PROBLEMS-8

Example-1: A 0.100-kg ball is thrown straight up into the air with an initial speed of 15.0 m/s. Find the momentum of the ball (a) at its maximum height and (b) halfway up to its maximum height.

Answers:

(a) At maximum height $\mathbf{v} = 0$, so $\mathbf{p} = \boxed{0}$.

(b) Its original kinetic energy is its constant total energy,

$$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(0.100)\text{kg}(15.0\ \text{m/s})^2 = 11.2\ \text{J}.$$

At the top all of this energy is gravitational. Halfway up, one-half of it is gravitational and the other half is kinetic:

$$K = 5.62\ \text{J} = \frac{1}{2}(0.100\ \text{kg})v^2$$

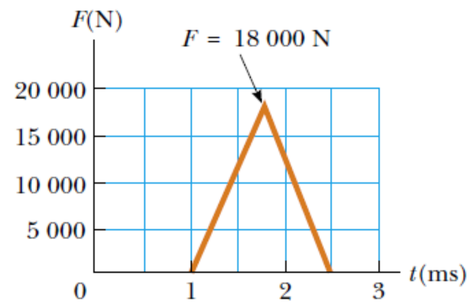
$$v = \sqrt{\frac{2 \times 5.62\ \text{J}}{0.100\ \text{kg}}} = 10.6\ \text{m/s}$$

Then $\mathbf{p} = m\mathbf{v} = (0.100\ \text{kg})(10.6\ \text{m/s})\hat{\mathbf{j}}$

$$\mathbf{p} = \boxed{1.06\ \text{kg} \cdot \text{m/s}\,\hat{\mathbf{j}}}.$$

Example-2: An estimated force–time curve for a baseball struck by a bat is shown in Figure. From this curve, determine (a) the impulse delivered to the ball, (b) the average force exerted on the ball, and (c) the peak force exerted on the ball.

Answers:



(a) $I = \int F dt =$ area under curve

$$I = \frac{1}{2}\left(1.50\times10^{-3}\ \text{s}\right)\left(18\,000\ \text{N}\right) = \boxed{13.5\ \text{N}\cdot\text{s}}$$

(b) $$F = \frac{13.5\ \text{N}\cdot\text{s}}{1.50\times10^{-3}\ \text{s}} = \boxed{9.00\ \text{kN}}$$

(c) From the graph, we see that $F_{max} = \boxed{18.0\ \text{kN}}$

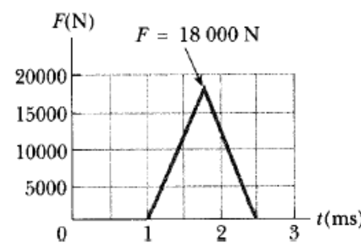


FIG. P9.7

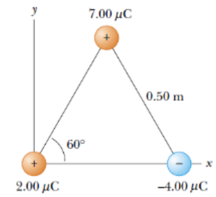
Example-3 : High-speed stroboscopic photographs show that the head of a golf club of mass 200 g is traveling at 5.0m/s just before it strikes a 46.0-g golf ball at rest on a tee. After the collision, the club head travels (in the same direction) at 40.0 m/s. Find the speed of the golf ball just after impact) at 40.0 m/s. Find the speed of the golf ball just after impact.

Answers:

$$(200\ \text{g})(55.0\ \text{m/s}) = (46.0\ \text{g})v + (200\ \text{g})(40.0\ \text{m/s})$$

$$v = \boxed{65.2\ \text{m/s}}$$

Example-4 : 90.0-kg fullback running east with a speed of 5.00 m/s is tackled by a 95.0-kg opponent running north with a speed of 3.00 m/s. If the collision is perfectly inelastic, (a) calculate the speed and direction of the players just after the tackle and (b) determine the mechanical energy lost as a result of the collision. Account for the missing energy.



Answers:

(a) First, we conserve momentum for the system of two football players in the x direction (the direction of travel of the fullback).

$$(90.0\ \text{kg})(5.00\ \text{m/s}) + 0 = (185\ \text{kg})V\cos\theta$$

where θ is the angle between the direction of the final velocity V and the x axis. We find

$$V\cos\theta = 2.43\ \text{m/s} \qquad (1)$$

Now consider conservation of momentum of the system in the y direction (the direction of travel of the opponent).

$$(95.0\ \text{kg})(3.00\ \text{m/s}) + 0 = (185\ \text{kg})(V\sin\theta)$$

which gives, $V\sin\theta = 1.54\ \text{m/s}$ (2)

Divide equation (2) by (1) $\tan\theta = \dfrac{1.54}{2.43} = 0.633$

From which $\boxed{\theta = 32.3°}$

Then, either (1) or (2) gives $V = \boxed{2.88\ \text{m/s}}$

(b)

$$K_i = \frac{1}{2}(90.0\ \text{kg})(5.00\ \text{m/s})^2 + \frac{1}{2}(95.0\ \text{kg})(3.00\ \text{m/s})^2 = 1.55 \times 10^3\ \text{J}$$

$$K_f = \frac{1}{2}(185\ \text{kg})(2.88\ \text{m/s})^2 = 7.67 \times 10^2\ \text{J}$$

Thus, the kinetic energy lost is $\boxed{\text{783 J into internal energy.}}$

Example-5 : Three point charges are located at the corners of an equilateral triangle as shown in Figure. Calculate the resultant electric force on the 7.00-microCoulomb charge.

Answers:

$$F_1 = k_e \frac{q_1 q_2}{r^2} = \frac{\left(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2\right)\left(7.00 \times 10^{-6}\ \text{C}\right)\left(2.00 \times 10^{-6}\ \text{C}\right)}{(0.500\ \text{m})^2} = 0.503\ \text{N}$$

$$F_2 = k_e \frac{q_1 q_2}{r^2} = \frac{\left(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2\right)\left(7.00 \times 10^{-6}\ \text{C}\right)\left(4.00 \times 10^{-6}\ \text{C}\right)}{(0.500\ \text{m})^2} = 1.01\ \text{N}$$

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

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

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

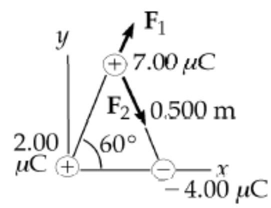
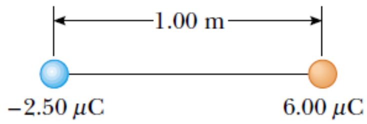


FIG. P23.7

Example-6 : In Figure P23.15, determine the point (other than infinity) at which the electric field is zero.



Answers:

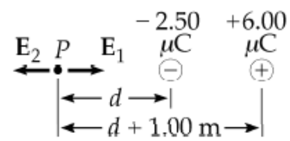


FIG. P23.15

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

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

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

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

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

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

which yields $\quad d = 1.82\ \mathrm{m}$

or $\quad d = -0.392\ \mathrm{m}$.

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

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

Example-7 : A 40.0-cm-diameter loop is rotated in a uniform electric field until the position of maximum electric flux is found. The flux in this position is measured to be 5.210^5 Nm^2/C. What is the magnitude of the electric field?.

Answers:

$$\Phi_E = EA\cos\theta \qquad A = \pi r^2 = \pi(0.200)^2 = 0.126 \text{ m}^2$$

$$5.20\times10^5 = E(0.126)\cos 0^\circ \qquad E = 4.14\times10^6 \text{ N/C} = \boxed{4.14 \text{ MN/C}}$$

Example-8 : 10. The electric field everywhere on the surface of a thin spherical shell of radius 0.750 m is measured to be 890 N/C and points radially toward the center of the sphere. (a) What is the net charge within the sphere's surface? (b) What can you conclude about the nature and distribution of the charge inside the spherical shell?

Answers:

(a) $E = \dfrac{k_e Q}{r^2}$: $\qquad 8.90\times10^2 = \dfrac{(8.99\times10^9)Q}{(0.750)^2}$

But Q is negative since **E** points inward. $\qquad Q = -5.56\times10^{-8} \text{ C} = \boxed{-55.6 \text{ nC}}$

(b) The $\boxed{\text{negative}}$ charge has a $\boxed{\text{spherically symmetric}}$ charge distribution.