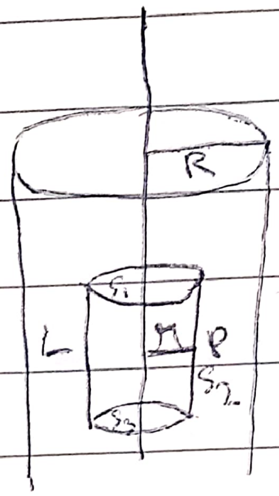
(1) PH-222-2A

Gauss's Law II

1 Ans:- Given :- A long cylinder of radius R and uniform volume charge density ρ.

(i) At an internal point $(r < R)$



According to Gauss's theorem :-

$$\oint \vec{E} \cdot \hat{n}\, ds = \frac{q}{\varepsilon_0}$$

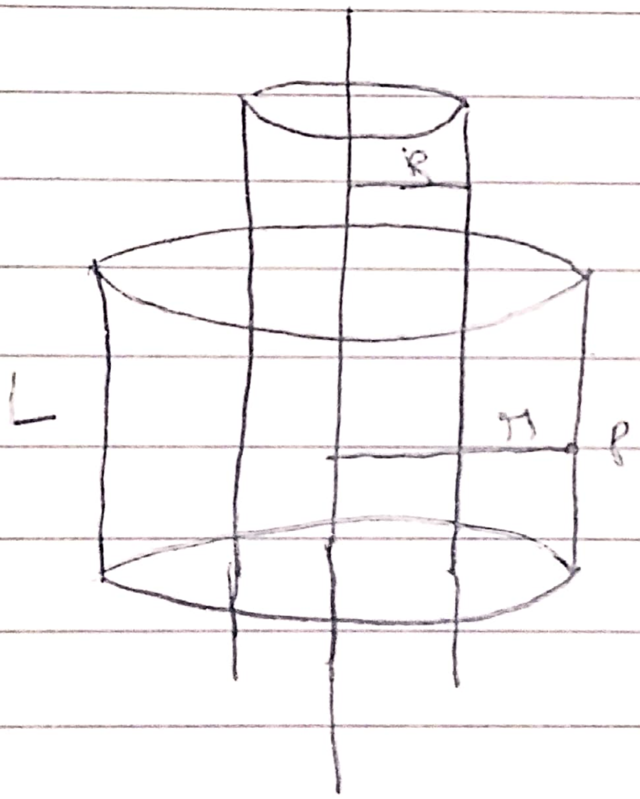
$$\Rightarrow \int_{S_1} \vec{E} \cdot \hat{n}\, ds + \int_{S_2} \vec{E} \cdot \hat{n}\, ds + \int_{S_3} \vec{E} \cdot \hat{n}\, dS = \frac{\pi r^2 L \rho}{\varepsilon_0}$$

$$\Rightarrow 0 + E \times 2\pi r L + 0 = \frac{\pi r^2 L \rho}{\epsilon_0}$$

$$\therefore E = \frac{\rho r}{2\epsilon_0} \quad (\text{for } r \le R)$$

(ii) <u>At an external point ($R < r$)</u>

Let us take an external point P at a distance r from the axis of the cylinder.



According to Gauss theorem:-

$$\int \vec{E} \cdot \hat{n}\, dS = \frac{q}{\epsilon_0}$$

③

$$\therefore \; E \times 2\pi r L = \frac{\pi R^2 L \rho}{\epsilon_0}$$

$$\Rightarrow \; E = \frac{\rho R^2}{2\epsilon_0 r}$$

$$\Rightarrow \; E = \frac{\rho R^2}{2\epsilon_0 r}, \text{ for } r > R$$