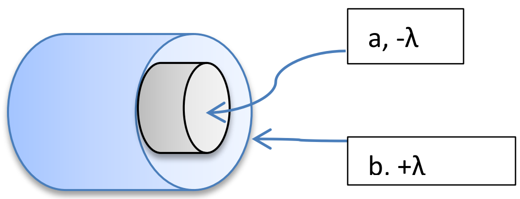
Physics 4B Problem Set 3 – Gauss's Law

1. Use Gauss's Law to prove that the electric field anywhere inside the hollow of a charged spherical shell must be zero. Repeat for a charged hollow infinite cylinder.
2. A small sphere of mass m carries a charge of q. It hangs from a silk thread which makes an angle θ with a large charged non-conducting sheet. Calculate the surface charge density on the sheet.

3. The figure shows a section through two long concentric cylinders of radii a and b. The cylinders carry equal and opposite charges per unit length of λ. Using Gauss's law, prove that (a) E = 0 for r > b and for r < a and (b) that between the cylinders E is given by $E = \frac{1}{2\pi\epsilon}\frac{lambda}{r}$



4. A spherically symmetric charge distribution has a charge density given by ρ = a/r, where a is a constant with the units of C/m^2. Find the electric field within the charge distribution as a function of r.

5. A single isolated, large conducting plate has a charge per unit area σ on its surface. Because the plate is a conductor, the electric field at its surface is perpendicular to the surface and has magnitude $E = \sigma/\varepsilon_o$
    a. The field from a large, uniformly charged sheet with charge per unit area σ has magnitude $E = \sigma/2\varepsilon_o$. Why is there a difference?
    b. Regard the charge distribution on the conducting plate as two sheets of charge (one on each surface), each with charge per unit area σ. Find the electric field inside and outside the plate.

6. An infinitely long insulating cylinder of radius R has a volume charge density that varies with the radius as $\rho = \rho_o\left(a - \frac{r}{b}\right)$, where ρ_o, a and b are positive constants and r is the distance from the axis of the cylinder. Use Gauss's law to determine the magnitude of the electric field at radial distances (a) r < R and (b) r > R
7. Use Gauss's law to show the electric field given by $\mathbf{E} = x^2\mathbf{i}$ cannot exist in nature.
8. Use Gauss's law to find the E field *just* outside a conducting shell of charge. Radius R, total charge Q given.
9. Use Gauss's law to find the E field *just* outside a small hole that was punched out of an otherwise charged conducting sphere.

10. Consider a solid uniformly charged dielectric sphere where the charge density is give as ρ. The sphere has a radius R. Say that a hollow of charge has been created within the sphere that is offset from the center of the large sphere such that the small hollow has its center on the x axis where x = R/2. Using a standard frame where the large frame has its center at the origin, find the Electric field vector at the following points.
    a. The origin
    b. Anywhere inside the hollow (challenging)
    c. x = 0, y = R
    d. x = -R, y =0

11. Starting from Gausssss' Law, derive the magnitude of the Coulomb field due to a point source.