Elasticity Homework

1) From basic physics, we know that Force = Mass*Acceleration. The acceleration I feel standing on the ground is equal to gravity, \( g = 9.8 \text{ meters/s}^2 \). Stress, on the other hand, is Force per Unit Area.

   a) What is the net Force, in Newtons (Kg-M/S\(^2\)) that I exert on a 1x1 meter tiling floor by standing on it and distributing my weight out evenly over the whole tile? I weigh 85 Kilograms.

   b) What is the Stress (in Pascals, PA, Newtons/Meter\(^2\)) in the same situation as part a)?

   c) What is the net force on the 1x1 meter tiling floor if instead I stand on a deck of cards, which measures 5 cm x 5 cm?

   d) What is the stress on the piece of the floor which is in contact with the card deck when I am standing on it?

   e) For c) and d) above, if you gave your answer in Pascals, here give the answer in pounds per square inch. Conversion factors: 1kg = 2.2 lbs; 1 inch = 2.54 Cm.

2) The box below shows an infinitesimal cube. The axes of the coordinate system are as shown.

   a) If we’re standing on the Y axis, looking toward the Origin of the reference system below, which face of the cube are we looking at? Which face is off to our right? To our left?

   b) Using arrows, draw in the following stresses, making sure to get both the plane and direction correct: \( \sigma_{zx}, \sigma_{zy}, \sigma_{xx}, \sigma_{yz} \). You can represent the stress over the whole area as an arrow.
3) Strain questions.
   a) Draw arrows to represent the strains $e_{xx}$, $e_{yy}$, and $e_{zz}$.
   b) Sketch on top of the cube below how the cube would look if it were to experience a small amount of positive $e_{xx}$ and $e_{yy}$ strain, and negative $e_{zz}$ strain.

4) The Rigidity of most rocks is approximately $10^{11}$ Pascals. Suppose we have a cube of rock which we are shearing with a pure shear stress.
   a) What is the stress required to cause a shear strain of .01? (ie, $e_{ij} = .01$, where i does not equal j). What are the units?
   b) Suppose our cube of rock is 1m X 1m on a side. What force, in Newtons, is required to produce the stress which causes a shearing strain of .01?
   c) Suppose now we produced this number of Newtons of shear force by physically gluing some mass of heavy material to the side of the 1m x 1m cube, the idea being to let gravity pull down on this mass, which in turn would shear the side of the rock to which it was glued. How many kilograms of this material would we need?
   d) If typical rock weighs 3 grams/cm³, what volume of rock are we talking about here?

5) The bulk modulus, $K$, of sandstone is about 17 GPa., the rigidity $\mu$ is 6 GPa, and Lamda, $\lambda$ is 13 Gpa.
   a) If I want to compress a sphere of sandstone by 50%, what compressive stress do I need to
achieve this amount of compression?

b) Suppose I have a long rod of sandstone, as shown above, which I want to stretch by 10% along its x axis. How much strain is this, and what amount of longitudinal stress do I need to provide to achieve this? Should the stress be tensile or compressive?

c) Suppose now that I want to contract the rod across its cross section (i.e., along the y axis) by 10%. What amount of strain along the x-axis do I need to achieve this?

d) What is Poisson’s Ratio for water? A hint: How rigid are fluids?