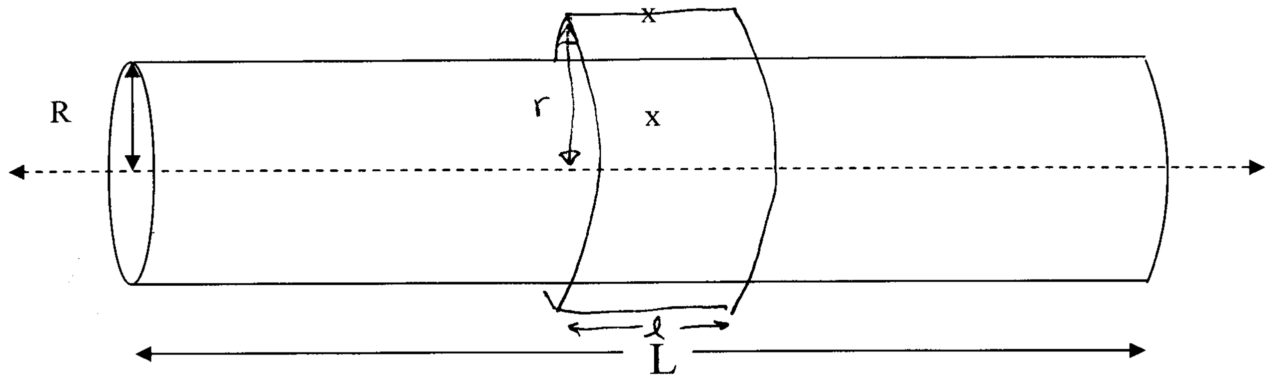
Name ________________
Section 1121/3321

SP222 CDR Tucholski
Quiz 1 Feb 2011

A very long **metal (conducting) cylinder** has excess positive charge, Q, and dimensions as shown. We want to use Gauss' Law to determine the electric field all around the cylinder near the middle at the x's.



a. What is the magnitude of the electric field at the x inside the cylinder? (1.5 points)

$$E = 0$$

b. What is the value of the appropriate charge density for this charged conductor (in terms of Q, and dimensions given)? (1 points)

$$\sigma = \frac{Q}{2\pi R L}$$

c. Sketch a Gaussian surface that will allow you to find the electric field outside the cylinder at the "x". (1 points)

d. Label the dimensions of your Gaussian surface. (1 points)

e. Gauss's Law says: $\Phi_E = \oint \vec{E} \bullet d\vec{A} = \frac{q_{inside}}{\varepsilon_o}$ If you have picked a proper Gaussian surface, the integral part of Gauss's law is a simple product. What is the flux using the integral part of Gauss's law in terms of the unknown electric field magnitude and any appropriate dimensions on your diagram? (2 points)

$$\Phi = \oint E \cdot dA = E(2\pi r \ell)$$

f. In terms of the charge density and any appropriate dimensions on your diagram, how much charge is inside your Gaussian surface? Find the flux through your Gaussian surface using this charge. (2 points)

$$q_{INSIDE} = \sigma\, 2\pi R \ell \qquad \Phi = \frac{\sigma\, 2\pi R \ell}{\epsilon_0} = \frac{Q}{\cancel{2\pi R} L} \frac{\cancel{2\pi R}\ell}{\epsilon_0} = \frac{Q \ell}{\epsilon_0 L}$$

g. Now equate the two flux calculations and solve for the unknown electric field magnitude. Substitute your expression for charge density (from a.) and express your answer in terms of the total charge and the dimension on your diagram. (1.5 points)

$$E(\cancel{2\pi} r \cancel{\ell}) = \frac{\sigma(\cancel{2\pi} R \cancel{\ell})}{\epsilon_0}$$

$$E = \frac{\sigma R}{\epsilon_0 r} = \frac{Q}{2\pi \cancel{R} L} \frac{\cancel{R}}{\epsilon_0 r} = \frac{1}{2\pi\epsilon_0} \frac{Q}{L} \frac{1}{r}$$

$$= \frac{2k\lambda}{r}$$

Extra Credit: Real physics again. If the cylinder has a positive charge of 5.00 μC it is because many electrons were removed. How many?

$$N = \frac{5 \times 10^{-6} C}{1.6 \times 10^{-19} C} = 3.1 \times 10^{13}$$