Phyx 135-2, Fall 2016, Quiz #2
Section 01 (10 am)

Name ____
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1) A charge of uniform linear density λ = 2.0 nC/m is distributed along a long, thin, non-conducting rod. The rod is coaxial with a long conducting cylindrical shell (inner radius = 5.0 cm, outer radius = 10 cm). The net charge on the shell is zero.

a) (10 points) What is the magnitude of the electric field 15 cm from the axis of the shell?

Solution: From Gauss' Law, and using cylindrical symmetry, we know that (electric field) X (area of cylinder) = (charge enclosed) / ε_0. The conducting shell is inside our given radius of 15 cm, but that doesn't matter because it has no *net* charge on it.

So, $E(2\pi r)l = \lambda l / \varepsilon_0$, or $E = \lambda / 2\pi r\, \varepsilon_0$. Inserting numbers,
$E = (2.0 \times 10^{-9}\ \text{C/m}) / (2)(3.14159)(0.15\ \text{m})(8.85 \times 10^{-12}\ \text{C}^2 / \text{N m}^2) = 2.4 \times 10^2$ N/C.

b) (10 points) What is the surface charge density σ on the inner and outer surfaces of the shell?

Solution: The shell is a conductor, thus the electric field inside it must equal zero. This can only happen if the charge on the shell equals the enclosed charge, i.e., it must have an induced linear charge density of $-\lambda$ on the inner radius of the shell and $+\lambda$ on the outer radius of the shell. For the inner radius we have $\sigma = -\lambda / 2\pi r = (-2.0\ \text{nC/m}) / (2)(3.14159)(0.05\ \text{m}) = -6.37\ \text{nC/m}^2$. The outer radius will have half of this, or $\sigma = +3.18\ \text{nC/m}^2$.