P24.1 (a) \[ \Phi_E = EA \cos \theta = (3.50 \times 10^3)(0.350 \times 0.700) \cos 0^\circ = 886 \text{ N} \cdot \text{m}^2/\text{C} \]

(b) \[ \theta = 90.0^\circ \quad [\Phi_E = 0] \]

(c) \[ \Phi_E = (3.50 \times 10^3)(0.350 \times 0.700) \cos 40.0^\circ = 637 \text{ N} \cdot \text{m}^2/\text{C} \]

P24.4 (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) \[ \Phi_{E, A} = EA \cos \theta = (7.80 \times 10^4)(A) \cos 60.0^\circ \]
\[ A = (30.0 \text{ cm})(0.0300 \text{ cm}) = 600 \text{ cm}^2 = 0.0600 \text{ m}^2 \]
\[ \Phi_{E, A} = (7.80 \times 10^4)(0.0600) \cos 60.0^\circ = +2.34 \text{ kN} \cdot \text{m}^2/\text{C} \]

(c) The bottom and the two triangular sides all lie parallel to \( E \), so \( \Phi_E = 0 \) for each of these. Thus,
\[ \Phi_{E, \text{total}} = -2.34 \text{ kN} \cdot \text{m}^2/\text{C} + 2.34 \text{ kN} \cdot \text{m}^2/\text{C} + 0 + 0 = 0 \]

P24.10 (a) \[ E = \frac{kQ}{r^2} \quad 8.90 \times 10^3 = \frac{(8.99 \times 10^9)Q}{(0.750)^2} \]
But \( Q \) is negative since \( E \) points inward. \[ Q = -5.56 \times 10^{-6} \text{ C} = -55.6 \text{ nC} \]

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

P24.11 \[ \Phi_E = \frac{q_{\text{tot}}}{e_0} \]
Through \( S_1 \) \[ \Phi_E = \frac{-2Q + Q}{e_0} = \frac{-Q}{e_0} \]
Through \( S_2 \) \[ \Phi_E = \frac{+Q - Q}{e_0} = 0 \]
Through \( S_3 \) \[ \Phi_E = \frac{-2Q + Q - Q}{e_0} = \frac{-2Q}{e_0} \]
Through \( S_4 \) \[ \Phi_E = 0 \]
If \( R \leq d \), the sphere encloses no charge and \( \Phi_E = \frac{q_{in}}{\varepsilon_0} = 0 \).

If \( R > d \), the length of line falling within the sphere is \( 2\sqrt{R^2 - d^2} \)

so \( \Phi_E = \frac{2\lambda \sqrt{R^2 - d^2}}{\varepsilon_0} \).

The charge distributed through the nucleus creates a field at the surface equal to that of a point charge at its center: \( E = \frac{kq}{r^2} \)

\[
E = \frac{\left(8.99 \times 10^9 \text{ Nm}^2/\text{C}^2\right) \left(82 \times 1.60 \times 10^{-15} \text{ C}\right)}{(208)^{1/3} \cdot 1.20 \times 10^{-15} \text{ m}}
\]

\[
E = 2.33 \times 10^{21} \text{ N/C away from the nucleus}
\]

\( \sigma = \left(8.60 \times 10^{-6} \text{ C/cm}^2\right) \left(\frac{100 \text{ cm}}{m}\right)^2 = 8.60 \times 10^{-2} \text{ C/m}^2 \)

\[
E = \frac{\sigma}{2 \varepsilon_0} = \frac{8.60 \times 10^{-2}}{2 \left(8.85 \times 10^{-12}\right)} = 4.86 \times 10^9 \text{ N/C away from the wall}
\]

The field is essentially uniform as long as the distance from the center of the wall to the field point is much less than the dimensions of the wall.
**P24.34** The charge density is determined by \( Q = \frac{4}{3} \pi a^3 \rho \), \( \rho = \frac{3Q}{4\pi a^2} \)

(a) The flux is that created by the enclosed charge within radius \( r \).

\[
\Phi_E = \frac{q_{ea}}{\varepsilon_0} = \frac{4\pi r^3 \rho}{3 \varepsilon_0} = \frac{4\pi r^3 \frac{3Q}{4\pi a^2}}{3 \varepsilon_0} = \frac{Qr^3}{\varepsilon_0 a^2}
\]

(b) \( \Phi_E = \frac{Q}{\varepsilon_0} \). Note that the answers to parts (a) and (b) agree at \( r = a \).

(c) 

![Graph showing \( \Phi_E \) vs. \( r \)]

FIG. P24.34(c)

**P24.35**

(a) \( E = \frac{2k_e}{r} = \frac{2(8.99 \times 10^9 \ N \cdot m^2/C^2)[(2.00 \times 10^{-6} \ C)/7.00 \ m]}{0.100 \ m} \)

\( E = 51.4 \ \text{kN/C}, \text{ radially outward} \)

(b) \( \Phi_E = EA \cos \theta = E(2\pi r) \cos \theta \)

\( \Phi_E = (5.14 \times 10^4 \ \text{N/C}) [2\pi(0.100 \ m)(0.020 \ m)(1.00)] = 646 \ \text{N} \cdot \text{m}^2/\text{C} \)