Chapter 23

P23.8 $F = k_e \frac{q_1 q_2}{r^2} = \frac{\left(8.99\times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(1.60\times 10^{-19}\ \text{C}\right)^2\left(6.02\times 10^{23}\right)^2}{\left[2\left(6.37\times 10^6\ \text{m}\right)\right]^2} = \boxed{514\ \text{kN}}$

P23.15 The point is designated in the sketch. The magnitudes of the electric fields, E_1, (due to the -2.50×10^{-6} C charge) and E_2 (due to the 6.00×10^{-6} C charge) are

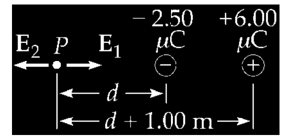

FIG. P23.15

$$E_1 = \frac{k_e q}{r^2} = \frac{\left(8.99\times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(2.50\times 10^{-6}\ \text{C}\right)}{d^2} \qquad (1)$$

$$E_2 = \frac{k_e q}{r^2} = \frac{\left(8.99\times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(6.00\times 10^{-6}\ \text{C}\right)}{\left(d+1.00\ \text{m}\right)^2} \qquad (2)$$

Equate the right sides of (1) and (2)

to get $\left(d+1.00\ \text{m}\right)^2 = 2.40d^2$

or $d+1.00\ \text{m} = \pm 1.55d$

which yields $d = 1.82\ \text{m}$

or $d = -0.392\ \text{m}$.

The negative value for d is unsatisfactory because that locates a point between the charges where both fields are in the same direction.

Thus, $d = \boxed{1.82\ \text{m to the left of the } -2.50\ \mu\text{C charge}}$.

P23.20 (a) $E = \frac{k_e q}{r^2} = \frac{\left(8.99\times 10^9\right)\left(2.00\times 10^{-6}\right)}{(1.12)^2} = 14\ 400\ \text{N/C}$

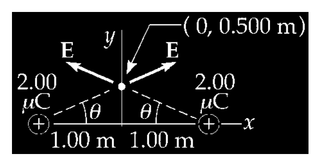

FIG. P23.20

$E_x = 0$ and $E_y = 2(14\ 400)\sin 26.6° = 1.29\times 10^4\ \text{N/C}$

so $\boxed{\mathbf{E} = 1.29\times 10^4\hat{\mathbf{j}}\ \text{N/C}}$.

(b) $\mathbf{F} = q\mathbf{E} = \left(-3.00\times 10^{-6}\right)\left(1.29\times 10^4\hat{\mathbf{j}}\right) = \boxed{-3.86\times 10^{-2}\hat{\mathbf{j}}\ \text{N}}$

P23.26 $E = \int \frac{k_e dq}{x^2}$, where $dq = \lambda_0 dx$

$E = k_e\lambda_0 \int_{x_0}^{\infty} \frac{dx}{x^2} = k_e\lambda_0\left(-\frac{1}{x}\right)\Big|_{x_0}^{\infty} = \boxed{\frac{k_e\lambda_0}{x_0}}$ $\boxed{\text{The direction is } -\hat{\mathbf{i}} \text{ or left for } \lambda_0 > 0}$

P23.30 $E = 2\pi k_e \sigma\left(1 - \frac{x}{\sqrt{x^2 + R^2}}\right)$

$$E = 2\pi\left(8.99\times10^{9}\right)\left(7.90\times10^{-3}\right)\left(1 - \frac{x}{\sqrt{x^2 + (0.350)^2}}\right) = 4.46\times10^{8}\left(1 - \frac{x}{\sqrt{x^2 + 0.123}}\right)$$

(a) At $x = 0.050\,0$ m, $E = 3.83\times10^{8}$ N/C = $\boxed{383 \text{ MN/C}}$

(b) At $x = 0.100$ m, $E = 3.24\times10^{8}$ N/C = $\boxed{324 \text{ MN/C}}$

(c) At $x = 0.500$ m, $E = 8.07\times10^{7}$ N/C = $\boxed{80.7 \text{ MN/C}}$

(d) At $x = 2.00$ m, $E = 6.68\times10^{8}$ N/C = $\boxed{6.68 \text{ MN/C}}$

P23.38

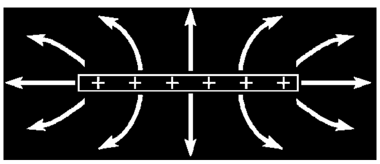

FIG. P23.38

P23.39

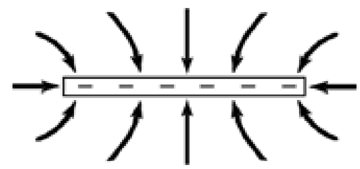

FIG. P23.39

P23.44 (a) $|a| = \frac{qE}{m} = \frac{\left(1.602\times10^{-19}\right)\left(6.00\times10^{5}\right)}{\left(1.67\times10^{-27}\right)} = 5.76\times10^{13}$ m/s so $\mathbf{a} = \boxed{-5.76\times10^{13}\,\hat{\mathbf{i}} \text{ m/s}^2}$

(b) $v_f = v_i + 2a\left(x_f - x_i\right)$

$0 = v_i^2 + 2\left(-5.76\times10^{13}\right)\left(0.070\,0\right)$ $\boxed{\mathbf{v}_i = 2.84\times10^{6}\,\hat{\mathbf{i}} \text{ m/s}}$

(c) $v_f = v_i + at$

$0 = 2.84\times10^{6} + \left(-5.76\times10^{13}\right)t$ $t = \boxed{4.93\times10^{-8} \text{ s}}$

P23.49 $v_i = 9.55\times10^{3}$ m/s

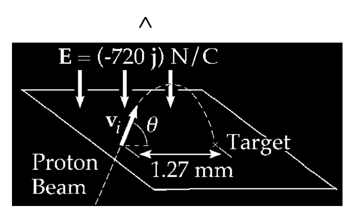

FIG. P23.49

(a) $a_y = \frac{eE}{m} = \frac{\left(1.60\times10^{-19}\right)(720)}{\left(1.67\times10^{-27}\right)} = 6.90\times10^{10}$ m/s^2

$R = \frac{v_i^2 \sin 2\theta}{a_y} = 1.27\times10^{-3}$ m so that

$\frac{\left(9.55\times10^{3}\right)^2 \sin 2\theta}{6.90\times10^{10}} = 1.27\times10^{-3}$

$\sin 2\theta = 0.961$ $\theta = \boxed{36.9°}$ $90.0° - \theta = \boxed{53.1°}$

(b) $t = \frac{R}{v_{ix}} = \frac{R}{v_i \cos\theta}$ If $\theta = 36.9°$, $t = \boxed{167 \text{ ns}}$. If $\theta = 53.1°$, $t = \boxed{221 \text{ ns}}$.

P23.54 From the free-body diagram shown,

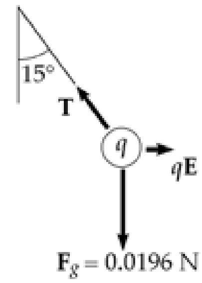

FIG. P23.54

$\sum F_y = 0$: $\quad T\cos 15.0° = 1.96 \times 10^{-2}$ N.

So $\quad T = 2.03 \times 10^{-2}$ N.

From $\sum F_x = 0$, we have $\quad qE = T\sin 15.0°$

or $\quad q = \dfrac{T\sin 15.0°}{E} = \dfrac{(2.03 \times 10^{-2}\text{ N})\sin 15.0°}{1.00 \times 10^3 \text{ N/C}} = 5.25 \times 10^{-6}\text{ C} = \boxed{5.25\ \mu\text{C}}$.

P23.57 $\quad F = \dfrac{k_e q_1 q_2}{r^2}$: $\quad \tan\theta = \dfrac{15.0}{60.0}$

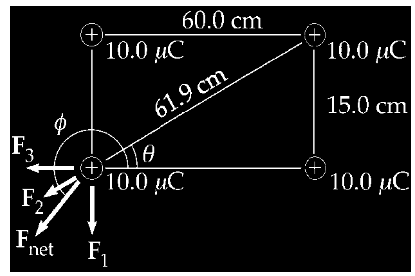

FIG. P23.57

$$\theta = 14.0°$$

$$F_1 = \frac{(8.99 \times 10^9)(10.0 \times 10^{-6})^2}{(0.150)^2} = 40.0 \text{ N}$$

$$F_3 = \frac{(8.99 \times 10^9)(10.0 \times 10^{-6})^2}{(0.600)^2} = 2.50 \text{ N}$$

$$F_2 = \frac{(8.99 \times 10^9)(10.0 \times 10^{-6})^2}{(0.619)^2} = 2.35 \text{ N}$$

$$F_x = -F_3 - F_2\cos 14.0° = -2.50 - 2.35\cos 14.0° = -4.78 \text{ N}$$

$$F_y = -F_1 - F_2\sin 14.0° = -40.0 - 2.35\sin 14.0° = -40.6 \text{ N}$$

$$F_{net} = \sqrt{F_x^2 + F_y^2} = \sqrt{(4.78)^2 + (40.6)^2} = \boxed{40.9 \text{ N}}$$

$$\tan\phi = \frac{F_y}{F_x} = \frac{-40.6}{-4.78}$$

$$\phi = \boxed{263°}$$