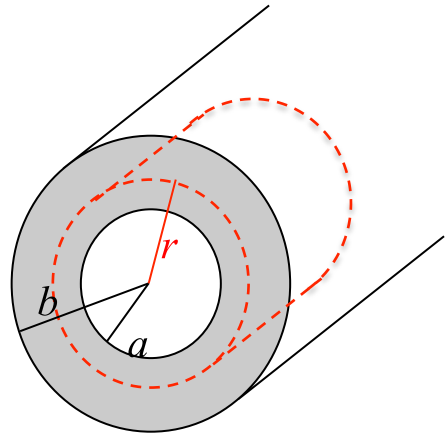
Name____________________________

Physics 125: Analytical Physics II
No Risk Quiz – Gauss' Law

The picture shows the cross-section of a thick-walled cylindrical pipe, with outer radius $b = 12.0$ cm and inner radius $a = 6.0$ cm. The insulating material of the pipe carries a uniform charge density of $\rho = 32.0\ \mu\text{C/m}^3$.



Use Gauss' Law to determine the electric field strength at a distance r from the central axis, where $a < r < b$.

(1) [3 pts] Draw the appropriate Gaussian surface for this problem on the figure.

The dashed line, a cylinder of radius r and length h.

(2) [7 pts] Show how to get ***a formula*** for the electric field strength. Your answer should be a function of r, a, b, ρ, and physical constants. (**DO NOT** put the numerical values in your answer. They are just to help you think about the problem.)

(1)

$$\oint \vec{E} \cdot d\vec{A} = \frac{1}{\varepsilon_0} q_{\text{enc}}$$

On the left, the standard flux for cylindrical symmetry, with the area of a cylinder's curved surface.

For enclosed charge, the charge fills the volume of the Gaussian surface ***except*** for the interior cavity with radius a.

(2) (3)

$$E(2\pi r h) = \frac{1}{\varepsilon_0} \rho(\pi r^2 h - \pi a^2 h)$$

$$E 2r = \frac{\rho}{\varepsilon_0}(r^2 - a^2)$$

Then solve for E...

(1)

$$E = \frac{\rho}{2\varepsilon_0} \frac{(r^2 - a^2)}{r}$$

From the Formula Sheet:

$k = 8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$\varepsilon_0 = 8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2$

cylinder: $2\pi RL$

$\pi R^2 L$

$\Phi_E = \int \vec{E} \cdot d\vec{A}$

$\varepsilon_0 \Phi_E = q_{\text{enc}}$