Take Home Exam I: Elasticity

Assigned: Sunday 02/13/2022

Due (as pdf by email) 02/27/2022 (in two weeks)

•All questions carry equal weight.

•You may submit your answers in one of two ways:

1) For typed answers: as a .docx file (as is) or converted into a pdf file. (DO NOT SEND GOOGLE DOC)

For handwritten answers: Please scan as images, and group together into one pdf file. Or you may hand them manually to my office (ECME-212)

HW 01.1

Explain (in a brief paragraph) why such a heavy machine is used to test very small samples.

HW 01.2

•Write down the principal stresses and principal strains in a simple uniaxial test.

•Now separate the stress tensor into (i) hydrostatic and (ii) shear components.

HW 01.3

Further in HW 01.2, show that the first corresponds only to volume change, and the second to shape change at constant volume.

HW 01.4

Further in Question 01.2:

Using the accepted definitions of the Youngs Modulus, E, the Poission's Ratio, ν, the shear modulus, G,and the Bulk Modulus, B, show at

$$G = \frac{E}{2(1+\nu)}; \text{ and } \quad B = \frac{E}{3(1-2\nu)}$$

HW 01.5

Describe an experiment with an Instron to determine (i) the shear modulus and (ii) the bulk modulus of an "isotropic" material.

HW 01.6

Show the magnitudes of the shear stress in the Mohr Circle for the following cases (using arbitrary units)
(i) both principal stresses are equal to 5 units
(ii) one of them is +2, and the other is +10
(iii) one of them is -2 and the other is -10

HW 01.7

In the water molecule the oxygen and hydrogen bond has mixed covalent and ionic character. Explain (qualitatively) how this type of bonding creates a molecule with a significant dipole moment (assume that the dipole moment of a "+" and a "-" charge spaced by a distance, "x", is related to the product of the magnitude of the charge(s) and "x").

HW 01.8

Write a 100 word essay (with one or two figures) on sp^2 and sp^3 hybridization of orbitals in carbon, and how this leads to graphite and diamond structure.

HW 01.9

In class we derived the following equation

$$\Delta H = \frac{EV_{mole}}{4\pi^2} Z \qquad (1)$$

with the assumption that the force displacement curve is a sine wave with the force going to zero when the displacement is equal to one half of the interatomic distance ($\Omega^{1/3}$)

Re-derive Eq. (1) with the condition that the force goes to zero at $\alpha\,\Omega^{1/3}$ where $\alpha < 1$.

Sketch a rough graph for the ratio $\frac{\Delta H}{E}$ vs. α (assuming $\frac{V_{mole}}{4\pi^2} Z = \text{constant}$) to show whether the ratio increases or decreases with alpha.

HW 01.10

Derive the equation for the Youngs Modulus of a transversely aligned fiber composite to be

$$\frac{1}{E_{comp}} = \frac{v_f}{E_{fiber}} + \frac{1 - v_f}{E_{polymer}}$$

where the elastic modulus appears in the denominator(s) and teh volume fraction of the fibers in the numerator(s).