Physics 416 Problem Set 1 Due Weds, Sept. 7

(1) For these four cases, identify whether the lattice described is a Bravais lattice. Furthermore, if it is a Bravais lattice identify three possible primitive lattice vectors, or if it isn't identify the smallest basis set.

(i) "Body-centered triclinic": simple triclinic lattice with an atom at (0, 0, 0), plus an identical atom at each primitive cell center, which would be position ($a/2$, $b/2$, $c/2$), where the three numbers are multiples of the primitive latice vectors.

(ii) "Base-centered tetragonal", having a simple tetragonal cell (dimensions $a \times a \times c$) with an atom at each corner, and additional identical atoms in the centers of the square $a \times a$ base of the cell.

(iii) "Edge-centered FCC", which would be a normal FCC lattice with the addition of identical atoms at the centers of each of the 12 cube edges.

(iv) "Triangle-centered hexagonal:" start with a simple hexagonal (3D) lattice; connecting all of the atoms in the basal planes yields a network of equilateral triangles. The triangle-centered positions are the centers of these triangles, equidistant from the three corners. Occupy the simple hexagonal sites and also all of the centered sites with identical atoms.

(2) Kittel problem 1.3

(3) Consider a <u>simple tetragonal</u> lattice. This lattice has mutually perpendicular primitive lattice vectors, with lengths $|\vec{a}_1| = |\vec{a}_2| = a$, and $|\vec{a}_3| = c$, where $c \neq a$ (the usual notation for such a lattice). Symmetry operations would include:

- a 90° rotation about $\vec{a}_3$;
- a 180° rotation about $\vec{a}_1$;
- a 180° rotation about $\vec{a}_2$.

Find the most general form for the conductivity tensor in this case. Use the method shown in class; by rotating the tensor, and comparing for the required symmetry, determine which elements may be zero or equivalent.

(4) [a] For the simple cubic lattice of cube edge a, show that the lattice planes indexed by Miller indices (h, k, ℓ) are separated by the distance (measured perpendicular to the planes),

$$d = \frac{a}{\sqrt{h^2 + k^2 + \ell^2}}$$

[b] For the simple tetragonal lattice, having a rectangular cell with edges a, a, and c, find the corresponding relationship for d in terms of the Miller indices. [You can do this using the cell-intercept method. To get the distance it may be helpful to use the rule for direction cosines, which is: for a given vector the sum of the three squares of cosines of the angle to each axis is equal to 1.]