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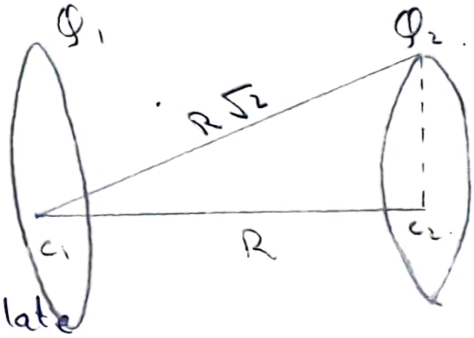
Q.) Two identical thin rings of radius R, are coaxially placed at a' distance R apart. If Q_1 and Q_2 are respectively the charges uniformly spread on the two rings, the work done in moving a charge q from centre of one ~~sig~~ ring to that of other is? Find eq. of potential at centre of ring.?

In this question we have to find the work done to move the charge.



We know that

$W = \Delta U = q\,\Delta V$. ie change in potential energy. So we first calculate potential at centre.

$$V_{C_1} = V_{Q_1} + V_{Q_2} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q_1}{R} + \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q_2}{R\sqrt{2}}.$$

$$= \frac{1}{4\pi\varepsilon_0 R}\left(Q_1 + \frac{Q_2}{\sqrt{2}}\right).$$

Similarly

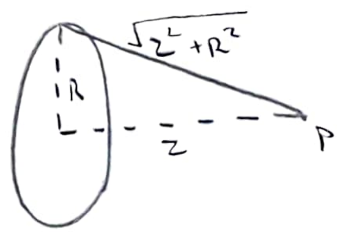
$$V_{C_2} = \frac{1}{4\pi\varepsilon_0 R}\left(Q_2 + \frac{Q_1}{\sqrt{2}}\right).$$

$$\therefore \Delta V = V_{c_1} - V_{c_2} = \frac{1}{4\pi\varepsilon_0 R}\left[(\varphi_1-\varphi_2) - \frac{1}{\sqrt{2}}(\varphi_1-\varphi_2)\right].$$

$$= \frac{(\varphi_1-\varphi_2)}{4\pi\varepsilon_0 R(\sqrt{2})} \cdot (\sqrt{2}-1)$$

$$\therefore W = q\Delta V = q\,\frac{(\varphi_1-\varphi_2)(\sqrt{2}-1)}{\sqrt{2}(4\pi\varepsilon_0 R)}.$$

let the charge density be λ.



$$\therefore dq = \lambda\, dl = \lambda R\, d\theta$$

Potential at a poin P due to small element

$$dv = \frac{k\,dq}{r} \Rightarrow \text{Total potential} = v = \int \frac{k\,dq}{r}.$$

$$v = k\int \frac{\lambda R\, d\theta}{r}. \Rightarrow v = k\int \frac{\lambda R\, d\theta}{\sqrt{R^2+z^2}}.$$

$$\Rightarrow v = k\int_0^{2\pi} \frac{\lambda R\, d\theta}{\sqrt{R^2+z^2}} \Rightarrow v = \frac{\lambda R k}{\sqrt{R^2+z^2}}[2\pi].$$

$$v = \frac{1}{4\pi\varepsilon_0}\frac{\varphi}{\sqrt{R^2+z^2}}$$