PHYS 1304 HW #1 Solutions (7th Edition)

P23.7

$$F_1 = k_e \frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(7.00\times10^{-6}\ \text{C})(2.00\times10^{-6}\ \text{C})}{(0.500\ \text{m})^2} = 0.503\ \text{N}$$

$$F_2 = k_e \frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(7.00\times10^{-6}\ \text{C})(4.00\times10^{-6}\ \text{C})}{(0.500\ \text{m})^2} = 1.01\ \text{N}$$

$$F_x = 0.503\cos 60.0^\circ + 1.01\cos 60.0^\circ = 0.755\ \text{N}$$

$$F_y = 0.503\sin 60.0^\circ - 1.01\sin 60.0^\circ = -0.436\ \text{N}$$

$$\mathbf{F} = (0.755\ \text{N})\hat{\mathbf{i}} - (0.436\ \text{N})\hat{\mathbf{j}} = \boxed{0.872\ \text{N at an angle of } 330^\circ}$$

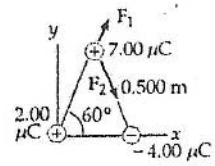


FIG. P23.7

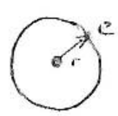
P23.9 (a) The force is one of $\boxed{\text{attraction}}$. The distance r in Coulomb's law is the distance between centers. The magnitude of the force is

$$F = \frac{k_e q_1 q_2}{r^2} = (8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{(12.0\times10^{-9}\ \text{C})(18.0\times10^{-9}\ \text{C})}{(0.300\ \text{m})^2} = \boxed{2.16\times10^{-5}\ \text{N}}.$$

(b) The net charge of -6.00×10^{-9} C will be equally split between the two spheres, or -3.00×10^{-9} C on each. The force is one of $\boxed{\text{repulsion}}$, and its magnitude is

$$F = \frac{k_e q_1 q_2}{r^2} = (8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{(3.00\times10^{-9}\ \text{C})(3.00\times10^{-9}\ \text{C})}{(0.300\ \text{m})^2} = \boxed{8.99\times10^{-7}\ \text{N}}.$$

23.11



$r = 0.529\times10^{-10}$ m

a) $$F = \frac{k q_1 q_2}{r^2} = \frac{(9\times10^9)\cdot(1.6\times10^{-19})(1.6\times10^{-19})}{(0.529\times10^{-10})^2} = \boxed{82.2\times10^{-9}\ N = 82.2\ nN}$$

b) $$F = \frac{m_e v^2}{r} \Rightarrow v = \sqrt{\frac{F\cdot r}{m_e}} = \sqrt{\frac{(82.2\times10^{-9})\cdot(0.529\times10^{-10})}{(9.11\times10^{-31})}}$$

$$= \boxed{2.18\times10^6\ m/s = 2.18\ Mm/s}$$

P23.12 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

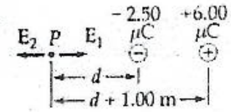


FIG. P23.15

$$E_1=\frac{k_eq}{r^2}=\frac{\left(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(2.50\times10^{-6}\ \text{C}\right)}{d^2} \qquad (1)$$

$$E_2=\frac{k_eq}{r^2}=\frac{\left(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(6.00\times10^{-6}\ \text{C}\right)}{(d+1.00\ \text{m})^2} \qquad (2)$$

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

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

or $d+1.00\ \text{m}=\pm1.55d$

which yields $d=1.82$ m

or $d=-0.392$ 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, $d=$ $\boxed{1.82\ \text{m to the left of the } -2.50\ \mu\text{C charge}}$.

P 23.13 a)

$\downarrow E$ $\quad \uparrow F=q_eE$, $\downarrow m_e g$

$$q_eE=m_eg \Rightarrow E=\frac{m_eg}{q_e}=\frac{(9.11\times10^{-31})\times9.81}{1.6\times10^{-19}}$$

$\boxed{E\downarrow \text{ down}}$

$$=\boxed{55.85\times10^{-12}\ N/C=55.8\ pN/C}$$

b) $\uparrow E$ $\quad \uparrow F=q_pE$, $\downarrow m_pg$

$$q_pE=m_pg \Rightarrow E=\frac{m_pg}{q_p}=\frac{(1.67\times10^{-27}).\ 9.81}{1.6\times10^{-19}}$$

$\uparrow E$ up

$$=\boxed{10.24\times10^{-8}N/C=102\ nN/C}$$

P23.18 (a) $E=\frac{k_eq}{r^2}=\frac{\left(8.99\times10^9\right)\left(2.00\times10^{-6}\right)}{(1.12)^2}=14\,400$ N/C

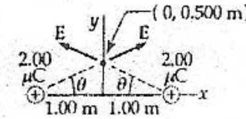


FIG. P23.20

$E_x=0$ and $E_y=2(14\,400)\sin26.6°=1.29\times10^4$ N/C

so $\boxed{\mathbf{E}=1.29\times10^4\hat{\mathbf{j}}\ \text{N/C}}$.

(b) $\mathbf{F}=q\mathbf{E}=\left(-3.00\times10^{-6}\right)\left(1.29\times10^4\hat{\mathbf{j}}\right)=\boxed{-3.86\times10^{-2}\hat{\mathbf{j}}\ \text{N}}$

P23.24 $E = 2\pi k_e \sigma\left(1 - \frac{x}{\sqrt{x^2 + R^2}}\right)$

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

(a) At $x = 0.0500$ 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 $= \boxed{6.68 \text{ MN/C}}$

P23.35 (a) The electric field at point P due to each element of length dx, is $dE = \frac{k_e dq}{x^2 + y^2}$ and is directed along the line joining the element to point P. By symmetry,

$E_x = \int dE_x = 0$ and since $dq = \lambda dx$,

$E = E_y = \int dE_y = \int dE\cos\theta$ where $\cos\theta = \frac{y}{\sqrt{x^2 + y^2}}$.

Therefore, $E = 2k_e\lambda y\int_0^{\ell/2}\frac{dx}{\left(x^2 + y^2\right)^{3/2}} = \boxed{\frac{2k_e\lambda\sin\theta_0}{y}}$.

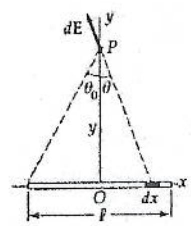


FIG. P23.35

(b) For a bar of infinite length, $\theta_0 = 90°$ and $E_y = \boxed{\frac{2k_e\lambda}{y}}$.

The integral part: $x = y\tan\theta \Rightarrow dx = \frac{y\,d\theta}{\cos^2\theta}$, at $\ell/2 \rightarrow \theta = \theta^\circ$

$$E = 2k\lambda y\int_0^{\ell/2}\frac{dx}{(x^2+y^2)^{3/2}} = 2k\lambda y\int_0^{\ell/2}\frac{1}{(y^2\tan^2\theta + y^2)^{3/2}}\cdot\frac{y\,d\theta}{\cos^2\theta}$$

$$= 2k\lambda y\int_0^{\ell/2}\frac{y\,d\theta}{y^3(1+\tan^2\theta)^{3/2}\cos^2\theta} = \frac{2k\lambda}{y}\int_0^{\theta_0}\frac{d\theta}{\frac{1}{\cos^3\theta}\cdot\cos^2\theta} = \frac{2k\lambda}{y}\int_0^{\theta_0}\cos\theta\,d\theta$$

$$= \frac{2k\lambda}{y}\Big[\sin\theta\Big]_0^{\theta_0} = \frac{2k\lambda\sin\theta_0}{y}$$

P 23.39

$e \longrightarrow K$ $\qquad K = \frac{1}{2}m_e v^2 \Rightarrow v = \sqrt{\frac{2K}{m_e}}$

$F_e \longleftarrow$

$\longrightarrow \vec{E}$ in the direction of beam $\qquad F_e = q_e E = m_e a \Rightarrow a = \frac{q_e E}{m_e}$

$v_f^2 = v_i^2 - 2ad$

$0 = \frac{2K}{m_e} - 2\cdot\frac{q_e E}{m_e}\cdot d \quad \Rightarrow \boxed{E = \frac{K}{q_e d}}$