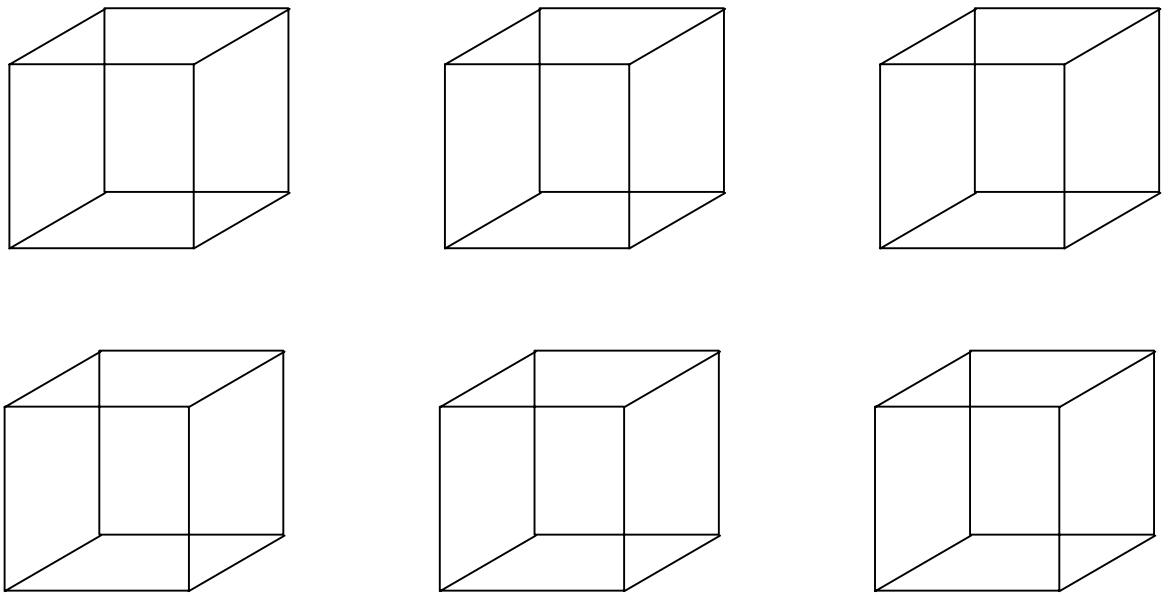
Homework #2 **487 Intro MEMS**

Hemker **REVISED DUE DATE: MONDAY, FEB 17**

1. The crystal structure for nickel is FCC and its lattice parameter is a_o = 0.35 nm. There are 4 atoms per unit cell of an FCC metal and the volume of a unit cell is a_o^3. Assume that a US quarter is stamped from pure nickel and that the size of the grains in the quarter is 10 μm across.
    a. Estimate the number of atoms in each Ni grain. *(think 3D and show your work)*
    b. Estimate the total number of grains in a Ni quarter. *(ditto)*

2. The accelerometer that you measured for Homework #1 is made of polysilicon and has columnar grains that are 0.3 μm in diameter and as long as the device is thick, e.g. 2 μm. There are 8 atoms per unit cell for Si and the lattice parameter of Si is 0.54 nm.
    a. Estimate the number of atoms in each columnar polysilicon grain. *(think 3D and show your work)*
    b. Estimate the total number of grains in one beam and in the whole accelerometer. *(ditto)*

3. Use the cubes given below to draw the following atomic planes: (011), (111), (-111), (021), (112) and (-101). *(Label which is which)*



4. Consider a (001) single-crystalline Si wafer.

    a. Make a 2D drawing of the top surface of the wafer and indicate the low indice directions (e.g. <001>, <011> or <111>) that are on this face. Give the angles between the various directions.

    b. Do the same for a (011) wafer of Si.

5. Calculate the Young's modulus (E) for single-crystalline Si for the following crystallographic directions:

    a. $E_{[100]}$

    b. $E_{[110]}$

    c. $E_{[111]}$

    Which direction is the stiffest? The most compliant?
    (Use the equations, relations and constants given in class)

6. If the fracture toughness (K_{Ic}) of Si is 0.9 MPa $m^{1/2}$, calculate the flaw (crack) size that would cause it to fail at a stress of 2 GPa.
    (Use the relation given in class)

7. Give the Miller indices for the following planes.