PROBLEM:

Q.1. In an electron gun of a television set, an electron with initial speed of 10^3 m/s enters a region where it is electrically accelerated. It emerges out of this region after 1 microsecond with speed of 4×10^5 m/s. What is the maximum length of the electron gun? Calculate the acceleration.

Given Data:

Time = $t = 1\ \mu sec = 1 \times 10^{-6}$ sec
Initial speed of electron = $V_i = 10^3$ m/sec
Final speed of electron = $V_f = 4 \times 10^5$ m/sec

To Find:

Acceleration of electron = $a = ?$
Electron gun length = $\ell = ?$

Solution:

Using the equation of motion

$$V_f = V_i + at$$
$$4 \times 10^5 = 10^3 + a \times 10^{-6}$$
$$4 \times 10^5 - 10^3 = 10^{-6} a$$
$$a = \frac{4 \times 10^5 - 10^3}{10^{-6}}$$
$$a = 10^3 (4 \times 10^2 - 1) \times 10^6$$
$$a = (400 - 1)\ 10^9$$
$$\boxed{a = 399 \times 10^9\ m/sec^2} \quad \textbf{Ans.}$$

Now we find length of electron gun by the equation.

$$2as = V_f^2 - V_f^2$$
$$2 \times 399 \times 10^9 \times \ell = (4 \times 10^5)^2 - (10^3)^2$$
$$798 \times 10^9\ \ell = 16 \times 10^{10} - 10^6$$
$$\ell = \frac{16 \times 10^{10} - 10^6}{798 \times 10^9}$$
$$\boxed{\ell = 0.2005\ m} \quad \textbf{Ans.}$$

Q.2. A car is waiting at a traffic signal and when it turns green, the car starts ahead with a constant acceleration of 2 m/s^2. At the same time a bus travelling with a constant speed of 10 m/s overtakes and passes the car.

(a) How fast beyond its starting point will the car overtake the bus?
(b) How fast will the car be moving?

Solution:

Suppose the car overtakes the bus at a distance 's' from the signal in time 't'

For Car:

Initial velocity of the car = $v_i = 0$
Acceleration of the car = $a = 2 m/sec^2$
Distance = $S = ?$
using the equation of motion

$$S = V_i t + \frac{1}{2} a t^2$$
$$S = 0 \times t + \frac{1}{2} 2t^2$$
$$\boxed{S = t^2} \longrightarrow (1)$$

For Bus:

Speed of bus = v = 10 m/sec (constant)

Time = t

Distance = s

$s = vt$

$\boxed{S = 10t} \longrightarrow (2)$

Comparing equation (1) and (2)

$t^2 = 10t$

$\frac{t^{\cancel{2}}}{\cancel{t}} = 10$

$t = 10$ sec

putting the value of 't' in equation (1)

$s = (10)^2$

$\boxed{S = 100 \text{ m}}$ **Ans.**

The velocity with which the car overtake the bus

$V_f = V_i + at$

$V_f = 0 + 2 \times 10$

$\boxed{V_f = 20 \text{ m/sec}}$ **Ans.**

Self Test (1):

As the traffic light turns green a car starts from rest with a constant acceleration of 4 m/sec^2. At the same time a motorcyclist travelling with constant speed 36Km/h, overtakes and passes the car. Find (a) How far beyond the starting point will the car overtake? the motorcyclist (b) what will be speed of the car at the time when it overtakes the motorcyclist?

Ans: ($S = 50$m, $V_f = 20$m/s)

Q.3. A helicopter is ascending at a rate of 12 m/s. At a height of 80m above the ground, a package is dropped. How long does the package take to reach the ground?

Solution:

Consider upward motion from B to C.

Initial velocity of package at B = $V_i = 12$ m/sec

Final velocity of package at C = $V_f = 0$

Time from B to C = t_1 =?

$a = -g = -9.8 \text{m/s}^2$

Using the equation of motion

$V_f = V_i + at$

$0 = 12 + (-9.8)\, t_1$

$9.8\, t_1 = 12$

$t_1 = \frac{12}{9.8}$

$\boxed{t_1 = 1.2 \text{ sec}}$ **Ans.**

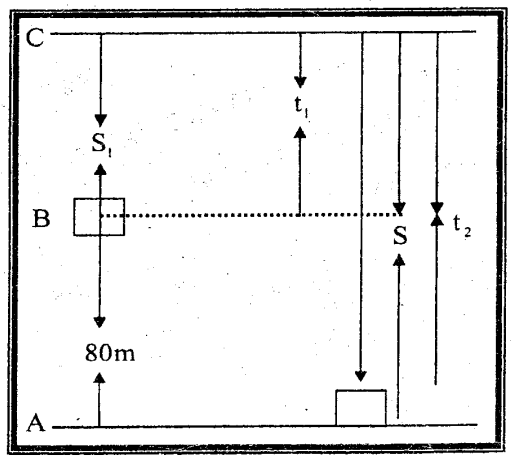
To calculate distance from B to C = s_1

$s = v_i t + \frac{1}{2} g t^2$

$s_1 = 12 \times 1.2 + \frac{1}{2} \times (-9.8)\,(1.2)^2$

$s_1 = 14.4 - 7.06$

$s_1 = 7.34$ m



Consider downward motion from C to A

$$S = 80 + S_1$$
$$S = 80 + 7.34$$
$$= 87.34m$$
$$V_i = 0$$
$$g = 9.8m/sec^2$$
$$t_2 = ?$$

using equation of motion

$$S = v_i t + \frac{1}{2}gt^2$$
$$87.34 = 0 \times t_2 + \frac{1}{2}(9.8)\, t_2^2$$
$$87.34 = 4.9\, t_2^2$$
$$t_2^2 = \frac{87.34}{4.9}$$
$$t_2^2 = 17.82$$
$$\boxed{t_2 = 4.22 \text{ sec}}$$ **Ans.**

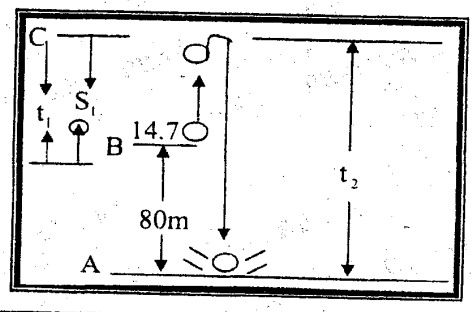
Hence total time the package take to reach the ground is

$$t = t_1 + t_2$$
$$t = 1.2 + 4.22$$
$$\boxed{t = 5.42 \text{ sec}}$$ **Ans.**

Self Test (2):

(i) A helicopter is ascending at the rate of 19.6 m/sec. When it is at a height of 156.8m above the ground a package is dropped. How long does the package take to reach the ground? **$\boxed{t = 8 \text{ Sec}}$ Ans.**

(ii)Q.4. A boy throws a ball upwards from the top of a cliff with a speed of 14.7 m/s. On the way down it just misses the thrower and falls on the ground 49 metres below. Find (i) How long the ball rises? (ii) How high it goes? (iii) How long it is in air and (iv) with what velocity it strikes the ground?



$\boxed{\text{(i) } t_1 = 1.5 \text{ Sec (ii) } S_1 = 11.025\text{m (iii) } t = 5 \text{ Sec (iv) } V_f = 34.3\text{m/s}}$ Ans. (2008)

(iii) A ball dropped from the top of a tower. If it takes 3 seconds to hit the ground find the height of the tower and the velocity with which it will hit the ground.

Ans. (44.1m, 29.4m/s) **(2009S)**

Q.5. A helicopter weighs 3920 Newtons.
Calculate the force on it if it is ascending up at a rate of 2 m/s².
What will be force on of helicopter if it is moving up with the constant speed of 4m/s ?

Given Data:

Weight of helicopter = W = 3920 N

(i) Acceleration of helicopter = $a = 2\ m/sec^2$

(ii) Constant velocity of helicopter = $v = 4$ m/sec

To Find:

(i) Force acting on helicopter = F = ?
(ii) Force acting on helicopter = F = ?

Solution:

Mass of helicopter = $m = \frac{w}{g}$

$$m = \frac{3920}{9.8} = 400kg$$

(i) Since helicopter is ascending up therefor the net force on helicopter is

$F - W = ma$
$F = ma + w$
$F = 3920 + 400 \times 2$
$F = 3920 + 800$
$\boxed{F = 4720\ N}$ **Ans.**

(ii) Force on of helicopter when ascending with constant velocity.

$F - W = ma$

In this case acceleration of helicopter is zero

$F - W = m \times 0$
$F - W = 0$
$F = W$
$\boxed{F = 3920\ N}$ **Ans.**

Q.6. A bullet having a mass of 0.005 kg is moving with a speed of 100 m/s. It penetrates into a bag of sand and is brought to rest after moving 25cm into the bag. Find the decelerating force on the bullet. Also calculate the time in which it is brought to rest.

Given Data:

Mass of bullet = m = 0.005kg.

Initial velocity of bullet = v_i = 100 m/sec

Distance covered = s = 25cm = $\frac{25}{100}$

= 0.25 m

Final velocity of bullet = $V_f = 0$

To Find:

Decelerating force on bullet = F = ?
Time in which bullet brought to rest = t = ?

Solution:

To calculate 'a' using the equation of motion

$2a\,s = V_f^2 - V_i^2$
$2 \times a \times 0.25 = (0)^2 - (100)^2$
$0.5\,a = -1000$
$a = -\frac{10000}{0.5}$
$\boxed{a = -20000\ m/s^2}$ **Ans.**

According to Newton's second law of motion

$F = ma$
$F = (0.005)(-2000)$
$F = -100\ N$
Decelerating force = 100 N **Ans.**

Now $V_f = V_i + at$
$0 = 100 + (-2000)\,t$
$0 = 100 - 2000\,t$
$2000\,t = 100$
$t = \frac{100}{2000}$
$\boxed{t = 0.005\ sec}$ **Ans.**

Self Test (3):

Q.7 A car weighing 9800 N is moving with a speed of 40 km/h. On the application of the brakes it comes to rest after travelling a distance of 50 metres. Calculate the average retarding force. $\boxed{F = -1234.3N}$ **Ans.**

Self Test (4):

Q.8. An electron in a vacuum tube starting from rest is uniformly accelerated by an electric field so that it has a speed of 6×10^6 m/s after covering a distance of 1.8cm. Find the force acting on the electron. Take the mass of electron as 9.4×10^{-31} kg. $\boxed{F = 9.1 \times 10^{-16} N}$ **Ans.**

Q.9. **Two bodies A and B are attached to the ends of a string which passes over a pulley, So that the two bodies hang vertically. If the mass of the body A is 4.8 kg. Find the mass of body B which moves down with an acceleration of 0.2 m/s^2. The value of g can be taken as 9.8 m/s^2.**

Given Data:

Mass of body A = m_2 = 4.8 kg
Acceleration of body B = a = 0.2 m/s^2
Acceleration due to gravity = g = 9.8 m/sec^2

To Find:

Mass of body B = m_1 =?

Solution:

We know when two bodies hang vertically, then acceleration is

$$a = \frac{(m_1 - m_2)}{m_1 + m_2} g$$

$$0.2 = \frac{(m_1 - 4.8)}{(m_1 + 4.8)} 9.8$$

$$\frac{0.2}{9.8} = \frac{(m_1 - 4.8)}{(m_1 + 4.8)}$$

$$\frac{1}{49} = \frac{(m_1 - 4.8)}{(m_1 + 4.8)}$$

Cross multiplication

$$(m_1 + 4.8) = 49\,(m_1 - 4.8)$$
$$m_1 + 4.8 = 49\,m_1 - 49 \times 4.8$$
$$m_1 - 49\,m_1 = -235.2 - 4.8$$
$$-48\,m_1 = -240$$
$$m_1 = \frac{-240}{-48}$$

$\therefore$ $\boxed{m_1 = 5\ kg}$ **Ans.**

Self Test (5):

Two bodies A and B are attached to the ends of a string which passes over a pulley, so that the bodies hang vertically. If the mass of the body A is 96kg. Find the mass of body B which moves down with an acceleration of 0.2 m/sec^2. The value of g can be taken as 9.8 m/sec^2. $\boxed{m_1 = 100kg}$ Ans. **(1998)**

Example:

Two bodies A and B are attached to the ends of a string which passes over a pulley so that the two bodies hang vertically. If the mass of body A is 5Kg and that of body B is 4.8Kg. Find the acceleration and tension in the string. The value of g is 9.8 m/s^2.

Given Data:

Mass of body A $= m_1 = 5Kg$
Mass of body B $= m_2 = 4.8Kg$
$g = 9.8\ m/s^2$

To Find:

Acceleration $= a = ?$
Tension in the string $= T = ?$

Solution:

We know when two bodies hang vertically, than acceleration is

$$a = \frac{(m_1 - m_2)}{m_1 + m_2} g$$

$$a = \frac{(5 - 4.8)}{5 + 4.8} 9.8$$

$$a = \frac{0.2 \times 9.8}{9.8}$$

$\boxed{a = 0.2\ m/s^2}$ **Ans.**

We know two bodies hang vertically, than tension is.

$$T = \frac{2\ m_1 m_2}{m_1 + m_2} g$$

$$T = \frac{2 \times 5 \times 4.8 \times 9.8}{5 + 4.8}$$

$$T = \frac{48 \times 9.8}{9.8}$$

$\boxed{T = 48N}$ **Ans.**

Self Test (6):

Two bodies of masses 0.5Kg and 5.5Kg are attached to the ends of a string which passes over a pulley, so that the two bodies hang vertically calculate acceleration and tension in the string.

$\boxed{a = 8.166\ m/s^2, T = 8.98\ N}$ **Ans.**

Q10: Two bodies of masses 10.2 Kg and 4.5 Kg are attached to the two ends of a string which passes over a pulley in such a way that the body of mass 10.2 Kg lies on a smooth horizontal surface and the other body hangs vertically. Find the acceleration of the bodies, the tension of the string and also the force which the surface exerts on the body of mass 10.2 Kg. (2001)

Given Data:

Mass of body A $= m_1 = 4.5Kg$
Mass of body B $= m_2 = 10.2Kg$
Acceleration due to gravity $= g = 9.8\ m/sec^2$

To Find:

(i) Acceleration of bodies $= a = ?$
(ii) Tension is string $= T = ?$
(iii) Force of surface $= F = ?$

Solution:

(i)

$$a = \frac{m_1 g}{m_1 + m_2}$$

$$a = \frac{4.5 \times 9.8}{4.5 + 10.2}$$

$$a = \frac{44.1}{14.7}$$

$\boxed{a = 3\ m/sec^2}$ **Ans.**

(ii)

$$T = \frac{m_1 m_2 g}{m_1 + m_2}$$

$$T = \frac{4.5 \times 10.2 \times 98}{4.5 + 10.2}$$

$$T = \frac{449.82}{14.7}$$

$\boxed{T = 30.6\ N}$ **Ans.**

$$F = W_2 = m_2 g$$

$$F = 10.2 \times 9.8$$

$\boxed{F = 99.96\ N}$ **Ans**

Q.11. A 100 grams bullet is fired into a 10 Kg gun with a speed of 1000m/s. what is the speed of recoil of the gun. (2004 Failures, 2002 Supp.)

Given Data:

Mass of bullet $= m_1 = 100g$

Mass of bullet $= m_1 = \frac{100}{1000} = 0.1$ Kg

Mass of gun $= m_2 = 10Kg$

velocity of bullet before firing $= u_1 = 0$

velocity of gun before firing $= u_2 = 0$

velocity of bullet of the after firing $= v_1 = 1000$ m/s

To Find:

velocity of gun after firing $= v_2 = ?$

Solution:

According to the law of conservation of linear momentum.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$0.1x0 + 10x0 = 0.4x1000 + 10\,v_2$$

$$0 + 0 = 100 + 10v_2$$

$$v_2 = \frac{-100}{10}$$

$$\boxed{v_2 = -10 \text{ m/s}}$$

Negative sign show that the direction of velocity of recoil of gun, whose magnitude is 10 m/s and direction of recoil is opposite to the direction of velocity of bullet.

Self Test (7):

(i) A 150gm bullet is fired from 15kg gun with speed of 1500m/s. What is the speed of recoil of the gun. **(2003 P.M)**

Ans. $\boxed{V_1 = -15 \text{ m/s}}$

(ii) A black ball of mass 2kg moving at velocity of 10m/sec collide with a stationary white ball of mass 3Kg. Find their common velocity if they stick together after collision?

Ans. $\boxed{V = 4 \text{ m/s}}$

(iii) An arrow of mass 0.1Kg is shot into an apple of mass 0.2Kg which is resting on the top of a wall. At the moment of impact the arrow is travelling horizontally at 15 m/s calculate the common speed of the arrow and the apple immediately after impact.

Ans. $\boxed{V = 5 \text{ m/s}}$

Q.12. A 50 grams bullet is fired into a 10Kg block that is suspended by a long cord so that it can swing as a pendulum. If the block is displaced so that its center of gravity rises by 10cm, what was the speed of the bullet?

Given Data:

Mass of bullet $= m_1 = 50g = \frac{50}{1000} = 0.05Kg$

Mass of block $= m_2 = 10Kg$

Height $= h = 10cm = \frac{10}{100} = 0.1m$

velocity of block before impact $= u_2 = 0$

velocity of bullet after impact $= v_1 = V$

velocity of block after impact $= v_2 = V$

To Find:

velocity of bullet before impact $= u_1 = ?$

Solution:

According to law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$0.05 \times u_1 + 10 \times 0 = 0.05v + 10 \times v$$

$$0.05u_1 = 10.05v$$

$$u_1 = \frac{10.05}{0.05} v$$

$$\mathbf{u_1 = 201v} \quad \text{——————} \quad \mathbf{(1)}$$

According law of conservation of energy

loss of K.E = gain of P.E

$$\frac{1}{2}(m_1 + m_2)v^2 = (m_1 + m_2)gh$$

$$\frac{1}{2}v^2 = gh$$

$$v^2 = 2gh$$

$$v = \sqrt{2gh}$$

$$v = \sqrt{2 \times 9.8 \times 0.1}$$

$$v = 1.4 \text{ m/s}$$

putting the value of v is eq (1)

$$u_1 = 201 \times 1.4$$

$$\boxed{u_1 = 281.4 \text{ m/s}} \quad \textbf{Ans.}$$

Self Test (8):

A 100g bullet is fired into a 12Kg block which is suspended by a long cord. If the bullet is imbedded in the block and the block rise by 5cm. What was the speed of the bullet. $\boxed{u_1\ 119.78 \text{ m/s}}$ **Ans.** **(1997)**

Q.13. A machine gun fires 10 bullets per second into a target. Each bullet weighs 20gm and had a speed of 1500m/s. Find the force necessary to hold the gun in position.

Given Data:

Mass of bullet $= m = 20g = \frac{20}{1000} = 0.02Kg$

Number of bullet $= 10$

Mass of 10 bullets $= M = 10 \times 0.02 = 0.2Kg$

Time $= t = 1s$

Initial velocity of bullet $= v_i = 0$

Final velocity of bullet $= v_f = 1500$ m/sec

To Find:

Force $= F = ?$

Solution:

Force necessary to hold the gun = change in momentum of bullets per second.

$$F = \frac{Mv_f - Mv_i}{t}$$

$$F = \frac{0.2 \times 1500 - 0.2 \times 0}{1}$$

$\therefore$ $\boxed{F = 300 \text{ N}}$ **Ans.**

Self Test (9):

(i) A machine gum fires 20 bullets per second into a target. Each bullet of mass 10gm and has a speed of 1500m/s. Find the force necessary to hold the gun in position. **(2002 P.E)**

Ans. **F = 300 N**

(ii) A car of mass 1200Kg is brought to rest from a speed of 20m/s by a constant force of 3000N. Calculate the change in momentum produced by the force and the time taken by the car to come to rest.

Ans. **ΔP = 24000 Ns' t = 8 Sec**

(iii) A machine gun fires 17 bullets per second at a target. Each bullet weights 20 gm and has a speed 2000m/s; find the force necessary to hold the gun in position.

Ans. **F = 680 N** **(2009 F)**

Q.15. The engine of a motor car moving up 45° slope with a speed of 63 km/h stop working suddenly. How far will the car move before coming to rest? (Assume the friction to be negligible).

Given Data:

Ans. Initial velocity of car $= v_i = 63\text{km/h}$

$$= \frac{63 \times 1000}{60 \times 60} = 17.5\text{m/s}$$

Final velocity of car $= v_f = 0$

Angle of inclination $= \theta = 45°$

To Find:

Distance covered before coming to rest = s = ?

Solution:

We first calculate acceleration 'a' using formula

$a = -g \sin\theta$

$a = -9.8 \sin 45°$

$a = -9.8 \times 0.7076$ $(\because \sin 45° = 0.7076)$

$a = -6.928\ m/s^2$

Now using the equation of motion

$2as = V_f^2 - V_i^2$

$2 \times -6.928S = (0)^2 - (17.5)^2$

$-13.8565 = -306.25$

$S = \frac{306.25}{13.856}$

$\therefore$ **S = 22.102 m Ans.**

Self Test (10):

(i) A motor car is moving up a slope of 30° with a velocity of 72km/h. Suddenly the engine fails. How much distance will the car move before coming of rest. Assuming friction to be negligible. **(2000)**

Ans. **S = 40.81m**

Q.14 A cyclist is going up a slope of 30° with a speed of 3.5m/s. if he stops pedalling, how much distance will he move before coming to rest? (Assume the friction to be negligible). **(2004 supp)**

Ans. **S = 1.25m**

Q.16. Find the distance that the car moves, if it weighs 19.600N and the frictional force is 2000N.

Given Data:

Initial velocity of car = $v_i = 63\text{km/h} = \frac{63 \times 1000}{60 \times 60} = 17.5\text{m/s}$

Final velocity of car = $v_f = 0$

Angle of inclination = $\theta = 45^\circ$

Weight of car = $w = 19600\text{N}$

Frictional force = $f = 2000\text{N}$

To Find:

Distance covered by car before coming to rest = s = ?

Solution:

Mass of car = $m = \frac{w}{g} = \frac{19600}{9.8} = 2000\text{Kg}$

We first calculate acceleration 'a' using formula

$-ma = (mg \sin\theta + f)$

$-2000a = 2000 \times 9.8 \sin 45^\circ + 2000 \quad \because \sin 45^\circ = 0.707$

$-2000a = 2000 \times 9.8 \times 0.707 + 2000$

$-2000a = 13857.2 + 2000$

$-2000a = 15857.2$

$a = \frac{15857.2}{-2000}$

$\boxed{a = -7.928\ \text{m/s}^2}$

Now using the equation of motion

$2as = v_f^2 - v_i^2$

$2 \times -7.928\ S = (0)^2 - (17.5)^2$

$-15.857\ S = -306.25$

$S = \frac{306.25}{15.857}$

$\boxed{S = 19.313\ \text{m}}$ **Ans.**

Self Test (11):

An inclined plane makes an angle of 40° with the horizontal. A body weighing 4000N initial at rest, moves down the slope. Calculate the distance travelled by the body in 5 seconds if force of friction is 1500N. $\boxed{S = 32.8\ \text{m}}$ **Ans.**

Q.17. In the figure (a) find the acceleration of the masses and the tension in the string

Solution:

Consider downward motion of block A.

Weight of block A = $W_1 = 98\text{N}$

Mass of block A = $m_1 = \frac{W_1}{g} = \frac{98}{9.8} = 10\text{Kg}$

Slope of inclined plane = $\theta = 30^\circ$

Tension in the string = $T = ?$

Acceleration of the system = a = ?

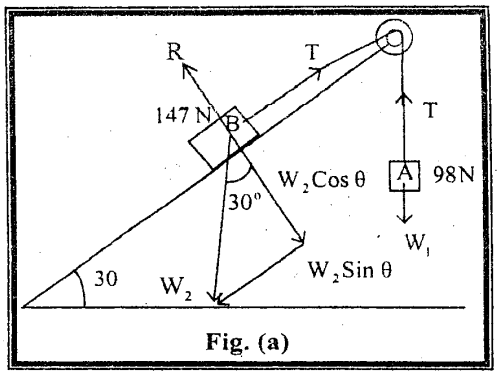


Fig. (a)

Resultant force on block A is

$F_1 = W_1 - T$

$m_1a = W_1 - T$ $\quad \because F_1 = m_1 a$

$10\,a = 98 - T$ ⟶ (1)

Consider upward motion of block B.

Weight of block B = W_2 = 147N

Mass of block B $= m_2 = \frac{W_2}{g} = \frac{147}{9.8} = 15Kg$

Resultant force on block B is

$F_2 = T - W_2 \sin\theta$

$m_2a = T - W_2 \sin\theta$ $\quad \because F_2 = m_2a$

$15a = T - 147 \sin 30^\circ$ $\quad \because \sin 30^\circ = 0.5$

$15a = T - 147 \times 0.5$

$15a = T - 73.5$ ⟶ (2)

add eq. (1) and eq. (2)

$10a = 98 - T$

$15a = T - 73.5$

$25a = 98 - T + T - 73.5$

$25a = 24.5$

$a = \frac{24.5}{25}$

$a = 0.98\ m/s^2$ **Ans.**

putting the value of a in eq. (1)

$10(0.98) = 98 - T$

$9.8 = 98 - T$

$T = 98 - 9.8$

$T = 88.2$ N **Ans.**

Q.18. Two blocks are connected as shown in fig.b. If the pulley and the planes on which the blocks are resting are frictionless, find the acceleration of the blocks and the tension in the string.

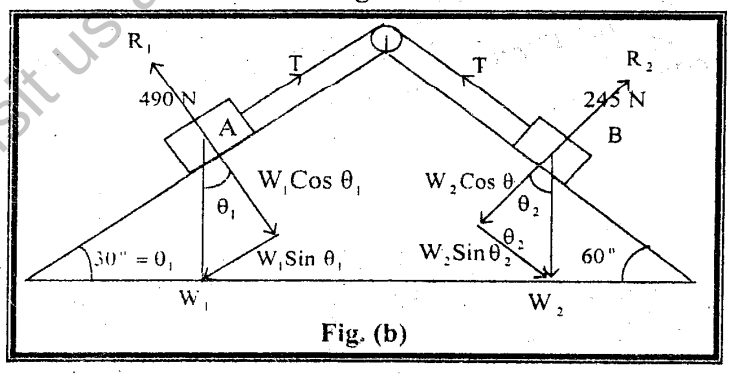


Fig. (b)

Solution:

Consider downward motion of block A.

Weight of block A w_1 = 490N

Mass of block A $m_2 = \frac{W_2}{g} = \frac{490}{9.8} = 50Kg$

Tension in the string = T = ?

Acceleration of the system = a = ?

Resultant force on block A

$F_1 = W_1 \text{ Sin } \theta_1 - T$

$m_1 a = W_1 \text{ Sin } \theta_1 - T$ $\quad \because F_1 = m_1 a$

$50\ a = 490 \text{ Sin } 30° - T$

$50\ a = 490 \times 0.5 - T$ $\quad \because \text{Sin } 30° = 0.5$

$50\ a = 245 - T$ ⟶ (1)

Consider upward motion of block B.

Weight of block B $W_2 = 245N$

Mass of block B $= m_2 = \frac{W_2}{g} = \frac{245}{9.8} = 25Kg$

Resultant force on block B is

$F_2 = T - W_2 \text{ Sin } \theta_2$

$m_2 a = T - W_2 \text{ Sin } \theta_2$ $\quad \because F_2 = m_2 a$

$25\ a = T - 245 \text{ Sin } 60°$ $\quad \because \text{Sin } 60° = 0.866$

$25\ a = T - 245 \times 0.866$

$25\ a = T - 212.17$ ⟶ (2)

add eq. (1) and equation. (2)

$50\ a = 245 - T$

$25\ a = T - 212.17$

$75\ a = 245 - \cancel{T} + \cancel{T} - 212.17$

$75\ a = 32.83$

$a = \frac{32.83}{75}$

$a = 0.437\ m/s^2$ Answer

putting the value of a in equation. (1)

$5a \times 0.437 = 245 - T$

$21.5 = 245 - T$

$T = 245 - 21.5$

$T = 223.5N$ Ans.

Self Test (12):

Q.19. Two blocks each weighing 196N rest on planes as shown in fig.c. If the planes and pulleys are frictionless, find the acceleration and tension in the cord.

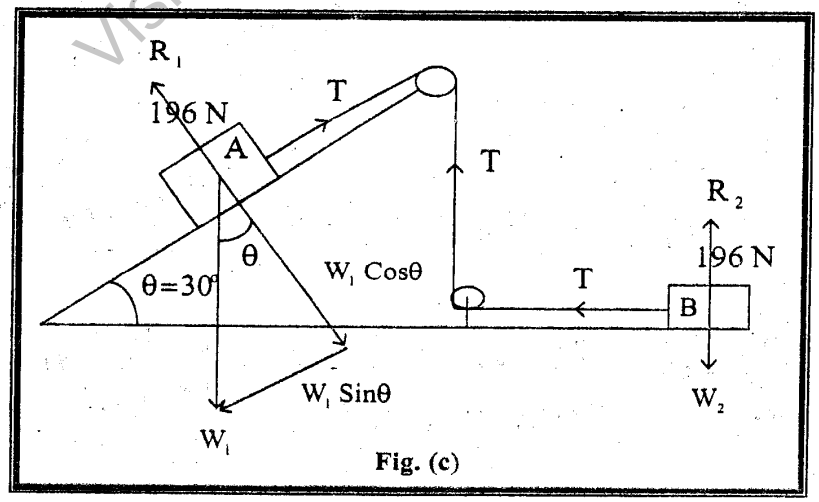


Fig. (c)

Ans: ($a = 2.45 m/s^2$, $T = 49N$)

EXTRA PROBLEM:

Q.1 A 12kg gun mounted on wheels Shots a 100gm projectile with a muzzle velocity of 1800m/s at an angle of 60° above the horizontal. Find the horizontal recoil velocity of the gun. **(1992)**

Given Data:

Mass of gun = $m_1 = 12kg$
Mass of projectile = $m_2 = 100gm = 0.1kg$
Initial velocity of gun = $u_{1x} = 0$
Initial velocity of projectile = $u_{2x} = 0$
Final velocity of projectile = $v_2 = 1800$ m/sec
$\theta = 60°$

To Find:

Horizontal recoil velocity of gun = $V_{1x} = ?$

Solution:

Horizontal velocity of projectile = $V_{2x} = V_2 \cos\theta$
$= 1800 \cos 60° = 1800 \times 0.5$ $(\because \cos 60° = 0.5)$
$= 900$ m/s

$m_1U_1x + m_2U_2x = m_1V_1x + m_2V_2x$
$12 \times 0 + 0.1 \times 0 = 12 \times V_1x + 0.1 \times 900$
$0 = 12V_1x + 90$

$$V_1x = \frac{-90}{12}$$

$\therefore$ **$V_1x = -7.5$ m/s Ans.**

SELF TEST (13):

A 10kg gun mounted on wheel. Shots a 75gm projectile with a muzzile velocity of 1900 m/s at an angle of 30° above the horizontal. Find the horizontal recoil velocity of the gun.

Ans. **$V_1x = 12.34$ m/s**

Q.2 A minibus starts moving form the position of rest at a bus stop with a uniform acceleration. During the 10^{th} sec of its motion it covers a distance of 95m. Calculate its acceleration and the total distance it covers in 10 seconds. **(1994)**

Solution:

Distance covered by the minibus in 10 second = S_{10}
Initial velocity of the minibus $= V_i = 0$
Time $= t = 10$ sec
Acceleration $= a = ?$

Using equation of motion.

$$S = Vit + \frac{1}{2} at2$$

$$S10 = 0 \times 10 + \frac{1}{2} (a)(10)2$$

$$S10 = 0 + \frac{1}{2} a \times 100$$

$S_{10} = 50a \longrightarrow$ (1)

Distance covered by the minibus in 9 second = S_9
Initial velocity of the minibus $= V_i = 0$
Time $= t = 9$sec
Acceleration $= a = ?$

Using equation of motion

$$S = Vit + \frac{1}{2}at^2$$

$$S_9 = 0 \times 9 + \frac{1}{2}(a)(9)^2$$

$$S_9 = 0 + \frac{1}{2} \times a \times 81$$

$$\mathbf{S_9 = 40.5a \longrightarrow (2)}$$

Now the distance covered by the minibus in 10^{th} second.

$$= S_{10} - S_9 = 95$$

$$50a - 40.5a = 95$$

$$9.5a = 9.5$$

$$a = \frac{95}{9.5}$$

$\therefore$ $\boxed{\mathbf{a = 10m/s^2}}$ **Ans.**

Putting the value of a in equation. (1)

$$S_{10} = 50a$$

$$a = 10m/s^2$$

$$S_{10} = 50 \times 10 = 500m$$

$\therefore$ $\boxed{\mathbf{S_{10} = 500m}}$ **Ans.**

SELF TEST (14):

A car starts from constant acceleration. During the 5^{th} second of its motion it covers a distance of 36m calculate

(a) the acceleration of the car

(b) the total distance covered by the car during these 5sec. **(2003 P.E)**

Ans. $\boxed{\mathbf{S = 100m\ a = 8m/s^2}}$

Q.3 A 100 gm golf ball moving with velocity of 20m/s collides with a 8kg steel ball at rest. If the collision is elastic, compute the velocity of both balls after the collision. **(2006, 2004)**

Given Data:

Mass of golf ball = $m_1 = 100gm = \frac{100}{1000} = 0.1kg.$

Mass of steel ball = $m_2 = 8kg.$

Initial velocity of golf ball = $U_1 = 20m/s$

Initial velocity of steel ball = $U_2 = 0$

To Find:

Final velocity of golf ball = $V_1 = ?$

Final velocity of steel ball = $V_2 = ?$

Solution:

Final velocity of golf ball after collision.

$$V_1 = \frac{(m_1 - m_2)U_1}{m_1 + m_2} + \frac{2m_2 U_2}{m_1 + m_2}$$

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

$$V_1 = \frac{-7.9 \times 20}{8.1} + 0$$

$\therefore$ $\boxed{\mathbf{V_1 = -19.5\ m/s}}$ **Ans.**

(Here –Ve sign show that golf ball will return back in opposite direction after collision).

Find Velocity of steel ball after collision.

$$V_2 = \frac{2m_1U_1}{m_1+m_2} + \frac{(m_2-m_1)U_2}{m_1+m_2}$$

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

$\therefore$ $\boxed{V_2 = 0.49 m/s}$ **Ans.**

SELF TEST (15):

A 70gm ball collides with another ball of mass 140gm. The initial velocity of first ball is 9m/s to the right while the second ball is at rest. If the collisions were perfectly elastic what would be the velocity of the two balls after the collision?

Ans. $\boxed{V_1 = -3m/s, V_2 = 6m/s}$

Q.4 A ball is thrown vertically upward from the ground with a speed of 25 m/s. on its way down it is caught of a point 5m above the ground how long did the trip take. (4.9 Sec) **(2007)**

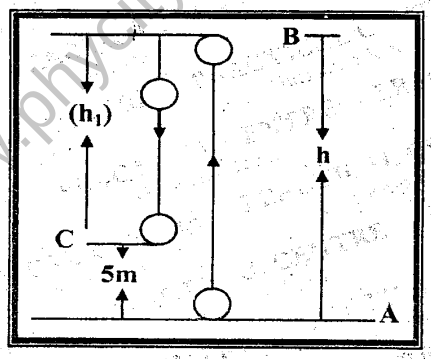
Give Data:

From A to B

$V_i = 25$ m/s

$V_f = g = -9.8$ m/sec

Height achieved = h



From B to C:

$V_i = 0$

Height covered = h_1

$a = +g = 9.8$ m/s^2

To Find

Time from A to B = t_1 = ?

Time from B to C = t_2 = ?

Total time = $t = t_1 + t_2$ = ?

Solution:

Consider upward motion from A to B

$$V_f = V_i - gt_1$$

$$0 = 25 - 9.8\,t_1$$

$$9.8t_1 = 25$$

$$t_1 = \frac{25}{9.8}$$

$$t_1 = 2.55102 \text{ sec.}$$

Finding h from A to B

$$h = Vit_1 - \frac{1}{2}gt_1^2$$

$$h = 25 \times 2.55 - \frac{1}{2}(9.8)(2.55)^2$$

$$h = 63.75 - 31.862$$

$$h = 31.888 \text{ m}$$

Consider downward motion from B to C

$$h_1 = h - 5 = 31.888 - 5$$

$$= 26.888 \text{ m}$$

$$h_1 = V_it_2 + \frac{1}{2}gt_2^2$$

$$26.888 = 0 \times t_2 + (4.9)t_2^2$$

$$26.888 = 4.9\,t_2^2 \text{ -------(1)}$$

$26.888 = 4.9t_2^2$

$t_2^2 = \frac{26.888}{4.9}$

$t_2^2 = 5.4873$

$t_2 = 2.34 \text{ sec}$

Now:

$t = 2.55 + 2.34$

$\boxed{t = 4.89 \text{ sec}}$ **Ans.**

SELF TEST (16):

A boy throuws a ball vertically upward with a speed of 25m/s, on it is way down it is caught at a point 5m above the ground. How fast was it coming down at out the point how long did the trip take **(1996)**

$\boxed{V_f = 22.96 \text{ m/s}}$ **Ans.**

Q.5. A car weighing 9800 N is moving at 25 m/s if the frictional force acting on it is 2000 N, how fast is the car moving when it has traveled 60m? **(2007)**

Given Data:

Mass of car = m = 9800 N
Initial velocity = V_i = 25 m/s
Force of friction = f = 2000 N
Distance = S = 60 m

To Find:

Final velocity = Vf = ?

Solution:

$$\text{Mass of car} = m = \frac{w}{g}$$

$$m = \frac{9800}{9.8}$$

$\boxed{m = 1000 \text{kg}}$

Determine the acceleration of car

$F = ma$

$\boxed{f = ma}$

$2000 = -1000a$

$$A = -\frac{2000}{1000}$$

$\boxed{a = -2 \text{m/s}^2}$

The final velocity of car when it has traveled 60m.

$2aS = V_f^2 - V_i^2$

$2x - 2x60 = V_f^2 - (25)^2$

$-240 = V_f^2 - 625$

$625 - 240 = V_f^2$

$385 = V_f^2$

$V_f^2 = 385$

$\therefore$ $\boxed{V_f = 19.62 \text{ m/s}}$ **Ans.**

SELF TEST (17):

A car weighing 19600N moving at 25 m/s if the frictional force acting on it 4000N, how fast is the car moving when it has traveled 30m?

$\boxed{V_f = 22.47 \text{ m/s}}$ **Ans.**

SELF TEST (18):

A boy throws a ball upward from the top of a tower with a speed of 12m/s. On the way down it just misses the thrower and falls to the ground 50m below. Find how long the ball remains in the air. (t = 4.64 Sec) **(2008)**

(Hint: Compare with Q.3 and Q.4)

Extra problem:

A car of mass 1600kg moving with an initial velocity of 18 ms^{-1} hits another stationary car of mass 1400kg and they lock together. With what velocity do they move after an elastic collision? **(2008 Failure)**

Data:

Given:

$m_1 = 1600$ kg
$m_2 = 1400$ kg
$u_1 = 18\ ms^{-1}$
$u_2 = 0$
$v_1 = v_2 = v$

To Find:

$v = ?$

Formula:

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Solution:

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$1600 \times 18 + 1400 \times 0 = 1600v + 1400v$

$28800 + 0 = 3000v$

$28800 = 3000v$

$$v = \frac{28800}{3000}$$

$$\boxed{v = 9.6\ ms^{-1}}$$