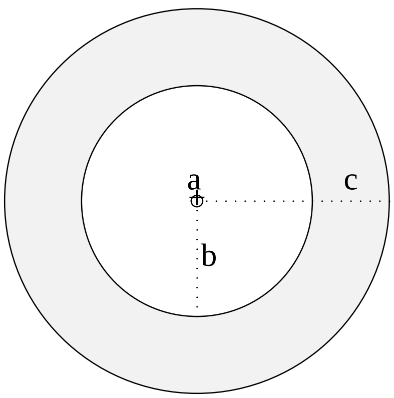
3. (50 pts.) A Geiger counter is a device used to detect ionizing radiation. The counter consists of a thin, positively charged central wire surrounded by a concentric circular conducting cylindrical shell with an equal negative charge. Thus a strong electric field is set up inside the cylinder. Suppose that the inner wire has a radius $a = 2.5 \times 10^{-5}$m and a charge per unit length $\lambda = 2 \times 10^{-8}$C/m, and that the outer cylinder has an inner radius $b = 0.014$m, an outer radius $c = 0.018$m, and a charge per unit length -2×10^{-8}C/m (see figure). Assume that both the wire and cylinder extend infinitely in the direction perpendicular to the paper.



a. (5 pts.) Sketch the Gaussian surface you would use to calculate the electric field at a distance $r = 0.01$m from the center. (This is in the region between the two cylinders.) You may do this right on the figure.

b. (20 pts.) Use Gauss's law to calculate the electric field at $r = 0.01$m from the center.

c. (5 pts.) What is the electric field at $r = 0.015\text{m}$? (This is inside the outer conducting cylinder, *i.e.*, between b and c.) Explain briefly.

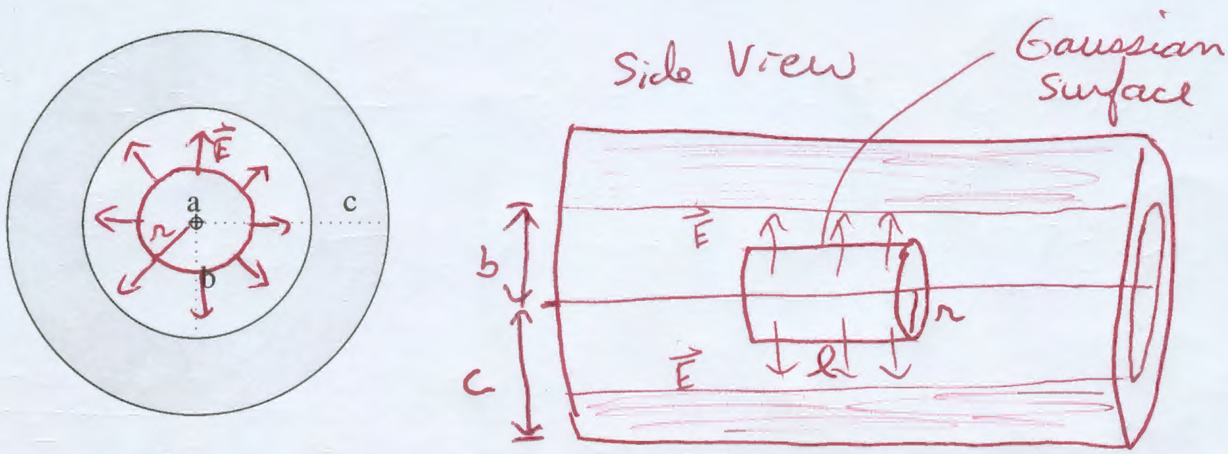
d. (5 pts.) What is the charge per unit length on the inner surface (b) of the outer conducting cylinder? Explain briefly.

e. (5 pts.) What is the charge per unit length on the outer surface (c) of the outer conducting cylinder? Explain briefly.

f. (5 pts.) What is the electric field at $r = 0.03\text{m}$? (This is outside both cylinders.) Explain briefly.

g. (5 pts.) Suppose an additional charge per unit length $\lambda_2 = -4 \times 10^{-8}\text{C/m}$ were placed on the outer cylinder. Would any of your previous answers change? If so, explain why. If not, explain why not. *Do not recalculate anything. Just state in words what happens.*

3. (50 pts.) A Geiger counter is a device used to detect ionizing radiation. The counter consists of a thin, positively charged central wire surrounded by a concentric circular conducting cylindrical shell with an equal negative charge. Thus a strong electric field is set up inside the cylinder. Suppose that the inner wire has a radius $a = 2.5 \times 10^{-5}$m and a charge per unit length $\lambda = 2 \times 10^{-8}$C/m, and that the outer cylinder has an inner radius $b = 0.014$m, an outer radius $c = 0.018$m, and a charge per unit length -2×10^{-8}C/m (see figure). Assume that both the wire and cylinder extend infinitely in the direction perpendicular to the paper.



a. (5 pts.) Sketch the Gaussian surface you would use to calculate the electric field at a distance $r = 0.01$m from the center. (This is in the region between the two cylinders.) You may do this right on the figure.

b. (20 pts.) Use Gauss's law to calculate the electric field at $r = 0.01$m from the center.

$$\Phi = Q_{inside}/\epsilon_0$$

$$E(2\pi r \ell) = \lambda \ell/\epsilon_0$$

$$E = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r}$$

$$= \frac{1}{2\pi\epsilon_0}\frac{(2\times10^{-8})}{(0.01)} = \boxed{35{,}960 \text{ N/C}}$$

Note all flux is through the sides of the cylinder — None is through the ends.

c. (5 pts.) What is the electric field at $r = 0.015$m? (This is inside the outer conducting cylinder, *i.e.*, between b and c.) Explain briefly.

$\boxed{0}$ $E = 0$ inside a conductor in electrostatic equilibrium.

d. (5 pts.) What is the charge per unit length on the inner surface (b) of the outer conducting cylinder? Explain briefly.

$\Phi = \frac{Q_{inside}}{\epsilon_0}$

$E(2\pi r \ell) = Q_{inside}/\epsilon_0$

$0 = Q_{inside}/\epsilon_0$

→ But $Q_{inside} = \lambda_a \ell + \lambda_b \ell$

$\therefore \lambda_b = -\lambda_a = \boxed{-2 \times 10^{-8}\,C/m}$

e. (5 pts.) What is the charge per unit length on the outer surface (c) of the outer conducting cylinder? Explain briefly.

Since the total charge density on the outer cylinder is $\lambda_b + \lambda_c = -2 \times 10^{-8}\,C/m$, all of it is on the inner surface. $\boxed{\lambda_c = 0}$

f. (5 pts.) What is the electric field at $r = 0.03$m? (This is outside both cylinders.) Explain briefly.

$\Phi = \frac{Q_{inside}}{\epsilon_0}$. Since $Q_{inside} = 0$, $\boxed{E = 0.}$

---

a, b, c, and d would all stay the same, since they all concern inside radius c. e and f would change. The extra

g. (5 pts.) Suppose an additional charge per unit length $\lambda_2 = -4 \times 10^{-8}$C/m were placed on the outer cylinder. Would any of your previous answers change? If so, explain why. If not, explain why not. *Do not recalculate anything. Just state in words what happens.*

charge would go to the outer surface. $\lambda_c = -4 \times 10^{-8}\,C/m$, and $E_{outside} = \frac{1}{2\pi\epsilon_0} \frac{\lambda_c}{r}$.