Phys 771
Condensed Matter Physics
Problem Set # 1

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1. Marder 1.1
2. Marder 1.2
3. Marder 1.4
4. (a) Draw the lattice vectors and the primitive unit cell of the 2D lattice shown in Figure 1. How many lattice points are there in the primitive cell?

   (b) Show that the 2D lattice shown in figure is not Bravais lattice

   (c) Show that this non-Bravais lattice may be expressed in terms of three Bravais lattices

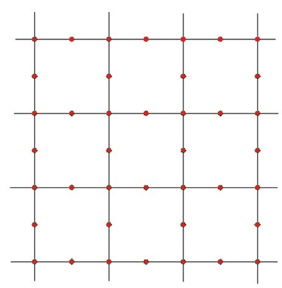

Figure 1:

5. (a) Draw the lattice vectors and the primitive unit cell of the honeycomb lattice (Graphene lattice) shown in Figure 2. How many lattice points are there in the primitive cell?

   (b) Show that the lattice is not Bravais lattice

   (c) Show that this non-Bravais lattice may be expressed in terms of two Bravais lattices

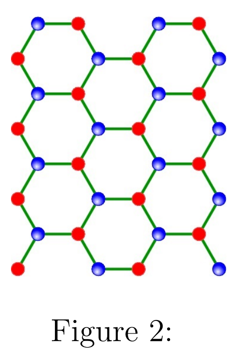

Figure 2:

6. Consider a cube of side length 2 as shown in Figure 3, with the origin of coordinates at the center. Write down the transformation matrix that takes the point (1, -1, 1) into the point (1, -1, -1) using the following symmetry operations in order: first, a 90-degree clockwise rotation around the z-axis, then a reflection across the xz-plane, and finally an inversion about the cube's center.

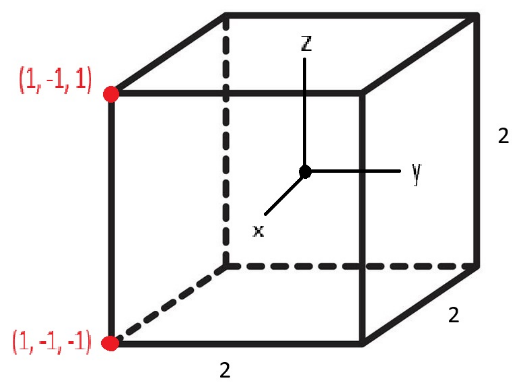

Figure 3:

7. Consider the following matrix

$$R = \begin{pmatrix} 0 & 0 & 1 \\ 0 & -1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

   (a) Verify that the matrix is a rotational matrix by proving that its determinant = +1
   (b) Find the axis and angle of rotation
   (c) Work out the effect of the matrix on the unit vectors i, j, and k separately

8. To reflect a point through a plane $hx + ky + lz = 0$ (which passes through the origin), where (h, k, l) are Miller indices that represent the vector normal to the plane, one can use the following matrix form

$$\sigma = \frac{1}{h^2+k^2+l^2} \begin{pmatrix} -h^2+k^2+l^2 & -2hk & -2hl \\ -2hk & h^2-k^2+l^2 & -2kl \\ -2hl & -2kl & h^2+k^2-l^2 \end{pmatrix}$$

   (a) Set up the reflection matrices for the xy, xz, and yz planes shown in Figure 4.
   (b) set up the reflection matrix though the plane $-x + y = 0$ shown in Figure 4. Use the resulting matrix to verify that the matrix represents a reflection through the plane $-x + y = 0$
   (c) Find the image of the point (1, 0, 1/2)

   Hint : to visualize planes in crystals, use the following webpages
   $https : //www.doitpoms.ac.uk/tlplib/miller_indices/lattice_draw.php$
   $https : //technology.cpm.org/general/3dgraph/$

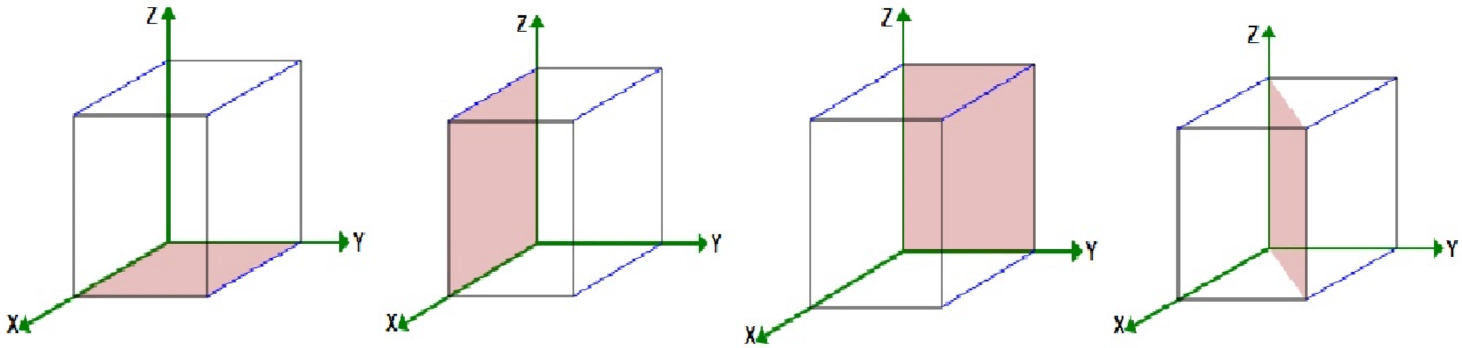

Figure 4: