Physics 861 – Fall 01
Problem set 9 - Due Tuesday, Nov 20

1. Three pulls make a negative pressure.

(a) Consider a uniaxial pull in the x direction on an elastically isotropic solid bar of sides $L_x; L_y; L_z$ and show that the fractional volume change (within the elastic range) is

$$\frac{\delta V}{V} = (1 - 2\nu)\frac{S_{xx}}{E} \tag{1}$$

where E is the Young modulus (also called Y) and ν is the Poisson ratio (also called σ). Similarly, write down expressions for the volume changes caused by uniaxial pulls in the y and z directions.

(b) Replace the bar by a crystal with cubic symmetry. A uniaxial pull along a cubic axis will, again, cause an elongation and a lateral shrinkage. Express the (effective) Young modulus and Poisson constant in this case in terms of the conventional elastic constants C_{11} and C_{12}.

(c) Recall that the volume change caused by a hydrostatic pressure p is $\delta V/V = -p/B$, where B is the bulk modulus. Argue that three orthogonal pulls of equal magnitude are equivalent to a negative hydrostatic pressure and obtain the relation $E = 3B(1 - 2\nu)$.

(d) Using the results of part (b), or more directly, express B in terms of C_{11} and C_{12}.

2.

The general relation of isotropic elasticity is

$$S_{ij} = B\,\Delta\,\delta_{ij} + 2\mu\left(E_{ij} - \frac{\Delta}{3}\delta_{ij}\right) \tag{2}$$

(a) How is the dilation Δ related to $(\delta V/V)$ of problem 1 and to the strains E_{ij}?

(b) Consider again a uniaxial pull and show that $E = 2\mu(1 + \nu)$:

(c) Consider a pure shear stress acting on a cubic crystal of axes x, y, z.. Find the (effective) μ if the shear is parallel to a cubic face.

(d) Find the (effective) μ if the shear is in the diagonal plane $x = y$.

3.

Problem 3, page 486, of Ashcroft - Mermin. For part (c), it is up to you to pick the momentum transfer q in such a way that the experiment will give interesting results. Assume room temperature.