Homework #1 (Due 03/08 at the beginning of lecture)

1. (10%) In crystals of the salt cesium chloride, cesium ions Cs^+ form the eight corners of a cube and a chlorine ion Cl^- is at the cube's center (Fig. 1-1). The edge length of the cube is 0.40 nm. The Cs^+ ions are each deficient by one electron (and thus each has a charge of $+e$), and the Cl^- ion has one excess electron (and thus has a charge of $-e$). (a)What is the magnitude of the net electrostatic force exerted on the Cl^- ion by the eight Cs^+ ions at the corners of the cube? (b) If one of the Cs^+ ions is missing, the crystal is said to have a *defect*; what is the magnitude of the net electrostatic force exerted on the Cl^- ion by the seven remaining Cs^+ ions?

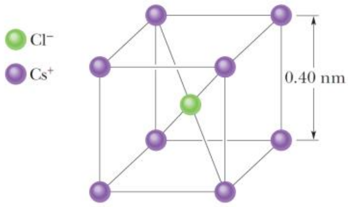

Figure 1-1

2. (10%) Two large parallel copper plates are 8.0 cm apart and have a uniform electric field between them as depicted in Fig. 1-2. An electron is released from the negative plate at the same time that a proton is released from the positive plate. Neglect the force of the particles on each other and find their distance from the positive plate when they pass each other. (Does it surprise you that you need not know the electric field to solve this problem?)

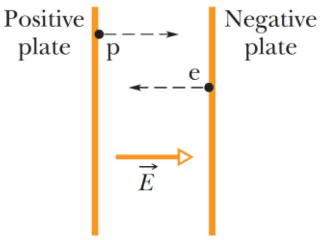

Figure 1-2

3. (10%) In Fig. 1-3, two curved plastic rods, one of charge $+q$ and the other of charge $-q$, form a circle of radius $R = 8.50$ cm in an xy plane. The x axis passes through both of the connecting points, and the charge is distributed uniformly on both rods. If $q = 15.0$ pC, what are the (a) magnitude and (b) direction (relative to the positive direction of the x axis) of the electric field $\vec{E}$ produced at P, the center of the circle?

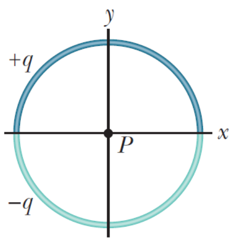

Figure 1-3

4. (10%) Suppose you design an apparatus in which a uniformly charged disk of radius R is to produce an electric field. The field magnitude is most important along the central perpendicular axis of the disk, at a point P at distance $2.00R$ from the disk (Fig. 1-4 *a*). Cost analysis suggests that you switch to a ring of the same outer radius R but with inner radius $R/2.00$ (Fig. 1-4 *b*).Assume that the ring will have the same surface charge density as the original disk. If you switch to the ring, by what percentage will you decrease the electric field magnitude at P?

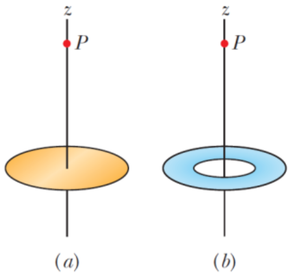

Figure 1-4

5. (10%) A certain electric dipole is placed in a uniform electric field $\vec{E}$ of magnitude 50 N/C. Figure 1-5 gives the potential energy U of the dipole versus the angle θ between $\vec{E}$ and the dipole moment $\vec{p}$.The vertical axis scale is set by $U_s = 100 \times 10^{-28}$ J. What is the magnitude of $\vec{p}$?

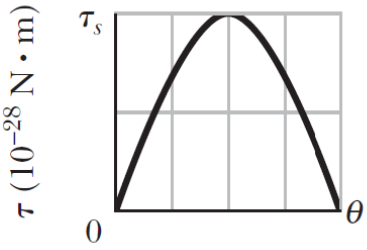

Figure 1-5

6. (10%) In Fig. 1-6, a nonconducting spherical shell of inner radius a = 2.00 cm and outer radius b = 2.40 cm has (within its thickness) a positive volume charge density $\rho = A/r$, where A is a constant and r is the distance from the center of the shell. In addition, a small ball of charge q = 45.0 fC is located at that center. What value should A have if the electric field in the shell ($a \leqq r \leqq b$) is to be uniform?

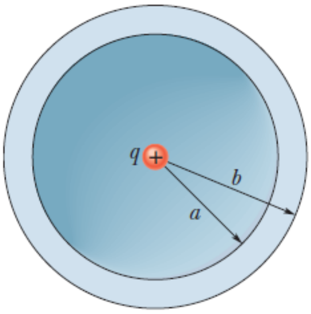

Figure 1-6

7. (10%) In Fig. 1-7, a solid sphere of radius a = 2.00 cm is concentric with a spherical conducting shell of inner radius b = 2.00a and outer radius c = 2.40a. The sphere has a net uniform charge q_1 = +5.00 fC; the shell has a net charge $q_2 = q_1$.What is the magnitude of the electric field at radial distances (a) r = 0, (b) $r = a/2.00$, (c) $r = a$, (d) r = 1.50a, (e) r = 2.30a, and (f) r = 3.50a? What is the net charge on the (g) inner and (h) outer surface of the shell?

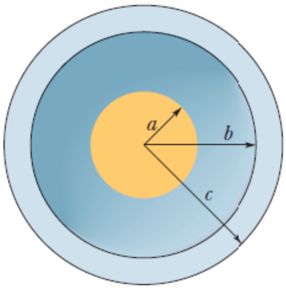

Figure 1-7

8. (10%) *Flux and conducting shells.* A charged particle is held at the center of two concentric conducting spherical shells. Figure 1-8 *a* shows a cross section. Figure 1-8 *b* gives the net flux & through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere. The scale of the vertical axis is set by Φs = 5.0 $\times 10^5$ N·m^2/C. What are (a) the charge of the central particle and the net charges of (b) shell A and (c) shell B?

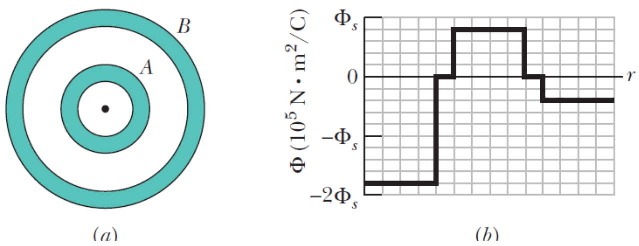

Figure 1-8

9. (10%) *Flux and nonconducting shells.* A charged particle is suspended at the center of two concentric spherical shells that are very thin and made of nonconducting material. Figure 1-9 *a* shows a cross section. Figure 1-9 *b* gives the net flux Φ through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere. The scale of the vertical axis is set by Φs = 5.0 $\times 10^5$ N·m^2/C. (a) What is the charge of the central particle? What are the net charges of (b) shell A and (c) shell B?

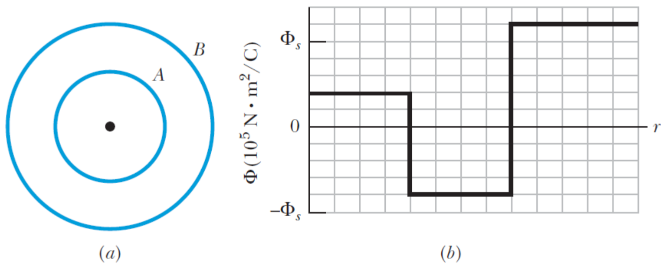

Figure 1-9

10. (10%) Figure 1-10 is a section of a conducting rod of radius R_1 = 1.30 mm and length L = 11.00 m inside a thin-walled coaxial conducting cylindrical shell of radius R_2 = 10.0R1 and the (same) length L. The net charge on the rod is Q_1= +3.40 $\times 10^{-12}$ C; that on the shell is Q_2 = -2.00 Q_1. What are the (a) magnitude E and (b) direction (radially inward or outward) of the electric field at radial distance r = 2.00 R_2? What are (c) E and (d) the direction at r = 5.00 R_1? What is the charge on the (e) interior and (f) exterior surface of the shell?

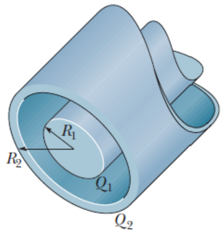

Figure 1-10

11. (20%) Two spherical cavities, of radii a and b, are hollowed out from the interior of a neutral conducting sphere of radius R, as shown in the Figure1-11. At the center of each cavity a point charge is placed; call these charges q_a and q_b. (a) Find the surface charges σ_a, σ_b, and σ_R. (b) What is the field outside the conductor? (c) What is the field within each cavity? (d) What is the force on q_a and q_b? (e) Which of these answers would change if a third charge q_c where brought near the conductor?

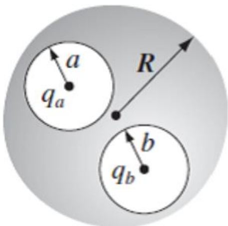

Figure 1-11