Practice Problems Ch.21-24

This is meant to provide additional practice for studying for midterm 2. This is not an exhaustive list of material that may be covered on the exam.

Problem 1. A spherical charge distribution is given by

$$\rho = \rho_0(1 - r/a),\ r < a$$
$$\rho = 0,\ r > a.$$

a. Calculate the total charge Q.
b. Find the electric field and potential for r > a.
c. Find the electric field and potential for r < a.
d. Find the electrostatic energy of this charge distribution.

Problem 2. A charge of 1 C sits at the origin. A charge of -2 C is at x=1 on the x axis.

a. Find a point on the x axis where the electric field is zero
b. Locate, at least approximately, a point on the y axis where the electric field is parallel to the x axis.

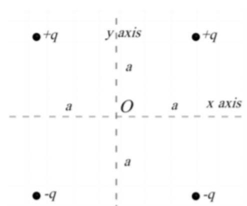
Problem 3.

a. 12 equal charges are placed at the corners of a regular 12- sided polygon. What is the net force on a test charge Q at the center?
b. Now 13 equal charges are placed at the corners of a regular 13-sided polygon. What is the force on a test charge Q at the center?

Problem 4. An electron is constrained to the central axis of the ring of charge with radius R and total charge Q. Show that the electrostatic force exerted on the electron can cause it to oscillate through the center of the ring with an angular frequency $\omega = \sqrt{\frac{eq}{4\pi\epsilon_0 m R^3}}$.

Problem 5. A pyramid has a square base of side a, and four faces which are equilateral triangles. A charge Q is placed on the center of the base of the pyramid. What is the net flux of electric field emerging from one of the triangular faces of the pyramid?

Problem 6. Four charged point-like objects, two of charge +q and two of charge -q, are arranged on the vertices of a square with sides of length 2a, as shown in the sketch.



a. What is the electric field at point O, which is at the center of the square? Indicate the direction and the magnitude.
b. What is the electric potential V at point O, the center of the square, taking the potential at infinity to be zero?
c. Sketch on the figure below one path leading from infinity to the origin at O where the integral $\int_{\infty}^{0} \vec{E} \cdot d\vec{s}$ is trivial to do by inspection. Does your answer here agree with your result in b)?

Problem 7. Consider a spherical vacuum capacitor (with no dielectric material) consisting of inner and outer thin conducting spherical shells with charge + Q on the inner shell of radius a and charge - Q on the outer shell of radius b . You may neglect the thickness of each shell.

a. What are the magnitude and direction of the electric field everywhere in space as a function of r , the distance from the center of the spherical conductors?

b. What is the capacitance of this capacitor?

c. Now consider the case that the dimension of the outer shell is doubled from b to 2b. Assuming that the charge on the shells is not changed, how does the stored potential energy change? That is, find an expression for $\Delta U = U_{before} - U_{after}$ in terms of Q , a, b , and any constants as needed.

Problem 8. Consider the configuration shown below. Find the equivalent capacitance, assuming that all the capacitors have the same capacitance C.