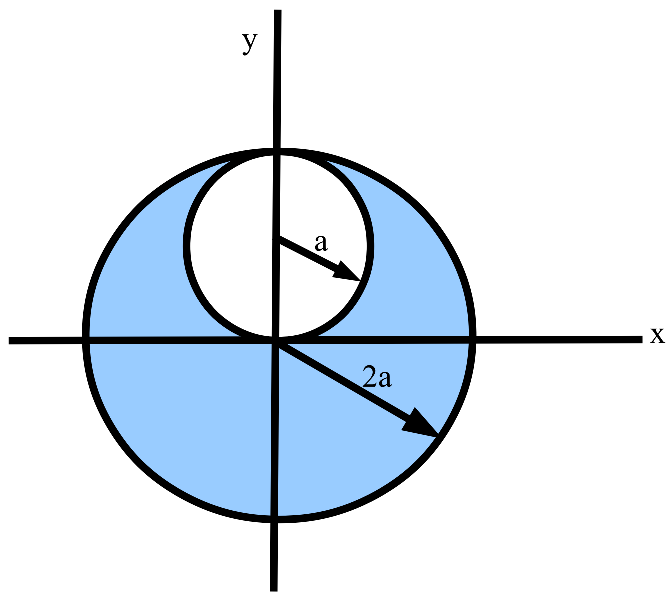
Assignment 5 – Due Oct. 20, 2015 by 3pm
(hand in to drop box outside 3L24)

1. Another example of calculating flux. Suppose you have a cube of side length L that has one corner at the origin and three edges aligned with the x, y, and z axes. With a diagram, label the six sides of the cube, and then calculate the electric flux through each of the sides when there is a uniform electric field $\mathbf{E} = (Ex, Ey, Ez)$ in the region of the cube. Show that this flux adds up to zero, as expected by Gauss' law, since there is no charge inside the cube.

2. A sphere of radius 2a is made of a non-conducting material that has a uniform volume charge density ρ (Assume the material does not affect the electric field). A spherical cavity of radius a is now removed from the sphere, as shown in the figure. Show that the electric field within the cavity is uniform and is given by $E_x=0$ and $E_y=\rho a/3\varepsilon_0$. (Hint: Use the superposition of the field due to the original uncut sphere, minus the absence of field due to the cut out smaller sphere.)



3. An early (incorrect) model of the hydrogen atom suggested by J.J. Thomson, proposed that a positive cloud of charge +e was uniformly distributed throughout the volume of a sphere of radius R, with the electron an equal-magnitude negative point charge -e at the centre. (a) Using Gauss's law, show that the electron would be in equilibrium at the centre, and if displaced from the centre a distance $r<R$, would experience a restoring force of the form $F=-Ar$, where A is a constant. (b) Show that $A=k_e e^2/R^3$. (c) Find an expression for the frequency f of simple harmonic oscillations that an electron of mass me would undergo if displaced a small distance (< R) from the centre and released. (d) Calculate a numerical value for R that would result in a frequency of 2.47×10^{15}Hz, the frequency of the light radiated in the most intense line in the hydrogen spectrum.

4. Consider three infinite sheets of uniform charge density, σ, that are at 90 degrees to each other, and intersect along the x, y and z axes at 0, 0, 0. Ie. One is in the xy-plane, the second is in the xz-plane, and the third is in the yz-plane.
(a) By adding up the fields from each of the sheets, find the electric field at all points in space.
(b) Find the field instead by using Gauss' law. Explain why Gauss's law is in fact useful in this problem.

5. Forces on three parallel sheets. Consider three charged sheets A, B and C. The sheets are parallel with A above B above C. The sheets have a uniform charge density: -4×10^{-5} C/m^2 on A, 7×10^{-5} C/m^2 on B and -3×10^{-5} C/m^2 on C. What is the magnitude of the electrical force per unit area (pressure) on each sheet? Check that Newton's laws are obeyed in that the total force per unit area on the three sheets is zero.