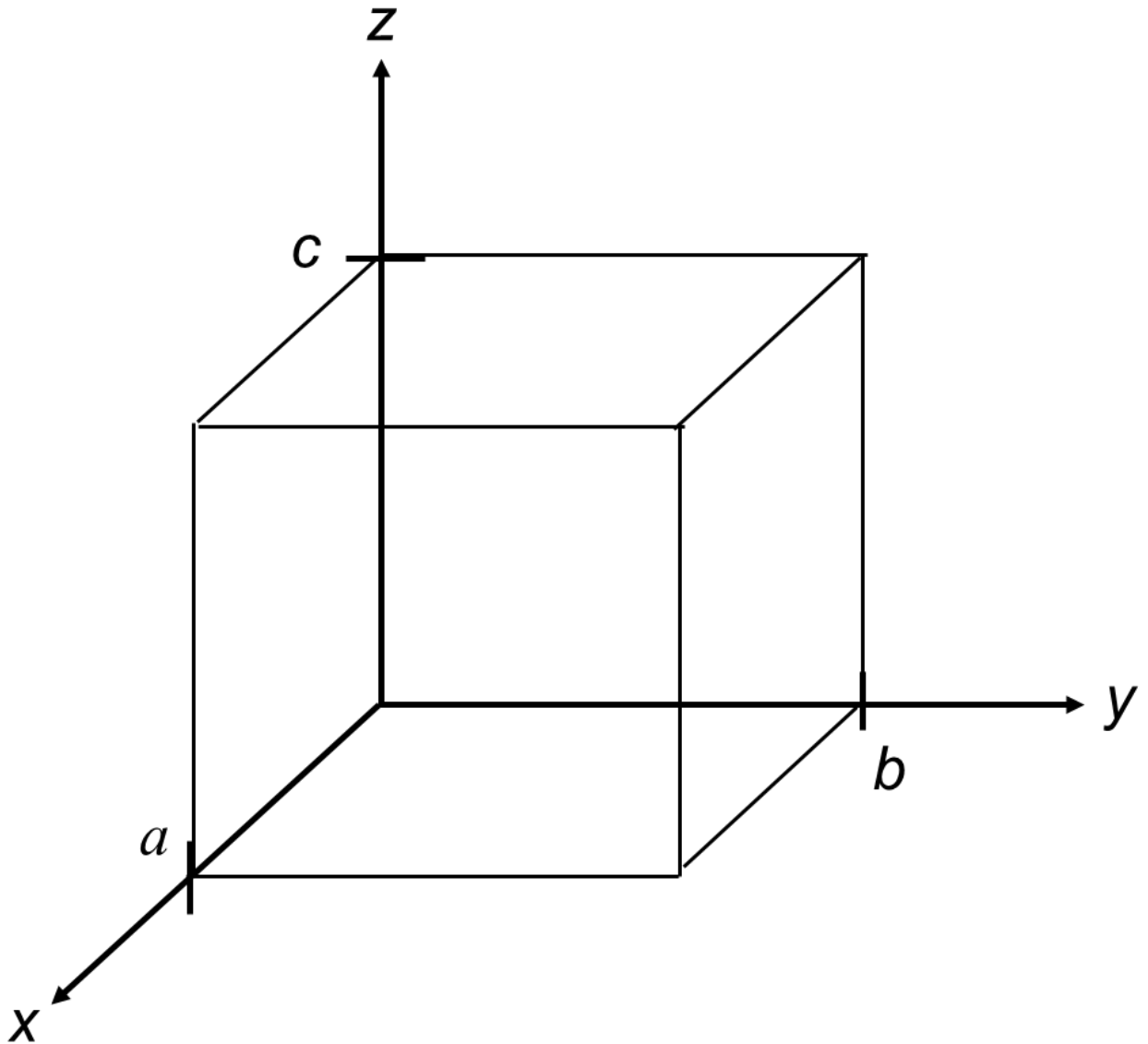
- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes (one double-sided sheet of formulas is allowed).
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

1. Show that the atomic packing factor for the BCC crystal structure is 0.68.

2. A cylindrical rod of brass originally 10 mm in diameter is to be cold worked by drawing. The circular cross section will be maintained during deformation. A cold-worked tensile strength in excess of 380 MPa and a ductility of at least 15 %EL are desired. Furthermore, the final diameter must be 7.5 mm. Explain how this may be accomplished.



3. Sketch $(10\bar{1})$ and (221) planes within the following cubic unit cell.



4. In materials science, several key methods exist for enhancing the strength of metals. Consider the following two mechanisms for strengthening materials.
- (a) Grain Size: Explain why reducing the grain size of a metal increases its strength. Discuss how this mechanism affects dislocation motion and why the number of grain boundaries plays a role in hindering dislocation movement.
 - (b) Strain hardening: After a metal undergoes plastic deformation, its strength increases. Discuss how dislocations play a role in strain hardening and explain how the dislocation density and dislocation interactions contribute to the increased strength.