9 Conductors

- $\vec{E}$ in the bulk of a conductor is zero.
- Excess charge can only be found on the surface of a conductor: $\rho = 0$
- Outside the surface of a conductor, $\vec{E} = (\sigma/\epsilon_0)\hat{n}$.
- The electric field inside an empty cavity is zero.

29-19 A positive point charge q is located at the center of a hollow metal sphere. What charges appear on (a) the inner surface and (b) the outer surface of the sphere? (c) If you bring an (uncharged) metal object near the sphere, will it change your answers to (a) or (b) above? Will it change the way charge is distributed over the sphere?

29-17 A conducting sphere carrying charge Q is surrounded by a spherical conducting shell, (a) What is the net charge on the inner surface of the shell? (b) Another charge q is placed outside the shell. Now what is the net charge on the inner surface of the shell? (c) If q is moved to a position between the shell and the sphere, what is the net charge on the inner surface of the shell? (d) Are your answers valid if the sphere and shell are not concentric? What if they are not spherical?

29-28 A uniform conducting sphere of radius a and net charge $+q$ is placed at the center of an electrically neutral spherically-conducting shell of inner radius b and outer radius c. *(a)* Sketch the configuration. *(b)* What is $\vec{E}(\vec{r})$ for $r < a$? *(c)* For $a < r < b$? *(d)* For $b < r < c$? *(e)* For $c < r$? *(f)* What is the charge density on the inner and outer surfaces of the shell?

29-29 A very long conducting cylinder (length L) carrying a total charge q is surrounded by a conducting cylindrical shell (also of length L), with total charge $-2q$. The two cylinders are coaxial. Use Gauss' law to find *(a)* the electric field at points outside the conducting shell, *(b)* the distribution of charge on the conducting shell, and *(c)* the electric field in the region between the cylinders.

P-1 A point charge q is located at an arbitrary position inside a neutral conducting spherical shell. Explain why the electric field outside the shell is the same as the spherically symmetric field due to a charge q located at the center of the shell (with the shell removed, although the point is that this doesn't matter).

P-2 A spherical conductor A contains two spherical cavities. The total charge on the conductor itself is zero. However, there is a point charge q_b at the center of one cavity and q_c at the center of the other. *(a)* What is the force on each of A, q_b, and q_c? *(b)* An additional charge q_d is placed a large distance r away from the center of the conductor. What force acts on each of the four objects A, q_a, q_b, q_c? Which answers, if any, are only approximate, and depend on r being relatively large?

P-3 If a point charge is located outside a hollow conducting shell, there is an electric field outside, but no electric field inside. On the other hand, if a point charge is located inside a hollow conducting shell, there is an electric field both inside and outside (although the external field would be zero in the special case where the shell happened to have charge exactly equal and opposite to the point charge). The situation is therefore not symmetric with respect to inside and outside. Explain why this is the case, by considering where electric field lines can begin and end.