Physics 131  
Homework #3  
Assigned: 25-Jan-16  
Due: 1-Feb-16

Reading: Chapter 23

Reminder: The first one-hour exam will be held on Friday, 5-Feb-16. It will cover material from chapters 21-23. You may bring a one-page ‘cheat sheet’ for use during the exam. You may not use a calculator during the exam.

1. An isolated conductor of arbitrary shape has a net charge of $+10 \times 10^{-6}$ C. Inside the conductor is a cavity within which is a point charge $q = +3.0 \times 10^{-6}$ C. What is the charge (a) on the cavity wall and (b) on the outer surface of the conductor?

2. In the figure, short sections of two very long parallel lines of charge are shown, fixed in place, separated by $L = 8.0$ cm. The uniform linear charge densities are $+6.0 \mu$C/m for line 1 and $-2.0 \mu$C/m for line 2. Where along the $x$-axis shown is the net electric field from the two lines zero?

3. A long, non-conducting, solid cylinder of radius 4.0 cm has a non-uniform volume charge density $\rho$ that is a function of radial distance $r$ from the cylinder axis: $\rho = Ar^2$. For $A = 2.5 \mu$C/m$^3$, what is the magnitude of the electric field at (a) $r = 3.0$ cm and (b) $r = 5.0$ cm?

4. The figure shows a cross section through a very large non-conducting slab of thickness $d = 9.40$ mm and uniform volume charge density $\rho = 5.80$ fC/m$^3$. The origin of an $x$-axis is at the slab’s center. What is the magnitude of the slab’s electric field at an $x$ coordinate of (a) 0, (b) 2.00 mm, (c) 4.70 mm, and (d) 26.0 mm?

5. In the figure, 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?

6. A charge distribution that is spherically symmetric but not uniform radially produces an electric field of magnitude $E = Kr^4$, directed radially outward from the center of the sphere. Here $r$ is the radial distance from that center, and $K$ is a constant. What is the volume density $\rho$ of the charge distribution?
7. The figure shows, in cross section, two solid spheres with uniformly distributed charge throughout their volumes. Each has radius $R$. Point $P$ lies on a line connecting the centers of the spheres, at radial distance $R/2.00$ from the center of sphere 1. If the net electric field at point $P$ is zero, what is the ratio $q_2/q_1$ of the total charge $q_2$ in sphere 2 to the total charge $q_1$ in sphere 1?

8. The electric field at point $P$ just outside the outer surface of a hollow spherical conductor of inner radius 10 cm and outer radius 20 cm has magnitude 450 N/C and is directed outward. When an unknown point charge $Q$ is introduced into the center of the sphere, the electric field at $P$ is still directed outward but is now 180 N/C. (a) What was the net charge enclosed by the outer surface before $Q$ was introduced? (b) What is charge $Q$? After $Q$ is introduced, what is the charge on the (c) inner and (d) outer surface of the conductor?

9. The figure shows, in cross section, three infinitely large nonconducting sheets on which charge is uniformly spread. The surface charge densities are $\sigma_1 = +2.00 \ \mu C/m^2$, $\sigma_2 = +4.00 \ \mu C/m^2$, and $\sigma_3 = -5.00 \ \mu C/m^2$, and distance $L = 1.50$ cm. In unit-vector notation, what is the net electric field at point $P$?

10. A nonconducting solid sphere has a uniform volume charge density $\rho$. Let $\vec{r}$ be the vector from the center of the sphere to a general point $P$ within the sphere. (a) Show that the electric field at $P$ is given by $\vec{E} = \rho r/3\epsilon$, (Note that the result is independent of the radius of the sphere.) (b) A spherical cavity is hollowed out of the sphere, as shown in the figure. Using superposition concepts, show that the electric field at all points within the cavity is uniform and equal to $\vec{E} = \rho \vec{a}/3\epsilon$, where $\vec{a}$ is the position vector from the center of the sphere to the center of the cavity. (Note that this result is independent of the radius of the sphere and the radius of the cavity.)