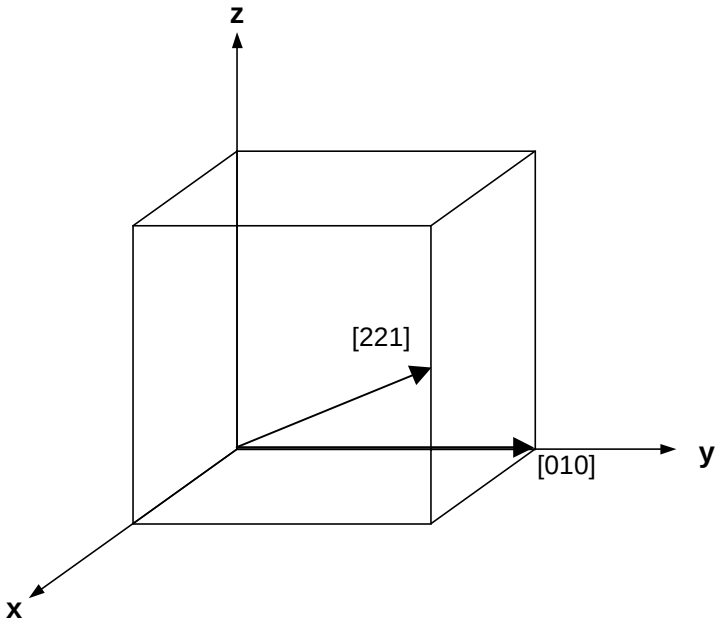
ENGR 240 Science of Materials – Spring 2001
Homework Assignment 3 Solutions
- 16 points -

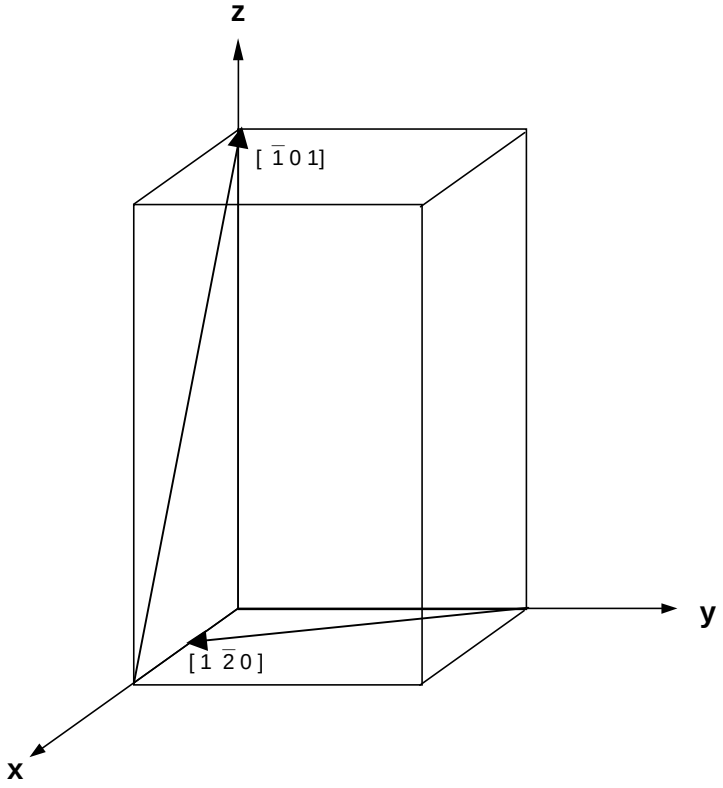
1. [2 points] Sketch a cubic unit cell. Within the unit cell, sketch and label the following:

   a. [0 1 0]
   b. [2 2 1].



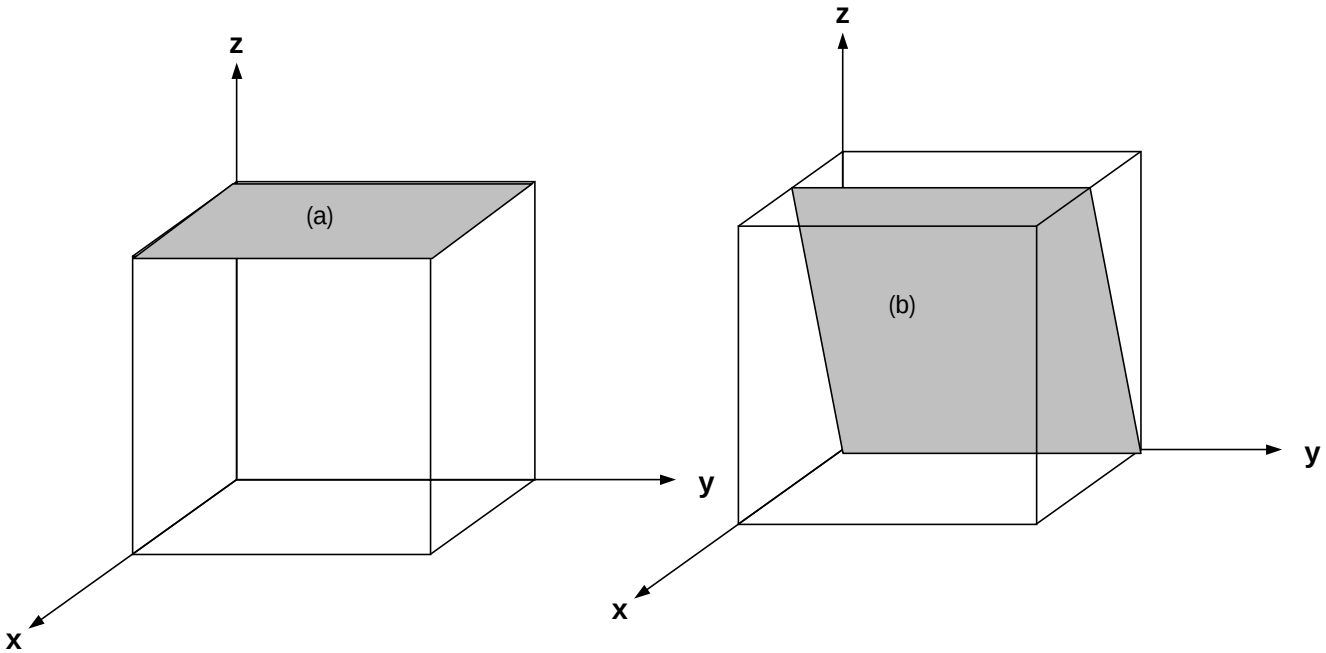
2. [2 points] Sketch a tetragonal unit cell with lattice parameters a = 3 nm and c = 5 nm. Within the unit cell, sketch and label the following:

   a. [1 $\bar{2}$ 0]
   b. [$\bar{1}$ 0 1].



3. [2 point] Sketch a cubic unit cell. Within the unit cell, sketch and label the following:

   a. (0 0 1)
   b. (2 0 $\bar{1}$).



4. [4 points] Callister Problem 3.29 – crystallographic directions

   a. **[0 $\bar{1}$ $\bar{1}$]**
   b. **[$\bar{2}$ 1 0]**
   c. **[1 1 2]**
   d. **[1 1 $\bar{2}$]**

5. [2 points] Callister Problem 3.34 – crystallographic planes.

   a. **(3 2 $\bar{2}$)**
   b. **($\bar{1}$ 0 1)**

6. [2 points] Bicycle components such as handle bars, wheel rims, and brake calipers are often manufactured using heat-treated aluminum alloys. An aluminum rim on a mountain bike typically weighs about 400 grams. Assuming the aluminum rim is made entirely of aluminum (Al has the fcc structure), calculate:
   a. The volume of aluminum used for the rim.
   b. The approximate number of aluminum unit cells in the rim.

   a. Use density of Al to determine the volume in cm^3:

      400 g Al x 1 cm^3/2.71 g = **147.6 cm^3**

b. Unit cell volume for fcc = $a^3 = (2R\sqrt{2})^3$
R for Al is 0.143 nm = 0.143 x 10^{-7} cm (value is given inside the front cover of textbook)
a^3 = 6.617 x 10^{-23} cm^3

Number of unit cells = 147.6 cm^3 x (1 cell/6.617 x 10^{-23} cm^3) = **2.23 x 10^{24}**

7. [1 point] Calculate the volume of the bcc unit cell in terms of the atomic radius R.

Atoms contact along the body diagonals in the bcc structure. Body diagonals have a length of $a\sqrt{3}$. If the atomic radius is R, the a to R relationship in bcc is

$$a = \frac{4R}{\sqrt{3}}$$

Volume of the unit cell is:

$$a^3 = \left(\frac{4R}{\sqrt{3}}\right)^3 = \frac{64R^3}{3\sqrt{3}}$$