Chapter 24 Solutions

24.1  (a)  $\Phi_E = EA \cos \theta = (3.50 \times 10^3)(0.350 \times 0.700) \cos 0 = 858 \text{ N} \cdot \text{m}^2/\text{C}$

(b)  $\theta = 90.0 \quad \Phi_E = 0$

(c)  $\Phi_E = (3.50 \times 10^3)(0.350 \times 0.700) \cos 40.0 = 657 \text{ N} \cdot \text{m}^2/\text{C}$

24.5  (a)  $A' = (10.0 \text{ cm})(30.0 \text{ cm})$

$A' = 300 \text{ cm}^2 = 0.0300 \text{ m}^2$

$\Phi_{E, A'} = EA' \cos \theta$

$\Phi_{E, A'} = (7.80 \times 10^4)(0.0300) \cos 180^\circ$

$\Phi_{E, A'} = -2.34 \text{ kN} \cdot \text{m}^2/\text{C}$

(b)  $\Phi_{E, A} = EA \cos \theta = (7.80 \times 10^4)(A) \cos 60.0^\circ$

$A = (30.0 \text{ cm})(w) = (30.0 \text{ cm}) \left(\frac{10.0 \text{ cm}}{\cos 60.0^\circ}\right) = 600 \text{ cm}^2 = 0.0600 \text{ m}^2$

$\Phi_{E, A} = (7.80 \times 10^4)(0.0600) \cos 60^\circ = +2.34 \text{ kN} \cdot \text{m}^2/\text{C}$
\*24.10 (a) \( E = \frac{kQ}{r^2} \)

\[ 8.90 \times 10^2 = \frac{(8.99 \times 10^9)Q}{(0.750)^2}, \]

But \( Q \) is negative since \( E \) points inward.

\[ Q = -5.56 \times 10^{-8} \text{ C} = -55.6 \text{ nC} \]

(b) The negative charge has a spherically symmetric charge distribution.

24.14 The flux through the curved surface is equal to the flux through the flat circle, \( E_0 \pi r^2 \).

24.19 The total charge is \( Q - 6 |q| \). The total outward flux from the cube is \( (Q - 6 |q|)/\varepsilon_0 \), of which one-sixth goes through each face:

\[ (\Phi_E)_{\text{one face}} = \frac{Q - 6 |q|}{6 \varepsilon_0} \]

\[ (\Phi_E)_{\text{one face}} = \frac{Q - 6 |q|}{6 \varepsilon_0} = \frac{(5.00 - 6.00) \times 10^{-6} \text{ C} \cdot \text{N} \cdot \text{m}^2}{6 \times 8.85 \times 10^{-12} \text{ C}^2} = -18.8 \text{ kN} \cdot \text{m}^2/\text{C} \]
24.24  
(a)  \( \Phi_E = \frac{q_n}{e_0} \)

\[
8.60 \times 10^4 = \frac{q_n}{8.85 \times 10^{-12}}
\]

\( q_n = 7.61 \times 10^{-7} \text{ C} = \boxed{761 \text{ nC}} \)

(b) Since the net flux is positive, the net charge must be positive. It can have any distribution.

(c) The net charge would have the same magnitude but be negative.

24.27  
(a)  \( E = \frac{k_e Q r}{r^3} = 0 \)

(b)  \( E = \frac{k_e Q r}{r^3} = \frac{(8.99 \times 10^9)(26.0 \times 10^{-6})(0.100)}{(0.400)^3} = 365 \text{ kN/C} \)

(c)  \( E = \frac{k_e Q}{r^2} = \frac{(8.99 \times 10^9)(26.0 \times 10^{-6})}{(0.400)^2} = 1.46 \text{ MN/C} \)

(d)  \( E = \frac{k_e Q}{r^2} = \frac{(8.99 \times 10^9)(26.0 \times 10^{-6})}{(0.600)^2} = 649 \text{ kN/C} \)

The direction for each electric field is radially outward.

*24.28  
(a)  \( E = \frac{2k_e \lambda}{r} \)

\[
3.60 \times 10^4 = \frac{2(8.99 \times 10^9)(Q/2.40)}{(0.190)}
\]

\( Q = +9.13 \times 10^{-7} \text{ C} = \boxed{+913 \text{ nC}} \)

(b) \( E = 0 \)
24.34 (a) \( \rho = \frac{Q}{\frac{4}{3} \pi a^3} = \frac{5.70 \times 10^{-6}}{\frac{4}{3} \pi (0.0400)^3} = 2.13 \times 10^{-2} \text{ C/m}^3 \)

\( q_m = \rho \left( \frac{\frac{4}{3} \pi r^3}{4 \pi} \right) = (2.13 \times 10^{-2}) \left( \frac{4}{3} \pi (0.0200)^3 \right) = 7.13 \times 10^{-7} \text{ C} = 713 \text{ nC} \)

(b) \( \sigma \quad a = 5.70 \mu \text{C} \)

24.46 (a) \( E = kq \frac{Q}{r^2} = \left( \frac{8.99 \times 10^9}{(0.150)^2} \right) (6.40 \times 10^{-6}) = 2.56 \text{ MN/C, radially inward} \)

(b) \( E = 0 \)

24.48 (a) The charge +q at the center induces charge −q on the inner surface of the conductor, where its surface density is:

\( \sigma_a = \frac{-q}{4 \pi a^2} \)

(b) The outer surface carries charge Q + q with density

\( \sigma_b = \frac{Q + q}{4 \pi b^2} \)