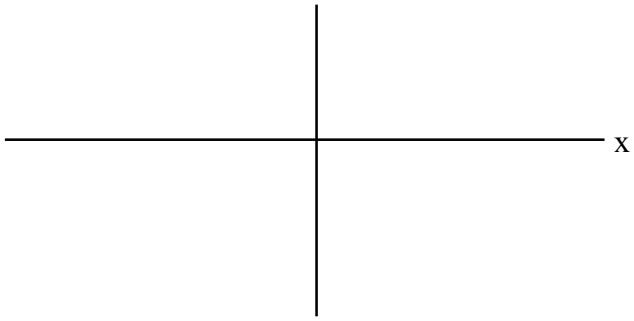
Tutorial 2: Lightening strike at SLAC!

Part 1



i. Sketch: $f(x) = \delta(x-3)$

(can you *really* sketch this?)

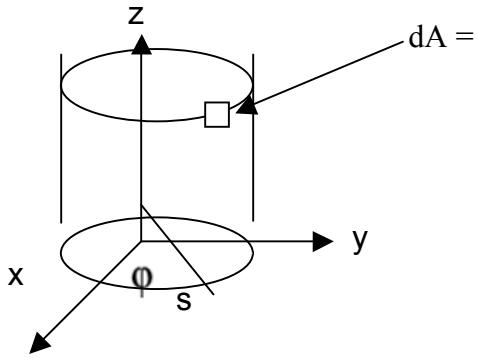
ii. Integrate:

$$\int_{-10}^{10} c \cdot f(x) \cdot dx =$$

$$\int_{-\infty}^{\infty} c \cdot x \cdot f(x) \cdot dx =$$

iii. What is the physical situation represented by this volume charge density? Make a 3-D sketch of the charge distribution: $\rho(x,y,z) = c \cdot \delta(x-3)$

iv. What is the infinitesimal area, dA, of a small patch on a cylindrical shell centered on the z-axis?



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Part 2

SLAC (Stanford Linear Accelerator Center) is where quarks (including the charm quark), and the z-boson were discovered. Particles are accelerated inside a long hollow metal cylinder, which is 3 miles long and has a 70 cm diameter.

One afternoon, the beam line is struck by lightening, which gives it a surface charge density σ. Moments after the lightening strikes, Stanford physicists run an experiment and claim they've discovered a new particle! You will investigate whether the surface charge of the beam line could have affected the experiment.

i. Determine an expression for the volume charge density, ρ, of the beam line.

(note: this is similar to HW3 Q2b)

ii. Check your answer by integrating to find the total charge. (are the units correct?)

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iii. What are the units of your delta function in (i.)? (This is another way of checking your answer to (i.), so don't *only* use your answer to (i.) to check the units)

iv. What direction does the E-field point at all points in space? Explain in detail how you know.

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v. Use Gauss's Law to find the E-field at all points in space.

(note: This is the E-field produced by *just* the outer shell of the coax cable on HW3 Q7)

vi. Does the charge σ on the beam line affect the particles being accelerated inside it? Could it affect the electronic equipment outside the tunnel? Could the Stanford scientists have discovered a new particle while the beam tunnel was charged?

Challenge Problem:

You have found that when charged, SLAC's beam line produces an E-field. In all space, where is this E-field's divergence zero? Where is it non-zero?

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