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RANK	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Avg %	2021 (M. Marks 360) Marks	Rank	2021 (M. Marks 360) Marks	Rank
1	85.48	91.67	96.01	92.22	92.78	93.06	86.02	92.62	93.61	93.01	88.89	91.40	348	1	196	1544
10	81.39	85.42	88.48	85.83	86.94	83.92	78.49	86.88	86.11	82.80	81.06	84.99	324	8	185	2043
100	70.76	79.79	78.68	76.39	77.50	69.84	68.61	83.33	74.72	72.85	71.72	74.93	323	13	178	2395
500	62.17	72.08	69.36	66.67	68.61	60.32	54.57	77.32	64.44	61.02	59.34	65.08	313	25	160	3542
1000	57.87	68.13	64.46	61.67	63.33	56.75	49.46	72.95	58.59	55.65	53.28	60.22	310	27	154	4137
2000	52.97	62.50	58.33	55.56	57.22	49.21	43.55	67.48	53.06	50.00	46.46	54.21	302	46	145	5005
3000	49.69	59.17	54.41	51.94	53.61	45.44	42.74	63.38	49.17	46.77	42.42	50.79	297	66	135	6180
4000	47.03	56.67	51.72	49.17	51.11	42.66	37.90	60.38	46.39	44.09	39.39	47.86	296	70	131	6750
5000	44.99	54.38	49.51	47.22	48.89	40.48	36.02	57.65	43.89	41.94	37.12	45.64	286	94	126	7516
6000	43.35	52.17	47.55	45.56	47.22	38.69	34.41	55.45	41.94	40.32	35.10	43.85	266	201	121	8494
7000	41.92	51.04	45.83	43.89	45.56	37.10	33.33	53.55	40.28	38.71	33.59	42.25	254	299	109	10848
8000	40.49	49.79	43.38	42.50	44.44	35.91	31.99	51.63	38.61	37.63	32.32	40.79	245	395	102	12874
9000	39.47	48.54	43.14	41.11	43.06	34.52	30.91	50.27	37.22	36.29	30.81	39.58	239	471	100	13215
10000	38.85	47.71	41.91	40.00	41.94	33.33	29.84	48.90	36.11	35.22	29.80	38.51	231	600	85	18547
QUAL%	38.85	47.71	34.55	33.88	35.00	23.81	20.16	22.50	25.00	25.00	17.42	29.44	212	1006	79	21157

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Chapter 1

Kinematics

Remember

Before beginning this chapter, you should be able to:

- Learn the importance of classifying motion into different groups
- Define the scalar and vector quantities and to classify the different quantities into scalar and vectors
- Understand the terms and to determine the equations of motions relating to these terms

Key Ideas

After completing this chapter you should be able to:

- Understand the different physical quantities and different systems of units
- Recognize the importance of accuracy of measurements and to understand how vernier callipers is used to measure the length more accurately
- Study the methods of determining physical quantities like area, volume, mass and density
- Find the relation between various physical quantities

INTRODUCTION

One can study the motion of a body in a given time interval if its initial velocity, final velocity, acceleration, and displacement are known.

The relation between $\vec{v}$, $\vec{u}$, $\vec{a}$, t and $\vec{s}$ for a body moving with uniform acceleration in a straight path are well known to us. Equations which relate these quantities are known as equations of motion.

The equations of motion are:

1. $v = u + at$
2. $s = ut + ½ at^2$
3. $v^2 = u^2 + 2as$
4. $s_n = u + a\,(n - 1/2)$

Do the above equations hold good for a body which is dropped from a height, or projected vertically upwards?

Answer to the above can be found out by the example given below.

Example: Drop two stones, of masses 1 kg and 5 kg, respectively simultaneously, from the same height. Note the time taken by the two stones to reach the ground. Which stone reaches the ground first? We observe that both the stones reach the ground in approximately the same time.

The above fact was proved experimentally by Galileo. He dropped a heavy iron ball and a light wooden ball simultaneously from the leaning tower of Pisa. Both the balls reached the ground at the same time though their masses were different.

Further experiments proved that wherever air resistance is negligible, all bodies, irrespective of their masses would take the same time to reach the ground when dropped from the same height. In fact, a body dropped from a height would accelerate as it travels downwards, i.e., its velocity increases as it moves down. On the other hand, the velocity of a body projected vertically upwards would decrease as it moves up. Since this acceleration is due to the gravitational force exerted by the earth, it is generally referred to as 'acceleration due to gravity' and is denoted by the letter '*g*'.

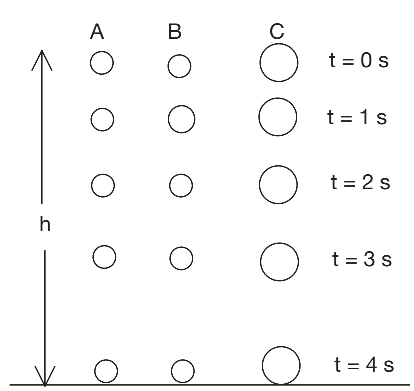


FIGURE 1.1 Objects A, B and C dropped from a height 'h'

The value of this '*g*' at mean sea level is approximately 9.8 m s^{-2} or 10m s^{-2}.

For obvious reasons, the acceleration due to gravity acts downwards and would take a '+' sign or '–' sign depending on the sign convention chosen. And as a body moves along a straight line path either when dropped from a height or when projected vertically up, the same equations of motion may be used in both the cases by taking appropriate signs for 'g'. Thus, the equations of motion for a body moving vertically under the influence of gravity are

1. $v = u \pm gt$
2. $s = ut \pm \frac{1}{2} gt^2$
3. $v^2 = u^2 \pm 2gs$
4. $s_n = u \pm g(n - \frac{1}{2})$

The value of 'g' at mean sea level is taken as 9.8 m s^{-2} or 10 m s^{-2} approximatly.

FREELY FALLING BODY

When an apple drops from a tree, the initial velocity of the apple is zero due to inertia of rest. The apple moves towards the earth under the influence of gravity. Though the motion is opposed by friction of air, the resistance of air may be considered negligible in comparison to the weight of the body. Such a motion which takes place under the influence of only gravity is called free-fall.

Equations of Motion for a Freely Falling Body

Let us consider a special case of a freely falling body released from rest (i.e., dropped) which means the initial velocity 'u' is equal to zero. The body moves towards the earth due to the gravitational force of the earth.

Considering the downward direction as positive (you can also take it as negative) the equations of motion of a freely falling body, dropped from a height 'h' from the ground, are obtained by substituting zero for u, h for s, and g for a in the equations of motion. Then, we get

1. $v = gt$
2. $h = \frac{1}{2} gt^2$
3. $v^2 = 2gh$
4. $s_n = g\,(n - \frac{1}{2})$

Equations of Motion for a Body Thrown Vertically Upwards

Let a ball be thrown vertically upwards. What do we observe?

The following facts are observed:

1. The impulsive force given to the ball provides an initial velocity to the ball for it to move upwards.
2. The ball reaches a certain maximum height where it stops (i.e., $v = 0$) and then returns to the ground.

Conclusions

1. It is impossible for a body to move away from the earth on its own due to the earth's gravitational pull. Hence, an initial velocity should be given to the body.
2. At low speeds, a body cannot keep going up indefinitely but will return to the ground after reaching a certain height.

Here, the acceleration due to gravity acts in a direction opposite to the direction of initial velocity.

Considering the upward direction as positive, the equations of motion for a body projected vertically upwards are obtained by substituting h for s and $-g$ for a as follows.

1. $v = u - gt$
2. $h = ut - \frac{1}{2} gt^2$
3. $v^2 = u^2 - 2gh$
4. $s_n = u - g\,(n - {}^1/_2)$

EXAMPLE

A ball is dropped from the top of a building 19.6 m high. Find the time taken by the ball to reach the ground.

SOLUTION

This is a case of a freely falling body. Since the ball is dropped, its initial velocity is zero. Thus, we have

$u = 0$

$s = 19.6$ m

$a = + g = + 9.8 \text{ m s}^{-2}$ ('+' sign since the body is moving downwards).

Using the second equation of motion, $s = ut + \frac{1}{2} at^2$

$$19.6 \text{ m} = 0 + \frac{1}{2} \times (9.8 \text{ m s}^{-2}) \times (t)^2$$

$$t^2 = \frac{19.6 \times 2}{98} = 4$$

$$\therefore\ t = 2 \text{ s}.$$

EXAMPLE

A Diwali rocket, when ignited at the ground level, rises vertically upwards to the level of a window 10 m from the ground. Find the magnitude of velocity of the rocket at the time of its take off.

SOLUTION

Since the body is moving up, the acceleration due to gravity 'g' is taken with a '–' sign in the equations of motion. The body rises up to a height of 10 m, i.e., its velocity at this height is zero, substituting these values in the 3rd equation of motion, $v^2 = u^2 + 2as$, we get

$$0 = u^2 - 2(9.8 \text{ m s}^{-2})\ (10 \text{ m})$$

$$\therefore\ u^2 = 196$$

$$u = 14 \text{ m s}^{-1}$$

EXAMPLE

A stone is released from a hot-air balloon which is rising steadily with a velocity of 4 m s^{-1}. Find the velocity of the stone at the end of 3 s after it is released.

SOLUTION

Let the downward direction be positive. As the stone was moving with the balloon, the initial velocity of the stone is the same as that of the balloon, i.e., 4m s^{-1} upwards directions. Thus, we have

($\because$ Intial velocity of the stone is opposite to displacement of stone)

$$u = -\ 4 \text{ m s}^{-1}$$

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

$$t = 3 \text{ s}$$

Considering the first equation of motion,

$v = u + at$, and substituting the values of u, a and t

$$v = -4 + 9.8 \times 3$$

$$v = -4 + 29.4$$

$$v = 25.4 \text{ m s}^{-1}$$

EXAMPLE

A stone is dropped by a person from the top of a building, which is 200 m tall. At the same time, another stone is thrown upwards, with a velocity of 50 m s.$^{-1}$ by a person standing at the foot of the building. Find the time after which the two stones meet.

SOLUTION

Let the two stones meet at a distance of x m from the top of the building, and 't' be the time taken.

Let us assume the downward direction as positive,

For the stone, that is dropped, its initial velocity u = 0 m s^{-1}; displacement s = x and acceleration = acceleration due to gravity (g).

Using $s = ut + \frac{1}{2}at^2$, a $x = (0)\ t + \frac{1}{2}gt^2$ (1)

For the stone that is projected vertically upwards, its initial velocity, $u = -50$ m s^{-1}; displacement $s = -(200 - x)$ and acceleration $a = g$. Using $s = ut + \frac{1}{2}at^2$,

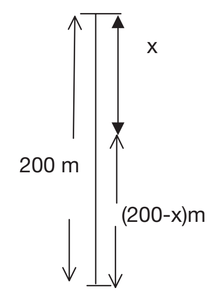


FIGURE 1.2 A 200 m tall building

we get

$$-(200 - x) = -50 \times t + ½\ gt^2$$

$$200 = 50\ t - ½\ gt^2 + x \qquad (2)$$

From the equations (1) and (2), we have

$$200 = 50t - ½\ gt^2 + ½\ gt^2$$

$$200 = 50t$$

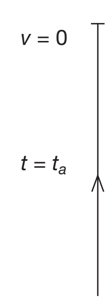
$$\therefore t = 4\ \text{s}$$

Maximum Height Reached by a Body Projected Vertically Upwards

Consider two balls A and B, and let A be thrown upwards with a higher initial velocity than B. Observe which reaches greater height. Ball A reaches a greater height than ball B.

Thus, the maximum height reached by a body depends on its initial velocity and is independent of its mass.

When a body is thrown upwards, the velocity of the body decreases continuously and finally becomes zero at a certain height. This height where the final velocity of the body is zero is called the maximum height. (denoted by h_{max} or H).



At the maximum height, $v = 0$

$\therefore$ From $v^2 = u^2 - 2gh$, we get

$$0 = u^2 - 2g\, h_{\max}$$

$$\Rightarrow h_{\max} \text{ or } H = \frac{u^2}{2g}$$

Here, $h_{\max}$ refers to the maximum height attained by the body thrown vertically upwards. From this expression it is evident that the maximum height depends on the velocity of projection.

Time of Ascent (t_a)

It is the time taken by a body, projected vertically upwards, to reach the maximum height.

At maximum height, the final velocity of the body $v = 0$.

From the equation,

$$v = u + at, \text{ we get}$$

$$\Rightarrow 0 = u - gt_a$$

$$\Rightarrow t_a = \frac{u}{g}$$

Thus, the time of ascent of a body, projected vertically upwards, depends on the velocity of projection. Hence, greater the initial velocity, greater will be the maximum height attained by a body and its time of ascent.

Time of Descent (t_d)

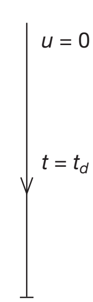
It is the time taken by a body, projected vertically upwards, to return to/come back the point of projection from its position of maximum height.

Let t_d be the time of descent of a body projected vertically upwards. Let 'u' be the velocity of projection of the body and $h_{\max}$ be its maximum height. In the return journey of the body from its position of maximum height, its initial velocity is zero. Hence, using

$$s = ut + \frac{u}{g} at^2,$$

we get

$$h_{\max} = 0 + ½\, g\, t_d^2 \Rightarrow t_d = \sqrt{\frac{h_{\max} \times 2}{g}}$$



$$\text{As } h_{\max} = \frac{u^2}{2g},$$

we get

$$t_d = \sqrt{\frac{u^2}{2g} \times \frac{2}{g}} \Rightarrow t_d = \sqrt{\frac{u_2}{g_2}} \Rightarrow t_d = \frac{u}{g}$$

Thus, we find that the time of ascent is always equal to the time of descent.

Time of Flight (*T*)

It is the total time taken by a body projected vertically upwards to reach the position of maximum height and then return to the point of projection. It is denoted by *T*. It is the total time for which the body remains in the air, and is equal to the sum of the time of ascent and the time of descent.

Time of flight = $t_a + t_d$

$$\Rightarrow \mathrm{T} = u/g + u/g \Rightarrow T = \frac{2u}{g}$$

Velocity on Reaching the Ground

For a freely falling body dropped from certain height '*h*', the initial velocity is zero.

From $v^2 = u^2 + 2as$, substituting $u = 0$, $a = g$ and s = h, we get

$$v^2 = 2gh$$

$$\therefore v = \sqrt{2gh} \tag{1.1}$$

Here, v is the final velocity on reaching the ground and h is the height from which the body is dropped. When a body is projected vertically upwards with initial velocity u, then at the maximum height, $v = 0$

$$0 = u^2 - 2gh \text{ (From the equation } v^2 = u^2 + 2as)$$

$$u^2 = 2gh$$

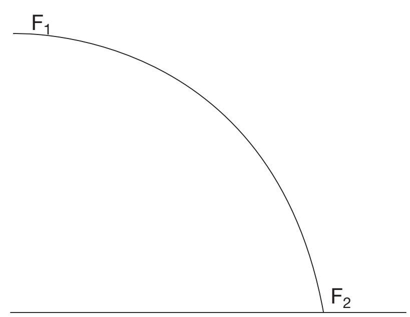
$$u = \sqrt{2gh} \tag{1.2}$$

From equations (1.1) and (1.2) it is seen that on reaching the ground, the velocity of the body dropped from a certain height is equal to the velocity with which it is projected vertically upwards.

TWO-DIMENSIONAL MOTION

EXAMPLE

An aeroplane is flying horizontally at a height of 500 m with a velocity of 72 km h^{-1} over a flood affected area. Food packets are to be dropped for the people standing at a particular place on the ground. At what horizontal distance from that place should the food packets be released from the plane, so as to reach the intended place?



SOLUTION

When a food packet is released from an aeroplane moving horizontally, due to inertia the food packets would have an initial velocity equal the velocity of the plane, i.e., 72 km h^{-1} in the horizontal direction, while the initial velocity in the vertical direction would be zero. Thus, the motion of the body is in two dimensions – vertical, under the influence of gravity (acceleration = $+g$ m s^{-2}) and horizontal due to its initial velocity as shown in figure.

Furthermore, let us neglect the effects of wind and air drag. Considering the vertical motion alone, the time taken by a packet to reach the ground is, time of descent,

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 500}{10}} = \sqrt{100} = 10 \text{ s}$$

Simultaneously, the packet is also moving horizontally. Packet travels with uniform velocity

$u = 72$ km h^{-1} = $72 \times \frac{5}{18}$ m s^{-1} = 20 m s^{-1}, in the horizontal direction is not any force acting in the horizontal direction.

Let x be the horizontal distance travelled by the packet in the time of descent.

Using $s = ut + \frac{1}{2}at^2$ in the horizontal direction, $\because a = 0$, we get $x = (20 \text{ m s}^{-1}) \times (10 \text{ s})$ = 200 m. ($\therefore a_n = 0$)

Thus, the food packets should be dropped from the plane at a horizontal distance of 200 m from the intended place for the people to be able to receive them.

SIGN CONVENTION

While solving numerical questions, it would be convenient to adopt one single sign convention rather than remembering two sets of equations of motion for bodies moving along a vertical path under the influence of gravity, whether freely falling bodies or those projected vertically upwards.

According to this sign convention, displacement velocity and acceleration, being vector quantities are taken as positive quantities when directed upwards and as negative quantities when directed downwards.

According to this sign convention, displacement, velocity and acceleration, being vector quantities, are taken as positive quantities when directed upwards and as negative quantities when directed downwards.

Quantity	Body projected downwards (Freefall)	Body projected upwards
Initial velocity	$-u$	$+u$
Final velocity	$-v$	$+v$
Acceleration	$-g$	$-g$
Displacement	$-h$	$+h$
$V = u + at$	$-v = -u - gt$ $\Rightarrow v = u + gt$	$V = u - \text{gt}$

Quantity	Body projected downwards (Freefall)	Body projected upwards
$V^2 - u^2 = 2as$	$v^2 - u^2 = 2(-g)(-h)$ $\Rightarrow v^2 - u^2 = 2gh$	$v^2 - u^2 = 2(-g)(+h)$ $\Rightarrow v^2 - u^2 = -2gh$
$s = ut + 1/2at^2$	$-h = -ut - 1/2gt^2$ $\Rightarrow h = ut + 1/2gt^2$	$+h = ut + 1/2(-g)(t^2)$ $\Rightarrow h = ut - 1/2gt^2$
$S_n = u + a/2\,(2n - 1)$	$-Hn = -u + (-g)/2\,(2n - 1)$ $\Rightarrow Hn = u + g/2\,(2n - 1)$	$+Hn = u + (-g)/2\,(2n - 1)$ $\Rightarrow Hn = u - g/2\,(2n - 1)$

EXAMPLE

A body at rest falls from a height and covers 34.3 m in the last second of its fall. Find the height from which the body is dropped.

SOLUTION

Let the body take 'n' seconds to reach the ground. Thus, nth second is its last second of fall. Initial velocity of the body, $u = 0$ m s^{-1}. The distance covered by the body in its nth second $s_n = 34.3$ m. Using $s_n = u + g\,(n - ½)$, we get $34.3 = 0 + 9.8\left(n - \frac{1}{2}\right) \Rightarrow n = 4$

Thus, the duration of the fall for the body is $t = 4$ seconds.

$\therefore$ The height from which the body is dropped, $h = \frac{1}{2}gt^2 = \frac{1}{2}(9.8)(4)^2 = 78.4$ m.

EXAMPLE

A stone is dropped from the top of a tower and it reaches the ground in 8 s. How much time will it take to cover the first quarter of the distance from the top?

SOLUTION

Let the height from which the stone is dropped be x. Since the stone is dropped its initial velocity, $u = 0$ m s^{-1}, $s = -x$, $a = -g$

Time of descent of the stone, $t = 8$ s

$\therefore$ From the equation $s = ut + \frac{1}{2}at^2$, we have

$$x = ½\,g \times 8^2$$

$$x = 32\,g \qquad (1)$$

Let t_1 be the time taken to cover first quarter of the distance

$\therefore \frac{1}{2} = ½\, gt_1^2$

$\therefore x/4 = ½\, gt_1^2$

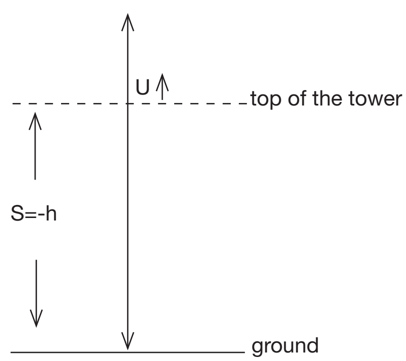
$\Rightarrow \frac{32g}{4} = ½\, gt_1^2$

$\Rightarrow t_1^2 = 16$

$\Rightarrow t_1 = 4$ s

EXAMPLE

A ball is thrown vertically upwards from the top of a tower with a velocity 10 m s^{-1}. The ball reaches the ground with a velocity of 30 m s^{-1}. What is the height of the tower? (Take g = 10 m s^{-2})



SOLUTION

According to the sign convention, taking the vectors in the upward direction as positive

Initial velocity, $u = +10$ m s^{-1}

Final velocity, $v = -30$ m s^{-1}

Displacement, s = $-h$, where h is the height of the tower and acceleration, $a = -10$ m s^{-2}.

Using $v^2 = u^2 + 2as$,

we get

$$(-30)^2 = (10)^2 + 2\,(-10)\,(-h)$$

$$\therefore\ h = \frac{(-30)^2 - 10^2}{2 \times 10} = \frac{900 - 100}{20} = 40\text{m}$$

TEST YOUR CONCEPTS

Very Short Answer Type Questions

1. Motion of an aeroplane is an example of __________ dimensional motion.
2. Define maximum height.
3. A particle is projected up with a velocity of $\sqrt{29}$ m s^{-1} from the top of a tower of height 10 m. Its velocity on reaching the ground is __________m s^{-1}
4. In a velocity time graph, the negative slope indicates __________.
5. Define time of ascent and time of descent.
6. A body is falling freely under gravity. The distances covered by it in the first, second and third seconds of its motion are in the ratio of __________.
7. The equations of motion are applicable only when the body moves with __________.
8. A hollow iron ball and a solid iron ball are dropped from the same height. Which ball reaches the ground first?
9. Show that for a body, the magnitude of velocity of projection in the upward direction is the same as the magnitude of velocity of the body on reaching the point of projection in its downward motion.
10. The sum of the time of ascent and the time of descent is called __________.
11. What is acceleration due to gravity?
12. A stone is dropped from the top of tower and it reaches the ground after 3 s. Then the height of that tower is __________ $g = 10$ m s^{-2}.
13. Two balls are dropped from heights h_1 and h_2, respectively. The ratio of their velocities on reaching the ground is __________.
14. What is the acceleration of a body when it is projected vertically upwards?
15. Two bodies of different masses m_1 and m_2 are dropped from two different heights h_1 and h_2. The ratio of the times taken by the two to reach the ground is __________.
16. If an object is thrown vertically up with a velocity of 19.6 m s^{-1}, it strikes the ground after _________s.
17. Write the equations of motion for a body projected vertically downwards.
18. If a body is projected horizontally from top of a building. In 2 second, it falls vertically through a distance of __________ m. ($g = 10$ m s^{-2})
19. What is time of flight?
20. If two balls are thrown vertically upwards with the same velocity, what is the difference in the maximum height gained by them?

Short Answer Type Questions

21. Deduce an expression for the maximum height reached by a body.
22. Obtain an expression for time of flight.
23. Why does the velocity decrease when the body is projected upwards?
24. Show that the time of ascent is equal to time of descent for a body projected vertically upward.
25. Derive an expression for the velocity when a body dropped from a height reaches the ground.

Essay Type Questions

26. Two kids standing on different floors of an apartment block drop balls from the balconies. The second kid standing at a lower level drops the ball 2 seconds after the first kid does. Both the balls reach the ground simultaneously, 5 seconds from the time the first ball was dropped. What is the difference between the heights of the two balconies? (Take $g = 10$ m s^{-2})
27. A ball is dropped from a certain height. If it takes 0.2 s to cross the last 6.2 m before hitting the ground, find the height from which it was dropped. (Take $g = 10$ m s^{-2})
28. A ball is thrown vertically upwards with a speed of 30 m s^{-1}. Draw a graph showing the velocity of the ball as a function of time. (Take $g = 10$ m s^{-2})
29. A man standing at a distance of 6 m from a building 21.6 m high observes a kid slipping from the top floor. With what speed should he run to catch the kid at a height of 2 m from the ground? (Assume speed of the person to be uniform; g = 10 m s^{-2})
30. A stone is dropped from a height of 45 m. What will be the distance travelled by it during the last second of its motion? (Take $g = 10$ m s^{-2})

Directions for questions 16 to 40:

For each of the question, four choices have been provided. Select the correct alternative.

16. A body projected vertically up has displacement of 16 m in the first n seconds while it was moving up. Its magnitude of displacement in the last n second while falling down is

(a) 8 m (b) 4 m
(c) 16 m (d) 2 m

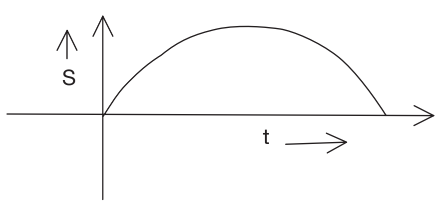
17. The acceleration of a moving body can be found out from

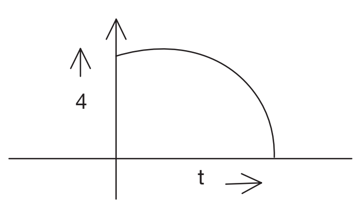
(a) slope of velocity time graph.
(b) area under velocity time graph.
(c) slope of distance time graph.
(d) area under distance time graph.

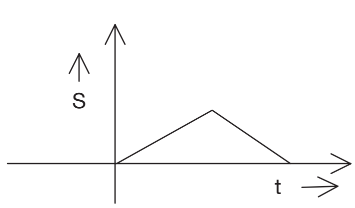
18. Two bodies are projected from the ground with the same speed. If the angles of their projection from the ground are 45° and 15°, respectively, the ratio of their ranges is

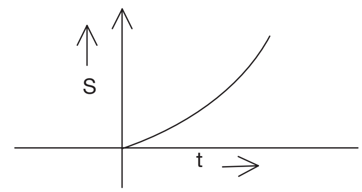
(a) 1 : 2 (b) 2 : 1
(c) $\sqrt{3}:2$ (d) $1:\sqrt{2}$

19. The displacement–time, graph for a body thrown vertically up and falling back to the point of projection, is ___________.

(a)


(b)


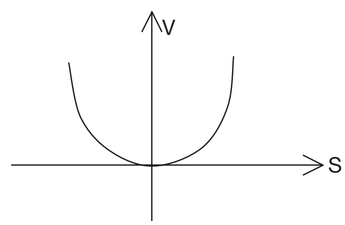
(c)


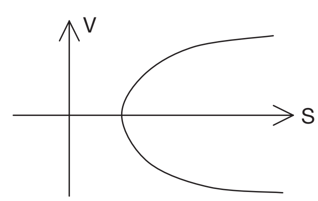
(d)


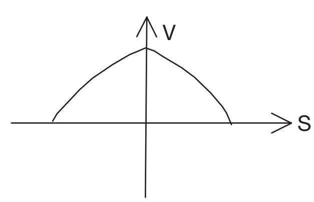
20. A stone dropped from the top of a tower travels 4.9 m in the last second, then the velocity of the stone on reaching the ground is

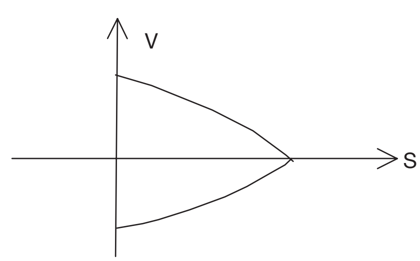
(a) 19.6 m s^{-1} (b) 9.8 m s^{-1}
(c) 4.9 m s^{-1} (d) 29.4 m s^{-1}

21. The graph of velocity versus displacement of a body which is thrown vertically up and falling back to the point of projection is ___________.

(a)


(b)


(c)


(d)


22. A body is projected vertically up from the ground with certain velocity. Its velocity is reduced to $\frac{1}{4}$th of its intial velocity at 75 m height. Then the maximum height reached by the body is

(a) 75m (b) 80m
(c) 100m (d) 40m

23. If a body is projected with certain velocity making an angle 30° with the horizontal, then

(a) its horizontal velocity remains constant.
(b) its vertical velocity changes.
(c) on falling to the ground, its vertical displacement is zero.
(d) All of the above

24. A freely falling body from rest acquires velocity V in falling through a distance h. If here after the body falls through a further distance h, velocity acquired by it is

(a) 2V (b) V
(c) $\sqrt{2}$V (d) 4V

25. Two cars A and B move such that car A moving with a uniform velocity of 15 m s^{-1} over takes car B moving from rest with an acceleration of 3 m s^{-2}. The time, after which, they meet again, is

(a) 5 s (b) 15 s
(c) $\sqrt{3}s$ (d) 10 s

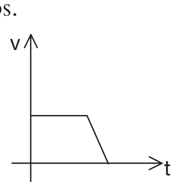
26. A stone dropped from the top of a tower travels 15 m in the last second of its motion. If g = 10 m s^{-2}, then the time of fall is

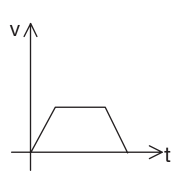
(a) 2 s (b) 2.5 s
(c) 5 s (d) 3 s

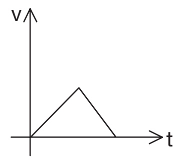
27. A body is projected vertically upward with certain velocity. The magnitude of its displacement in the last second of its upward motion is ________.

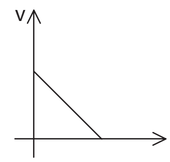
(a) $2g$ (b) $\frac{g}{3}$
(c) $\frac{g}{2}$ (d) $\frac{3g}{2}$

28. In the following v–t graphs, identify the graph that represents a body moving initialy with uniform velocity and then with uniform retardation until it stops.

(a)


(b)


(c)


(d)


29. Three bodies A, B and C are thrown simultaneously with the same speed from the top of a building. A is thrown vertically upward, B horizontally and C, vertically downward. All the three, on reaching the ground,

(a) have equal velocities.
(b) have equal vertical displacements.
(c) take equal time to reach the ground.
(d) Both (a) and (b)

30. An ant moves along the sides of a square room ABCD of length 4 m starting from A, it reaches the opposite corner C by travelling from A to B and from B to C. If the time taken is 2 s, the average velocity of the ant is

(a) 4 m s^{-1} (b) $2\sqrt{2}$ m s^{-1}
(c) 2 m s^{-1} (d) $4\sqrt{2}$ m s^{-1}

31. A body started with a velocity of 20 m s^{-1} and moving with an acceleration of 2 m s^{-2}. The distance travelled by the body in the 8th second is ________ m.

(a) 35 (b) 20
(c) 120 (d) 10

32. A body starts from rest and moving with an acceleration 2 m s^{-2} and covering a distance of 10 m. The final velocity of the body is ________ m s^{-1}.

(a) $\sqrt{98}$ (b) $\sqrt{40}$
(c) $\sqrt{20}$ (d) $\sqrt{12}$

33. A body initially moving with a velocity of 5 m s^{-1}, attains a velocity of 25 m s^{-1}. The acceleration of the body in 5s is ____________ m s^{-2}.

(a) 8 (b) 7
(c) 4 (d) 3

34. A body starts from rest, and moving with an acceleration of 1 m s^{-2}. The displacement of the body in 5 seconds is __________ m.

(a) 12.5 (b) 25
(c) 7.5 (d) 15

35. Two bodies of different masses are dropped from heights of 2 m and 8 m, respectively, then the ratio of the time taken by them is _____ m.

(a) 1 : 4 (b) 1 : 1
(c) 1 : 2 (d) 1 : 3

36. An object is thrown vertically upward with a velocity of 10 m s^{-1}. It strikes the ground after __________ seconds. (Take g = 10 m s^{-2})

(a) 10 (b) 2
(c) 5 (d) 1

37. An object is released from a balloon rising up with a constant speed of 2 m s^{-1}. Its magnitude of velocity after 1 s is __________ m s^{-1}.

(a) 5.3 (b) 7.8
(c) 2.8 (d) 6.4

38. A ball is projected vertically up with a velocity of 20 m s^{-1}. Its velocity when it reaches 15 m height is __________ m s^{-1}. (Take g = 10 m s^{-2})

(a) 10 (b) 15
(c) -10 (d) Both (a) and (c).

39. Two balls are projected horizontally from the top of a building simultaneously with velocities 15 m s^{-1} and 20 m s^{-1}, respectively.The ratio of times taken by them to reach the ground __________ is.

(a) 2 : 3 (b) 3 : 4
(c) 1 : 1 (d) 4 : 9

40. A body 'A' is dropped from a height h and the other body B is thrown horizontally with a velocity of 10 m s^{-1} from the same height simultaneously. If the time taken by the body A to reach the ground is 3 s, arrange the following steps in a proper sequence to find the velocity of the body 'B', in vertical direction when it is at a vertical height of 20 m above the ground.

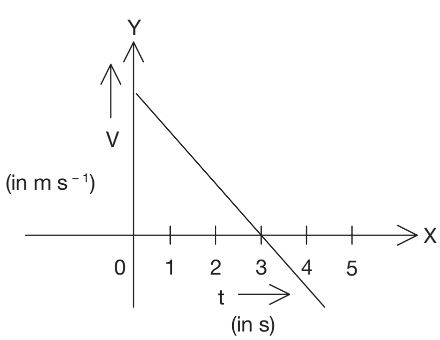
(a) Find the displacement covered by the body B when it is at a height of 20 m.
(b) Calculate of the vertical height from the ground through which both the bodies are falling.
(c) Write the required equation of motion and calculate the velocity at the given point.
(d) Analyse the relation between the motions of two bodies.

(a) *d c a b* (b) *d b a c*
(c) *a b c d* (d) *d b c a*

Level 2

41. A lift ascends from rest with uniform acceleration of 4 m s^{-2}. Then it moves with uniform velocity and finally comes to rest with a uniform retardation of 4 m s^{-2}. If the total distance covered during ascending is 28 m and the total time for ascending 8 s, respectively, then find the time for in which the lift moves with uniform velocity. Also find its uniform velocity.

42. The following graph represents the velocity-time graph of a body projected vertically upward under gravity.
Find the maximum height attained by the body. (Take g = 10 m s^{-2})



43. A body moves with a uniform speed in a circular path of radius *r*. What is the displacement of the body on covering (1/4) th of the revolution?

44. A body is projected vertically upward. Show that the

(i) distance covered by it in the first '*n*' seconds of ascent is equal to the distance covered by it in the first '*n*' seconds of its descent.

(ii) the distance covered by it in the last '*n*' seconds of ascent is equal to the distance covered by it in the first '*n*' seconds of its descent.

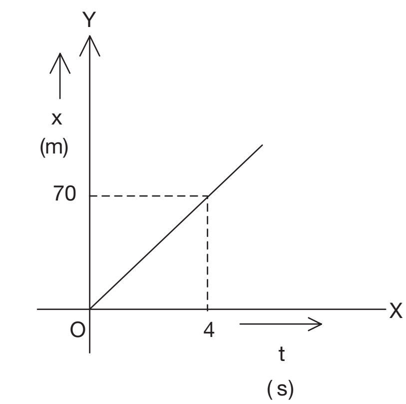
45. A missile is launched from the ground making 45° with the horizontal to hit a target at a horizontal distance of 300 km. If it is required to hit a target at a horizontal distance of 675 km launched at same angle with horizontal, find the percentage change in its velocity of projection.

PRACTICE QUESTIONS

46. A freely falling body acquires a velocity 'v' m s^{-1} in falling through a distance of 80 m. How much further distance should it fall, so as to acquire a velocity of '$2v$' m s^{-1}? (Take g = 10 m s^{-2})

47. A body is dropped from certain height H. If the ratio of the distances traveled by it in $(n - 3)$ seconds to $(n - 3)$rd second is 4 : 3, find H. (Take g = 10 m s^{-2})

48. The variation of horizontal displacement (x) of a projectile with time (t) is as shown in the figure below. If the angle of projection is 60°, find the velocity of projection.

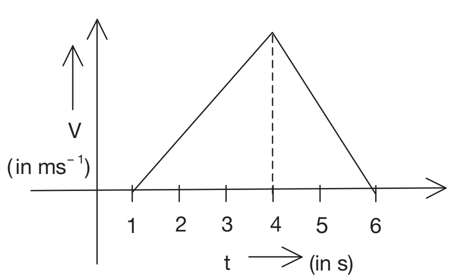


49. A juggler sets 4 balls in motion in succession to a height of 19.6 m from his hand. What is the velocity of projection of each ball? Once set in motion, what are the displacements of the other three balls when the 2nd ball just leaves his hand?

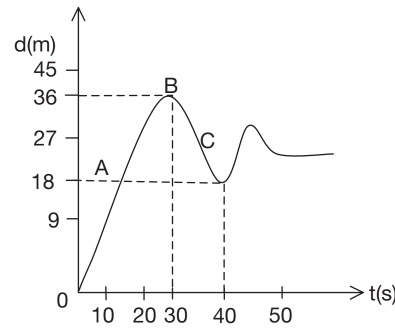
50. A person watching through the window of an apartment sees a ball that rises vertically up and then vertically down for a total time of 0.5 s. If the height of the window is 2 m, find the maximum height above the window reached by the ball. (g = 10 m s^{-2}).

51. A freely falling body crosses points P, Q and R with velocities V, $2V$ and $3V$, respectively. Find the ratio of the distances PQ to QR.

52. The velocity-time graph of a car is as shown in the figure below.
Find the acceleration and deceleration of the car if its total displacement is 90 m.



53. In the displacement versus time graph below find the average velocity in the time interval of 0 to 30 second. Comment on the signs of velocities at points A, B and C.



54. Are the equations of motion applicable to bodies projected vertically up with any velocity, say 8 km s^{-1}, for determining the maximum height?

55. A stone is thrown horizontally from a tower with certain velocity and at the same time, another stone is dropped freely from the same height. Which stone reaches earlier? Explain.

56. In the 2008 Olympics held in Beijing, Usain Bolt of Jamaica set a new world record in 100 meter race, He completed the 100 meter run in 9.69 s.

(a) Determine his average speed in km h^{-1}.

(b) If he has travelled 90 m in 8.69 s, calculate his average velocity in the last second.

(c) If he has maintained a uniform acceleration for the first 8.69 s, calculate the acceleration and the velocity at the end of 8.69 s.

57. Drag racing is a competition in which the vehicles compete to be the first to cross the finishing point along a straight path. In July 2009 Schumacher set a record by completing 400 m in 4.428 s in the drag racing competition.

(a) Determine the average velocity of his car.

(b) If he maintained a uniform velocity for the last 50 m and he covered that distance in 1 s determine the velocity at the end of 350 m.

(c) Determine the acceleration if he maintained a uniform acceleration in the first second and the distance travelled is 37.5 m. The velocity at the end of first second is 75 m s^{-1}.

58. What is the condition for which the average velocity and average speed of a body are equal?

59. Two bodies are projected from the ground with the same speed. If the angles of their projection from the ground are 30° and 60°, respectively, what is the ratio of their horizontal displacements after 2 s?

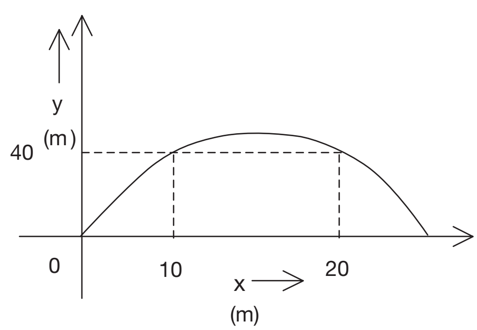
60. Compare the motion of a body dropped to that of a horizontal projectile, both falling from the same height.

Level 3

61. The displacement (x) variation of a particle with time (t) is given by expression $x = -15\,t^2 + 20t + 30$ find the position of the body at $t = 0$ s and $t = 6$ s. Is this particle moving with uniform acceleration? Explain.

62. The horizontal range of a bullet fired with angle of projection 45° to the horizontal is 360 m. If it is fired from a lorry moving in the direction of bullet with the uniform velocity 18 km hr^{-1} and with same elevation, what is the new range horizontal distance traveled by the bullet? (Take g = 10 m s^{-2}).

63. The graph of vertical displacement (y) versus horizontal displacement (x) of a projectile is as shown below.



From the values given in the graph, find the time at which the projectile has the displacements, as indicated in the graph.

64. A body moving linearly with uniform acceleration covers distances p, q, r and s after successive intervals of time, t s. Find the ratio of $\frac{(s-p)}{(r-q)}$

65. A small steel ball is dropped from a height of 2.5 m into a tall glycerin jar. It hits the surface of glycerin with certain velocity and sinks to the bottom by losing 20% of its velocity at the surface. If the time taken to reach the bottom after it is dropped is 2 s and velocity in glycerin is lost at constant rate, then find the average velocity of the ball over the whole journey.

66. A person travels two parts of the total distance in the ratio 2 : 1 with constant speeds of 30 km h^{-1} and 40 km h^{-1}, respectively. What is the average speed of the journey?

67. An automobile traveling with a speed of 72 km h^{-1}, can be stopped within a distance of 30 m, by applying brakes. What will be the stopping distance, if the automobile speed is increased to $\sqrt{3}$ times and the same breaking force is applied?

68. A body takes 't' seconds to reach a maximum height 'H' m, when projected vertically upward from the ground. Find the position of the body after $\frac{t}{2}$ seconds from the ground in terms of H.

69. A hot air balloon, released from ground, moves up with a constant acceleration of 5 m s^{-2}. A stone is released from it at the end of 8 seconds. Find the height of the stone from the ground at the end of 8 seconds after it is released from the balloon. (Take g = 10 m s^{-2})

70. A stone thrown from the ground just crosses a wall of height 5 m in 2 s. If the wall is at a horizontal distance 25 m, from the point of projection of the stone, find at what distance the stone falls behind the wall. (Take g = 10 m s^{-2}).

CONCEPT APPLICATION

Level 1

True or false

1. True **2.** True **3.** False **4.** True **5.** True **6.** False **7.** False

Fill in the blanks

8. zero, g **9.** 0 **10.** $\sqrt{\frac{2h}{g}}$ **11.** $\sqrt{h_1} : \sqrt{h_2}$ **12.** $-u$ m s^{-1} **13.** direction **14.** 180°

Match the following

15.(a) A : b B : a C : d D : c

(b) P : q Q : s R : p S : r

Multiple choice questions

16. (c)	**17.** (a)	**18.** (b)	**19.** (a)	**20.** (b)	**21.** (d)	**22.** (b)	**23.** (d)	**24.** (c)	**25.** (d)
26. (a)	**27.** (c)	**28.** (a)	**29.** (b)	**30.** (b)	**31.** (a)	**32.** (b)	**33.** (c)	**34.** (a)	**35.** (c)
36. (b)	**37.** (b)	**38.** (d)	**39.** (c)	**40.** (b)					

Explanation for questions 31 and 40:

31. $S_n = ?$, $u = 20\text{ms}^{-1}$, $a = 2\text{ms}^{-2}$, $n = 8$

$$S_n = u(1s) + a\left(n - \frac{1}{2}\right) = 20 + 2\left(8 - \frac{1}{2}\right)(1s)$$

$= 20 + (16 - 1) = 20 + 15 = 35$

32. $v^2 - u^2 = 2as$

$v^2 - 0 = 2 \times 2 \times 10 = 40 \Rightarrow v = \sqrt{40}$ ms^{-1}

33. $u = 5$ m s^{-1}, v = 25 m s^{-1}, $t = 5$ s

$$a = \frac{v - u}{t} = \frac{25 - 5}{5} = 20/5 = 4 \text{ ms}^{-2}$$

34. s = ?, $u = 0$, $a = 1$ m s^{-2}, $t = 5$s

$$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 1 \times 25 = 12.5\text{m}$$

35. $u = 0$

$h \propto t^2$

$$\therefore \sqrt{\frac{h_1}{h_2}} = \frac{t_1}{t_2}$$

$t_1 : t_2 = 1 : 2$

36. $u = 10$ m s^{-1}; $t = 2u/g = 2 \times 10/10 = 2$ s

37. $u = -2$ m s^{-1} ; $t = 1$ s

$v = u + at = -2 - 9.8 \times 1 = -7.8$

38. $u = 20$ m s^{-1}

s = 15 m,

$v^2 - u^2 = 2as$

$v^2 - (20)^2 = 2 \times 10 \times -15$

$v^2 = 100 \Rightarrow v = +10$ m s^{-1}

39. As the initial vertical velocity is zero in both the cases they take the same time to reach the ground.

40. (i) The vertical motion of a horizontal projectile is same as that of a freely falling body.

$\therefore$ The time taken to reach the ground for the horizontal projectile, $t = 3$ s.

(ii) $\therefore$ The vertical height from the ground,

$$h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 3^2 = 45\text{m}$$

(iii) The displacement covered by 'B' when it is at a height of 20 m from the ground, $h_1 = 45 - 20 = 25$ m.

(iv) $\therefore v^2 = u^2 + 2g\,h_1$

$v^2 = 2 \times 10 \times 25 = 500$

$v^2 = \sqrt{500} = 10\sqrt{5}$ ms^{-1}

Level 2

41. (i) Find the time for acceleration, retardation and uniform velocity by using equations of motion.

(ii) Find the time during it is moving with uniform velocity.

(iii) Find the uniform velocity time?

(iv) $4\ m\ s^{-1}$

42. (i) Find the velocity at $t = 3$ s. This gives the velocity v.

(ii) From $v = u - gt$, find the value of u by substituting the value of v, g and t.

(iii) Find the maximum height by substituting the values of u, v and g in equation $v^2 = u^2 - 2gh$.

(iv) 45 m

43. (i) Find the relation between the number of revolutions and the corresponding angle described.

(ii) Using the definition of displacement, identify the initial and final points

(iii) Using trigonometric ratios find the displacement for $\frac{1}{4}$th of the revolution.

(iv) $\sqrt{2}$

44. (i) Find the velocity v_1 of a body projected upwards after $t = (t_1 - n)$ seconds t_1 = time of ascent = (u_1/g) using equation $v_1 = u_1 - gt$

(ii) v_1 is the initial velocity in the beginning of last n seconds

(iii) Find s_1 by substituting $v = 0$ and $u = v_1$ in equation $v^2 = u^2 - 2gs_1$

(iv) Find the displacement s_2 for the body falling from rest for n seconds using equation $s = ut + ½\,gt^2$

(v) Compare s_1 and s_2.

45. (i) Consider the relation between the horizontal distance and the initial velocity.

(ii) 50% increase

46. (i) Let h_1 be the displacement during which the velocity changes from v to $2v$. Find h_1 by substituting $u = v$, $v = 2v$ in equation $v^2 = u^2 + 2gh_1$

(ii) Find v^2 for a body dropped from a height of 80 m from the equation $v^2 = u^2 + 2gh$

(iii) Substitute the value of v^2 in equation obtained in 1 and find h_1

(iv) 240 m

47. (i) Obtain the equation for the distance travelled in $(n - 3)$ seconds using equation $s_1 = ½\,gt^2$

(ii) Obtain equation for the distance travelled in $(n - 3)$rd second using equation $s_n = u + \frac{g}{2}(2n - 1)$

(iii) Divide equation obtained from 1 by equation obtained in 2

(iv) Equate the ratio to 4 : 3

(v) Find the value of n

(vi) Substitute the value of n in equation $s = ½\,gt^2$ $(t = n)$ and find s which gives the value of H.

(vii) 125 m

48. (i) Find the value of x and t in the graph

(ii) Find the value of velocity of projection, u, using the equation $x = u \cos \theta \cdot t$

(iii) $35\ m\ s^{-1}$

49. (i) Find h for all the balls using u and t.

(ii) 14.7↑, 19.6, 14.7↓

50. (i) Let h be height above the window by which the ball rises and t_1 be the time.

(ii) The height of the ball from its fall is given by, $h = ½\,gt^2{}_1$.

(iii) Time taken for the ball to cross the window = $(t_1 + ¼)$ seconds and distance covered to cross the window = $h + 2$.

(iv) Substitute $s = h + 2$, $u = 0$ and time $t = t_1 + ¼$ in the equation $s = ut + ½\,gt^2$.

(v) Equate R.H.S. of 2 and 4 and find t.

(vi) Substitute the value of t in 2 and find h.

(vii) 160 m

51. (i) Consider the equation of motion $v^2 = u^2 + 2gs$ for a freely falling body.

(ii) Velocity at P is the initial velocity and velocity at Q is the final velocity for the displacement PQ.

(iii) Substitute initial and final velocity in equation given in 1 and find S_1.

(iv) Similarly velocity at Q and velocity at R are initial and final velocity for the displacement $QR = S_2$.

(v) Substitute the initial velocity and final velocity for displacement QR in equation as given in 1 and then find S_2.

(vi) Find the ratio S_1 and S_2.

(vii) 3 : 5

52. (i) Area under $v - t$ graph gives the total displacement.

(ii) Area of triangle = ½ × base × height

(iii) Substitute the base and area of the triangle and find the height of the triangle.

(iv) The height of the triangle gives the maximum velocity attained by the car.

(v) Find the time taken to attain maximum velocity, t_1 and the time taken to come to rest, t_2 from maximum velocity from the graph.

(vi) Find acceleration using equation $v = at_1$ and deceleration using equation $v = u + at_2$ ($v = 0$ and substitute u, the maximum velocity of the car *from iv*)

(vii) Acceleration = 12 m s^{-2}

Deceleration = 18 m s^{-2}

53. (i) Average velocity $= \dfrac{\text{Total displacement}}{\text{total time}}$

(ii) 1.2 m s^{-1}

54. (i) When can the equations of motion be applied?

(ii) As the height of the body above the earth's surface increases, does acceleration due to gravity remain constant?

55. As the vertied initial velocity of two stones are zero, they will reach the ground in the same time.

56. Given data:-

Distance travelled, (s) = 100 m

Time taken, (t) = 9.69 s

(a) Average speed $= \dfrac{\text{total distance}}{\text{total time}}$

$$= \frac{100}{9.69}\text{ m s}^{-2} = \frac{100 \times 3600}{9.69 \times 1000}\text{ km h}^{-1}$$

$$= \frac{360}{9.69} = \frac{36000}{969} = 37.15\text{ km h}^{-1}$$

(b) Average velocity in the last second

$$= \frac{\text{total displacement in the last second}}{1\text{s}}$$

$$= \frac{(100-90)}{1} = \frac{10}{1}$$

$$= 10\text{ m s}^{-1} = \frac{10 \times 18}{5}\text{ km h}^{-1}$$

$$= 2 \times 18 = 36\text{ km h}^{-1}$$

(c) $u = 0$, $v = ?$ $a = ?$ $t = 8.69$ s, s = 90 m

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

$$90 = 0 + \frac{1}{2} \times a \times (8.69)^2$$

$$a = \frac{90 \times 2}{(8.69)^2} = \frac{180}{75.52} = 2.38\text{ m s}^{-2}$$

$$v = u + at = 0 + 2.38 \times 8.69 = 20.68\text{ m s}^{-1}$$

57. (a) S = 400 m, t = 4.42 s

$$\text{Average velocity} = \frac{\text{total displacement}}{\text{total time}}$$

$$= \frac{400}{4.42} = \frac{40{,}00}{442} = 90.5\text{ ms s}^{-1}$$

(b) As he maintained the uniform velocity for the last 50 m, and the initial velocity at the beginning of 50 m is equal to the final velocity at the end of 350 m.

$$\therefore\ \text{velocity} = \frac{50}{1} = 50\text{ m s}^{-1}$$

(c) $u = 75$ m s^{-1}, s = 37.5 m, $t = 1$ s; $a = ?$

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

$$37.5 = 0 \times 1 + \frac{1}{2}a \times 1^2$$

$$a = 37.5 \times 2 = 75\text{ m s}^{-2}$$

58. The average velocity is the ratio of total displacement and time. The average speed is the ratio of total distance and time. Therefore, the average speed and average velocity are equal if the total displacement is equal to the total distance. That is if the body travels along a straight line without changing the direction.

59. $S_H = u_H \times t$

$\therefore S_1 : S_2 = u \cos 30 \times 2 : u \cos 60 \times 2$

$$= \sqrt{\frac{3}{2}} : \frac{1}{2} = \sqrt{3} : 1$$

60. (i) When the two bodies fall from the same height, the time taken by them to reach the ground is the same.
(ii) The two bodies will have the same vertical displacement at any instant of time.
(iii) When the body is projected horizontally, it has an initial velocity in the horizontal direction, but the velocity in the vertical direction is zero. The velocity increases in the vertical direction, as it reaches the ground. The vertical motion of a horizontal projectile is similar to that of body dropped from the same height.

Level 3

61. (i) Change in position is displacement
(ii) Change in displacement in 1s and is velocity
(iii) Change in velocity in 1s and is acceleration.

62. (i) Using the formula for horizontal distance calculate the initial velocity to find the time of flight. Using this time of flight calculate the additional the horizontal distance traveled by bullet fired from the lorry due to the motion of the lorry.
(ii) 402.42 m

63. (i) Find the value of t_1 in terms of u by substituting $x = 10$ in the equation $x = u \cos \theta .\ t_1$
(ii) Similarly, find the value of t_2 by substituting $x = 20$ m in the above equation
(iii) Divide 1 and 2 to obtain the ratio t_1 and t_2.
(iv) Divide vertical displacement, $y = u \sin \theta \times t - ½ gt^2$ by $g/2$.
(v) Write the above equation in a quadratic form with variable t, i.e., in the form of $At^2 + Bt + C = 0$
(vi) The roots of the above equation are t_1 and t_2.
(vii) The product of roots, ie $t_1t_2 = C/A$.
(viii) Substitute the values of C and A and find t_1t_2.
(ix) Solve equation obtained from 3 and 8 which gives the value of t_1 and t_2, given $y = 40$ m corresponding to $x = 10$ m and $x = 20$ m.
(x) 2 s and 4 s

64. (i) Find p, q, r, s using $s = ut + \frac{1}{2}at^2$
(ii) Finding the ratio of $\frac{(s-p)}{(r-q)}$
(iii) 3 : 1

65. (i) Find the velocity with which the ball moves in glycerine. Then find time the for which it travels.
(ii) Find the distance traveled in glycerin.
(iii) Find average velocity.
(iv) 5.3 m s^{-1}

66. Let distances travelled be $2x$ and x.

Time taken to travel $2x$ distance $= \frac{2x}{30}$.

Time taken to travel x distance $= \frac{x}{40}$.

Total time $= \frac{2x}{30} + \frac{x}{40}$

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time taken}} = \frac{3x}{\frac{2x}{30} + \frac{x}{40}}$$

$$= \frac{3x}{\frac{8x + 3x}{120}} = \frac{3x \times 120}{11x} = \frac{360}{11} = 32.7 \text{ km h}^{-1}$$

67. Given,

$$a = 72\frac{\text{km}}{\text{h}} = 72 \times \frac{5}{18} = 20 \text{ ms}^{-1}$$

$s = 30$ m

v = 0

$$\therefore \frac{30}{s} = \frac{u^2}{2a}$$

HINTS AND EXPLANATION

Since a is same, s $\propto a^2$

$$\frac{30}{s} = \frac{u^2}{(\sqrt{3u})^2} \quad (\because u \text{ is increased to } \sqrt{3} \text{ times})$$

$$\frac{30}{s} = \frac{u^2}{3u^2}$$

$$s = 90\text{m}$$

68. Let 'h' be the height attained by the body in (t/2) second

$$s = ut - \frac{1}{2} gt^2$$

Substituting s = h, $t = \frac{1}{2}$

$$h = u \times \frac{t}{2} - \frac{1}{2} g\left(\frac{t^2}{4}\right) \quad (1)$$

$$H = \frac{u^2}{2g} \Rightarrow u = \sqrt{2gh} \quad (2)$$

$$t = \frac{u}{g} = \frac{\sqrt{2gH}}{g} \quad (2)$$

Substituting (2) and (3) in (1)

$$h = \sqrt{2gH} \times \frac{\sqrt{2gH}}{2g} - \frac{g}{2} \times \frac{2gH}{4g^2}$$

$$\frac{2gH}{2g} - \frac{H}{4} = H - \frac{H}{4} = \frac{3}{4}H$$

69. The velocity of the stone, when it is released from the balloon is given by, $v = u + at$ and is equal to the velocity of the balloon. Consider downward direction as positive and substitute, v = ?, u = 0, a = – 5 m s^{-2}, t = 8

v = – 5 × 8 = – 40 m s^{-1} (1)

The displacement of the stone after 8 s is

s = – ut + 1/2 gt^2

Substituting s = .h, u = – 40 m s^{-1},

t = 8s, g = 10 m s^{-2}

$$h = -40 \times 8 + \frac{1}{2} \times 10 \times 8^2$$

h = – 320 + 320 h = 0.

The stone returns back to the position from where it was released, i.e., the height of the balloon from the ground at the end of 8 seconds.

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

Substitute, u = 0,

a = – 5 m s^{-2}, t = 8s

s = – 1/2 × 5 × 8 × 8 = – 5 × 4 × 8

s = – 160 m

∴ The height of the balloon from the ground is 160 m.

70. The horizontal component of the initial velocity

$$= \frac{25\text{m}}{2\text{s}} = 12.5 \text{ m s}^{-1}$$

Let the vertical component of the initial velocity be u.

Then $s = ut + \frac{1}{2}at^2$

$$5 = 2u - \frac{1}{2} \times 10 \times 4$$

$$u = \frac{25}{2} = 12.5 \text{ m s}^{-1}$$

$$\therefore \text{ Time of light } = \frac{2u \sin\theta}{g} \frac{2 \times 12.5}{10} = 2.5\text{s}$$

∴ Horizontal range = (12.5 m s^{-1}) × (2.5 s)

= 31.25m.

Thus, the distance behind the wall

= 31.25 – 25 = 6.25 m.

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I read -I remember,
I do - I understand"

following this saying, measures like asking students to teach some subtopic will be taken.

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