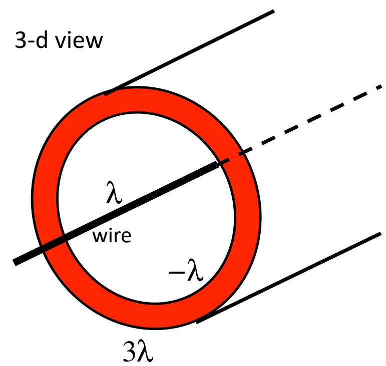
Problem 24.43



a.) The electric field inside any metallic structure must be zero, which means the charge enclosed inside any Gaussian surface that resides inside a metallic object must also be zero. If there is λ's worth of charge on the line down the central axis, there must be $-\lambda$'s worth of charge on the inside surface of the metallic cylinder so the total charge inside a Gaussian surface located inside the conductor will be net zero.

b.) The total free charge density associated with both structures on all surfaces is equal to $\lambda_{net} = \lambda + 2\lambda = 3\lambda$.

That means a Gaussian surface located outside the metallic cylinder must have 3λ's worth of net charge enclosed within its borders. With λ's worth on the wire and $-\lambda$'s worth on the inside of the cylinder, there must be 3λ's worth on the outside of the cylinder to get the appropriate "charge enclosed." All of this is pictured on the sketch.

c.) The left side of Gauss's Law for cylindrical symmetry is still $E(2\pi r\ L)$, where "L" is the length of the Gaussian surface, so Gauss's Law for outside the cylinder yields:

$$\int \vec{E} \bullet d\vec{A} = \frac{q_{enclosed}}{\varepsilon_o}$$

$$\Rightarrow \quad E(2\pi r\ L) = \frac{(3\lambda L)}{\varepsilon_o}$$

$$\Rightarrow \quad E = \frac{3\lambda}{2\pi\varepsilon_o r}$$

Note that this is the same as:

$$E = 6k\frac{\lambda}{r}$$