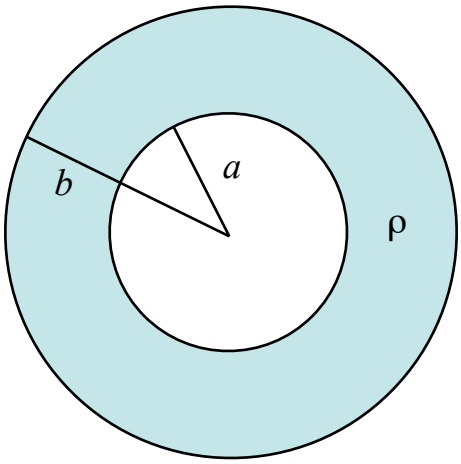
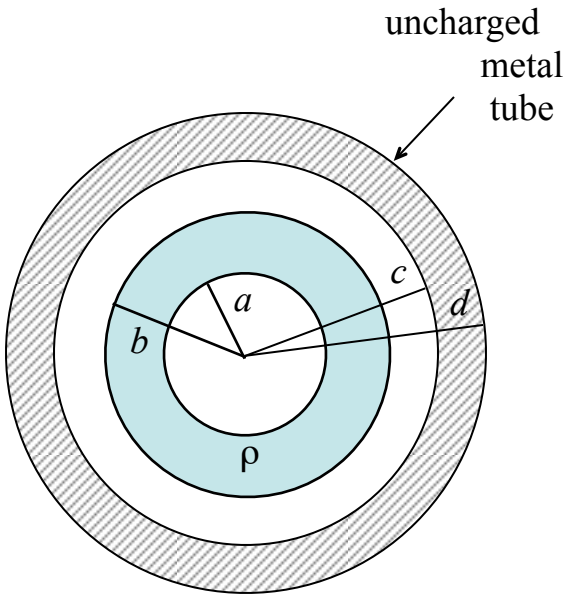
Discussion Question 3D
P212, Week 3
Electric Field Due to Charged Cylinders and Lines

Consider a **non-conducting** cylinder of infinite length with a hollow core. The inner radius is *a*, the outer radius is *b*, and the solid region in between carries a uniformly-distributed volume charge density ρ.

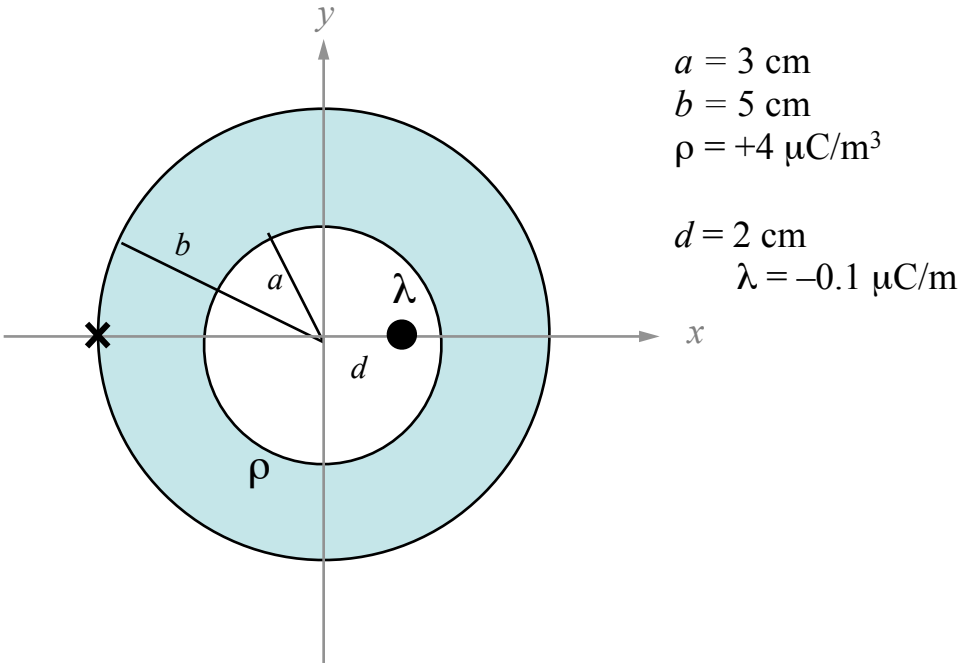


(a) Using Gauss' Law and the steps outlined earlier, calculate the electric field at a radius of *r* from the axis of the cylinder, where $a < r < b$. (This one is a bit challenging.)

(b) Now suppose a hollow **metal** cylinder of inner radius *c* and outer radius *d* is placed around the non-conducting tube. The metal tube carries no net charge. What is the surface charge density σ_c induced on the *inner* surface of the metal cylinder?



Now for a challenge! Suppose we add an infinite line charge inside the hollow cylinder, but at an **off-center** location: the line runs along the line $x = d$ where $d < a$. The line carries a charge per unit length λ. The values of all parameters are given in the figure.



a = 3 cm
b = 5 cm
$\rho = +4\ \mu C/m^3$

d = 2 cm
$\lambda = -0.1\ \mu C/m$

(c) What is the electric field at the position $(x,y) = (-b,0)$ (i.e. the point marked with an **x** on the figure)? Be sure to give both magnitude and direction.

This one takes a little thought: the problem looks like it does *not* have enough symmetry for you to apply Gauss' Law, but you *do* have the tools to solve it … think *superposition* …

(d) And finally, calculate the components of the electric field at the point $(x,y) = (0,b)$.