PHY102 : Assignment 3

1. Consider two parallel infinte non-conducting planes lying in the xy-plane and separated by a distance d. Each plane is uniformly charged with equal but opposite surface charge densities, $+\sigma$ and $-\sigma$ respectively. Find the electric field everywhere in space.

2. Find the electric potential for the three cases : (a) For a non-conducting rod of length l having a uniform charge density λ at a point P, perpendicular distance y above the midpoint of the rod (b) For a uniformly charged ring of radius R and charge density λ, at a distance z from the central axis (c) For a uniformly charged disk of radius R and charge density σ lying in the $xy-$ plane, at a distance z from the central axis.

3. (P&M 2.31) The vector function which follows represents a possible electrostatic field :

$$E_x = 6xy, \quad E_y = 3x^2 - 3y^2, \quad E_z = 0.$$

(We have ignored a multiplicative factor with units of $\mathrm{V/m^3}$ necessary to make the units correct.) Calculate the line integral of $\mathbf{E}$ from the point $(0, 0, 0)$ to the point $(x_1, y_1, 0)$ along the path which runs straight from $(0, 0, 0)$ to $(x_1, 0, 0)$ and thence to $(x_1, y_1, 0)$. Make a similar calculation for the path which runs along the other two sides of the rectangle, via the point $(0, y_1, 0)$. Is the above assertion that the function represents an electrostatic field true ? With the potential function $\phi(x, y, z)$, get back the components of the given field.

4. (P&M 2.42) An inflinitely long circular cylinder of radius a, is filled with a distribution of positive charge of density ρ.

   (a) Use Gauss's law to find the electric field inside and outside the cylinder.

   (b) Find the potential ϕ as a function of r, both inside and outside the cylinder, taking $\phi = 0$ at $r = 0$.

5. (P&M 2.45) A stick with length has charge Q uniformly distributed on it. It lies along the x axis between the points $x = -l$ and $x = 0$. A point charge also with charge Q lies on the x axis at the point $x = l$.

   (a) Let $x = a$ be the point on the x axis between the two objects where the electric field is zero. Find a.

   (b) There happens to be another point where the electric field is zero (it's inside the stick). In addition to this one, are there any other points in space where the electric field is zero? Why or why not ?

   (c) Make a rough sketch of the field lines and equipotential curves everywhere in the plane of the paper. Be sure to indicate how the lines and curves make the transition from their shapes close to the objects to their shapes far from them. (Don't worry about what's going on extremely close to the stick.) What do things look like near the point you found in part (a)?

6. (P&M 2.46) A right angled triangle with vertex P at the origin of coordinates, base length b and height a has a uniform density of surface charge σ. Determine the potential at the vertex P. You can first find the contribution of a vertical strip of width dx at x and then integrate. Find the potential at P.

7. (P&M 2.71) Find (and make rough plots of) the electric field and charge distribution that go with the following potential: $\phi(x) = B(l^2 - x^2)$ for $|x| \leq l$ and $\phi(x) = 0$ for $|x| > l$.