EXERCISE 6. UNIFORMLY *g* ACCELERATED MOTION

[In all problems $g = 9.8$ m s^{-2}]

1. A vase falls from a shelf 140 cm above the floor. Find the speed with which it strikes the floor.

2. A stone is dropped from a point 49 m above the ground. Find the time for it to reach the ground.

3. A stone is thrown down at 5 m s^{-1}. If its speed on hitting the ground is 19 m s^{-1} from what height was it thrown. How long does it take?

4. A stone is dropped from the top of a tower and falls to the ground. If it strikes the ground at 14 m s^{-1}, how high is the tower?

5. A ball is thrown vertically downwards from the top of a tower with an initial speed of 2 m s^{-1}. If it hits the ground 3 s later find
(i) the height of the tower,
(ii) the speed with which it hits the ground.

6. A stone is thrown upwards with a speed of 21 m s^{-1}. Find its height
(i) 1 s after projection,
(ii) 2 s after projection,
(iii) 3 s after projection.

7. A ball is thrown up at 14 m s^{-1} from a point 2 m above the ground. Find
(i) the speed when it returns to the level of projection,
(ii) the speed on the ground.

8. A ball is thrown vertically up at 28 m s^{-1}. Find
(i) the maximum height,
(ii) the time to reach the maximum height,
(iii) the velocity of return,
(iv) the total time for the journey.

9. A balloon is rising at a steady speed of 3 m s^{-1}. How high is it above the ground after 10 s? At this instant a man releases a stone. What is the initial velocity of the stone? How long does it take to reach the ground? How high is the balloon above the ground when the stone strikes the ground?

10. A stone is thrown up at 49 m s^{-1} from the ground. Find the times at which the particle is 78.4 m above the ground. Find the time interval for which the particle is above 78.4 m.

11. A ball is thrown up at 14 m s^{-1}. Find the times at which the particle is 9.1 m above the ground.

12. A ball is thrown up at 49 m s^{-1}. How long does it take to reach its maximum height? If an other ball was thrown up 1 s after the first one, how high is it above the ground when the first ball has reached its maximum height if it has the same initial velocity?

13. A jumper can jump 2 m on the Earth. What is his take-off speed? How high can he jump on the moon?
(Acceleration due to gravity of moon g = 1.6 m s^{-1})

14. A particle is thrown vertically upwards under gravity with a speed of 16 m s^{-1}. One second later another particle is fired upwards from the same point. Find the initial speed of this particle in order that the two particles will collide when the first particle has reached its highest point.

15. An object falls vertically past a window 2 m high in $\frac{1}{12}$ s. Find the height above the window from which the object was dropped.

16. A stone is dropped from a balloon rising at 10 m s^{-1} and reaches the ground in 8 s. How high was the balloon above the ground when the stone was dropped?

17. A body falls from the top of a tower and during the last second it falls $\frac{9}{25}$ of the total distance. Find the height of the tower.

18. A particle falls freely from rest from a point o passing three points a, b and c, the distances $|ab|$ and $|bc|$ being equal. If the particle takes 3 s to pass from a to b and 2 s from b to c, calculate $|ab|$.

19. A body falls freely from rest from a point o passing three points a, b and c, the distances $|ab|$ and $|bc|$ being equal. The time taken to go from a to b is 2 s and from b to c is 1 s. Find $|ab|$.

20. A particle falls freely under gravity from rest at a point p. After it has fallen for 1 s another particle is projected vertically downwards from p with speed 14.7 m s^{-1}. Find the time and distance from p at which they collide.

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21. A particle is projected vertically upwards and k seconds later another particle is projected vertically upwards with the same initial speed. Prove that if they meet, they will be travelling with equal and opposite velocities of magnitude $\frac{1}{2}gk$. What is the condition that they meet?

22. A particle P is projected vertically upwards form a point o with speed u. Find the greatest height h of P in terms of u. If $\frac{nu}{g}$ seconds after P is projected ($n > 0$) a second particle Q is let fall from rest from a height h above o prove that when P and Q meet they will have the same speed for all values of n, $0 \le n \le 1$.

23. A particle is projected vertically upwards, and t seconds later another particle is projected vertically upwards with the same initial speed. Prove that their velocities on meeting will be $\frac{1}{2}gt$. If u was the initial speed of each particle prove that the particles meet after $\left(\frac{t}{2}+\frac{u}{g}\right)$ seconds at a height of $\frac{(4u^2-g^2t^2)}{8g}$ m.

24. If a body thrown vertically upwards takes t seconds to reach a height h metres and t' more seconds to return to the point of projection show that $h=\frac{1}{2}gtt'$. Prove that the greatest height is $\frac{1}{8}g(t+t')^2$ m and the velocity of projection is $\frac{1}{2}g(t+t')$ m s^{-1}.

25. A particle is projected vertically upwards and at the same time another particle is let fall from rest to meet it. When the particles meet they have equal speeds. Show that by the time they meet the distance travelled by one of the particles is three times the distance travelled by the other.

26. Two points A and B are in the same vertical line with A a distance h above B. A particle b is projected from B with speed u towards A and T seconds later a particle a at A is let fall from rest. If $u > gt$ find the time after which a and b meet and the distance below A where this happens.

27. A ball is thrown vertically upwards close to a wall. When it comes down it is allowed to bounce and rise again. A person on the far side of the wall can see it for t_1 seconds when it rises for the first time and for t_2 seconds when it rises for the second time. Assuming that its velocity was reduced in the ratio e:1 ($e < 1$) when it bounces, find the initial velocity of the ball and the height of the wall.

28. A particle is projected vertically upwards with initial velocity u and reaches a height h above the point of projection in time t. Prove that $h=ut-\frac{1}{2}gt^2$. If the particle is at height H above the point of projection at times t_1 and t_2 subsequent to the instant of projection prove that $\frac{1}{t_1}+\frac{1}{t_2}=\frac{u}{H}$.

Answers
Exercise 6

1. 5.24 m s^{-1}

2. 3.16 s

3. 17.14 m, 1.43 s

4. 10 m

5. (i) 50.1 m (ii) 31.4 m s^{-1}

6. (i) 16.1 m (ii) 22.4 m (iii) 18.9 m

7. (i) 14 m s^{-1} (ii) 15.34 m s^{-1}

8. (i) 40 m (ii) $\frac{20}{7}$ s (iii) 28 m s^{-1} (iv) $\frac{40}{7}$ s

9. 30 m, 3 m s^{-1}, 2.8 s, 38.4 m

10. 2 s, 8 s, 6 s

11. 1 s, $\frac{13}{7}$ s

12. 5 s, 117.6 m

13. 6.26 m s^{-1}, 12.25 m

14. 23·7 m s^{-1}

15. 28.4 m

16. 233·6 m

17. 122·5 m

18. 147 m

19. 29.4 m

20. 2 s, 19.6 m

21. $k < \frac{2u}{g}$

22. $\frac{u^2}{2g}$

26. $\frac{2h - gT^2}{2(u - gT)}, \frac{g(2h - 2uT + gT^2)^2}{8(u - gT)^2}$

27. $\frac{g}{2}\left(\frac{t_1^2 - t_2^2}{1 - e^2}\right)^{\frac{1}{2}}, \frac{g}{8}\left(\frac{e^2 t_1^2 - t_2^2}{1 - e^2}\right)$