

Problems are from Tipler Chapter 22:

**(1)18** Two infinite vertical planes of charge are parallel to each other and are separated by a distance  $d = 4$  m. Find the electric field to the left of the planes, to the right of the planes, and between the planes (a) when each plane has a uniform surface charge density  $\sigma = +3 \mu\text{C m}^{-2}$  and (b) when the left plane has a uniform surface charge density  $\sigma = +3 \mu\text{C m}^{-2}$  and that of the right plane is  $\sigma = -3 \mu\text{C m}^{-2}$ . Draw the electric field lines in each case. **(NOTE: This is a superposition problem).**

**(2) 25** (a) Using a spreadsheet **(NOTE: Excel is recommended)** make a graph of the electric field on the axis of a disk of radius  $r = 30$  cm carrying a surface charge density of  $\sigma = 0.5 \times 10^{-9} \text{ C m}^{-2}$  (b) Compare the field to the approximation  $E = 2\pi k\sigma$ . At what distance does the approximation differ from the exact solution by 10 percent?

**(3) 34** Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is  $6.0 \times 10^3 \text{ N m}^2 \text{ C}^{-1}$  (a) What is the net charge inside the box? (b) If the net outward flux through the surface of the box were zero, could you conclude that there were no charges inside the box? Why or why not?

**(4) 42** Consider two concentric conducting spheres (Figure 22-38). The outer sphere is hollow and initially has a charge  $-7Q$  deposited on it. The inner sphere is solid and has a charge  $+2Q$  on it. (a) How is the charge distributed on the outer sphere? That is, how much charge is on the outer surface and how much charge is on the inner surface? (b) Suppose a wire is connected between the inner and outer spheres. After electrostatic equilibrium is established, how much total charge is on the outside sphere? How much charge is on the outer and inner surfaces of the outside sphere? Does the electric field at the surface of the inside sphere change when the wire is connected? If so, how? (c) Suppose we return to the original conditions in part (a), with  $+2Q$  on the inner sphere and  $-7Q$  on the outer. We now connect the outer sphere to ground with a wire and then disconnect it. How much total charge will be on the outer sphere? How much charge will be on the inner and outer surfaces of the outer sphere?

**(5) 47** A thick, nonconducting spherical shell of inner radius  $a$  and outer radius  $b$  has a uniform volume charge density  $\rho$ . Find (a) the total charge and (b) the electric field everywhere.

**(6)50** A infinitely long nonconducting cylinder of radius  $R$  carries a uniform volume charge density of  $\rho(r) = \rho_o$ . Show that the electric field is given by

$$E = \frac{\rho R^2}{2\epsilon_o r} = \frac{\lambda}{2\pi\epsilon_o r} \quad r > R$$

$$E = \frac{\rho r}{2\epsilon_o} = \frac{\lambda r}{2\pi\epsilon_o R^2} \quad r < R$$

where  $\lambda = \rho\pi R^2$  is the charge per unit length.

**(7) 62** The electric field just above the surface of the Earth has been measured to be  $150 \text{ N C}^{-1}$  downward. What total charge on the Earth is implied by this measurement?

**(8) 64** If the magnitude of an electric field in air is as great as  $3 \times 10^6 \text{ N C}^{-1}$ , the air becomes ionized and begins to conduct electricity. This phenomenon is called dielectric breakdown. A charge of  $18 \mu\text{C}$  is to be placed on a conducting sphere. What is the minimum radius of a sphere that can hold this charge without breakdown.

**(9) 75** A quantum-mechanical treatment of the hydrogen atom shows that the electron in the atom can be treated as a smeared-out distribution of charge, which has the form  $\rho(r) = \rho_0 e^{-2r/a}$  where  $r$  is the distance from the nucleus and  $a$  is the Bohr radius. (a) Calculate  $\rho_0$  from the fact that the atom is uncharged (b) Calculate the electric field at any distance  $r$  from the nucleus. Treat the proton as a point charge. **HINT: the volume integral of a function  $f$  in spherical coordinates is given by  $V = \int_0^\infty f(r) 4\pi r^2 dr$**

**(10) 83** An infinite line charge  $\lambda$  is located along the  $z$  axis. A particle of mass  $m$  that carries a charge  $q$  whose sign is opposite to that of  $\lambda$  is in a circular orbit in the  $xy$  plane about the line charge. Obtain an expression for the period of the orbit in terms of  $m$ ,  $q$ ,  $R$  and  $\lambda$  where  $R$  is the radius of the orbit.