Potential Due to Concentric Spheres.

To find potential at a point due to concentric sphere following guideline are to be considered

Guideline 1: Identity the point (P) at which potential is to be determined.

Guideline 2: Start from inner most sphere, you should know where point (P) lies w.r.t. concerning sphere/shell (i.e. outside, at surface or inside)

Guideline 3: Then find the potential at the point (P) due to inner most sphere and then due to next and so on.

Guideline 4: Using the principle of superposition find net potential at required shell/sphere.

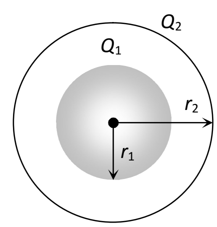
Standard cases

Case (i): If two concentric conducting shells of radii r_1 and r_2($r_2 > r_1$) carrying uniformly distributed charges Q_1 and Q_2 respectively. What will be the potential of each shell

To find the solution following guidelines are to be taken.

Here after following the above guideline potential at the surface of inner shell is

$$V_1 = \frac{1}{4\pi\varepsilon_0}.\frac{Q_1}{r_1} + \frac{1}{4\pi\varepsilon_0}.\frac{Q_2}{r_2}$$

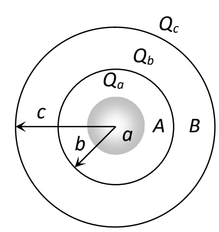


and potential at the surface of outer shell

$$V_2 = \frac{1}{4\pi\varepsilon_0}.\frac{Q_1}{r_2} + \frac{1}{4\pi\varepsilon_0}.\frac{Q_2}{r_2}$$

Case (ii) : The figure shows three conducting concentric shell of radii a, b and c (a < b < c) having charges Q_a, Q_b and Q_c respectively what will be the potential of each shell

After following the guidelines discussed above



Potential at A; $$V_A = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_a}{a} + \frac{Q_b}{b} + \frac{Q_c}{c}\right]$$

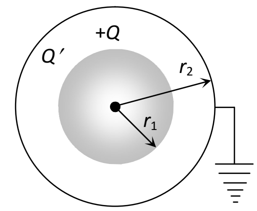
Potential at B; $$V_B = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_a}{b} + \frac{Q_b}{b} + \frac{Q_c}{c}\right]$$

Potential at C; $$V_C = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_a}{c} + \frac{Q_b}{c} + \frac{Q_c}{c}\right]$$

Case (iii): The figure shows two concentric spheres having radii r_1 and r_2 respectively ($r_2 > r_1$). If charge on inner sphere is +Q and outer sphere is earthed then determine.

(a) **The charge on the outer sphere**

(b) **Potential of the inner sphere**



(i) Potential at the surface of outer sphere $V_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_2} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q'}{r_2} = 0$

$\Rightarrow Q' = -Q$

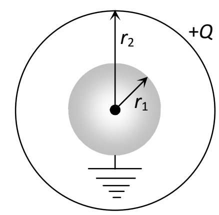
(ii) Potential of the inner sphere $V_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_1} + \frac{1}{4\pi\varepsilon_0} \frac{(-Q)}{r_2} = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$

Case (iv) : In the case III if outer sphere is given a charge +Q and inner sphere is earthed then

(a) **What will be the charge on the inner sphere**

(b) **What will be the potential of the outer sphere**

(i) In this case potential at the surface of inner sphere is zero, so if Q' is the charge induced on inner sphere



then $V_1 = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q'}{r_1} + \frac{Q}{r_2}\right] = 0$ i.e., $Q' = -\frac{r_1}{r_2} Q$

(Charge on inner sphere is less than that of the outer sphere.)

(ii) Potential at the surface of outer sphere

$$V_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q'}{r_2} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_2}$$

$$V_2 = \frac{1}{4\pi\varepsilon_0 r_2}\left[-Q\frac{r_1}{r_2} + Q\right] = \frac{Q}{4\pi\varepsilon_0 r_2}\left[1 - \frac{r_1}{r_2}\right]$$