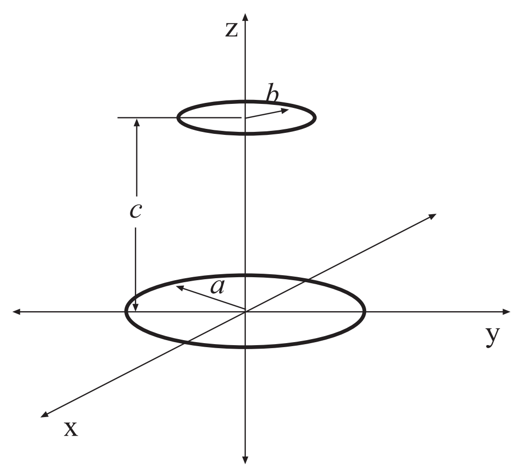
Computational Problems for 4610

This document will contain a listing of *possible* calculations one can do for the "computer problem" part of the course. Creative suggestions will be gladly accepted. The point is to do a calculation of the kind we normally do in 4610 (finding electric or magnetic forces, fields, potentials or whatnot) for an electrical system where a "closed–form" solution is not possible.

1. Electric force: charged rings.

Suppose we have uniformly charged ring of radius a and total charge Q_1 in the xy plane centered on the origin. We have another uniformly charged ring of radius b with total charge Q_2 situated coaxial with this ring and lying in plane $z = c$. (See figure at the right.)



Find the force between the two rings.

If is sufficient to find the force on the upper ring. You *can* use symmetry, so that we just need the z components of the forces from all charge elements, but even with this to simplify things it is still a hard problem.

You'll want to break up the lower ring into lots of angular sectors and sum up the forces they exert on the individual angular sectors of the top ring. As the number of sectors gets really big, the computation should approach the exact answer.

As this is a numerical calculation we need some definite values for Q_1 and Q_2 and for a, b, c. Well, maybe. Since the force between any two charge elements is proportional to the product Q_1Q_2, this is *not* an interesting number and we'd like to divide it out. Actually we'd like to divide out anything that is "obvious" and I suggest that it is clear that the force should be on the order of the force between two point charges separated by c (the distance between the center of the rings), namely

$$F_{\text{point}} = \frac{1}{4\pi\epsilon_0}\frac{Q_1Q_2}{c^2}$$

It is interesting to see how the force compares with *this* number so I would suggest dividing out the factor F_{point}.

2. Electric field plot: Ring of charge.

Suppose we have a uniform ring of charge (radius R) in the xy plane centered at the origin. Make a plot of the electric field in the yz plane. The plot should extend out to 4 times the radius of the ring. Past that I would expect the field to get close to that of a point charge at the origin.

You can pull out any numbers scale with the problem, but for definiteness you can let the total charge of the ring be $1.0\,\mu$C and the radius of the ring be 1.0 cm.

3. Electric field plot: Parallel finite plates.

Consider two parallel squares of uniform of uniform densities, each of side a. The squares carry charges $\pm Q$. We'll say that they are separated by a distance $a/5$. One square is parallel to the xy plane at $z = -a/10$ and other is at $z = +a/10$. We want a vector plot of the field in the yz plane (that is, a plane that cuts half–way thru the squares).

The plot should go out to $\pm\frac{3a}{2}$ in the y and z directions; we also want region ouside the plates. Again, some numbers in the problem can be scaled away but for definiteness one can choose $a = 5.0$ cm with a charge of $Q = \pm 1.0\,\mu$C