Homework #4 (10 points) - Show all work on the following problems:

Problem 1 (2 points):

a. Find the electric potential a distance of z above the center of a flat circular disc of radius R that carries a uniform surface charge density σ, using direct integration over the charge density.

b. Compute the z-component of the electric field from your answer to (a), and verify that you recover the solution from Problem 4 on Homework #2.

Problem 2 (2 points):

a. Use Gauss's law to compute the electric field inside and outside of a long hollow cylindrical tube that carries a uniform surface charge density σ.

b. Verify that the change in electric field between the inside and the outside of the tube agrees with Eq. 2.33

Problem 3 (2 points): Consider four charges arranged in a square with sides of length a. If the upper left and lower right charges are $-q$ and the upper right and lower left are $+q$, compute the total work needed to assemble this configuration.

Problem 4 (2 points): Find the electrostatic energy stored in a solid sphere of radius R with a uniform volume charge density throughout, summing to a total charge Q (same configuration as Problem 6 on Homework #3).

a. First, use Eq. 2.43, with the potential you solved for last week.

b. Next, use Eq. 2.45.

Problem 5 (2 points): Consider a metal sphere of radius R carrying charge Q, surrounded by a thin concentric metal shell (inner radius a, outer radius b) carrying no charge.

a. Find the surface charge density σ at r = R, r = a, and r = b.

b. Find the electric potential at the center of the sphere, with respect to infinity.

c. Now, touch the outer surface with a ground wire, which drains off the charge at r = b. How do your answers to (a) and (b) change?