CH#03

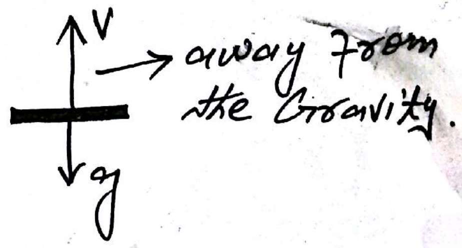
Short Answer's:-

Ans:-(3.1)

* In uniform velocity the rate of change of displacement is constant.
* In variable velocity the rate of change of displacement is Not constant.
* Rate of change of velocity is called Acceleration.
* S.I unit of velocity is "ms^{-1}" whereas Acceleration is "ms^{-2}".

Ans(3.2) As force of Gravity is acting always downward, so acceleration due to gravity "g" is also vertically downward.

When an object is thrown vertically upward, the sign of acceleration due to gravity is taken as negative.



Ans(3.3) Yes, when the body is thrown vertically upward at the highest point, the direction of velocity is reversed but the Magnitude of its acceleration remains $9.8\ ms^{-2}$, which is constant.

Ans(3.5) Both the Balls will reach the Ground with the same speed because Ist ball is thrown downward with velocity "v_i", while 2nd ball will attain the same velocity "v_i" when it reaches the same height while coming downward. Therefore both strike the ground with the same speed.

Ans:- (3.6) (i) When velocity of car is increasing.
(ii):- When the velocity of car is decreasing.
(iii):- When a body is moving in circular path.
(iv):- When breakes are applied, the car slows down and just comes to rest.
(v):- When car is moving with uniform velocity.

Ans:- (3.7) When a body is moving with constant "v" it will have zero acceleration. Since zero is constant. Therefore motion with constant velocity is special case of motion with constant acceleration.

Ans:- (3.8) Let a body of mass "m" is moving with velocity "V_i". A force "F" acts on it for time "t" and its velocity becomes V_f.
Then;

$$F = ma.$$

$$F = \frac{m(V_f - V_i)}{t}$$

$$F = \frac{mV_f - mV_i}{t}$$

$$F = \frac{\Delta P}{t}.$$

Hence, IInd law of motion can be stated as "Time rate of change in momentum is equal to the applied force."

Ans (3.9):- The force applied on a body in very short interval of time. is called Impulse.

$$\text{Impulse} = F \times t.$$

Relation:- According to IInd law of motion in term of momentum.

$$F \times t = mV_f - mV_i$$

$$\text{Impulse} = mV_f - mV_i$$

Ans:- (3.10) Statement:-

The total linear Momentum of an isolated system Remains constant.

Importance:-

In isolated system there is no external forces is applied on a body.

usefulness of law if system is not Isolated:-

If system is not completely isolated but the external forces are very Small as compared to the mutually interacting force within the system. the law can be hold.

Ans:- (3.11) The collision in which K.E is conserved. called Elastic Collision.

The collision in which K.E is not conserved is called Inelastic collision.

★ In Elastic collision If you drop a heavy ball on the hard floor, after collision it rebounds almost to origional height. It means K.E conserved.

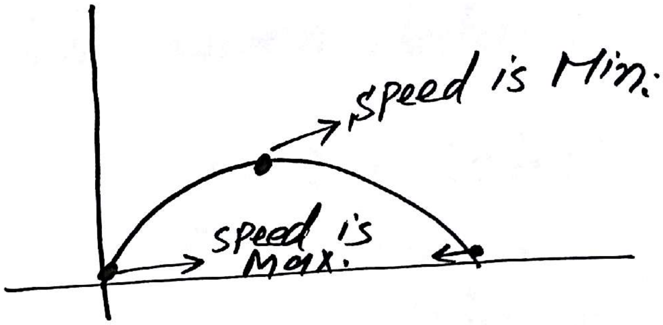
★ In an Inelastic collision, the ball can never gain its origional height because a part of its K.E is converted into sound and heat Energy.

Ans (3.12):-

See the Text Book.

Ans:-(3.13) The speed of projectile is maximum at the point of projection and again when it just hits the ground at the same level.

The speed is minimum at the highest point where y-components of velocity becomes zero.



Motion & force

PHYSICS → UNIT : 3

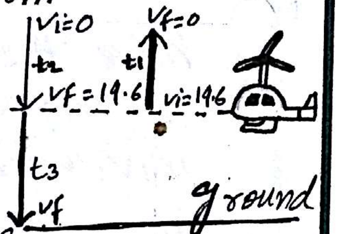
Numericals:

3.1 Given data:

$S = 156.8m$

$v = 19.$

$t = ?$



Solution:

By formula,

$t = t_1 + t_2 + t_3 = ?$

t_1 can be found by

*Case – I :- when stone moving upward :-

$v_f = v_1 + gt_1$

$0 = 19.6 + (-9.8)t_1$

$\therefore t_1 = \frac{-19.6}{-9.8} = 2 sec.$

*Case – II :- and t_2 as:-

$V_f = v_1 + gt_2$

$19.6 = 0 + gt_2$

$19.6 = 9.8t_2$

$\therefore t = 2 sec.$

*Case – III :- and t_3 as:-

$S = vit_3 + \frac{1}{2}gt_3^2$

$156.8 = 19.6t_3 + 4.9t_3^2$

$156.8 = 4.9(4t + t_3^2)$

$\frac{156.8}{4.9} = 4t + t^2$

$32 = 4t_3 + t_3^2$

$t_3^2 + 4t_3 - 32 = 0$

$t_3^2 + 8t_3 - 4t_3 - 32 = 0$

$(t_3 + 8)(t_3 - 4) = 0$

So; $t_3 = -8$ and $t_3 = 4 sec.$

here (-ive) value is neglected then:-

$t = t_1 + t_2 + t_3$

$t = 2 + 2 + 4$

$\therefore t = 8s$

3.3 Given data:

$vi = 1.0 \times 10^{7} ms^{-1}$

$S = 0.02cm \rightarrow \frac{0.02}{100} m$

$= 0.02 \times 10^{-2} m.$

$v_f = 2.0 \times 10^6 ms^{-1}.$

(a)- $a = ?$ (retardation)

(b)- $t = ?$

Solution:

(a)- Using IIIrd equation of motion, we get:-

$v_f^2 - vi^2 = 2aS.$

$(2.0 \times 10^6)^2 - (1.0 \times 10^7) = 2a \times 0.02 \times 10^{-2}.$

or $4.0 \times 10^{12} - 1.0 \times 10^{14} = 0.04 \times 10^{-2} a$

or $10^{12}(4 - 10^2) = 0.04 \times 10^{-2} a.$

or $10^{12}(4 - 100) = 0.04 \times 10^{-2} a.$

or $a = -2.4 \times 10^{17} ms^{-2}.$

(b)- We can find time by using Ist equation of motion:

$v_f = vi + at.$

$2.0 \times 10^6 = 1.0 \times 10^7 - 2.4 \times 10^{17} \times t$

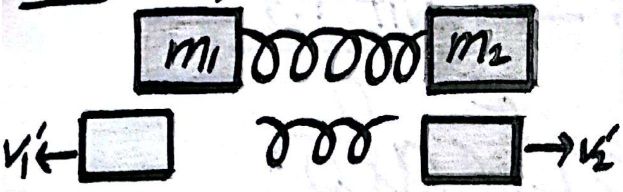
or $2.4 \times 10^{17} \times t = 1.0 \times 10^7 - 2.0 \times 10^6$

or $2.4 \times 10^{17} \times t = 10^6(10 - 2) = 10^6 \times 8$

or $t = \frac{8 \times 10^6}{2.4 \times 10^{17}}$

$\therefore t = 3.33 \times 10^{-11} s$

3.4 Given data:-



First mass $= m_1$

Second mass $= m_2$

→ Initial velocity of $m_1 = v_1 = 0$

and that of $m_2 = v_2 = 0$

→ Final velocity of $m_1 = v_1'$

and that of $m_2 = v_2'$

To find:

$v_1'/v_2' = ?$

Solution:

We know,

$$m_1v_1 + m_2v_1 = m_1v_1' + m_2v_2'$$

∵ initial velocities are '0' due to being at rest then;

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

$$0 = m_1v_1' + m_2v_2'$$

or $0 = (m_1v_1') + (-m_2v')$

(Because of being released, signs are opposed)

then;

$$m_1v_1' = m_2v_2'$$

or $\dfrac{v_1'}{v_2'} = \dfrac{m_2}{m_1}$.

3.6 Given data:-

$m_1 = 40g = \frac{40}{1000} kg = 0.04kg$

$m_2 = 200g = \frac{200}{1000} kg = 0.2kg$

$v_2' = 3ms^{-1}$

$v_1' = ?$

Solution:

Here we have the law of conservation of momentum as:

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'.$$

or $0 = m_1v_1' + m_2v_2'$.

R.H.S becomes zero, as both the masses are initially at rest i.e; $v_1 = 0$ and $v_2 = 0$.

then:

$$m_1v_1' = -m_2v_2'.$$

or $v_1' = \dfrac{-m_2v_2'}{m_1}$

putting the values, we have

$$v_1' = -\frac{0.2 \times 3}{0.04} = -15ms^{-1}$$

∴ $v_1' = 15ms^{-1}$. ∵ -ve sign shows Reverse Direction.

3.7 Given data:-

$m_1 = 9.1 \times 10^{-31} kg$.

$v_1 = 2.0 \times 10^{7} ms^{-1}$.

$m_2 = 1.67 \times 10^{-27} kg$.

$v_2 = 0$.

Solution: $v_2' = ?$

By using the formula;

$$v_2' = \frac{2m_1v_1}{m_1+m_2} + \frac{m_2-m_1}{m_1+m_2} v_2$$

Here $v_2 = 0$, then the equation becomes:

$$v_2' = \frac{2m_1v_1}{m_1+m_2}$$

or $$v_2' = \frac{2\times 9.1\times10^{-31}\times2.0\times10^{7}}{9.1\times10^{-31}+1.67\times10^{-27}}$$

$$= \frac{36.4\times10^{-24}}{(9.1\times10^{-4}+1.67)10^{-27}}$$

$$= \frac{36\times10^{-24}}{1.67091\times10^{-27}}$$

$$= 21.78\times10^{3}$$

$$= 2.178\times10^{4}$$

$$\therefore\ v_2' = 2.18\times10^{4}ms^{-1}.$$

3.8 Given data:

$m_1 = 25000kg$

$v_1 = 21ms^{-1}$

$m_2 = 1000kg$

$v_2 = 0$

$v_1' = v_2' = v = ?$

Solution:

By formula;

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

Here;

$L.H.S = m_1v_1 + m_2v_2$

$= (2500\times10) + (1000\times0)$

$= 52500\ kgms^{-1}.$

And;

$R.H.S = m_1v_1' + m_2v_2'$

$= (2500+1000)v$

$= (3500kg)v.$

$\because v_1' = v_2' = v.$

Equitting both sides, we have:-

$52500kgms^{-1} = 3500kg\,v$

or $$v = \frac{52500kgms^{-1}}{3500\ kg}$$

$\therefore\ v = 15ms^{-1}$. Ans.

3.9 Given data:

$m_1 = 2.0kg$

$m_2 = 0.5\ kg$

$P.E. = 10\ J$

$v_1' = ?$

$v_2' = ?$

Solution:

By formula;

Loss in P.E = Gain in K.E

We can say that total P.E is converted into K.E. So

$$10J = \frac{1}{2}m_1v_1'^2 + \frac{1}{2}m_2v_2'^2.$$

$$10 = \frac{1}{2}(2)v_1'^2 + \frac{1}{2}(0.5)v_2'^2.$$

$$= \frac{2v_1^2 + 0.5v_2^2}{2}$$

$$10(2) = 2v_1'^2 + 0.5v_2'^2 \text{ — (a)}$$

$$20 = 2v_1'^2 + 0.5v_2'^2.$$

Here the initial velocities v_1 and v_2 are zero then by law of conservation of momentum, we have:-

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

or $0 = 2v_1' + 0.5v_2'.$

or $-2v_1' = 0.5v_2'.$

or $$v_2' = \frac{-2v_1'}{0.5}$$

or $v_2' = -4v_1'$ — (g)

putting the value of v_2' in eq-(a), we have:-

$2v_1'^2 + 0.5(16v_1'^2) = 20$

$2v_1'^2 + 8v_1'^2 = 20$

$10v_1'^2 = 20$

$v_1'^2 = 2$

Taking square root on both sides:-

$\sqrt{v_1'^2} = \sqrt{2}$

$v_1' = \sqrt{2}$

$\therefore\ v_1' = 1.41 ms^{-1}$

putting the value of v_1 in eq — ⑨, we have

$v_2' = -4 \times 1.41$

$\therefore\ v_2' = -5.64 ms^{-1}$. Ans.

3.10 **Given data:**

$\theta = 30°$

$R = 40m$

$g = 9.8 ms^{-2}$

$v_i = ?$

Solution:

By formula, we have:

$$R = \frac{v_i^2 \sin 2\theta}{g}$$

putting the values in above equation:

$$40 = \frac{v_i^2 \sin(2\times30)}{9.8}$$

$$40 = \frac{v_i^2 \sin 60}{9.8}$$

$$v_i^2 = \frac{40 \times 9.8}{\sin 60}$$

$$v_i^2 = \frac{392}{0.866}$$

Taking square root on both sides, we have:

$$\sqrt{v_i^2} = \sqrt{\frac{392}{0.866}}$$

or $v_i = 21.27 ms^{-1}$

$\therefore\ v_i = 21.3 ms^{-1}$.

3.11 **Given data:**

$v_{ix} = 21 ms^{-1}$

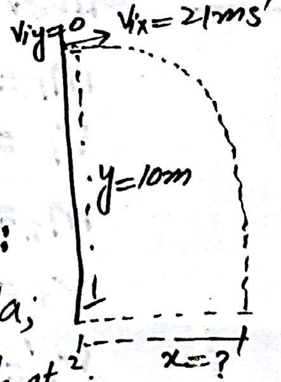
$v_{iy} = 0 ms^{-1}$

(height) $y = 10\,m$ → vertical distance

$g = 9.8 ms^{-2}$

(horizontal distance) $x = ?$

(to hit the ground) $v = ?$



Solution:

(a)- By formula;

$$y = v_{iy}t + \frac{1}{2}gt^2$$

putting the values, we have:

$$10 = 0 + \frac{1}{2} \times 9.8t^2 = 4.9t^2$$

or $t^2 = \frac{10}{4.9}$ — Taking square root

$$\sqrt{t^2} = \sqrt{\frac{10}{4.9}}$$

$\therefore\ t = 1.41 s$.

Now to find horizontal distance, we use

$x = v_{ix} \times t$.

putting the values, we get:-

$x = 21 \times 1.42$

$= 30m$

(b)- By formula;

$v_{fy} = v_{iy} + gt$.

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putting the values:

$$v_{fy} = 0 + 9.8 \times 1.42$$
$$= 13.9 ms^{-1}.$$
$$\therefore v_{fy} = 14 ms^{-1} \text{(approx)}$$

Here, having all the values velocity to hit the ground (v) can be found by:-

$$v = \sqrt{v_{fx}^2 + v_{fy}^2}$$

where $v_{fx} = v_{ix} = 21 ms^{-1}$

$$So, v = \sqrt{(21)^2 + (14)^2}$$
$$or\ v = \sqrt{637}$$
$$\therefore v = 25 ms^{-1}.$$

3.12 **Given data:**

(Horizontal 'v' of bomber = 'v' of bomb)

$$\underset{(bomb)}{v_{ix}} = 300\ kmh^{-1}$$
$$= \frac{300 \times 1000}{3600}$$
$$= 83.3 ms^{-1}.$$
$$\underset{(bomb)}{v_{iy}} = 0$$
$$\underset{(height)}{y} = 490 m.$$
$$g = 9.8 ms^{-2}.$$

(b)- $t = ?$

(a)- [$x = ?$
Did the bomb hit the ground =?

Solution:

$$y = v_{iy}t + \frac{1}{2}gt^2.$$
$$490 = 0t + \frac{1}{2}(9.8)t^2.$$
$$490 = 4.9t^2.$$
$$or\ t^2 = \frac{490}{4.9}$$

Taking squares, we have

$$\sqrt{t^2} = \sqrt{\frac{490}{4.9}}$$
$$or\ t = 10 s.$$

(a)- To find 'x' we have:-

(i)- $x = v_{ix} \times t$.

$$or\ x = 83.3 \times 10$$
$$\therefore x = 833 m.$$

(ii)- **Yes! the bomb will hit the ground.**

3.13 **Given data:**

max height (h) = horizontal R.

$$\theta = ?$$
$$h = \frac{v_i^2 \sin^2\theta}{2g}$$
$$R = \frac{v_i^2 \sin 2\theta}{g}$$

Solution:

$$h = R$$

putting the values:-

$$\frac{\cancel{v_i^2}\sin^2\theta}{2\cancel{g}} = \frac{\cancel{v_i^2}\sin 2\theta}{\cancel{g}}$$
$$or\ \frac{\sin^2\theta}{2} = \sin 2\theta.$$
$$or\ \frac{\sin^2\theta}{2} = 2\cancel{\sin\theta}\cos\theta$$
$$or\ \frac{\sin\theta}{\cos\theta} = 4.$$
$$\therefore \tan\theta = 4$$
$$or\ \theta = \tan^{-1}(4)$$
$$= 76°.$$

3.14 Given data:

$\theta = 45°$
(for max range)

→ (if we subtract and add a same amount of 5° it falls and exceeds a short of 45° by angles of projection 40° and 50°

$R = ?$
(in both cases)

Solution:

Using the formula:-

$$R = \frac{v_i^2 \sin 2\theta}{g}$$

(i)- for $\theta = 50°$

$$R_1 = \frac{v_i^2 \sin(2\times 50)}{g}$$

$$= \frac{v_i^2 \sin 100}{g}$$

$$\therefore \quad R_1 = \frac{v_i^2 0.984}{g}$$

(ii)- For $\theta = 40°$

$$R_2 = \frac{v_i^2 \sin(2\times 40)}{g}$$

$$= \frac{v_i^2 \sin 80}{g}$$

$$\therefore \quad R_2 = \frac{v_i^2 0.984}{g}$$

Hence proved

$$R_1 = R_2$$

3.15 Given data:

$R = 3000\,km = 3\times10^6\,m$

$\theta = 45°.$

(a)- $v_i = ?$

(b)- $t = ?$

Solution:

By formula, we have:-

(a) $$R = \frac{v_i^2 \sin 2\theta}{g}.$$

or $$v_i^2 = \frac{Rg}{\sin 2\theta}$$

putting the values, we have:-

$$v_i^2 = \frac{3000\times1000\times9.8}{\sin(2\times45)}$$

$$= \frac{3000\times1000\times9.8}{\sin 90}$$

or $$v_i^2 = 3000000\times9.8$$

Taking square root:-

$$\sqrt{v_i^2} = \sqrt{3000000\times9.8}$$

$$v_i = 5422.17\,ms^{-1}$$

$$\therefore\ v_i = 5.42\,kms^{-1}.$$

(b)- $$t = \frac{2v_i \sin\theta}{g}$$

putting the values, we have:-

$$t = \frac{2\times5.42\times10^3\times\sin45}{9.8}$$

$$t = \frac{7663.8}{9.8}$$

" $t = 782\,s$ "

or $$t = \frac{782}{60} = 13\,mins$$

$$\therefore\ t = 13\,mins.$$