UNIT 3 DYNAMICS

ASSIGMENT SOLUTION

1. A pitcher throws a 0.45-kg baseball, accelerating it from rest to a speed of about 36 km/h to a distance of 2.0 m. Estimate the force exerted by the pitcher on the ball.

[11.25 N]

DATA:

$m = 0.45\ kg$

$v = 36k\ km/h = \frac{36 \times 1000}{3600} = 10\ m/s$

$S = 2\ m$

$F = ?$

SOLUTIONS

$2\ a\ S = v_f^2 - v_i^2$

$2 \times a\ (2) = (10)^2 - (0)$

$4\ a = 100$

$a = 25\ m/s^2$

$F = m\ a$

$F = (0.45)\ (25) = 11.25\ N$

2 A box of mass m_1 = 12 kg rests on a smooth, horizontal floor in contact with a box of mass m_2 = 5.0 kg. You now push on box 1 with a horizontal force of magnitude F = 34 N. What is the acceleration of the boxes?

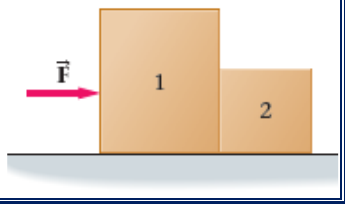
Data:

$m_1 = 12\ kg$

$m_2 = 5.0\ kg$

$F = 34\ N$

$a = ?$



SOLUTION:

$F = (m_1 + m_2)\ a$

$34 = (12 + 5.0)\ a$

$a = \frac{17}{34}$

$a = 0.50\ m/s^2$

3. A 150 g bullet is fired from a 15 Kg gun with a speed of 1500 m/s. What is the speed of the recoil of the gun?

Data:

$m_1 = 150\ g = \frac{150}{1000} = 0.15\ kg$

$m_2 = 15\ kg$

Initially the bullet is at rest $U_1 = 0$

Initially the gun is at rest $U_2 = 0$

$V_1 = 1500\ m/s$

$V_2 = ?$

SOLUTION:

Applying the Law of conservation of momentum

$$m_1U_1 + m_2U_2 = m_1V_1 + m_2V_2$$

$$0.15(0) + 15(0) = 0.15(1500) + 15V_2$$

$$0 + 0 = 225 + 15V_2$$

$$-225 = 15V_2$$

$$-\frac{225}{15} = V_2$$

$$V_2 = -15 ms^{-1}$$

4. A hockey puck with a mass of 0.45 kg is sliding on the ice at a velocity of 10 m/s. It collides with a wall and bounces back with a velocity of -8 m/s. The collision lasts for 0.1 seconds. Calculate the impulse experienced by the hockey puck and the change in its momentum.

[Piitial = 4.5 kg m/s, Pfinal = - 3.6 kg m/s, Δp = - 8.1 kg m/s, impulse =Δp= -.81 Nm]

Data:

$m = 0.45\ kg$

$v_1 = 10\ m/s$

$v_2 = -8\ m/s$

$t = 0.1\ s$

$impulse\ (I) = ?$

$\Delta P = ?$

SOLUTION:

$initial\ momentum\ P_i = mv$

$P_i = 0.45 \times 10 = 4.5\ kg\ m/s$

$final\ momentum\ P_f = mv$

$P_f = 0.45 \times (-8) = -3.6\ kg\ m/s$

$change\ in\ momentum\ \Delta P = P_f - P_i$

$\Delta P = -3.6 - 4.5 = -8.1\ kg\ m/s$

$impulse = \Delta P$

$impulse = -8.1\ Nm$

5. A force of 50 N is exerted on an object of mass 0.5 kg for a time duration of 0.1 seconds. If the initial velocity of the object is 2 m/s calculate the final velocity.

[12 m/s]

Data:

$F = 50\ N$

$m = 0.05\ kg$

$t = 0.1\ s$

$v_i = 2\ m/s \quad , \quad v_f = ?$

SOLUTION:

$\Delta P = F\,t$

$\Delta P = 50 \times 0.1 = 5\ Ns$

$m\,v_f - m\,v_i = \Delta P$

$(0.5)\,v_f - (0.5)\,(2) = 5$

$(0.5)\,v_f - 1 = 5$

$(0.05)\,v_f = 5 + 1$

$(0.5)\,v_f = 6$

$v_f = \dfrac{6}{0.5}$

$v_f = 12\ m/s$

6. A 100 gm golf ball at rest moving with a velocity of 20 m/s collide with 8Kg steel ball at rest. If the collision is elastic, computer the velocities of both balls after the collision.

Data:

$m_1 = 100\ g = \dfrac{100}{1000} = 0.1\ kg$

Initially veocity of first ball $U_1 = 20$ m/s

$m_2 = 8$ kg

Initially veocity of second ball $U_2 = 0$

$V_1 = ?$ $V_2 = ?$

SOLUTION:

Velocity V_1 of golf ball after collision is given by:

$$v_1 = \frac{(m_1 - m_2)}{(m_1 + m_2)} u_1 + \frac{2m_2}{(m_1 + m_2)} u_2$$

$$V_1 = \frac{(0.1 - 8)}{(0.1 + 8)} \times (20) + \frac{2 \times 8}{(0.1 + 8)} \times (0)$$

$$V_1 = \frac{(-7.9)}{(8.1)} \times 20 + 0 = -19.5\ m/s$$

$$v_2 = \frac{(m_2 - m_1)}{(m_1 + m_2)} u_2 + \frac{2m_1}{(m_1 + m_2)} u_1$$

$$V_2 = \frac{(8 - 0.1)}{(0.1 + 8)} \times (0) + \frac{2 \times 0.1}{(0.1 + 8)} \times 20$$

$$V_2 = 0 + \frac{0.2 \times 20}{(8.1)}$$

$$V_2 = 0.493\ m/s$$

7 A 0.34 kg glider on a track is moving at 1.5 m/s collides with a 0.51 kg glider that is initially at rest. They collide and stick together. How fast are the two gliders traveling after the collision?

Data:

$\mathbf{m_1 = \ 0.34\ kg}$

Initially the bullet is at rest $\mathbf{U_1 = 1.5\ m/s}$

$\mathbf{m_2 = 0.51\ kg}$

Initially the gun is at rest $\mathbf{U_2 = 0}$

$v_1 = v$

$v_2 = v$

v =?

SOLUTION:

Applying the Law of conservation of momentum

$$\mathbf{m_1U_1 + \ m_2U_2 = \ m_1v_1 + \ m_2v_2}$$

$$\mathbf{0.34(1.5) + \ 15(0) = \ 0.34}v \mathbf{+ \ 0.51}v$$

$$\mathbf{0.51 + 0 = \ 0.85}\ v$$

$$\frac{\mathbf{0.51}}{\mathbf{0.85}} = \ v$$

$$v = \ \mathbf{0.6\ m/s}$$

7 A 20 g bullet moving horizontally at 50 m/s strikes a 7.0 kg block resting on a table. The bullet embeds in the block after the collision. Find the speed of the block after collision. [0.14 m/s]

Data:

$\mathbf{m_1 = \ 20\ g = \ 0.020\ kg}$

Initially the bullet is at rest $\mathbf{U_1 = 50\ m/s}$

$\mathbf{m_2 = 7.0\ kg}$

Initially the gun is at rest $\mathbf{U_2 = 0}$

$v_1 = v$

$v_2 = v$

v =?

SOLUTION:

Applying the Law of conservation of momentum

$$\mathbf{m_1U_1 + \ m_2U_2 = \ m_1v_1 + \ m_2v_2}$$

$$\mathbf{0.02(50) + \ 7.0(0) = \ 0.02}\ v \mathbf{+ \ 7.0}\ v$$

$$\mathbf{1.0 + 0 = \ 7.02}\ v$$

$$\frac{\mathbf{1.0}}{\mathbf{7.02}} = \ v$$

$$v = \ \mathbf{0.14\ m/s}$$