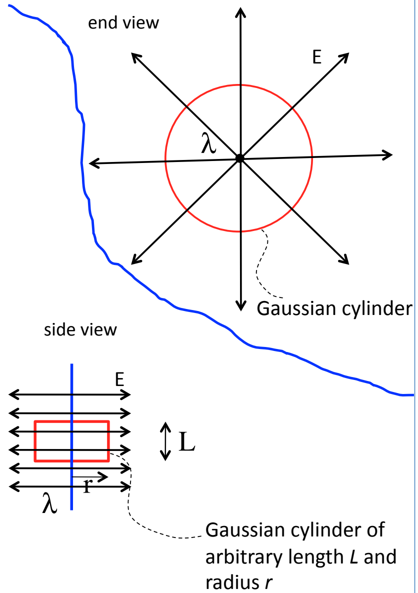
Problem 24.29

A wire of length 7 meters has 2.00 micro-coulombs of charge on it. A 2 cm long, 10 cm radius cylinder surrounds the wire. To a good approximation:

a.) what's the electric field at the cylinder's surface:



The first thing to notice is that, to a good approximation, all of the electric field lines will go through the cylindrical part of the structure with essentially none of them passing through the end-caps. That means the area part of the Gauss's Law integral will be the area of the cylindrical part of the surface. Also, the amount of charge inside will be the *charge per unit length* times the length "L" of the Gaussian surface. Soooo . . .

Gauss's Law yields:

$$\int_A \vec{E} \bullet d\vec{A} = \frac{q_{enclose}}{\varepsilon_o}$$

$$\int_{cyl} E\, dA_{cyl} \cos 0^\circ = \frac{\lambda L}{\varepsilon_o}$$

$$\Rightarrow \quad E \int_{cyl} dA_{cyl} = \frac{\lambda L}{\varepsilon_o}$$

$$\Rightarrow \quad E(2\pi R L) = \frac{\lambda L}{\varepsilon_o}$$

$$\Rightarrow \quad E = \frac{\lambda}{2\pi\varepsilon_o R}$$

$$\Rightarrow \quad E = \frac{\left[2\text{x}10^{-6} \text{C}/7\text{m}\right]}{2\pi\left(8.85\text{x}10^{-12}\ \text{C}^2/\text{m}^2\bullet\text{N}\right)(.1\text{m})}$$

$$\Rightarrow \quad E = 5.14\text{x}10^4\ \text{N/C}$$

b.) You can get the flux two ways:

$$\begin{aligned}\Phi_E &= EA_{cyl}\\ &= E(2\pi RL)\\ &= \left(5.14\text{x}10^4\ \text{N/C}\right)\left(2\pi(.1\text{m})(.02\text{m})\right)\\ &= 646\ \text{N}\bullet\text{m}^2/\text{C}\end{aligned}$$

The alternative:

$$\begin{aligned}\Phi_E &= \frac{q_{enclosed}}{\varepsilon_o}\\ &= \frac{\lambda L}{\varepsilon_o}\\ &= \frac{\left[2\text{x}10^{-6} \text{C}/7\text{m}\right](.02\text{m})}{\left(8.85\text{x}10^{-12}\ \text{C}^2/\text{m}^2\bullet\text{N}\right)}\\ &= 646\ \text{N}\bullet\text{m}^2/\text{C}\end{aligned}$$