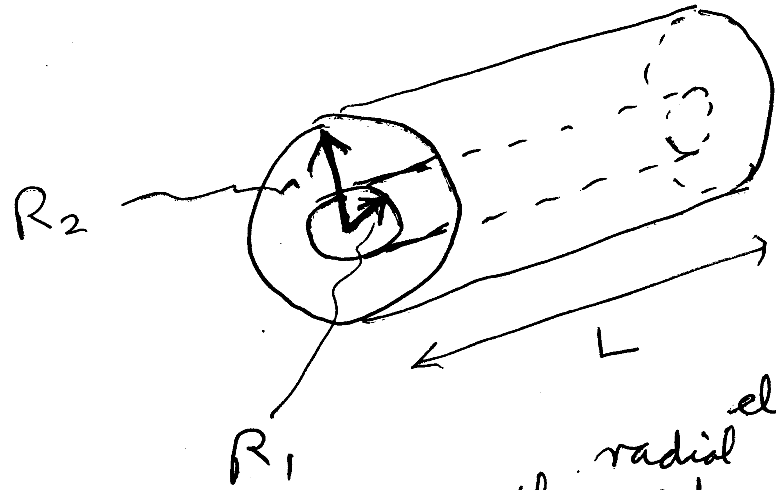
PROBLEM SET 3 2019

SOLUTIONS



By symmetry, any electric field must be radial and depend only on the perpendicular distance r from the axis of the cylinders.

(a) Charge on inner cylinder

$= (\text{charge per unit area}) \times (\text{area})$

$= \sigma \times 2\pi R_1 L$

$= \sigma 2\pi R_1 L$

(b) Charge on outer cylinder

$= (\text{charge per unit area}) \times \text{area}$

$= -\sigma \times 2\pi R_2 L$

$= -\sigma 2\pi R_2 L$

(c) Choose as a Gaussian surface a cylinder of radius $r < R_1$,

The charge enclosed $= 0$

$\Rightarrow$ flux through surface of cylinder is zero

$\Rightarrow$ electric field is zero

(any nonzero electric field would be perpendicular to the axis of the cylinder and would yield a nonzero flux).

(d). Choose a Gaussian surface which is a cylinder of length L and radius $R_1 < r < R_2$.

Charge enclosed

$=$ charge on inner cylinder

$= \sigma \, 2\pi R_1 L$

Gauss's law:

$$E(r) \cdot 2\pi r \cdot L = \frac{\sigma \, 2\pi R_1 L}{\varepsilon_0}$$

$$\Rightarrow E(r) = \frac{\sigma R_1}{\varepsilon_0 r}$$

(e) Choose as the Gaussian surface a cylinder of length L and radius $r > R_2$.

Charge enclosed

$=$ charge on inner cylinder + charge on outer cylinder

$= \sigma 2\pi R_1 L - \sigma 2\pi R_2 L$

$= \sigma 2\pi (R_1 - R_2) L$

Gauss's law

$$\Rightarrow E(r) \, 2\pi r L = \frac{\sigma 2\pi (R_1 - R_2) L}{\varepsilon_0}$$

$$\Rightarrow E(r) = \frac{\sigma (R_1 - R_2)}{\varepsilon_0 r} \underline{\underline{< 0}}$$

(f)