Chapter 10

A bullet of mass 30.0 gm travelling at 600 m/s penetrates 12.0 cm into a block of wood. What average force does it exert on the block ?

A. 39.2*(10**3) N
B. 45.0*(10**3) N
C. 33.8*(10**3) N
D. 24.2*(10**3) N
E. 20.0*(10**3) N

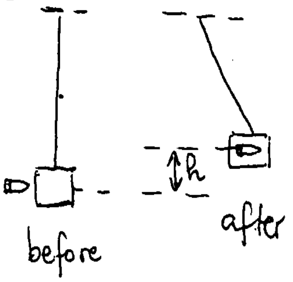
$$\bar{F} = \frac{I}{\Delta t} = \frac{\Delta p}{\Delta t} = \frac{0.03(0-600)}{\Delta t} = \frac{-18}{4\times10^{-4}} = -45000\,N$$

$$\cancel{v^2} = v_0^2 + 2ad \Rightarrow a = -\frac{v_0^2}{2d} = -1.5\times10^{6}\,m/s^2$$

$$\cancel{v} = v_0 + at \Rightarrow t = -\frac{v_0}{a} = 4\times10^{-4}\,sec$$

A bullet of mass 20.0 gm strikes a ballistic pendulum of mass 10.0 kg. The centre of gravity of the pendulum is observed to rise a vertical distance of 6.00 cm. The bullet remains embedded in the pendulum. Calculate the initial velocity of the bullet.

A. 543 m/s
B. 496 m/s
C. 444 m/s
D. 627 m/s
E. 587 m/s



$m = 20\,g \quad h = 6\,cm$

$M = 10\,kg$

$$\Delta K + \Delta U_g = 0$$

$$\left(0 - \tfrac{1}{2}(M+m)V^2\right) + (m+M)gh = 0$$

$$\Rightarrow V = \sqrt{2gh} = 1.08\,\frac{m}{s}$$

$$mv = (M+m)V \Rightarrow v = \left(\frac{M+m}{m}\right)V = 543\,\frac{m}{s}$$

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ich of the following five statements are TRUE ?

)In an inelastic collision both momentum and total energy are conserved even if kinetic energy is not.
)In any kind of collision momentum is always conserved.
)A collision is said to be elastic if the colliding bodies do not stick together.
)The ballistic pendulum is an example of a completely elastic collision.
)In any kind of collision kinetic energy is always conserved.

a and d
b and d
b and c
a and b
d and e

A force of 50 N acting on a 10-kg object changes its speed from 5.0 m/s to 15 m/s in the same direction. Find the magnitude of the impulse given to the object by the force.

$I = \Delta p = m(v_f - v_i) = 10(15 - 5)$
$= 100$ kg m/s

A. 150 kg.m/s
B. 25 kg.m/s
C. 50 kg.m/s
D. 100 kg.m/s
E. 500 kg.m/s

A 0.1-kg block is resting on a smooth horizontal surface. A 0.02-kg bullet is fired into the block with a speed of 200 m/s. The bullet emerges (comes out) from the block with a speed of 100 m/s. Calculate the loss in the kinetic energy (of the bullet-block system) due to the collision of the bullet and the block ?

$K_i = \frac{1}{2} m v_{1i}^2 = \frac{1}{2}(0.02)(200)^2 = 400 J$

$K_f = \frac{1}{2} m v_{1f}^2 + \frac{1}{2} M v_{2f}^2 = 100 + 20 = 120 J$

Conservation of momentum; $m v_{1i} = m v_{1f} + M v_{2f}$

$\Rightarrow v_{2f} = \frac{m(v_{1i} - v_{1f})}{M} = 20$ m/s

A. 180 J
B. 300 J
C. 280 J
D. 380 J
E. 0 because the surface is smooth

$K_f - K_i = \Delta K = 280 J$

Body A has a mass of 5 kg and a velocity of + 2*i m/s. Body B has a mass of 3 kg and a velocity of - 2*i m/s, where i is the unit vector in x-direction. The two bodies collide head-on and the collision is completely inelastic. Find the loss in kinetic energy due to the collision.

Conservation of momentum $\Rightarrow 10 - 6 = 8V \Rightarrow V = 0.5$ m/s

$K_i = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = 10 + 6 = 16 J$

$K_f = \frac{1}{2}(m_1 + m_2) V^2 = 1 J$ $\Delta K = K_f - K_i = -15 J$

A. 15 J
B. 16 J
C. 3 J
D. 17 J
E. 1 J

Consider a collision between an isolated system of two particles. Which of the following statements is TRUE in this case ?

A. The total linear momentum is always conserved.
B. The total kinetic energy as well as the total linear momentum are both conserved if the collision is perfectly inelastic.
C. The total linear momentum is conserved only if the collision is perfectly elastic.
D. The total kinetic energy is conserved only if the collision is perfectly inelastic
E. The total kinetic energy is always conserved.

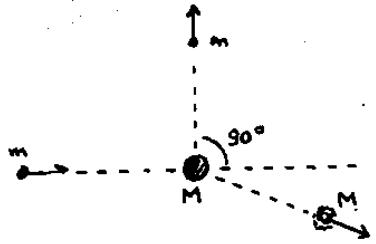
A constant force accelerates a 5 kg object from a velocity of (2*i + 3*j) m/s to a velocity of (-2*i + 4*j) m/s in a time of t seconds. Find the impulse acting on the object in this time (i and j are unit vectors in the x and y directions, respectively).

$\vec{J} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i = m(\vec{v}_f - \vec{v}_i)$

$= 5(-4\hat{i} + 1\hat{j}) = -20\hat{i} + 5\hat{j}$ N.s

A. (-20*i + 5*j) N.s
B. (35*j) N.s
C. It cannot be found because the time is unknown.
D. (20*i - 5*j) N.s
E. - 15*j N.s

A particle of mass m is scattered (deflected) through 90 degrees in an elastic collision with a body of mass M=4*m, initially at rest (see figure). What fraction of its original kinetic energy does the particle lose ?

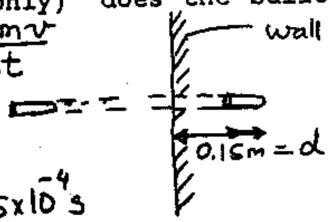


A. 0.3
B. 0.1
C. 0.2
D. 0.5
E. 0.4

Solution in the last page

A 0.030 kg bullet initially travelling at 400 m/s penetrates 0.15 m into a vertical wall. What average force (magnitude only) does the bullet exert on the wall ?

$\bar{F} = \frac{I}{\Delta t} = \frac{\Delta p}{\Delta t} = \frac{0 - mv}{\Delta t}$



$\cancel{v^2} - v_0^2 = 2ad \Rightarrow a = -\frac{v_0^2}{2d}$

$a = -5.3\times10^5\ m/s^2$

$\cancel{v} = at + v_0 \Rightarrow t = -\frac{v_0}{a} = 7.5\times10^{-4}$ s

$|F| = \frac{(0.03)(400)}{7.5\times10^{-4}} = 1.6\times10^4$ N

A. 7.5*10**3 N
B. 5.0*10**3 N
C. 3.7*10**4 N
D. 1.6*10**4 N
E. 2.5*10**3 N

A 5.00 gram bullet is fired horizontally into a 3.00 kg wooden block resting on a horizontal surface. The bullet remains embedded in the block which is observed to slide 25.0 cm along the surface. If the coefficient of sliding friction between the block and the surface is 0.200, find the initial velocity of the bullet.

Conservation of linear momentum $\Rightarrow m v_i = (m+M)V$ — (1)

$\Delta K + \cancel{\Delta U} = -f_k d \Rightarrow 0 - \frac{1}{2}(m+M)V^2 = -\mu_k (M+m) g d$

$\Rightarrow V = \sqrt{2\mu_k g d} = 0.99$ m/s $\Rightarrow v_i = \frac{m+M}{m} V = 595$ m/s

A. 595 m/s
B. 311 m/s
C. 375 m/s
D. 683 m/s
E. 816 m/s

A body of mass 2-kg moving with velocity (i - 3*j) m/s collides completely inelastically with another body of mass 1-kg having a velocity (7*i - 6*j) m/s. Find the kinetic energy of the combined system after the collision. (i and j are the unit vectors along the x-axis and y-axis, respectively)

Conservation of linear momentum

$$2(\hat{i}-3\hat{j}) + 1(7\hat{i}-6\hat{j}) = 3(v_x\hat{i}+v_y\hat{j})$$

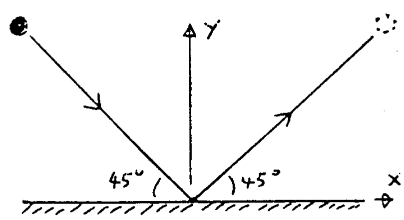
$$9\hat{i} - 12\hat{j} = 3v_x\hat{i} + 3v_y\hat{j} \Rightarrow \begin{cases} v_x = \frac{9}{3} = 3\ m/s \\ v_y = -\frac{12}{3} = -4\ m/s \end{cases}$$

$$\vec{v} = 3\hat{i} - 4\hat{j}\ m/s$$

$$K = \frac{1}{2}(m_1+m_2)v^2 = \frac{1}{2}(3)(9+16) = 37.5\ J \Leftarrow$$

A. 37.5 J
B. 42.5 J
C. 0.5 J
D. 24.5 J
E. zero

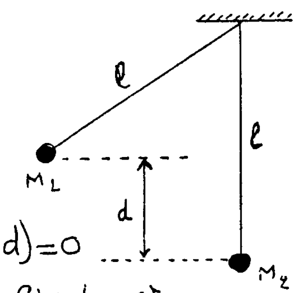
A 4.0 kg object moving with a speed of 30.0 m/s strikes a steel plate at angle of 45 degrees and rebounds at the same speed and angle (see figure). Calculate the impulse (magnitude and direction) delivered to the object.



A. 170 kg.m/s along the - y-axis
B. 340 kg.m/s at 45.0 degrees with the + x-axis
C. 170 kg.m/s along the + y-axis
D. 170 kg.m/s along the + x-axis
E. 170 kg.m/s along the - x-axis

$$I = \Delta p_y = 2mv\sin 45° = 170\ kg\,\frac{m}{s}$$

Two pendulums each of length l are situated as shown in the figure. The first pendulum (M1 = 100 gm) is released from rest and strikes the second one (M2 = 300 gm). Assume that the collision is completely inelastic and neglect the mass of the strings and any frictional effects. If d = 320 cm, how high does the center of mass rise after the collision?



$$\Delta K + \Delta U = 0 \Rightarrow \left(\frac{1}{2}M_1 v^2 - 0\right) - (M_1 g d) = 0$$

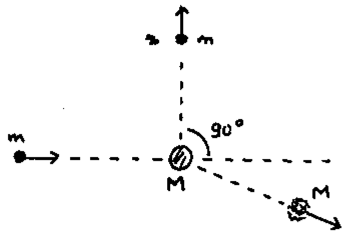
$$\Rightarrow v^2 = 2gd \Rightarrow v = \sqrt{2gd} = 7.91\ m/s = v_{1i}$$

$$M_1 v_{1i} = (M_1+M_2)V \Rightarrow V = \frac{M_1 v_{1i}}{M_1+M_2} = 1.97\ m/s$$

$$\left(0 - \frac{1}{2}(M_1+M_2)V^2\right) + (M+M_2)gh = 0 \Rightarrow h = \frac{V^2}{2g} = 0.2\ m$$

A. 0.80 m
B. 0.05 m
C. 0.20 m
D. 0.0
E. 1.80 m

A particle of mass m is scattered (deflected) through 90 degrees in an elastic collision with a body of mass M=4*m, initially at rest (see figure). What fraction of its original kinetic energy does the particle lose ?



A. 0.3
B. 0.1
C. 0.2
D. 0.5
E. 0.4

Conservation of $p_x \Rightarrow \quad m v_{1i} = 4m\, v_{2fx}$ —— (1)

" " $p_y \Rightarrow \quad 0 = m v_{1f} - 4m\, v_{2fy}$ —— (2)

" " Kinetic energy $\Rightarrow \quad \frac{1}{2} m v_{1i}^2 = \frac{1}{2} m v_{1f}^2 + \frac{1}{2}(4m) v_{2f}^2$ —— (3)

$(1) \Rightarrow \quad v_{1i} = 4\, v_{2fx}$

$(2) \Rightarrow \quad v_{1f} = 4\, v_{2fy}$

$$(3) \Rightarrow \quad v_{1i}^2 = v_{1f}^2 + 4 v_{2f}^2 = v_{1f}^2 + 4\left(v_{2fx}^2 + v_{2fy}^2\right)$$

$$= v_{1f}^2 + 4\left(\frac{v_{1i}^2}{16} + \frac{v_{1f}^2}{16}\right)$$

$$= v_{1f}^2 + \frac{v_{1i}^2}{4} + \frac{v_{1f}^2}{4}$$

$$\Rightarrow \quad \frac{3 v_{1i}^2}{4} = \frac{5 v_{1f}^2}{4} \quad \Rightarrow \quad \frac{v_{1i}^2}{v_{1f}^2} = \frac{5}{3} = 1.67$$

$$\text{fraction lost} = \frac{K_i - K_f}{K_i} = 1 - \frac{K_f}{K_i} = 1 - \frac{v_{1f}^2}{v_{1i}^2} = 1 - 0.6$$

$$= \underline{\underline{0.4}}$$