MOTION UNDER GRAVITY

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Here we will consider motion of a particle thrown vertically upward (θ = 90° from horizontal) or falling vertically from any height.

<< methods of solving problems on motion under gravity >>

METHOD I

* For stone thrown upward, motion can be divided into two parts :

PART 1 - **stone going upward :** speed decreasing with time due to gravity, which is pulling it downward. Therefore, this is the case of deceleration, so equations of motion in scalar form will be as $v = u - gt$, $s = ut - 1/2gt^2$, $v^2 = u^2 - 2gh$

PART 2 - **stone falling downward :** speed increasing with time due to gravity, which is pulling it downward.

Therefore, this is the case of accelerated motion, so equations of motion in scalar form will be as $v = u + gt$, $s = ut + 1/2\ gt^2$, $v^2 = u^2 + 2gh$

CAUTION : You have to consider upward and downward motion separately.

METHOD II

Here, you can consider complete up and down motion as one motion and applying equations of motion in vector form with proper sign convention will give result with +/- sign, which can be interpreted according to sign convention.

SIGN CONVENTION

(1) Upward positive , downward negative.

(2) Point of projection to be taken as origin.

(3) All the distances to be measured from point of projection.

$\therefore$ distance above point of projection is positive & vice-versa

For motion under gravity, acceleration vector due to gravitational force will always be downward, whatever be the direction of velocity, so $\vec{a}_g = -9.8\ m/s^2$ always.

BASIC FIND OUTS OF MUG :

(a) If a particle is projected up with velocity u, then

(i) Maximum height reached by the particle, $H = \dfrac{u^2}{2g}$

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Ex.1 *A particle, thrown up with a velocity of 10m/sec, will reach the maximum height equal to : ($g = 10\ m/s^2$)*

(A) 3m *(B) 5m* *(C) 7m* *(D) 10m*

Sol. (B)

Here, u = 10m/sec.

$$\therefore \quad H = \frac{(u)^2}{2g} = \frac{10 \times 10}{2 \times 10} = 5m.$$

(ii) Time taken to reach the maximum height, $t = \frac{u}{g} = \sqrt{\frac{2H}{g}}$

Ex.2 *In the previous case, the time taken to reach the highest point is :*

(A) 1 sec *(B) 1.5 sec* *(C) 2 sec* *(D) 2.5 sec*

Sol. (A)

$$t = \frac{u}{g} = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 5}{10}} = 1 \text{ sec.}$$

(iii) Time taken to come back to the point of projection : (Time of flight) $T = \frac{2u}{g}$

Ex.3 *In the previous case, the total time taken to come back to the point of projection is :*

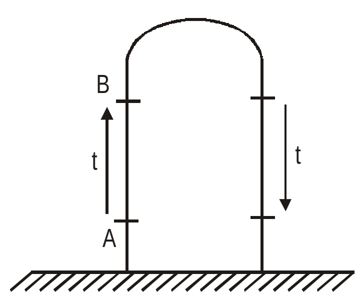
(A) 1.5 sec *(B) 2 sec* *(C) 2.5 sec* *(D) 3 sec*

Sol. (B)

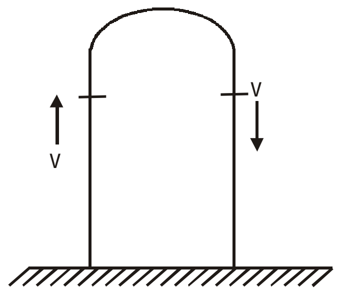
Simply, total time = 2 × time taken to reach highest point.

$\therefore$ total time = 2 × 1 = 2 sec.

(b) A ball thrown vertically up takes the same time to go up and come down and it is true for any part of its motion.



(c) A particle has the same speed at a point on the path while going vertically up and down.



(d) If a particle is dropped from a height H above the ground, then

(i) Velocity of the particle when it reaches the ground i.e. $v = \sqrt{2gH}$

(ii) Time taken to reach the ground i.e. $t = \sqrt{\frac{2H}{g}}$

(e) Whenever a ball is dropped, its initial velocity is equal to the velocity of the body, from where it is being dropped. Just after dropping, acceleration for the ball will be equal to free fall acceleration i.e. gravitational acceleration g.

Ex.1 *A balloon is moving vertically with a velocity of 4 m sec^{-1}. When it is at a height of h, a body is gently released from it. If it reaches the ground in 4 seconds, the height of the balloon, when the body is released is :*

(A) 62.4 m *(B) 42.4m* *(C) 78.4 m* *(D) 82.2 m*

Sol. (A)

u = – 4 m/sec

t = 4 seconds

To calculate : h

$$h = -(4)(4) + \frac{1}{2} \times 9.8\,(4)^2$$

$$= -16 + 4.9 \times 16$$

$$= 16\,(3.9) = 62.4 \text{ m.}$$

Ex.2 *A body is dropped from a balloon moving up with a velocity of 4 m sec^{-1} when the balloon is at a height of 120.5 m from the ground. The height of the body after five seconds from the ground is :*

(A) 8m *(B) 12m* *(C) 18m* *(D) 24 m*

Sol. (C)

$$S = ut + \frac{1}{2}at^2 = 4 \times 5 - \frac{1}{2} \times 9.8 \times 25$$

= 20 – 122.5 = – 102.5 m

This shows that the body is 102.5m below the initial position.

i.e. Height of the body = 120.5 – 102.5 = 18m.

(f) If we consider constant retarding force due to air resistance, then the ball takes less time to reach the highest position and larger time to reach the ground as compared to that in the absence of air resistance.

(g) If the body is dropped from a height H, as in time t, it has fallen a distance h from it's initial position, the height of the body from the ground will be h' = H – h, with $h = \frac{1}{2}gt^2$.

(h) As $h = \left(\frac{1}{2}\right)gt^2$, i.e. $h \propto t^2$, distance fallen in time t, 2t, 3t etc. will be in the ratio of $1^2 : 2^2 : 3^2$ ....

i.e. square of integers.

Ex. *A particle is released from rest from a tower of height 3h. The ratio of times to fall equal heights h i.e. $t_1 : t_2 : t_3$ is :*

(A) $\sqrt{3} : \sqrt{2} : 1$ *(B) 3 : 2 : 1*

(C) 9 : 4 : 1 *(D) $1 : (\sqrt{2} - 1) : (\sqrt{3} - \sqrt{2})$*

Sol. (D)

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

$$2h = \frac{1}{2}g\,(t_1 + t_2)^2$$

and $3h = \frac{1}{2}g\,(t_1 + t_2 + t_3)^2$

i.e. $t_1 : (t_1 + t_2) : (t_1 + t_2 + t_3) = (1 : \sqrt{2} : \sqrt{3})$

or $t_1 : t_2 : t_3 = 1 : (\sqrt{2} - 1) : (\sqrt{3} - \sqrt{2})$

(i) The distance fallen in n^{th} second i.e. $h_n - h_{n-1} = \frac{1}{2}g(n)^2 - \frac{1}{2}g(n-1)^2 = \frac{1}{2}g(2n-1)$.

So, distance fallen in I^{st}, II^{nd}, III^{rd} sec. will be in the ratio 1 : 3 : 5 i.e. odd integers only.

Ex.1 *A stone is dropped from a height of 122.5 m. The distance travelled by it in the last one second of it's motion will be :*

(A) 35.1 m *(B) 44.1 m* *(C) 54.1 m* *(D) 23.1 m*

Sol. (B)

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

or $122.5 = 0 + \frac{1}{2} \times 9.8 \times t^2$

$\therefore$ Total time of fall = t = 5 seconds.

Now, Distance travelled in n^{th} sec = $\frac{1}{2}$ g(2n – 1)

Putting n = 5, we get

S_5 = 44.1 m.

Ex.2 *The ratio of the distance, through which a body falls in 4^{th}, 5^{th} & 6^{th} second is :*

(A) 7 : 9 : 11 *(B) 4 : 5 : 6* *(C) 5 : 7 : 9* *(D) 6 : 8 : 10*

Sol. (A)

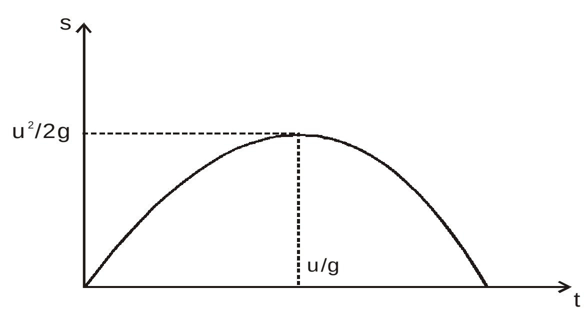
Distance travelled in n^{th} second = $\frac{1}{2}g\,[2n - 1]$

so ratio = $\frac{g}{2}[2 \times 4 - 1] : \frac{g}{2}[2 \times 5 - 1] : \frac{g}{2}[2 \times 6 - 1]$

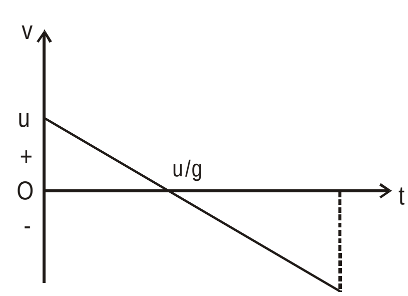
= 7 : 9 : 11.

(j) Graphs for a body thrown vertically upward :

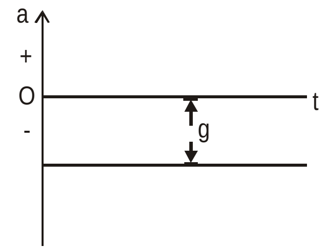
Distance - time graph :



velocity - time graph :



acceleration - time graph :



Distance travelled in vertical motion = $|\frac{u^2}{2a}| + \frac{1}{2}|a(t-t_o)^2|$ for $t > t_o$

EXAMPLES BASED ON MOTION UNDER GRAVITY

Ex.1 A ball is thrown upwards from the top of a tower 40 m high with a velocity of 10 m/s. Find the time when it strikes the ground. Take g = 10 m/s^2.

Sol. In the problem

u = +10 m/s

a = –10 m/s^2 and s = –40 m

(at the point where stone strikes the ground)

Substituting in $s = ut + \frac{1}{2}at^2$, we have

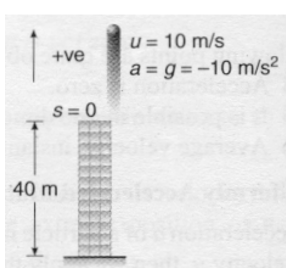
$-40 = 10t - 5t^2$

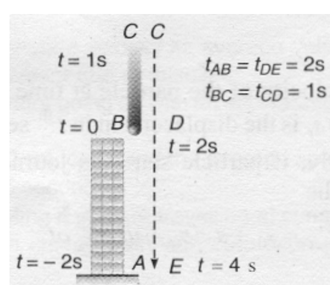
or $5t^2 - 10t - 40 = 0$

or $t^2 - 2t - 8 = 0$

Solving this, we have t = 4s and –2s. Taking the positive value, t = 4s.

NOTE The significance of t = –2s can be understood by following figure :

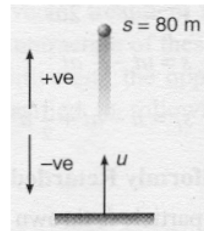




Ex.2 A ball is thrown upwards from the ground with an initial speed of u. The ball is at a height of 80 m at two times, the time interval being 6s. Find u. Take g = 10 m/s^2.

Sol. Here, u = u m/s, a = g = –10 m/s^2 and s = 80 m.

Substituting the values in $s = ut + \frac{1}{2}at^2$, we have



$$80 = ut - 5t^2$$

or $$5t^2 - ut + 80 = 0$$

or $$t = \frac{u + \sqrt{u^2 - 1600}}{10} \text{ and } \frac{u - \sqrt{u^2 - 1600}}{10}$$

Now it is given that

$$\frac{u + \sqrt{u^2 - 1600}}{10} - \frac{u - \sqrt{u^2 - 1600}}{10} = 6$$

or $$\frac{\sqrt{u^2 - 1600}}{5} = 6$$

or $$\sqrt{u^2 - 1600} = 30$$

or $$u^2 - 1600 = 900$$

$\therefore$ $$u^2 = 2500$$

or $$u = \pm 50 \text{ m/s}$$

Ignoring the negative sign, we have u = 50 m/s.

EFFECTS OF MEDIUM ON MOTION UNDER GRAVITY

On a vertically falling body, three forces may act on it at a time

(1) Weight = mg (downward)

(if mass is same for different bodies, then w does not depend on volume V or density ρ).

(2) Thrust force (Th) = mass of medium displaced (upward) by the falling body x g

Th = volume of body x density of medium x g = $V\sigma$ g

($\therefore$ Th $\alpha\ \sigma$ i.e. more is the density of medium, more is the thrust force $\therefore$ less is the net acceleration downward).

If $\rho < \sigma$, then thrust force will be greater than the weight of the body and the body will move up eg. Hydrogen balloon.

So, net downward acceleration = $\frac{\text{Net downward force}}{\text{total mass}} = \frac{W - T_n}{m} = g - \frac{V\sigma g}{V\rho}$; $g' = g\left(1 - \frac{\sigma}{\rho}\right)$

(Where, m = Vρ & w = Vρg), But here $\sigma > \rho$, so g' is –ve.

(3) Viscous force = F_v = $6\pi\eta rv$ (upward)

(F_v acts in the direction opposite to motion, so it can act in both upward or downward directions, but in the usual case, in which body is falling downward, F_v is upward)

$6\pi\eta$ are constant, r=radius of body, v is instantaneous velocity of body.

F_v depends on velocity, ie. more v, more F_v which opposes v, so v goes an decreasing

$\therefore$ Fv goes on decreasing

$\therefore$ at an instant, when F_v = w, no net force acts on body, so it falls thereafter with uniform velocity called terminal velocity.

i.e. $mg = 6\pi\eta rv_t$ or $\frac{4}{3}\pi r^3\rho g = 6\pi\eta rv_t$ so $v_t \propto r^2$.

$\therefore$ net downward acc. = $\frac{Net\ downward\ force}{mass} = \frac{W - F_v}{mass} = \frac{mg - 6\pi\eta rv}{m}$; $g'' = g - \frac{6\pi\eta rv}{m}$

(m can be replaced by $\Rightarrow m = V\rho = \frac{4}{3}\pi r^3\rho$)

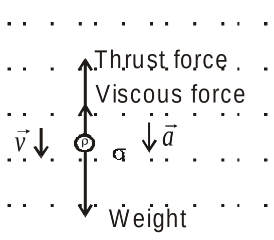
So, here downward acceleration comes out to be a function of v. So it's a case of non uniform acceleration.

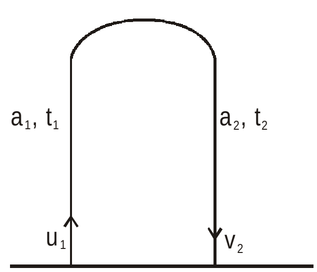
If thrust force is also acting along with viscous force then g in above eqn. will be replaced by g'

i.e. $g'' = \left[g' - \frac{6\pi\eta\, rv}{m}\right] = \left[g\left(1 - \frac{\sigma}{\rho}\right) - \frac{6\pi\eta rv}{m}\right]$

<u>CONCEPT</u> If air resistance opposes motion under gravity, then

$a_1 > a_2$, $t_1 < t_2$, $v_2 < u_1$





Ex. A ball is thrown up. If the air resistance is taken into account and is supposed to be constant, prove that the time of ascent will be longer than the time descent-

Sol. Let F be the constant force on the body. Then for its upward journey, mg + F = ma, where a is the retardation.

or $a = g + \frac{F}{m} = g + g'$, where $g' = \frac{F}{m}$

Then, $v_0 = (g + g')\, t_{ascent}$ and $v_0^2 = 2(g + g')h$ (Where, v_0 is the velocity of projection)

$\therefore$ $t_{ascent} = \sqrt{\frac{2h}{g+g'}}$

During the downward journey

$mg - F = ma'$ (Where, a' is acceleration of downward motion)

or $a' = g - \frac{F}{m} = g - g'$

$\therefore$ $h = 0 + \frac{1}{2}(g - g')\, t^2_{descent}$ or $t_{descent} = \sqrt{\frac{2h}{g-g'}}$

Obviously $t_{descent} > t_{ascent}$.

MOTION OF PARTICLE PROJECTED UPWARD UNDER TWO CONDITIONS

S.N.	motion describing parameters	without air resistance	with air resistance
(1)	acceleration during upward motion	$a_1 = g$ (downward)	$a_1' = (g+a)$ downward
(2)	acceleration during downward motion	$a_2 = a_1 = g$ (downward)	$a_2' = (g-a)$ downward
(3)	maximum height attained	$H = \frac{u_1^2}{2g}$	$H' = \frac{u_1^2}{2(g+a)}$ $\therefore H'_{max} < H_{max}$
(4)	time to reach H_{max} from ground	$t_1 = \frac{u_1}{g} = \sqrt{\frac{2H}{g}}$	$t_1' = \frac{u_1}{g+a} = \sqrt{\frac{2H'}{g+a}}$ $\therefore t_1' < t_1$
(5)	time to fall to ground from H_{max}	$t_2 = t_1 \left(= \frac{u_1}{g}\right) = \sqrt{\frac{2H}{g}}$	$t_2' = \sqrt{\frac{2H'}{(g-a)}}$ $\therefore$ $t_2' > t_1'$ & $t_2' > t_2$ time to fall > time to rise
(6)	speed with which body falls on ground.	$v_2 = \sqrt{2gH} = u_1$ same as speed with which particle was thrown up	$v_2' = \sqrt{2(g-a)H'}$ $u_1 = \sqrt{2(g+a)H'}$ $\therefore v_2' < u_1$ & $v_2' < v_2$

LEVEL # 1

Q.1 A stone falls from a balloon that is descending at a uniform rate of 12 m/s. The displacement of the stone from the point of release after 10 sec is-
(A) 490 m (B) 510 m (C) 610 m (D) 725 m

Q.2 A ball is dropped on the floor from a height of 10m. It rebounds to a height of 2.5 m. If the ball is in contact with the floor for 0.01 sec, the average acceleration during contact is-
(A) 2100 m/sec^2 downwards (B) 2100 m/sec^2 upwards
(C) 1400 m/sec^2 (D) 700 m/sec^2

Q.3 A body A is projected upwards with a velocity of 98 m/s. The second body B is projected upwards with the same initial velocity but after 4 sec. Both the bodies will meet after-
(A) 6 sec (B) 8 sec (C) 10 sec (D) 12 sec

Q.4 Two bodies of different masses m_a and m_b are dropped from two different heights a and b. The ratio of the time taken by the two to cover these distances is-
(A) a : b (B) b : a (C) $\sqrt{a} : \sqrt{b}$ (D) $a^2 : b^2$

Q.5 A body falls freely from rest. It covers as much distance in the last second of its motion as covered in the first three seconds. The body has fallen for a time of-
(A) 3s (B) 5s (C) 7s (D) 9s

Q.6 A body is slipping from an inclined plane of height h and length ℓ. If the angle of inclination is θ, the time taken by the body to come from the top to the bottom of this inclined plane is-
(A) $\sqrt{\frac{2h}{g}}$ (B) $\sqrt{\frac{2\ell}{g}}$ (C) $\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$ (D) $\sin\theta\sqrt{\frac{2h}{g}}$

Q.7 A particle is projected up with an initial velocity of 80 ft/sec. The ball will be at a height of 96ft from the ground after-
(A) 2.0 and 3.0 sec (B) Only at 3.0 sec (C) Only at 2.0 sec (D) After 1 and 2 sec

Q.8 A body falls from rest, its velocity at the end of first second is (g = 32 ft/sec)
(A) 16 ft/sec (B) 32 ft/sec (C) 64 ft/sec (D) 24 ft/sec

Q.9 A stone thrown upward with a speed u from the top of the tower reaches the ground with a velocity 3u. The height of the tower is-
(A) $3u^2/g$ (B) $4u^2/g$ (C) $6u^2/g$ (D) $9u^2/g$

Q.10 Two stones of different masses are dropped simultaneously from the top of a building-
(A) Smaller stone hits the ground earlier
(B) Larger stone hits the ground earlier
(C) Both stones reach the ground simultaneously
(D) Which of the stones reaches the ground earlier depends on the composition of the stone.

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Q.11 A body thrown with an initial speed of 96 ft/sec reaches the ground after ($g = 32ft/sec^2$)

(A) 3 sec (B) 6 sec (C) 12sec (D) 8sec

Q.12 A stone is dropped from a certain height which can reach the ground in 5 second. If the stone is stopped after 3 second of its fall and then allowed to fall again, then the time taken by the stone to reach the ground for the remaining distance is-

(A) 2 sec (B) 3 sec (C) 4 sec (D) None of these

Q.13 A man in a balloon rising vertically with an acceleration of 4.9 m/sec^2 releases a ball 2 sec after the balloon is let go from the ground. The greatest height above the ground reached by the ball is ($g = 9.8\ m/sec^2$)

(A) 14.7 m (B) 19.6 m (C) 9.8 m (D) 24.5 m

Q.14 A particle is dropped under gravity from rest from a height h($g = 9.8\ m/sec^2$) and it travels a distance 9h/25 in the last second, the height h is-

(A) 100m (B) 122.5 m (C) 145 m (D) 167.5 m

Q.15 A ball is dropped from top of a tower of 100 m height. Simultaneously, another ball is thrown upward from bottom of the tower with a speed of 50 m/s ($g = 10m/s^2$). They will cross each other after-

(A) 1s (B) 2s (C) 3s (D) 4s

Q.16 A cricket ball is thrown up with a speed of 19.6 ms^{-1}. The maximum height it can reach is-

(A) 9.8 m (B) 19.6 m (C) 29.4 m (D) 39.2 m

Q.17 A very large number of balls are thrown vertically upwards in quick succession in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute is (take $g = 10\ ms^{-2}$).

(A) 120 (B) 80 (C) 60 (D) 40

Q.18 A body, falling from a high Minaret travels 40 meters in the last 2 seconds of its fall to ground. Height of Minaret in metres is (take $g = 10\ m/s^2$)

(A) 60 (B) 45 (C) 80 (D) 50

Q.19 A body falls from a height h = 200 m (at New Delhi). The ratio of distance travelled in each 2 sec during t = 0 to t = 6 second of the journey is-

(A) 1 : 4 : 9 (B) 1 : 2 : 4 (C) 1 : 3 : 5 (D) 1 : 2 : 3

Q.20 A man drops a ball downside from the roof of a tower of height 400 meters. At the same time, another ball is thrown upside with a velocity 50 meter/sec from the surface of the tower, then they will meet at which height from the surface of the tower ?

(A) 100 meters (B) 320 meters (C) 80 meters (D) 240 meters

Q.21 Two balls are dropped from heights h and 2h respectively from the earth surface. The ratio of time of these balls to reach the earth is-

(A) $1 : \sqrt{2}$ (B) $\sqrt{2} : 1$ (C) 2 : 1 (D) 1 : 4

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Q.22 The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on planet B. A man jumps to a height of 2m on the surface of A. What is the height of jump by the same person on the planet B-

(A) 18m (B) 6m (C) $\frac{2}{3}$m (D) $\frac{2}{9}$m

Q.23 A body falls from rest in the gravitational field of the earth. The distance travelled in the fifth second of its motion is (g = 10 m/s^2)

(A) 25m (B) 45m (C) 90m (D) 125m

Q.24 If a body is thrown up with the velocity of 15 m/s then maximum height attained by the body is (g = 10 m/s^2)

(A) 11.25 m (B) 16.2 m (C) 24.5 m (D) 7.62 m

Q.25 A balloon is rising vertically up with a velocity of 29 ms^{-1}. A stone is dropped from it and it reaches the ground in 10 seconds. The height of the balloon when the stone was dropped from it is (g = 9.8 ms^{-2})

(A) 100 m (B) 200 m (C) 400 m (D) 150 m

Q.26 A ball is released from the top of a tower of height h meters. It takes T seconds to reach the ground. What is the position of the ball in T/3 seconds ?

(A) h/9 meters from the ground (B) 7h/9 meters from the ground

(C) 8h/9 meters from the ground (D) 17h/18 meters from the ground

Q.27 Two balls are of same size but the density of one is greater than that of the other. They are dropped from the same height, then which ball will reach the earth first (air resistance is negligible)

(A) Heavy ball (B) Light ball

(C) Both simultaneously (D) Will depend upon the density of the balls

Q.28 A packet is dropped from a balloon which is going upwards with the velocity 12m/s. The velocity of the packet after 2 seconds will be-

(A) – 12 m/s (B) 12 m/s (C) – 7.6 m/s (D) 7.6 m/s

Q.29 A body, thrown upwards with some velocity reaches the maximum height of 50 m. Another body with double the mass thrown up with double the initial velocity will reach a maximum height of-

(A) 100 m (B) 200 m (C) 300 m (D) 400 m

Q.30 Three particles A, B and C are thrown from the top of a tower with the same speed. A is thrown up, B is thrown down and C is thrown horizontally. They hit the ground with speeds V_A, V_B and V_C respectively-

(A) $V_A = V_B = V_C$ (B) $V_A = V_B > V_C$ (C) $V_B > V_C > V_A$ (D) $V_A > V_B = V_C$

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Q.31 From the top of a tower, two stones, whose masses are in the ratio 1 : 2 are thrown one straight up with an initial speed u and the second straight down with the same speed u. Then, neglecting air resistance-

(A) The heavier stone hits the ground with a higher speed.

(B) The lighter stone hits the ground with a higher speed.

(C) Both the stones will have the same speed when they hit the ground.

(D) The speed can't be determined with the given data.

Q.32 When a ball is thrown up vertically with velocity V_0, it reaches a maximum height of 'h'. If one wishes to triple the maximum height then the ball should be thrown with velocity-

(A) $\sqrt{3}\,V_0$ (B) $3V_0$ (C) $9V_0$ (D) $3/2V_0$

Q.33 An object starts sliding on a frictionless inclined plane and from same height another object starts falling freely-

(A) Both will reach with same speed (B) Both will reach with same acceleration

(C) Both will reach in same time (D) None of these.

Q.34 A parachutist, after bailing out falls 50m without friction. When parachute opens, it decelerates at $2 m/s^2$. He reaches the ground with a speed of 3m/sec. At what height did he bail out ?

(A) 293 m (B) 111 m (C) 91 m (D) 182 m

LEVEL # 2

MORE THAN ONE CHOICE MAY BE CORRECT :

Q.1 A stone thrown upward with speed u, from the top of the tower, reaches the ground with a velocity 3u. The height of the tower is-

(A) $\frac{3u^2}{g}$ (B) $\frac{4u^2}{g}$ (C) $\frac{6u^2}{g}$ (D) $\frac{9u^2}{g}$

Q.2 A body is thrown up with a velocity of 40 ms^{-1}. At a height of 60 m, its velocity will be-

(A) 10 ms^{-1} upward (B) 20 ms^{-1} upward

(C) 10 ms^{-1} downward (D) 20 ms^{-1} downward

Q.3 A ball falling down strikes the floor vertically with a velocity 20 m/s and rises up with a velocity of 20 m/s. It is in contact with the floor for 0.1 s. What is the acceleration produced ?

(A) 0 (B) 4 m/s^2 (C) 40 m/s^2 (D) 400 m/s^2

Q.4 A ball is thrown vertically upwards from the top of a tower at 4.9 m/s and hits the ground near its base after 3 seconds. The height of the tower is-

(A) 14.7 m (B) 29.4 m (C) 73.5 m (D) 44.1 m

Q.5 A body of mass 2 kg is projected vertically upwards with a velocity of 2 ms^{-1}. The K.E. of the body just before striking the ground is

(A) 2 J (B) 1 J (C) 4 J (D) 8 J

Q.6 A body of mass 3 kg is thrown up vertically with a K.E. of 490 J. If g = 9.8 ms^{-2}, height at which the K.E. of the body becomes half the initial value is

(A) 50 m (B) 25 m (C) 12.5 m (D) 10 m.

Q.7 A body A of mass 4 kg is dropped from a height of 100 m. Another body B of mass 2 Kg is dropped from a height of 50 m at the same time.

(A) Both the bodies reach the ground simultaneously.

(B) A take nearly 0.7th of time required by B.

(C) B take nearly 0.7th of time required by A.

(D) A take double 0.7th of time required by B.

Q.8 From the top of a tower, a stone is thrown up and reaches the ground in time t_1. A second stone is thrown down with the same speed and reaches the ground in time t_2. A third stone is released from rest and reaches the ground in time t_3.

(A) $t_3 = \frac{1}{2}(t_1+t_2)$ (B) $t_3 = \sqrt{t_1 t_2}$ (C) $\frac{1}{t_3} = \frac{1}{t_2} - \frac{1}{t_1}$ (D) $t_3^2 = t_1^2\ t_2^2$

Q.9 Water drops fall at regular intervals from a roof. At an instant, when a drop is about to leave the roof, the separations between 3 successive drops below the roof are in the ratio

(A) 1 : 2 : 3 (B) 1 : 4 : 9 (C) 1 : 3 : 5 (D) 1 : 5 : 13

Q.10 Three particles A, B and C are thrown from the top of a tower with the same speed. A is thrown straight up, B is thrown straight down and C is thrown horizontally. They hit the ground with speeds υ_A , υ_B and υ_C respectively.

(A) $\upsilon_A = \upsilon_B = \upsilon_C$ (B) $\upsilon_B > \upsilon_C > \upsilon_A$ (C) $\upsilon_A = \upsilon_B > \upsilon_C$ (D) $\upsilon_A > \upsilon_B = \upsilon_C$

Q.11 A balloon starts rising from the ground with an acceleration of 1.25 m/s^2. After 8 s, a stone is released from the balloon. The stone will

(A) cover a distance of 40 m (B) have a displacement of 50 m

(C) reach the ground in 4 s (D) begin to move down after being released

Q.12 A particle thrown up vertically, reaches it's highest point in time t_1 and returns to the ground in further time t_2. The air resistance exerts a constant force on the particle opposite to its direction of motion.

(A) $t_1 > t_2$ (B) $t_1 = t_2$ (C) $t_1 < t_2$

(D) May be (A) or (B) depending on the ratio of the force of air resistance to the weight of the particle.

Q.13 A man on a moving cart, facing in the direction of motion, throws a ball straight up with respect to himself.

(A) The ball will always return to him.

(B) The ball will never return to him.

(C) The ball will return to him if the cart moves with a constant velocity.

(D) The ball will fall behind him if the cart moves with some acceleration.

ANSWER KEY

LEVEL # 1

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	C	B	D	C	B	C	A	B	B	C	B	C	A	B	B
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	B	C	B	C	C	A	A	B	A	B	C	C	C	B	A
Que.	31	32	33	34											
Ans.	C	A	A	A											

LEVEL # 2

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13
Ans.	B	B,D	D	B	C	C	C	B	C	A	C	C	C,D