# PH108 : Electricity & Magnetism : Problem Set 6

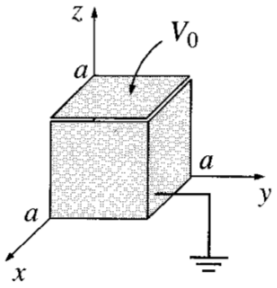
Only * problems are to be solved in the tut session

1. Two infinitely long grounded metal plates, at $y = 0$ and $y = a$, are connected at $x = \pm b$ by metal strips maintained at a constant potential $V_0$, (a thin layer of insulation at each corner prevents them from shorting out). Find the potential inside the resulting rectangular pipe.

2. * A cubical box of side length $a$ consists of five metal plates welded together and grounded. The sixth plate at the top is insulated from the rest and maintained at $V_0$.

   (a) Argue that the potential at the centre should be $\frac{V_0}{6}$

   (b) Find the potential inside the box.




3. A rectangular pipe, running parallel to the z-axis (from $-\infty$ to $+\infty$), has three grounded metal sides, at $y = 0$, $y = a$, and $x = 0$. The fourth side, at $x = b$, is maintained at a specified potential $V_0(y)$. Develop a general formula for the potential inside the pipe.

4. * Two infinitely long metal plates at y = 0 and y = a are connected at x = ±b by metal strips maintained at a constant potential $V_0$. The potential on the bottom (y = 0) is zero, however the potential on the top (y =a) is a nonzero constant $V_1$. A thin layer of insulation at each corner prevents the plates from shorting out. Find the potential inside the resulting rectangular pipe.

5. * Consider a spherical surface of a large radius $R$, the potential on the spherical surface is given below. Using the separation of variables find the potential $V(r, \theta)$ for $r \geq R$ upto order $O\left(1/r^6\right)$.

$$V(R, \theta) = \begin{cases} +V, & 0 \leq \theta < \frac{\pi}{2} \\ -V, & \frac{\pi}{2} < \theta \leq \pi \end{cases}$$

6. * Let a sphere of radius R have potential $V(r = R, \theta, \phi) = V_0 \cos^2 \theta$. Find the potential everywhere inside and outside the sphere.

7. An uncharged, conducting sphere of radius R is placed in a region where the electric field is uniform i.e. $\vec{E} = \vec{E_0}$. Can you guess $l$ value will be odd or even in potential outside the sphere? Find the electric field in the region after the sphere is put in place. [Hint:(a)Use spherical polar co-ordinate solution of Laplace equation. (b)Ponder over what boundary condition will be used to find coefficient $a_l$ and $b_l$ and take derivative to find electric field.]

8. Suppose the potential $V_0(\theta)$ at the surface of the sphere is specified, and there is no charge outside or inside the sphere.Show that charge density on the surface of the sphere is given by,

$$\sigma(\theta) = \frac{\epsilon_0}{2R} \sum_{l=0}^{\infty} (2l+1)^2 C_l P_l(cos\theta)$$

where, $C_l$ is,

$$C_l = \int_0^{\pi} V_0(\theta) P_l(cos\theta) sin\theta d\theta$$