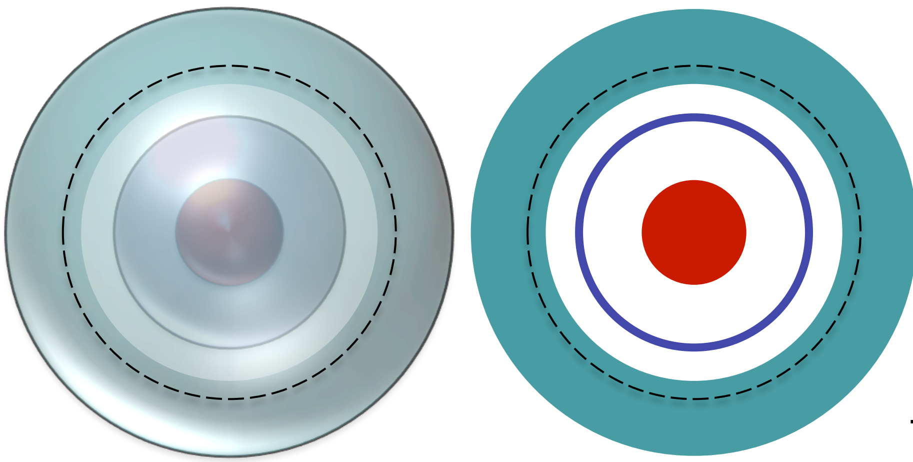
What is the charge enclosed?



core: ρ_1, radius a

thin shell: σ, radius b

thick shell: ρ_2, radii c & d

Gaussian sphere, radius r

$$\tfrac{4}{3}\pi a^3\rho_1 + 4\pi b^2\sigma + \tfrac{4}{3}\pi\left(r^3 - c^3\right)\rho_2$$

Find E at radius r:

$$\varepsilon_0 4\pi r^2 E = \tfrac{4}{3}\pi a^3\rho_1 + 4\pi b^2\sigma + \tfrac{4}{3}\pi\left(r^3 - c^3\right)\rho_2$$

$$E = \frac{1}{3\varepsilon_0 r^2}\left(a^3\rho_1 + 3b^2\sigma + \left(r^3 - c^3\right)\rho_2\right)$$

Take a very long insulating rod, radius a=0.05m and charge density ρ=60μC/m^3, surrounded by a conducting hollow cylinder of inner radius b=0.10m and outer radius c=0.15m.

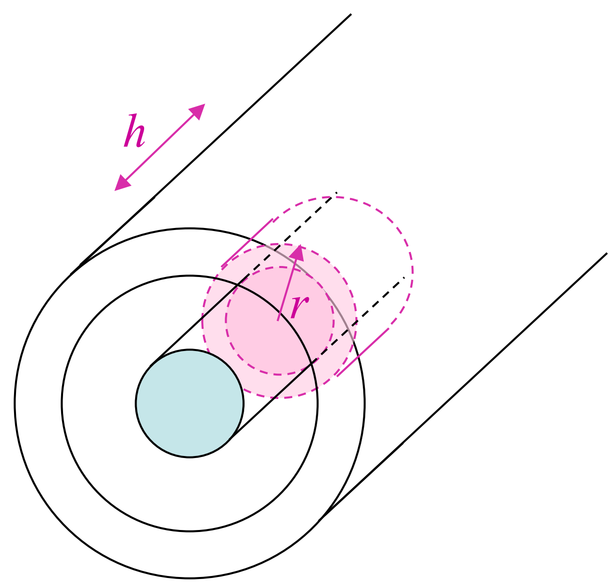
What is the magnitude of E at $a < r < b$?

$$\varepsilon_0 \Phi_E = q_{\text{enc}}$$

$$\varepsilon_0 \left(2\cancel{\pi} r \cancel{h} E_r \right) = \rho \left(\cancel{\pi} a^2 \cancel{h} \right)$$

$$E_r = \frac{\rho a^2}{2\varepsilon_0 r}$$

$$E_r = \frac{(60\,\mu\text{C/m}^3)(0.05\,\text{m})^2}{2(8.85\times10^{-12}\,\text{C}^2/\text{Nm}^2)r} = \frac{8475\,\text{Nm/C}}{r}$$

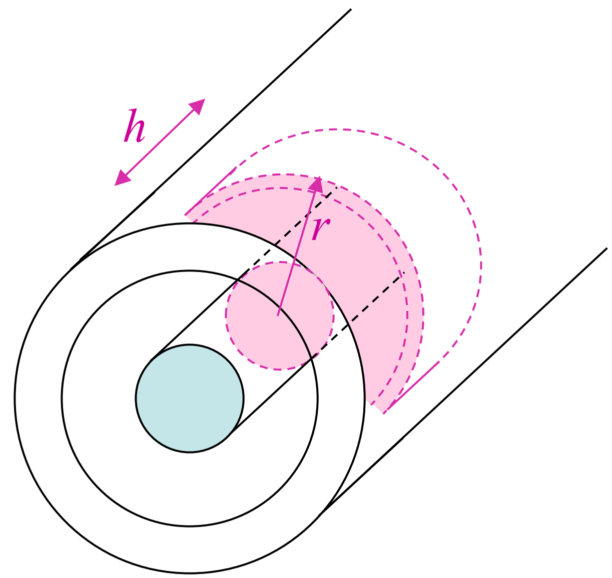


Take a very long insulating rod, radius a=0.05m and charge density ρ=60μC/m³, surrounded by a conducting hollow cylinder of inner radius b=0.10m and outer radius c=0.15m.

What is the magnitude of E at $b < r < c$?

$$E = 0 \quad !$$

$$\varepsilon_0 \Phi_E = q_{\text{enc}}$$



$$0 = \rho\left(\pi a^2 h\right) + \sigma\left(2\pi b h\right)$$

$$\sigma = -\frac{\rho a^2}{2b}$$

$$\sigma = -\frac{(60\,\mu\text{C/m}^3)(0.05\,\text{m})^2}{2(0.10\text{m})} = -0.75\,\mu\text{C/m}^2$$

Same setup:

long insulating rod, radius a=0.05m, ρ=60μC/m^3

conducting pipe inner and outer radius b=0.10m, c=0.15m,

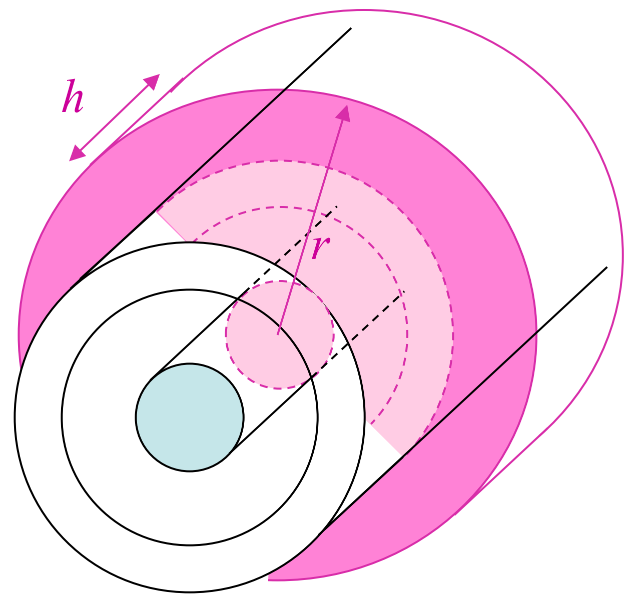
but now with charge λ=15μC/m.

What is the magnitude of E at $r > c$?

$$\varepsilon_0 \Phi_E = q_{\text{enc}}$$

$$\varepsilon_0 \left(2\pi r \not{h} E_r \right) = \rho \left(\pi a^2 \not{h} \right) + \lambda \not{h}$$

$$E_r = \frac{\rho \pi a^2 + \lambda}{2\pi \varepsilon_0 r}$$



$$E_r = \frac{(60\,\mu\text{C/m}^3)\pi(0.05\,\text{m})^2 + (15\,\mu\text{C/m})}{2\pi(8.85\times10^{-12}\,\text{C}^2/\text{Nm}^2)r} = \frac{2.78\times10^5\ \text{Nm/C}}{r}$$