Problem 24-10E

The flux through the flat surface encircled by the rim is given by
\[ \Phi = \pi a^2 E. \]
Thus the flux through the netting is \( \Phi' = -\Phi = -\pi a^2 E. \)

Problem 24-18E

(a) The charge on the surface of the sphere is the product of the surface charge density \( \sigma \) and the surface area of the sphere \((4\pi r^2, \text{where } r \text{ is the radius}). Thus
\[ q = 4\pi r^2 \sigma = 4\pi (1 \cdot 2m \cdot 4) \cdot (8 \cdot 10^{-6} \text{C/m}^2) = 3 \cdot 7 \times 10^{-5} \text{C} \]
(b) Choose a gaussian surface in the form a sphere, concentric with the conducting sphere and with a slightly larger radius. The flux is given by gauss’ law:
\[ \Phi = \frac{q}{\varepsilon_0} = \frac{4 \times 6.6 \times 10^{-9} \text{C}}{8.85 \times 10^{-12} \text{C}^2/\text{Nm}^2} = 4 \times 10^6 \text{N} \cdot \text{m}^2/\text{C}. \]

Problem 24-28P

Denote the inner (outer) cylinders with subscribts \( i \) and \( o \), respectively.

(a) Since \( r_i < r < 4 \text{ cm} < r_o \),
\[ E(r) = \frac{\lambda_i}{2\pi r_o} = \frac{5 \times 10^{-6} \text{C/m}}{2 \pi (8.85 \times 10^{-12} \text{C}^2/\text{Nm}^2)(4 \times 10^{-2} \text{m})} = 2 \times 3 \times 10^6 \text{N/C}. \]
\( E(r) \) points radially outward.

(b) Since \( r > r_o \),
\[ E(r) = \frac{\lambda_i + \lambda_o}{2\pi r_o} = \frac{5 \times 10^{-6} \text{C/m} - 7 \times 10^{-6} \text{C/m}}{2 \pi (8.85 \times 10^{-12} \text{C}^2/\text{Nm}^2)(8 \times 10^{-2} \text{m})} = -4 \times 5 \times 10^5 \text{N/C}, \]
where the minus sign indicates that \( E(r) \) points radially inward.

Problem 24-35P

The forces acting on the ball are shown in the diagram. The gravitational force has magnitude \( mg \), where \( m \) is the mass of the ball; the electrical force has magnitude \( qE \), where \( q \) is the charge on the ball and \( E \) is the electric field at the position of the ball; and the tension in the thread is denoted by \( T \). The electric field produced by the plate is normal to the plate and points to the right. Since the ball is positively charged the electric force on it also points to the right. The tension in the thread makes the angle \( \theta \) (30°) with the vertical.

Since the ball is in equilibrium the net force on it vanishes. The sum of the horizontal components yields \( qE - T \sin \theta = 0 \) and the sum of the vertical components yields \( T \cos \theta - mg = 0 \). The expression \( T = qE \sin \theta \) from the equation, is substituted into the second to obtain \( qE = mg \tan \theta \).

The electric field produced by a large uniform plane of charge is given by \( E = \sigma / 2\varepsilon_0 \), where \( \sigma \) is the surface charge density. Thus
\[ \frac{q}{2\varepsilon_0} = mg \tan \theta \]
and
\[ \sigma = \frac{2 \varepsilon_0 \cdot mg \tan \theta}{q} = \frac{2(8.85 \times 10^{-12} \text{C}^2/\text{Nm}^2)(1.0 \times 10^{-4} \text{Kg})(9.8 \text{m/s}^2)(\tan 30^\circ)}{2.0 \times 10^{-12} \text{C}} = 5.0 \times 10^{-9} \text{C/m}^2. \]

Problem 24-46E
(a) Since \( r_1 = 10.0 \text{cm} < r = 12.0 \text{cm} < r_2 = 15.0 \text{cm} \),
\[
E(r) = \frac{1}{4\pi\epsilon_0} \frac{q_1}{r^2} = \frac{8.99 \times 10^9 \text{N} \cdot \text{m}^2 / \text{C}^2 \cdot (4.00 \times 10^{-9} \text{C})}{(0.120 \text{m})^2} = 2.50 \times 10^4 \text{N} \cdot \text{C}.
\]
(b) Since \( r_1 < r < r_2 \),
\[
E(r) = \frac{1}{4\pi\epsilon_0} \frac{q_1+q_2}{r^2} = \frac{8.99 \times 10^9 \text{N} \cdot \text{m}^2 / \text{C}^2 \cdot (4.00 + 2.00) \times 10^{-9} \text{C}}{(0.200 \text{m})^2} = 1.35 \times 10^4 \text{N} \cdot \text{C}.
\]

**Problem 24-30P**

The net electric potential at point P is the sum of those due to the six charges:
\[
V_p = \sum_{i=1}^{6} \frac{q_i}{4\pi\epsilon_0 \cdot r_i} = \sum_{i=1}^{6} \left[ \frac{5.0q_i}{\sqrt{d^2+(d/2)^2}} + \frac{-2.0q_i}{\sqrt{d^2+(d/2)^2}} + \frac{3.0q_i}{\sqrt{d^2+(d/2)^2}} + \frac{-2.0q_i}{\sqrt{d^2+(d/2)^2}} + \frac{-5.0q_i}{\sqrt{d^2+(d/2)^2}} \right]
\]  
= \frac{-0.94q}{4\pi\epsilon_0 \cdot d^2}.

**Problem 24-36E**

\[
V_p = \frac{1}{4\pi\epsilon_0} \int_{rod} \frac{dq}{R} = \frac{1}{4\pi\epsilon_0} \int_{rod} dq = \frac{-Q}{4\pi\epsilon_0 \cdot R}.
\]

Problem 24-56E

Choose the zero of electric potential to be at infinity. The initial electric potential energy \( U_i \) of the system before the particles are brought together is therefore zero. After the system is set up the final potential energy is
\[
U_f = \frac{q^2}{4\pi\epsilon_0 \cdot \left( \frac{1}{a} - \frac{1}{a} + \frac{1}{a^2} - \frac{1}{a} + \frac{1}{a^2} - \frac{1}{a^2} \right)} = \frac{2q^2}{2 \pi \epsilon_0 \cdot a} \left( \frac{1}{a^2} - 2 \right) = \frac{0.21q^2}{\epsilon_0 \cdot a}.
\]
Thus the amount of work required to set up the system is given by
\[
W = \Delta U = U_f - U_i = -0.21q^2(\epsilon_0 \cdot a).
\]

**Problem 24-69P**

The idea for solving this problem is the same as that for the last one. In this case
\[
K = \frac{1}{4\pi\epsilon_0} \frac{qQ}{r_{min}^2},
\]
which gives \( r_{min} = qQ/\sqrt{4\pi \epsilon_0 K} \).

**Problem 24-79P**

(a) The potential would be
\[
V_e = \frac{Q}{4\pi\epsilon_0 \cdot R_e} = \frac{4\pi K \cdot \sigma_0}{4\pi \epsilon_0 \cdot R_e} = 4\pi(6.37 \times 10^6 \text{m})(1.0 \text{electron/m}^2)(-1.6 \times 10^{-19} \text{C/electron})(8.99 \times 10^9 \text{N} \cdot \text{m}^2 / \text{C}) = -0.12 \text{V}.
\]
(b)
\[
E = \frac{\sigma_0}{\epsilon_0} = \frac{V_e}{R_e} = \frac{-0.12 \text{V}}{6.37 \times 10^6 \text{m}} = -1.8 \times 10^{-8} \text{N/C},
\]
where the minus sign indicates that E is radially inward.