15.39 The area of the rectangular plane is $A = (0.350\text{ m})(0.700\text{ m}) = 0.245\text{ m}^2$.

(a) When the plane is parallel to the yz plane, $\theta = 0°$, and the flux is

$$\Phi_E = EA\cos\theta = (3.50\times10^3\text{ N/C})(0.245\text{ m}^2)\cos 0° = \boxed{858\text{ N}\cdot\text{m}^2/\text{C}}$$

(b) When the plane is parallel to the x-axis, $\theta = 90°$ and $\Phi_E = \boxed{0}$

(c) $\Phi_E = EA\cos\theta = (3.50\times10^3\text{ N/C})(0.245\text{ m}^2)\cos 40.0° = \boxed{657\text{ N}\cdot\text{m}^2/\text{C}}$

15.42 $\Phi_E = EA\cos\theta = \left(\dfrac{k_e q}{R^2}\right)(4\pi R^2)\cos 0° = 4\pi k_e q$

$$\Phi_E = 4\pi(8.99\times10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(5.00\times10^{-6}\text{ C}) = \boxed{5.65\times10^5\text{ N}\cdot\text{m}^2/\text{C}}$$

15.43 We choose a spherical gaussian surface, concentric with the charged spherical shell and of radius r. Then, $\Sigma EA\cos\theta = E(4\pi r^2)\cos 0° = 4\pi r^2 E$.

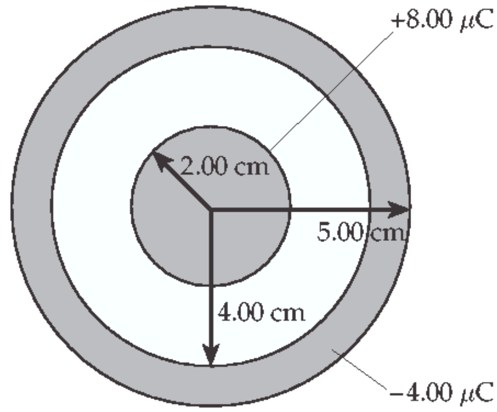
(a) For $r > a$ (that is, outside the shell), the total charge enclosed by the gaussian surface is $Q = +q - q = 0$. Thus, Gauss's law gives $4\pi r^2 E = 0$, or $E = \boxed{0}$.

(b) Inside the shell, $r < a$, and the enclosed charge is $Q = +q$.

Therefore, from Gauss's law, $4\pi r^2 E = \dfrac{q}{\epsilon_0}$, or $E = \dfrac{q}{4\pi\epsilon_0 r^2} = \dfrac{k_e q}{r^2}$

The field for $r < a$ is $\boxed{\vec{\mathbf{E}} = \dfrac{k_e q}{r^2}\text{ directed radially outward}}$.

15.53 Because of the spherical symmetry of the charge distribution, any electric field present will be radial in direction. If a field does exist at distance R from the center, it is the same as if the net charge located within $r \le R$ were concentrated as a point charge at the center of the inner sphere. Charge located at $r > R$ does not contribute to the field at $r = R$.



(a) At $r = 1.00$ cm, $\boxed{E = 0}$ since static electric fields cannot exist within conducting materials.

(b) The net charge located at $r \le 3.00$ cm is $Q = +8.00\ \mu\text{C}$.

Thus, at $r = 3.00$ cm,

$$E = \frac{k_e Q}{r^2}$$

$$= \frac{\left(8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(8.00\times10^{-6}\ \text{C}\right)}{\left(3.00\times10^{-2}\ \text{m}\right)^2} = \boxed{7.99\times10^{7}\ \text{N/C (outward)}}$$

(c) At $r = 4.50$ cm, $\boxed{E = 0}$ since this is located within conducting materials.

(d) The net charge located at $r \le 7.00$ cm is $Q = +4.00\ \mu\text{C}$.

Thus, at $r = 7.00$ cm,

$$E = \frac{k_e Q}{r^2}$$

$$= \frac{\left(8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(4.00\times10^{-6}\ \text{C}\right)}{\left(7.00\times10^{-2}\ \text{m}\right)^2} = \boxed{7.34\times10^{6}\ \text{N/C (outward)}}$$

16.2 (a) We follow the path from (0,0) to (20 cm,0) to (20 cm,50 cm). The work done on the charge by the field is

$$W = W_1 + W_2 = (qE)\cdot s_1 \cos\theta_1 + (qE)\cdot s_2 \cos\theta_2$$

$$= (qE)\left[(0.20\text{ m})\cos 0° + (0.50\text{ m})\cos 90°\right]$$

$$= \left(12\times10^{-6}\text{ C}\right)(250\text{ V/m})\left[(0.20\text{ m}) + 0\right] = 6.0\times10^{-4}\text{ J}$$

Thus, $\Delta PE_e = -W = \boxed{-6.0\times10^{-4}\text{ J}}$

(b) $\Delta V = \dfrac{\Delta PE_e}{q} = \dfrac{-6.0\times10^{-4}\text{ J}}{12\times10^{-6}\text{ C}} = -50\text{ J/C} = \boxed{-50\text{ V}}$

16.5 $E = \dfrac{|\Delta V|}{d} = \dfrac{25\,000\text{ J/C}}{1.5\times10^{-2}\text{ m}} = \boxed{1.7\times10^{6}\text{ N/C}}$

16.7 (a) $E = \dfrac{|\Delta V|}{d} = \dfrac{600\text{ J/C}}{5.33\times10^{-3}\text{ m}} = \boxed{1.13\times10^{5}\text{ N/C}}$

(b) $F = |q|E = \left(1.60\times10^{-19}\text{ C}\right)\left(1.13\times10^{5}\text{ N/C}\right) = \boxed{1.80\times10^{-14}\text{ N}}$

(c) $W = F\cdot s\cos\theta$

$$= \left(1.80\times10^{-14}\text{ N}\right)\left[(5.33-2.90)\times10^{-3}\text{ m}\right]\cos 0° = \boxed{4.38\times10^{-17}\text{ J}}$$

16.8 From conservation of energy, $\frac{1}{2}mv_f^2 - 0 = |q(\Delta V)|$ or $v_f = \sqrt{\dfrac{2|q(\Delta V)|}{m}}$

(a) For the proton, $v_f = \sqrt{\dfrac{2\left|\left(1.60\times10^{-19}\text{ C}\right)(-120\text{ V})\right|}{1.67\times10^{-27}\text{ kg}}} = \boxed{1.52\times10^{5}\text{ m/s}}$

(b) For the electron, $v_f = \sqrt{\dfrac{2\left|\left(-1.60\times10^{-19}\text{ C}\right)(+120\text{ V})\right|}{9.11\times10^{-31}\text{ kg}}} = \boxed{6.49\times10^{6}\text{ m/s}}$

16.12 $V = V_1 + V_2 = k_e\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$ where $r_1 = 0.60\text{ m} - 0 = 0.60\text{ m}$, and

$r_2 = 0.60\text{ m} - 0.30\text{ m} = 0.30\text{ m}$. Thus,

$$V = \left(8.99\times10^{9}\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left(\frac{3.0\times10^{-9}\text{ C}}{0.60\text{ m}} + \frac{6.0\times10^{-9}\text{ C}}{0.30\text{ m}}\right) = \boxed{2.2\times10^{2}\text{ V}}$$

16.14 $W = q(\Delta V) = q\left(V_f - V_i\right)$, and

$V_f = 0$ since the $8.00\ \mu\text{C}$ is infinite distance from other charges.

$$V_i = k_e\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right) = \left(8.99\times10^{9}\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left(\frac{2.00\times10^{-6}\text{ C}}{0.030\,0\text{ m}} + \frac{4.00\times10^{-6}\text{ C}}{\sqrt{(0.030\,0)^2 + (0.060\,0)^2}\text{ m}}\right)$$

$$= 1.135\times10^{6}\text{ V}$$

Thus, $W = \left(8.00\times10^{-6}\text{ C}\right)\left(0 - 1.135\times10^{6}\text{ V}\right) = \boxed{-9.08\text{ J}}$

16.18 Outside the spherical charge distribution, the potential is the same as for a point charge at the center of the sphere,

$V = k_e Q/r$, where $Q = 1.00\times10^{-9}\text{ C}$

Thus, $\Delta\left(PE_e\right) = q(\Delta V) = -ek_eQ\left(\frac{1}{r_f} - \frac{1}{r_i}\right)$

and from conservation of energy $\Delta(KE) = -\Delta\left(PE_e\right)$,

or $\frac{1}{2}m_e v^2 - 0 = -\left[-ek_eQ\left(\frac{1}{r_f} - \frac{1}{r_i}\right)\right]$ This gives $v = \sqrt{\frac{2k_eQe}{m_e}\left(\frac{1}{r_f} - \frac{1}{r_i}\right)}$, or

$$v = \sqrt{\frac{2\left(8.99\times10^{9}\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left(1.00\times10^{-9}\text{ C}\right)\left(1.60\times10^{-19}\text{ C}\right)}{9.11\times10^{-31}\text{ kg}}\left(\frac{1}{0.020\,0\text{ m}} - \frac{1}{0.030\,0\text{ m}}\right)}$$

$$v = \boxed{7.25\times10^{6}\text{ m/s}}$$

16.56 (a) The 1.0-μC is located 0.50 m from point P, so its contribution to the potential at P is

$$V_1 = k_e \frac{q_1}{r_1} = \left(8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(\frac{1.0\times10^{-6}\ \text{C}}{0.50\ \text{m}}\right) = \boxed{1.8\times10^{4}\ \text{V}}$$

(b) The potential at P due to the -2.0-μC charge located 0.50 m away is

$$V_2 = k_e \frac{q_2}{r_2} = \left(8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(\frac{-2.0\times10^{-6}\ \text{C}}{0.50\ \text{m}}\right) = \boxed{-3.6\times10^{4}\ \text{V}}$$