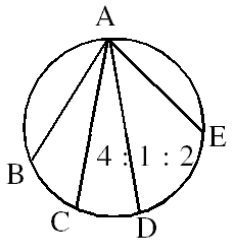
Motion under Gravity

1. **A disc arranged in a vertical plane has several grooves directed along chords drawn from a point 'A' as shown in the figure. Several bodies begin to slide down the respective grooves from 'A' simultaneously. The ratio of their times of slide will be in the ratio (neglect friction and air resistance)**



1) AB: AC: AD: AE 2) 1: 1: 1: 1 3) AE: AD: AC: AB 4) 1:2:3:4

2. **At the maximum height of a body thrown vertically up**

1) Velocity is not zero but acceleration is zero.

2) Acceleration is not zero but velocity is zero.

3) Both acceleration and velocity is zero.

4) Both acceleration and velocity are not zero.

3. **(A): A metal ball and a wooden ball of same radius are dropped from the same height in vacuum reach the ground same time.**

(R): In vacuum all the bodies dropped from same height take same time to reach the ground.

(1) Both (A) and (R) are true and (R) is the correct explanation of (A).

(2) Both (A) and (R) are true and (R) is not the correct explanation of (A).

(3) (A) is true but (R) is false.

(4) (A) is false but (R) is true.

4. **(A): A hunter fires with a un calibrated rifle at a monkey sitting on the top of a tree. Simultaneously, the monkey drops, but the bullet hits it.**

(R): The height lost by the bullet is the same as in the free ball.

(1) Both A and R are true and R is the correct explanation of A.

(2) Both A and R are true, but R is not the correct explanation of A.

(3) A is true, but R is false.

(4) A is false but R is true.

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5. An object is thrown vertically up with velocity u. It crosses a height h at time t_1 during ascent and re crosses the same height during descent at time t_2, both the time are reckoned from the instant the object thrown.

Match the following.

List - 1	List - 2
(a) $t_1 + t_2$	**(e) $\frac{2h}{g}$**
(b) $t_1 t_2$	**(f) $\frac{2u}{g}$**
(c) t_1 and t_2 are real	**(g) $\frac{2gh}{u^2} > 1$**
(d) t_1 and t_2 are imaginary	**(h) $\frac{2gh}{u^2} < 1$**

(1) a-f, b-e, c-g, d-h (2) a-f, b-e, c-h, d-g (3) a-e, b-f, c-h, d-g (4) a-e, b-f, c-g, d-h

6. A body projected vertically with a velocity 'u' from the ground. Its velocity

a) At half of maximum height u/2

b) At 3/4th of maximum height $\frac{u}{\sqrt{2}}$

c) At 1/3rd of maximum height $\sqrt{\frac{2}{3}}u$

d) At 1/4th of maximum height $\frac{\sqrt{3}}{2}u$

(1) a and b correct (2) b is correct (3) c and d correct (4) a is correct

7. A passenger in a train drops a ball from the window of a train running at acceleration 'a'. A pedestrian, on the ground, by the side of the rails, observes the ball falling along

(1) The vertical with an acceleration $\sqrt{g^2 + a^2}$ (2) The vertical with an acceleration $\sqrt{g^2 - a^2}$

(3) A parabola with an acceleration $\sqrt{g^2 + a^2}$ (4) A parabola with an acceleration 'g'

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8. A man sitting in a train in motion is facing the engine. He tosses a coin up and the coin falls behind him. The train is

(1) Moving forward with uniform speed (2) Moving backward with uniform speed

(3) Moving forward with acceleration (4) Moving forward with deceleration

9. A body falls freely from a height 'h' after two seconds if acceleration due to gravity is reversed the body

1) Continues to fall down

2) Falls down with retardation & goes up again with acceleration

3) Falls down with uniform velocity

4) Raises up with acceleration

10. From the top of a tower a body A is thrown up vertically with velocity u and another body B is thrown vertically down with the same velocity u. If v_A and v_B are their velocities when they reach the ground and t_A and t_B are their times of flight, then

1) $v_A = v_B$ and $t_A = t_B$ 2) $v_A > v_B$ and $t_A > t_B$

3) $v_A = v_B$ and $t_A > t_B$ 4) $v_A < v_B$ and $t_A < T_b$

11. A body is dropped from a height 122.5 m. If it's stopped after 3 seconds and again released the further time of descent is

1) 2 s 2) 3 s 3) 4 s 4) 5 s

12. A splash is heard 3.12s after a stone is dropped into a well 45m deep. The speed of sound in air is [g=10ms $^{-2}$]

1) 330 ms^{-1} 2) 375 ms^{-1} 3) 340 ms^{-1} 4) 346 ms^{-1}

13. A stone is dropped into a well of 20m deep. Another stone is thrown downward with velocity v one second later. If both stones reach the water surface in the well simultaneously, v is equal to (g=10ms^{-2})

1) 30 ms^{-1} 2) 15 ms^{-1} 3) 20 ms^{-1} 4) 10 ms^{-1}|

14. A body is projected vertically up with velocity 98ms^{-1}. After 2s if the acceleration due to gravity of earth disappears, the velocity of the body at the end of next 3s is

1) 49 ms^{-1} 2) 49.6 ms^{-1} 3) 78.4 ms^{-1} 4) 94.7 ms^{-1}

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15. The distance travelled by a body during last second of its total flight is d when the body is projected vertically up with certain velocity. If the velocity of projection is doubled, the distance travelled by the body during last second of its total flight is

1) 2 d 2) d 3) $2d+\frac{g}{2}$ 4) $2d-\frac{g}{2}$

16. Water drops fall from the roof of a building 20m high at regular time i intervals. If the first drop strikes thefloor when the sixth drop begins to fall, the heights of the second and fourth drops from the ground at that instant are ($g=10ms^{-2}$)

1) 12.8 m and 3.2 m 2) 12.8 m and 7.2 m 3) 19.2 m and 0.8 m 4) 7.2 m and 16.8 m

17. Two balls are dropped from the same height from places A and B. The body at B takes two seconds less to reach the ground at B and strikes the ground with a velocity greater than at A by 10 m/s. The product of the acceleration due to gravity at the two places A and B is

1) 5 2) 25 3) 125 4) 12.5

18. A boy sees a ball go up and then down through a window 2.45m high. If the total time that ball is in sight in 1s, the height above the window the ball raises is approximately

1) 2.45 m 2) 4.9 m 3) 0.3 m 4) 0.49 m

19. A ball is released from the top of a tower of height 'h' with zero initial velocity reaches the ground in 'T' second. Where was the ball at the time't/2' seconds later?

(1) At 3h/4 meters from the ground (2) At h/2 meters from the ground

(3) At h/6 meters from the ground (4) At h/4 meters from the ground

20. An object projected upwards acquires a velocity of 9.8 m/sec when it reaches half of the maximum height. The maximum height reached is

(1) 9.8 m (2) 8.8 m (3) 7.8 m (4) 4.9 m

21. A balloon is flying up with a constant velocity of 5m/s, at a height of 100 m. a stone is dropped from it. At the instant the stone reaches ground level, the height of the balloon will be

(1) 25 m (2) 50 m (3) 125 m (4) 100 m

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22. A stone is dropped from a height 'h' and simultaneously another stone is thrown up from the ground which reaches a height 4h. The two stones cross each other after time.

(1) $\sqrt{\frac{h}{8g}}$ (2) $\sqrt{8gh}$ (3) $\sqrt{2gh}$ (4) $\sqrt{\frac{h}{2g}}$

23. A balloon rises from rest with a constant acceleration g/8. A stone is released from it when it has risen to a height 'h'. The time taken by the stone to reach the ground is

(1) $4\sqrt{\frac{h}{g}}$ (2) $2\sqrt{\frac{h}{g}}$ (3) $\sqrt{\frac{2h}{g}}$ (4) $\sqrt{\frac{g}{h}}$

24. 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

(1) 6 sec (2) 8 sec

(3) 10 sec (4) 12 sec

25. A body freely falling from the rest has a velocity '*v*' after it falls through a height '*h*'. The distance it has to fall down for its velocity to become double, is

(1) $2h$ (2) $4h$

(3) $6h$ (4) $8h$

26. A body thrown vertically upwards with an initial velocity u reaches maximum height in 6 seconds. The ratio of the distances travelled by the body in the first second and the seventh second is

(1) 1: 1 (2) 11: 1

(3) 1: 2 (4) 1: 11

27. A man throws a ball vertically upward and it rises through 20 *m* and returns to his hands. What was the initial velocity (u) of the ball and for how much time (T) it remained in the air $[g = 10 m/s^2]$

(1) u = 10 *m/s*, T = 2*s* (2)u = 10 *m/s*, T = 4*s*

(3) u = 20 *m/s*, T = 2*s* (4)u = 20 *m/s*, T = 4*s*

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28. 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 5*m*, the number of ball thrown per minute is (taking $g = 10\, ms^{-2}$)

(1) 120 (2) 80

(3) 60 (4) 40

29. 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*

(1) $18m$ (2) $6m$

(3) $\frac{2}{3}m$ (4) $\frac{2}{9}m$

30. A ball is projected upwards from a height h above the surface of the earth with velocity v. The time at which the ball strikes the ground is

(1) $\frac{v}{g}+\frac{2hg}{\sqrt{2}}$ (2) $\frac{v}{g}\left[1-\sqrt{1+\frac{2h}{g}}\right]$

(2) $\frac{v}{g}\left[1+\sqrt{1+\frac{2gh}{v^2}}\right]$ (4) $\frac{v}{g}\left[1+\sqrt{v^2+\frac{2g}{h}}\right]$

31. A particle is dropped vertically from rest from a height. The time taken by it to fall through successive distances of 1 *m* each will then be

(1) All equal, being equal to $\sqrt{2/g}$ second

(2) In the ratio of the square roots of the integers 1, 2, 3..

(3) In the ratio of the difference in the square roots of the integers *i.e.*

$\sqrt{1},(\sqrt{2}-\sqrt{1}),(\sqrt{3}-\sqrt{2}),(\sqrt{4}-\sqrt{3})$....

(4) In the ratio of the reciprocal of the square roots of the integers *i.e.* $\frac{1}{\sqrt{1}},\frac{1}{\sqrt{2}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{4}}$

32. A man throws balls with the same speed vertically upwards one after the other at an interval of 2 seconds. What should be the speed of the throw so that more than two balls are in the sky at any time (Given $g = 9.8m/s^2$)

(1) At least 0.8 *m/s*

(2) Any speed less than 19.6 *m/s*

(3) Only with speed 19.6 *m/s*

(4) More than 19.6 *m/s*

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33. If a ball is thrown vertically upwards with speed u, the distance covered during the last t seconds of its ascent is

(1) $\frac{1}{2}gt^2$ (2) $ut - \frac{1}{2}gt^2$

(3) $(u - gt)t$ (4) ut d

34. A small block slides without friction down an inclined plane starting from rest. Let S_n be the distance travelled from time $t = n-1$ to $t = n$. then $\frac{S_n}{S_{n+1}}$ is

(1) $\frac{2n-1}{2n}$ (2) $\frac{2n+1}{2n-1}$

(3) $\frac{2n-1}{2n+1}$ (4) $\frac{2n}{2n+1}$

Key

1) 2	**2) 2**	**3)1**	**4) 1**	**5) 2**	**6) 3**	**7) 4**	**8) 3**
9) 2	**10) 3**	**11) 3**	**12) 2**	**13) 2**	**14) 3**	**15) 3**	**16)4**
17) 2	**18) 3**	**19) 1**	**20) 1**	**21) 3**	**22) 1**	**23) 2**	**24) 4**
25)2	**26) 2**	**27) 4**	**28)3**	**29) 1**	**30) 3**	**31)3**	**32) 4**
33)1	**34)3**						

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11. $h = \frac{1}{2} \times 9.8 \times 9 \Rightarrow 44.1$

$122.5 - 44.1 = 78.4$

$t = \sqrt{\frac{2 \times 78.4}{28}} \Rightarrow t = 4 \text{ s}$

12. $t = \sqrt{\frac{2 \times 45}{10}} = 3s$

$v = \frac{45}{0.12} = \frac{4500}{12} = 375 \text{ m/s}$

13. $t = \sqrt{\frac{2 \times 20}{10}} = 2s$

$t = 2 \text{ s}$

$20 = v(1) + \frac{1}{2} 10 \times 1^2 \quad v = 15 \text{ m/s}$

14. $v = 98 - 2 \times 9.8 = 78.4 \text{ m/s}$

15. $d = u - g/2 \quad d^1 = 2u - g/2$

$= 2\left(d + \frac{g}{2}\right) - \frac{g}{2} = 2d + g - g/2 \quad d^1 = 2d + g/2$

16. 5 drops are in motion

$9x + 7x + 5x + 3x + x = 20$

$25x = 20 \Rightarrow x = \frac{4}{5} = 0.8$

$h_{2nd} = 9x = 7.2m$

$h_{4th} = 21x = 16.8m$

17. $\frac{V}{t} = \sqrt{g_1 g_2} \quad \frac{10}{2} = \sqrt{g_1 g_2}$

$g_1 g_2 = 25$

18. $x = ut + \frac{1}{2} gt^2 \qquad 2.45 = \frac{g}{4}$

$\frac{g}{4} = u\left(\frac{1}{2}\right) + \frac{g}{2}\left(\frac{1}{2}\right)^2$

$\frac{g}{4} = \frac{u}{2} + \frac{g}{8}$

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$\frac{g}{4} = \frac{u}{2} \rightarrow u = \frac{g}{4}$

$h = \frac{u^2}{2g} = \frac{1}{2g} \times \frac{g^2}{16}$

$h = \frac{g}{32} = 0.3m$

19. $h = \frac{1}{2} gt^2 = g\frac{1}{2} T^2$

At time $\frac{T}{2}$, $s = \frac{1}{2} g\left(\frac{T}{2}\right)^2 = \frac{h}{4}$

Distance from ground = $h - \frac{h}{4} = \frac{3h}{4}$

20. $9.8^2 = u^2 - 2g \times \frac{h}{2} = u^2 - gh$

$0 = u^2 - 2gh$

$\Rightarrow 9.8^2 = gh$

$h = 9.8$ m

21. Time taken by the stone to reach the ground level

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

$100 = -5t + \frac{1}{2} \times 10t^2$

$t^2 - t - 20 = 0$

$t = \frac{1 \pm \sqrt{1+80}}{2} = 5$ sec

Additional distance covered by the balloon is 5s.

$d = v \times t = 5 \times 5 = 25$ m

$h = 100 + 25$ m $= 125$ m

22. Let the two stones cross each other at height x from the ground level

$v^2 = a^2 - 2gs$

$0 = u^2 - 2g(4h)$

$u = \sqrt{8gh}$

$x = \sqrt{8gh}\ t - \frac{1}{2} gt^2$, $h - x = \frac{1}{2} gt^2$

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$h = \sqrt{8gh}\ t \quad t = \sqrt{\frac{h}{8g}}$

23. Velocity of balloon at height h

$v = \sqrt{2as} = \sqrt{2 \times \frac{g}{8} \times h} = \sqrt{\frac{hg}{4}}$

$h = -\sqrt{\frac{gh}{4}}\ t + \frac{1}{2}\ gt^2$

$t^2 - \sqrt{\frac{h}{g}}\ t - \frac{2h}{g} = 0$

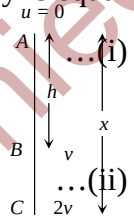
$t = \frac{\sqrt{h/g} \pm \sqrt{h/g + \frac{8h}{g}}}{2} = 2\sqrt{h/g}$

24. Let t be the time of flight of the first body after meeting, then $(t-4)sec$ will be the time of flight of the second body. Since $h_1 = h_2$

$\therefore 98t - \frac{1}{2}gt^2 = 98(t-4) - \frac{1}{2}g(t-4)^2$

On solving, we get $t = 12$ *seconds*

25. Let at point A initial velocity of body is equal to zero



For path AB : $v^2 = 0 + 2gh$ …(i)

For path AC : $(2v)^2 = 0 + 2gx$

$4v^2 = 2gx$ …(ii)

Solving (i) and (ii) $x = 4h$

26. Time of ascent $= \frac{u}{g} = 6\ \text{sec} \Rightarrow u = 60\ m/s$

Distance in first second $h_{\text{first}} = 60 - \frac{g}{2}(2 \times 1 - 1) = 55\ m$

Distance in seventh second will be equal to the distance in first second of vertical downward motion $h_{\text{seventh}} = \frac{g}{2}(2 \times 1 - 1) = 5\ m \Rightarrow h_{\text{first}} / h_{\text{seventh}} = 11:1$

27. $u = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20\ m/s$

And $T = \frac{2u}{g} = \frac{2 \times 20}{10} = 4\ sec$

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28. Maximum height of ball = 5 m

So velocity of projection $\Rightarrow u = \sqrt{2gh} = 10\ m/s$

Time interval between two balls (time of ascent)

$= \frac{u}{g} = 1\ sec = \frac{1}{60} min$.

So number of ball thrown per min. = 60

29. $H_{\max} = \frac{u^2}{2g} \Rightarrow H_{\max} \propto \frac{1}{g}$

On planet B value of g is $1/9$ times to that of A. So value of $H_{\max}$ will become 9 times

i.e. $2 \times 9 = 18\ metre$

30. Since direction of v is opposite to the direction of g and h so from equation of motion

$$h = -vt + \frac{1}{2}gt^2$$

$$\Rightarrow gt^2 - 2vt - 2h = 0$$

$$\Rightarrow t = \frac{2v \pm \sqrt{4v^2 + 8gh}}{2g}$$

$$\Rightarrow t = \frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right]$$

31. $h = ut + \frac{1}{2}gt^2 \Rightarrow 1 = 0 \times t_1 + \frac{1}{2}gt_1^2 \Rightarrow t_1 = \sqrt{2/g}$

Velocity after travelling 1m distance

$v^2 = u^2 + 2gh \Rightarrow v^2 = (0)^2 + 2g \times 1 \Rightarrow v = \sqrt{2g}$

For second 1 meter distance $1 = \sqrt{2g} \times t_2 + \frac{1}{2}gt_2^2 \Rightarrow gt_2^2 + 2\sqrt{2g}t_2 - 2 = 0$

$$t_2 = \frac{-2\sqrt{2g} \pm \sqrt{8g + 8g}}{2g} = \frac{-\sqrt{2} \pm 2}{\sqrt{g}}$$

Taking +ve sign $t_2 = (2 - \sqrt{2})/\sqrt{g}$

$\therefore \frac{t_1}{t_2} = \frac{\sqrt{2/g}}{(2-\sqrt{2})/\sqrt{g}} = \frac{1}{\sqrt{2}-1}$ and so on.

32. Interval of ball throw = 2 *sec*.

If we want that minimum three (more than two) ball remain in air then time of flight of first ball must be greater than 4 *sec*.

$T > 4\ sec$

$\frac{2u}{g} > 4\ sec \Rightarrow u > 19.6\ m/s$

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For u =19.6. First ball will just strike the ground(in sky)

Second ball will be at highest point (in sky)

Third ball will be at point of projection or at ground (not in sky)

33. The distance covered by the ball during the last t seconds of its upward motion = Distance covered by it in first t seconds of its downward motion

From $h = ut + \frac{1}{2} g t^2$

$h = \frac{1}{2} g\ t^2$ [*As* u = 0 for it downward motion]

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