

Voltage for cylindrical conductors

A very long conducting cylindrical rod of radius 1 cm carries a charge of $1 \mu\text{C}/\text{m}$. It is surrounded by a concentric hollow cylindrical pipe-shaped conductor of radius 3 cm, which carries a charge of $-1 \mu\text{C}/\text{m}$.

- a) Use Gauss' Law to determine the electric field between the conductors, as a function of radius.
Sketch the field.



$$1 \text{ cm} < r < 3 \text{ cm}$$

$$\oint \vec{E} \cdot d\vec{A} = \iint_{\text{left front}} + \iint_{\text{right front}} + \iint_{\text{left back}} + \iint_{\text{right back}} E dA$$

$$= E \frac{2\pi r^2}{2\pi R^2} h$$

$$\frac{q_{\text{enc}}}{\epsilon_0} = \frac{\lambda h}{2\pi} \rightarrow E = \frac{2\lambda}{2\pi \epsilon_0 r h}$$

- b) Calculate the voltage difference between the two cylinders.

$$\Delta V = \frac{\Delta PE}{q_0} = - \int \vec{F} \cdot d\vec{s} = - \int \vec{E} \cdot d\vec{s} = - \int \vec{E} \cdot d\vec{s}$$

dr
pick a path parallel to E !

$E \neq \text{const}$ You must DO the integral!

$$- \int \frac{\lambda}{2\pi \epsilon_0 r} dr = - \frac{\lambda}{2\pi \epsilon_0} \ln r \Big|_{1 \text{ cm}}^{3 \text{ cm}} = \boxed{- \frac{\lambda}{2\pi \epsilon_0} \ln 3}$$

$$= - \frac{1 \mu\text{C}/\text{m} \cdot 2(9 \times 10^9)}{2\pi \epsilon_0} \ln 3 = \sim 29000 \text{ V} !$$

- c) Based on your answer to b), which conductor is at higher voltage? Does this make sense with the electric field direction from a)?

low V @ outer (-) conductor.