Spring 2020: Mechanical Properties Materials Science (MPMS)

Take Home Exam I: (Elasticity)
Given out on Wednesday 02/19/2020, due in class on Wednesday 02/26/2020

Each question carries equal points; Please give your answers on the enclosed pages.

This exam is not very long. May I therefore ask you to think very carefully about your answers, and write them down in clear English. If you include derivations, then explain each step, and state the assumptions in the analysis.

The grade will depend on the clarity of your presentation.

1. Give three examples of iconic figures, or equations that pertain to the understanding of elastic deformation in solids.

2. Give a definition of the Youngs Modulus, and describe a cantilever beam experiment to measure it. Why is this method better than a simple uniaxial experiment.

3. Assuming a sinusoidal force displacement curve between atoms separated by a distance $\Omega^{1/3}$, where Omega is the volume per atom, derive the following equation that relates the elastic modulus to the heat of melting.

$$E^* = \frac{\Delta H_V}{\Omega}\frac{8\pi^2}{3}$$

In class we discovered that the above equation underestimated the elastic modulus of a metal, say copper. Sketch a modification to the force displacement curve, relative to the sinusoidal form, that can bring a closer agreement between theory and experiment.

4. Write short answers to the following statements:

(i) Covalent bonds are usually stronger than metallic bonds.

(ii) Compounds made to constituents with larger differences between their electronegativity values, are more likely to be ionically bonded.

(iii) Consider the Youngs Modulus and the Poisson's ratio at the two independent elastic constants in elastic deformation of an isotropic solid. *Explain in words* how the Bulk modulus may be related to the elastic modulus and the Poisson's ratio. The equation is given just below.

$$B = \frac{E}{3(1-2\nu)}$$

5. Using the equations provided in the notes for the elastic deformation of a spherical inclusion embedded within a matrix, show that incompatible expansion of the two materials will create only a shear stress in the surrounding matrix.