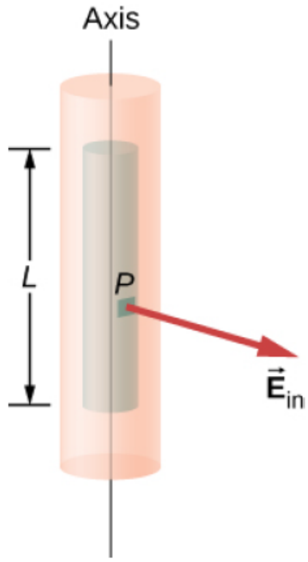
Chapter 6   Problem 50 †



Given
$\lambda = -5.0\ \mu C/cm = -5.0 \times 10^{-4}\ C/m$
$R = 3.0\ cm = 0.030\ m$

Solution
a) Find the electric field at $r = 3.0\ cm$, just outside the surface of the silver rod.

Sind the gaussian surface is just outside the surface of the rod, the enclosed charge equals the charge per length multiplied by the length of the cylinder discribed by our gaussian surface.

$$q_{enc} = \lambda L$$

From Gauss' Law

$$\oint_S \vec{E} \cdot \vec{A} = \Phi = \frac{q_{enc}}{\epsilon_0}$$

We are dealing with cylindrical symmetry, therefore the electric field is a constant over the integral of the cylinder wall and zero for the end caps of the cylinder. The surface area of the wall is the circumference multiplied by the length. Therefore,

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

The electric field is then

$$E = \frac{\lambda}{2\pi\epsilon_0 r} \qquad (Eq.1)$$

Substituting in our values gives

$$E = \frac{-5.00 \times 10^{-4}\ C/m}{2\pi(8.85 \times 10^{-12}\ C^2/Nm^2)(0.030\ m)}$$

$$E = -3.00 \times 10^{8}\ N/C$$

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† Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)

The negative sign means the electric field is entering the surface not leaving. This is opposite of what is illustrated in the provided diagram.

Notice that we are just above the surface of a conductor. Since the charge per length of the rod is $-3.0 \times 10^{-4}\ C/m$, we could calculate the surface charge density by dividing this number by the circumference of a circle. This effectively spreads the line charge our over a surface corresponding to the wall of the cylinder. This gives a value of

$$\sigma = \frac{\lambda}{2\pi r} = \frac{-5.0 \times 10^{-4}\ C/m}{2\pi(0.030\ m)} = -2.65 \times 10^{-3}\ C/m^2$$

Directly above the surface of a conductor, the electric field is

$$E = \frac{\sigma}{\epsilon_0}$$

Therefore,

$$E = \frac{-2.65 \times 10^{-3}\ C/m^2}{8.85 \times 10^{-12}\ C^2/Nm^2} = -3.00 \times 10^8\ N/C$$

Notice this gives you the same answer.

b) What is the electric field at $r = 2.0\ cm$.

Since the radius of the gaussian cylinder is inside the surface of the silver rod, there is no enclosed charge. The charge resides on the surface of conductors. Therefore, the electric field is

$$E = \frac{0\ C/m}{2\pi(8.85 \times 10^{-12}\ C^2/Nm^2)(0.030\ m)}$$

$$E = 0\ N/C$$