

Homework Assignment #1

Instructions: *Students are encouraged to discuss homework and course material with the instructor and classmates. However, the submitted homework solutions for HW #1 must involve only the individual student's effort.*

Due in class on Tue. Feb. 15th. No late homework will be accepted.

Problem 1

What exactly is meant by the term “peer-reviewed archival journal”?

Give an example of a peer-reviewed archival journal that either partially or exclusively contains articles related to nanoscience/nanotechnology. Who is the publisher of the journal? How often is it published? If possible, determine how long it typically takes articles to be published in this journal.

Briefly describe the process for submitting and publishing an article in this journal.

Where did you find the journal? What campus libraries is the journal available in? Is it available on the internet? If so, what is the URL?

Go to any campus library and find an article from the journal you have chosen which addresses a nanomechanics research topic. Do not use the internet for this task. On your homework, write down the precise reference information for the article. The reference information should be written down using precisely the same format that is used for journal references within the article itself.

Bring a photocopy of the article to class with your homework.

Write a 1-paragraph original summary of the content of the article as best as you can interpret it. Do not just copy the abstract. Include in your summary what the importance of the article is: is there a relevant technological application in mind? Does this contribute to the basic understanding of a particular phenomenon? Be prepared to be called on at random in class on the day this assignment is due to share your summary with the class.

Problem 2

1. (a) The angles between the tetrahedral bonds of diamond are the same as the angles between the body diagonals of a cube. Use elementary vector analysis to find the value of this angle.

(b) Show that the c/a ratio for an ideal hcp structure is $\left(\frac{8}{3}\right)^{1/2}$.

(c) What is the atomic packing factor for the simple cubic, bcc, fcc, and hcp crystal structures?

(d) Consider the (111), (110), and (100) surfaces of the fcc unit cell, assuming no reconstruction. Sketch both the 1st (*i.e.* topmost), 2nd, and 3rd planes starting from the surface (indicate the relative position of each plane as well). What is the coordination number (number of nearest neighbors) of the atoms for the 1st and 2nd planes?

(e) Considering the favorable nature of surface close packing, which of the three fcc low index planes do you expect to have the lowest surface energy and why?

Problem 3

A strip of SMA is constrained at constant length in a tensile testing machine, subjected to a small initial load, and heated electrically. The strip is initially at 20C and the material transformation temperatures are $A_s = 40\text{C}$ and $A_f = 80\text{C}$. The load measured by the machine increases during the $M \rightarrow A$ transformation, then falls off somewhat with further heating.

- a) Explain the observed decrease in load.
- b) What would be the optimum temperature at which to maintain the SMA to produce the maximum steady load?

Problem 4

For a perspective on surface-to-volume ratio, consider a sphere whose radius is 1 cm and determine its surface area and volume. If the sphere is now subdivided into identical spheres, whose radii are each 1 nm, how many spheres will there be if the total volume of the original large sphere is preserved in the collection of nanospheres? Determine the collective surface area of these nanospheres.

Problem 5

Create a table for face-centered cubic (FCC) unit cells that lists the numbers of surface and interior atoms as a function of cube size up to the size at which there are more interior than surface atoms. For the element Au with a unit cell edge length of about 4 Å, at about what size does the number of interior atoms exceed those on the surface?

Problem 6

Cleland, problem 2.4. Clarification - the problem should read:

Show that the fcc crystal lattice can be represented as a triangular lattice. In other words, using a triangular lattice in the plane with generating vectors \mathbf{a}_1 and \mathbf{a}_2 , find a third generating vector such that the three together generate the fcc crystal.