3. We use $\Phi = \vec{E} \cdot \vec{A}$, where $\vec{A} = A\,\hat{\text{j}} = (1.40\,\text{m})^2\,\hat{\text{j}}$.

(a) $\Phi = (6.00\,\text{N/C})\hat{\text{i}} \cdot (1.40\,\text{m})^2\hat{\text{j}} = 0$.

(b) $\Phi = (-2.00\,\text{N/C})\hat{\text{j}} \cdot (1.40\,\text{m})^2\hat{\text{j}} = -3.92\,\text{N}\cdot\text{m}^2/\text{C}$.

(c) $\Phi = [(-3.00\,\text{N/C})\hat{\text{i}} + (4.00\,\text{N/C})\hat{\text{k}}] \cdot (1.40\,\text{m})^2\hat{\text{j}} = 0$.

(d) The total flux of a uniform field through a closed surface is always zero.

7. (a) Let $A = (1.40\,\mathrm{m})^2$. Then

$$\begin{aligned}\Phi &= (3.00y\,\hat{\jmath}) \cdot (-A\,\hat{\jmath})|_{y=0} + (3.00y\,\hat{\jmath}) \cdot (A\,\hat{\jmath})|_{y=1.40} \\ &= (3.00)(1.40)(1.40)^2 = 8.23\ \mathrm{N{\cdot}m^2/C}\ .\end{aligned}$$

(b) The electric field can be re-written as $\vec{E} = 3.00y\hat{\jmath} + \vec{E}_0$, where $\vec{E}_0 = -4.00\hat{\imath} + 6.00\hat{\jmath}$ is a constant field which does not contribute to the net flux through the cube. Thus Φ is still $8.23\,\mathrm{N{\cdot}m^2/C}$.

(c) The charge is given by

$$q = \varepsilon_0 \Phi = \left(8.85 \times 10^{-12}\,\frac{\mathrm{C}^2}{\mathrm{N{\cdot}m^2}}\right)(8.23\,\mathrm{N{\cdot}m^2/C}) = 7.29 \times 10^{-11}\ \mathrm{C}$$

in each case.

21. We denote the inner and outer cylinders with subscripts i and o, respectively.

(a) Since $r_i < r = 4.0\,\text{cm} < r_o$,

$$E(r) = \frac{\lambda_i}{2\pi\varepsilon_0 r} = \frac{5.0\times10^{-6}\,\text{C/m}}{2\pi\,(8.85\times10^{-12}\,\text{C}^2/\text{N}\cdot\text{m}^2)\,(4.0\times10^{-2}\,\text{m})} = 2.3\times10^6\ \text{N/C}\ .$$

$\vec{E}(r)$ points radially outward.

(b) Since $r > r_o$,

$$E(r) = \frac{\lambda_i+\lambda_o}{2\pi\varepsilon_0 r} = \frac{5.0\times10^{-6}\,\text{C/m} - 7.0\times10^{-6}\,\text{C/m}}{2\pi\,(8.85\times10^{-12}\,\text{C}^2/\text{N}\cdot\text{m}^2)\,(8.0\times10^{-2}\,\text{m})} = -4.5\times10^5\ \text{N/C}\ ,$$

where the minus sign indicates that $\vec{E}(r)$ points radially inward.

26. According to Eq. 24-13 the electric field due to either sheet of charge with surface charge density σ is perpendicular to the plane of the sheet (pointing *away* from the sheet if the charge is positive) and has magnitude $E = \sigma/2\varepsilon_0$. Using the superposition principle, we conclude:

(a) $E = \sigma/\varepsilon_0$, pointing up;

(b) $E = 0$;

(c) and, $E = \sigma/\varepsilon_0$, pointing down.

43. At all points where there is an electric field, it is radially outward. For each part of the problem, use a Gaussian surface in the form of a sphere that is concentric with the sphere of charge and passes through the point where the electric field is to be found. The field is uniform on the surface, so

$$\oint \vec{E} \cdot d\vec{A} = 4\pi r^2 E$$

where r is the radius of the Gaussian surface.

(a) Here r is less than a and the charge enclosed by the Gaussian surface is $q(r/a)^3$. Gauss' law yields

$$4\pi r^2 E = \left(\frac{q}{\varepsilon_0}\right)\left(\frac{r}{a}\right)^3 \implies E = \frac{qr}{4\pi\varepsilon_0 a^3} .$$

(b) In this case, r is greater than a but less than b. The charge enclosed by the Gaussian surface is q, so Gauss' law leads to

$$4\pi r^2 E = \frac{q}{\varepsilon_0} \implies E = \frac{q}{4\pi\varepsilon_0 r^2} .$$

(c) The shell is conducting, so the electric field inside it is zero.

(d) For $r > c$, the charge enclosed by the Gaussian surface is zero (charge q is inside the shell cavity and charge $-q$ is on the shell). Gauss' law yields

$$4\pi r^2 E = 0 \implies E = 0 .$$

(e) Consider a Gaussian surface that lies completely within the conducting shell. Since the electric field is everywhere zero on the surface, $\oint \vec{E} \cdot d\vec{A} = 0$ and, according to Gauss' law, the net charge enclosed by the surface is zero. If Q_i is the charge on the inner surface of the shell, then $q + Q_i = 0$ and $Q_i = -q$. Let Q_o be the charge on the outer surface of the shell. Since the net charge on the shell is $-q$, $Q_i + Q_o = -q$. This means $Q_o = -q - Q_i = -q - (-q) = 0$.