NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 580 – Solid State Physics Fall 2024

Problem Set #2

Problem Set Due: Thurs., Sept. 5, 2024
Read Kittel: Chapter 1, powerpoint: *Miller Indices*

1. Give the Miller indices of all six sides of the simple cubic crystal (note, some of these planes pass through the origin). Draw the cubic crystal and label each side with its corresponding Miller index.

2. What is a family of planes? What are the members of the family of planes for the (112) plane of a cubic crystal?

3. For a cubic crystal:

   (a) What is the distance between the (100) planes?
   (b) What is the distance between the (200) planes?
   (c) What is the distance between the (112) planes?

4. On slide 17 of the "Miller Indices" powerpoint: show why the $\left(\frac{1}{2},\frac{1}{2},\frac{1}{2}\right)$ atom of a bcc cell does not lie on the (112) plane.

5. Iron forms a bcc structure with a lattice spacing of a_0 (watch the youtube video if you run into problems: https://www.youtube.com/watch?v=3ScvpIUtpKU)

   (a) What is the atomic radius, R, of Fe in terms of a_0 under the assumption that the atoms are spheres in contact with each other along the body diagonal? (see slide #51 in "Geometry of Crystals") This gives the largest packing density of the bcc lattice.

(b) Does the $\left(\frac{1}{2},\frac{1}{2},\frac{1}{2}\right)$ atom lie on the (110) plane for the bcc cell? Carefully explain why using slide 17 in "Miller Indices".

(c) What is the area of the (110) plane in terms of a_0?

(d) How many atoms lie in the (110) plane? (be careful with the corners)

(e) Calculate the (110) planar density (# atoms/area) in terms of a_0.

(f) Does the $\left(\frac{1}{2},\frac{1}{2},\frac{1}{2}\right)$ atom lie on the (111) plane for the bcc cell? Carefully explain why using slide 17 in "Miller Indices".

(g) What is the area of the (111) plane in terms of a_0?

(h) How many atoms lie in the (111) plane? (be careful with the corners)

(i) Calculate the (110) planar density (# atoms/area) in terms of a_0.

(j) How many atoms lie in the bcc unit cell?

(k) What is the packing fraction,

$$\text{Packing Fraction} = \frac{\text{total volume of atoms in the unit cell}}{\text{total volume of the unit cell}}$$

for the bcc unit cell (you should get a number—write it in terms of a percent). Assume all the atoms are spheres that are in contact in the unit cell. See slide #51 in "Geometry of Crystals".