MECHANICS

9709

(March, June and November series 2020 – 2023, Answers at the end)

Kinematics of motion is a straight line

Exercise - 1

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NOIDA

1 A particle P is projected vertically upwards with speed $20\,\text{m s}^{-1}$ from a point on the ground.

(a) Find the greatest height above the ground reached by P. [2]

(b) Find the total time from projection until P returns to the ground. [2]

QUESTION Question 1: sp_04_2020– 1: SP_20_04

2 A particle P moves in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t s is given by

$$\begin{aligned} v &= 5t(t-2) && \text{for } 0 \leqslant t \leqslant 4, \\ v &= k && \text{for } 4 \leqslant t \leqslant 14, \\ v &= 68 - 2t && \text{for } 14 \leqslant t \leqslant 20, \end{aligned}$$

where k is a constant.

(a) Find k. [1]

(b) Sketch the velocity–time graph for $0 \leqslant t \leqslant 20$. [3]

(c) Find the set of values of t for which the acceleration of P is positive. [2]

(d) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 20$. [5]

QUESTION – 6: SP_20_04

3.

A cyclist travels along a straight road with constant acceleration. He passes through points A, B and C. The cyclist takes 2 seconds to travel along each of the sections AB and BC and passes through B with speed $4.5\,\text{m s}^{-1}$. The distance AB is $\frac{4}{5}$ of the distance BC.

(a) Find the acceleration of the cyclist. [5]

(b) Find AC. [2]

QUESTION – 4: QP_M20_42

4.

A particle moves in a straight line through the point O. The displacement of the particle from O at time t s is s m, where

$$\begin{aligned} s &= t^2 - 3t + 2 && \text{for } 0 \leqslant t \leqslant 6, \\ s &= \frac{24}{t} - \frac{t^2}{4} + 25 && \text{for } t \geqslant 6. \end{aligned}$$

(a) Find the value of t when the particle is instantaneously at rest during the first 6 seconds of its motion. [2]

At $t = 6$, the particle hits a barrier at a point P and rebounds.

(b) Find the velocity with which the particle arrives at P and also the velocity with which the particle leaves P. [3]

(c) Find the total distance travelled by the particle in the first 10 seconds of its motion. [5]

QUESTION – 7: QP_M20_42

5.

A particle P is projected vertically upwards with speed $5\,\text{m s}^{-1}$ from a point A which is 2.8 m above horizontal ground.

(a) Find the greatest height above the ground reached by P. [3]

(b) Find the length of time for which P is at a height of more than 3.6 m above the ground. [4]

QUESTION – 3: QP_S20_41

6.

A particle moves in a straight line AB. The velocity $v\,\text{m s}^{-1}$ of the particle t s after leaving A is given by $v = k(t^2 - 10t + 21)$, where k is a constant. The displacement of the particle from A, in the direction towards B, is 2.85 m when $t = 3$ and is 2.4 m when $t = 6$.

(a) Find the value of k. Hence find an expression, in terms of t, for the displacement of the particle from A. [7]

(b) Find the displacement of the particle from A when its velocity is a minimum. [4]

QUESTION – 6: QP_S20_41

7.

A tram starts from rest and moves with uniform acceleration for 20 s. The tram then travels at a constant speed, $V\,\text{m s}^{-1}$, for 170 s before being brought to rest with a uniform deceleration of magnitude twice that of the acceleration. The total distance travelled by the tram is 2.775 km.

(a) Sketch a velocity-time graph for the motion, stating the total time for which the tram is moving. [2]

(b) Find V.

(c) Find the magnitude of the acceleration.

QUESTION – 1: QP_S20_42

8.

A particle P moves in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t s is given by

$$\begin{aligned} v &= 2t + 1 && \text{for } 0 \leqslant t \leqslant 5, \\ v &= 36 - t^2 && \text{for } 5 \leqslant t \leqslant 7, \\ v &= 2t - 27 && \text{for } 7 \leqslant t \leqslant 13.5. \end{aligned}$$

(a) Sketch the velocity-time graph for $0 \leqslant t \leqslant 13.5$. [3]

(b) Find the acceleration at the instant when $t = 6$. [2]

(c) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 13.5$. [5]

QUESTION – 6: QP_S20_42

9.

A car starts from rest and moves in a straight line with constant acceleration $a\,\text{m s}^{-2}$ for a distance of 50 m. The car then travels with constant velocity for 500 m for a period of 25 s, before decelerating to rest. The magnitude of this deceleration is $2a\,\text{m s}^{-2}$.

(a) Sketch the velocity-time graph for the motion of the car. [1]

(b) Find the value of a. [3]

(c) Find the total time for which the car is in motion. [3]

QUESTION – 4: QP_S20_43

10.

A particle travels in a straight line PQ. The velocity of the particle t s after leaving P is $v\,\text{m s}^{-1}$, where

$$v = 4.5 + 4t - 0.5t^2.$$

(a) Find the velocity of the particle at the instant when its acceleration is zero. [3]

The particle comes to instantaneous rest at Q.

(b) Find the distance PQ. [6]

QUESTION – 6: QP_S20_43

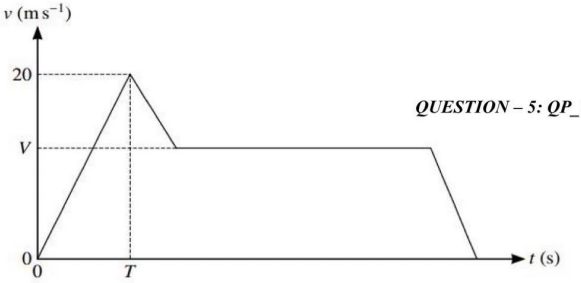
11.

A particle P moves in a straight line. It starts from rest at a point O on the line and at time t s after leaving O it has acceleration $a\,\text{m s}^{-2}$, where $a = 6t - 18$.

Find the distance P moves before it comes to instantaneous rest. [6]

QUESTION – 4: QP_W20_41

12.



QUESTION – 5: QP_W20_42

The diagram shows a velocity-time graph which models the motion of a car. The graph consists of four straight line segments. The car accelerates at a constant rate of $2\,\text{m s}^{-2}$ from rest to a speed of $20\,\text{m s}^{-1}$ over a period of T s. It then decelerates at a constant rate for 5 seconds before travelling at a constant speed of $V\,\text{m s}^{-1}$ for 27.5 s. The car then decelerates to rest at a constant rate over a period of 5 s.

(a) Find T. [1]

(b) Given that the distance travelled up to the point at which the car begins to move with constant speed is one third of the total distance travelled, find V. [4]

QUESTION – 4: QP_W20_42

13.

A particle P moves in a straight line, starting from a point O with velocity $1.72\,\text{m s}^{-1}$. The acceleration $a\,\text{m s}^{-2}$ of the particle, t s after leaving O, is given by $a = 0.1t^{\frac{3}{2}}$.

(a) Find the value of t when the velocity of P is $3\,\text{m s}^{-1}$. [4]

(b) Find the displacement of P from O when $t = 2$, giving your answer correct to 2 decimal places. [3]

QUESTION – 7: QP_W20_42

14.

A particle P is projected vertically upwards with speed $v\,\text{m s}^{-1}$ from a point on the ground. P reaches its greatest height after 3 s.

(a) Find v. [1]

(b) Find the greatest height of P above the ground. [2]

QUESTION – 1: QP_W20_43

15.

A particle P moves in a straight line. It starts at a point O on the line and at time t s after leaving O it has velocity $v\,\text{m s}^{-1}$, where $v = 4t^2 - 20t + 21$.

(a) Find the values of t for which P is at instantaneous rest. [2]

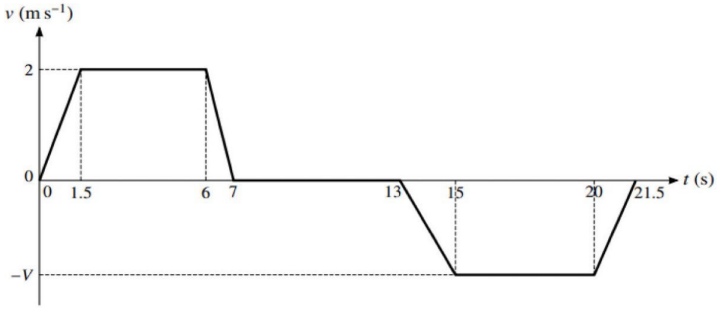
(b) Find the initial acceleration of P. [2]

(c) Find the minimum velocity of P. [2]

(d) Find the distance travelled by P during the time when its velocity is negative. [4]

QUESTION – 5: QP_W20_43

16.



An elevator moves vertically, supported by a cable. The diagram shows a velocity-time graph which models the motion of the elevator. The graph consists of 7 straight line segments.

The elevator accelerates upwards from rest to a speed of $2\,\text{m s}^{-1}$ over a period of 1.5 s and then travels at this speed for 4.5 s, before decelerating to rest over a period of 1 s.

The elevator then remains at rest for 6 s, before accelerating to a speed of $V\,\text{m s}^{-1}$ downwards over a period of 2 s. The elevator travels at this speed for a period of 5 s, before decelerating to rest over a period of 1.5 s.

(a) Find the acceleration of the elevator during the first 1.5 s. [1]

(b) Given that the elevator starts and finishes its journey on the ground floor, find V. [2]

(c) The combined weight of the elevator and passengers on its upward journey is 1500 kg. Assuming that there is no resistance to motion, find the tension in the elevator cable on its upward journey when the elevator is decelerating. [3]

QUESTION – 4: QP_M21_42

17.

A particle moves in a straight line. It starts from rest from a fixed point O on the line. Its velocity at time t s after leaving O is $v\,\text{m s}^{-1}$, where $v = t^2 - 8t^{\frac{3}{2}} + 10t$.

(a) Find the displacement of the particle from O when $t = 1$. [4]

(b) Show that the minimum velocity of the particle is $-125\,\text{m s}^{-1}$. [7]

18. *QUESTION – 6: QP_M21_42*

Two cyclists, Isabella and Maria, are having a race. They both travel along a straight road with constant acceleration, starting from rest at point A.

Isabella accelerates for 5 s at a constant rate $a\,\text{m s}^{-2}$. She then travels at the constant speed she has reached for 10 s, before decelerating to rest at a constant rate over a period of 5 s.

Maria accelerates at a constant rate, reaching a speed of $5\,\text{m s}^{-1}$ in a distance of 27.5 m. She then maintains this speed for a period of 10 s, before decelerating to rest at a constant rate over a period of 5 s.

(a) Given that $a = 1.1$, find which cyclist travels further. [5]

(b) Find the value of a for which the two cyclists travel the same distance. [2]

QUESTION – 4: QP_S21_41

19.

A particle moving in a straight line starts from rest at a point A and comes instantaneously to rest at a point B. The acceleration of the particle at time t s after leaving A is $a\,\text{m s}^{-2}$, where

$$a = 6t^{\frac{1}{2}} - 2t.$$

(a) Find the value of t at point B. [3]

(b) Find the distance travelled from A to the point at which the acceleration of the particle is again zero. [5]

QUESTION – 5: QP_S21_41

20.

A particle P moving in a straight line starts from rest at a point O and comes to rest 16 s later. At time t s after leaving O, the acceleration $a\,\text{m s}^{-2}$ of P is given by

$$\begin{aligned} a &= 6 + 4t \qquad 0 \leqslant t < 2, \\ a &= 14 \qquad\quad 2 \leqslant t < 4, \\ a &= 16 - 2t \qquad 4 \leqslant t \leqslant 16. \end{aligned}$$

There is no sudden change in velocity at any instant.

(a) Find the values of t when the velocity of P is $55\,\text{m s}^{-1}$. [5]

(b) Complete the sketch of the velocity-time diagram. [2]

(c) Find the distance travelled by P when it is decelerating. [3]

QUESTION – 7: QP_S21_42

21.

A particle is projected vertically upwards with speed u m s^{-1} from a point on horizontal ground. After 2 seconds, the height of the particle above the ground is 24 m.

(a) Show that $u = 22$. [2]

(b) The height of the particle above the ground is more than h m for a period of 3.6 s.

Find h. [4]

QUESTION – 4: QP_S21_43

22.

A particle moves in a straight line and passes through the point A at time $t = 0$. The velocity of the particle at time t s after leaving A is v m s^{-1}, where

$$v = 2t^2 - 5t + 3.$$

(a) Find the times at which the particle is instantaneously at rest. Hence or otherwise find the minimum velocity of the particle. [4]

(b) Sketch the velocity-time graph for the first 3 seconds of motion. [3]

(c) Find the distance travelled between the two times when the particle is instantaneously at rest. [3]

QUESTION – 6: QP_S21_43

23.

A bus moves from rest with constant acceleration for 12 s. It then moves with constant speed for 30 s before decelerating uniformly to rest in a further 6 s. The total distance travelled is 585 m.

(a) Find the constant speed of the bus. [2]

(b) Find the magnitude of the deceleration. [1]

QUESTION – 1:QP_W21_41

24.

A particle P moves in a straight line starting from a point O and comes to rest 14 s later. At time t s after leaving O, the velocity v m s^{-1} of P is given by

$$v = pt^2 - qt \qquad 0 \leqslant t \leqslant 6,$$
$$v = 63 - 4.5t \qquad 6 \leqslant t \leqslant 14,$$

where p and q are positive constants.

The acceleration of P is zero when $t = 2$.

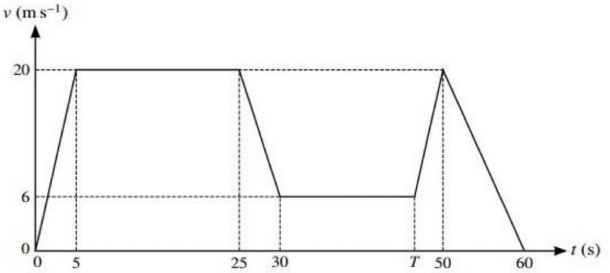
(a) Given that there are no instantaneous changes in velocity, find p and q. [3]

(b) Sketch the velocity-time graph. [3]

(c) Find the total distance travelled by P during the 14 s. [5]

QUESTION – 6: QP_W21_41

25.



The diagram shows a velocity-time graph which models the motion of a car. The graph consists of six straight line segments. The car accelerates from rest to a speed of $20\,\text{m s}^{-1}$ over a period of 5 s, and then travels at this speed for a further 20 s. The car then decelerates to a speed of $6\,\text{m s}^{-1}$ over a period of 5 s. This speed is maintained for a further $(T - 30)$ s. The car then accelerates again to a speed of $20\,\text{m s}^{-1}$ over a period of $(50 - T)$ s, before decelerating to rest over a period of 10 s.

(a) Given that during the two stages of the motion when the car is accelerating, the accelerations are equal, find the value of T. [2]

(b) Find the total distance travelled by the car during the motion. [2]

QUESTION – 1: QP_W21_41

26.

A cyclist starts from rest at a point A and travels along a straight road AB, coming to rest at B. The displacement of the cyclist from A at time t s after the start is s m, where

$$s = 0.004(75t^2 - t^3).$$

(a) Show that the distance AB is 250 m. [4]

(b) Find the maximum velocity of the cyclist. [3]

QUESTION – 4: QP_W21_42

27.

A particle P moves in a straight line, starting from rest at a point O on the line. At time t s after leaving O the acceleration of P is $k(16 - t^2)$ m s^{-2}, where k is a positive constant, and the displacement from O is s m. The velocity of P is 8 m s^{-1} when $t = 4$.

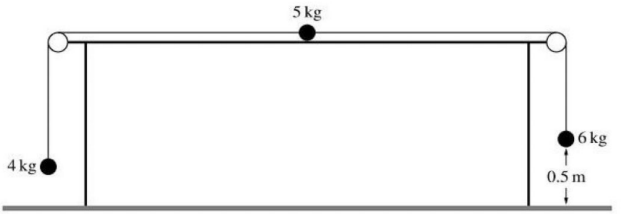
(a) Show that $s = \frac{1}{64}t^2(96 - t^2)$. [5]

(b) Find the speed of P at the instant that it returns to O. [3]

(c) Find the maximum displacement of the particle from O. [3]

QUESTION – 5: QP_W21_43

28.



The diagram shows a particle of mass 5 kg on a rough horizontal table, and two light inextensible strings attached to it passing over smooth pulleys fixed at the edges of the table. Particles of masses 4 kg and 6 kg hang freely at the ends of the strings. The particle of mass 6 kg is 0.5 m above the ground. The system is in limiting equilibrium.

(a) Show that the coefficient of friction between the 5 kg particle and the table is 0.4. [2]

29. ***QUESTION – 6(a): QP_W21_43***

A particle P is projected vertically upwards from horizontal ground with speed u m s^{-1}. P reaches a maximum height of 20 m above the ground.

(a) Find the value of u. [2]

(b) Find the total time for which P is at least 15 m above the ground. [3]

30. ***QUESTION – 2: QP_M21_42***

A cyclist starts from rest at a fixed point O and moves in a straight line, before coming to rest k seconds later. The acceleration of the cyclist at time t s after leaving O is a m s^{-2}, where $a = 2t^{-\frac{1}{2}} - \frac{3}{5}t^{\frac{1}{2}}$ for $0 < t \leqslant k$.

(a) Find the value of k. [4]

(b) Find the maximum speed of the cyclist. [3]

(c) Find an expression for the displacement from O in terms of t. Hence find the total distance travelled by the cyclist from the time at which she reaches her maximum speed until she comes to rest. [4]

QUESTION – 6: QP_M22_42

31.

A car starts from rest and moves in a straight line with constant acceleration for a distance of 200 m, reaching a speed of 25 m s^{-1}. The car then travels at this speed for 400 m, before decelerating uniformly to rest over a period of 5 s.

(a) Find the time for which the car is accelerating. [2]

(b) Sketch the velocity–time graph for the motion of the car, showing the key points. [2]

(c) Find the average speed of the car during its motion. [2]

QUESTION – 1: QP_S22_41

32.

A particle starts from a point O and moves in a straight line. The velocity v m s^{-1} of the particle at time t s after leaving O is given by

$$v = k(3t^2 - 2t^3),$$

where k is a constant.

(a) Verify that the particle returns to O when $t = 2$. [4]

(b) It is given that the acceleration of the particle is -13.5 m s^{-2} for the positive value of t at which $v = 0$.

Find k and hence find the total distance travelled in the first two seconds of motion. [6]

QUESTION – 6: QP_S22_41

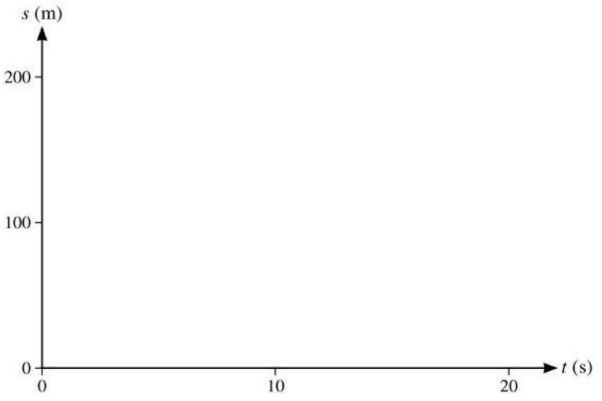
33.

A particle A, moving along a straight horizontal track with constant speed 8 m s^{-1}, passes a fixed point O. Four seconds later, another particle B passes O, moving along a parallel track in the same direction as A. Particle B has speed 20 m s^{-1} when it passes O and has a constant deceleration of 2 m s^{-2}. B comes to rest when it returns to O.

(a) Find expressions, in terms of t, for the displacement from O of each particle t seconds after B passes O. [3]

(b) Find the values of t when the particles are the same distance from O. [3]

(c) On the given axes, sketch the displacement-time graphs for both particles, for values of t from 0 to 20. [3]



QUESTION – 4: QP_S22_42

34.

A particle P moves in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t seconds is given by

$$v = 0.5t \qquad \text{for } 0 \leqslant t \leqslant 10,$$
$$v = 0.25t^2 - 8t + 60 \qquad \text{for } 10 \leqslant t \leqslant 20.$$

(a) Show that there is an instantaneous change in the acceleration of the particle at $t = 10$. [3]

(b) Find the total distance covered by P in the interval $0 \leqslant t \leqslant 20$. [6]

QUESTION – 7: QP_S22_42

35.

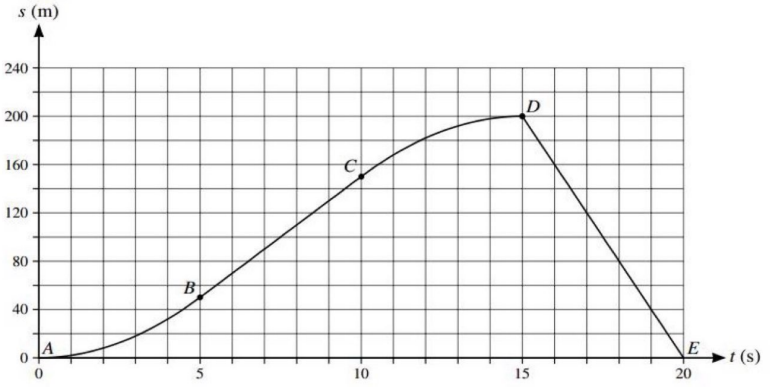
A particle P is projected vertically upwards from horizontal ground. P reaches a maximum height of 45 m. After reaching the ground, P comes to rest without rebounding.

(a) Find the speed at which P was projected. [2]

(b) Find the total time for which the speed of P is at least $10\,\text{m s}^{-1}$. [3]

QUESTION – 2: QP_S22_43

36.



The displacement of a particle moving in a straight line is s metres at time t seconds after leaving a fixed point O. The particle starts from rest and passes through points P, Q and R, at times $t = 5$, $t = 10$ and $t = 15$ respectively, and returns to O at time $t = 20$. The distances OP, OQ and OR are 50 m, 150 m and 200 m respectively.

The diagram shows a displacement-time graph which models the motion of the particle from $t = 0$ to $t = 20$. The graph consists of two curved segments AB and CD and two straight line segments BC and DE.

(a) Find the speed of the particle between $t = 5$ and $t = 10$. [1]

(b) Find the acceleration of the particle between $t = 0$ and $t = 5$, given that it is constant. [2]

(c) Find the average speed of the particle during its motion. [2]

QUESTION – 3: QP_S22_43

37.

A particle P moves in a straight line through a point O. The velocity $v\,\text{m s}^{-1}$ of P, at time t s after passing O, is given by

$$v = \frac{9}{4} + \frac{b}{(t+1)^2} - ct^2,$$

where b and c are positive constants. At $t = 5$, the velocity of P is zero and its acceleration is $-\frac{13}{12}\,\text{m s}^{-2}$.

(a) Show that $b = 9$ and find the value of c. [5]

(b) Given that the velocity of P is zero only at $t = 5$, find the distance travelled in the first 10 seconds of motion. [5]

QUESTION – 7: QP_S22_43

38.

A particle P moves on the x-axis from the origin O with an initial velocity of $-20\,\mathrm{m\,s^{-1}}$. The acceleration $a\,\mathrm{m\,s^{-2}}$ at time t s after leaving O is given by $a = 12 - 2t$.

(a) Sketch a velocity-time graph for $0 \leqslant t \leqslant 12$, indicating the times when P is at rest. [5]

(b) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 12$. [5]

QUESTION – 5: QP_W22_41

39.

A particle P travels in a straight line, starting at rest from a point O. The acceleration of P at time t s after leaving O is denoted by $a\,\mathrm{m\,s^{-2}}$, where

$$a = 0.3t^{\frac{1}{2}} \quad \text{for } 0 \leqslant t \leqslant 4,$$
$$a = -kt^{-\frac{3}{2}} \quad \text{for } 4 < t \leqslant T,$$

where k and T are constants.

(a) Find the velocity of P at $t = 4$. [2]

(b) It is given that there is no change in the velocity of P at $t = 4$ and that the velocity of P at $t = 16$ is $0.3\,\mathrm{m\,s^{-1}}$.

Show that $k = 2.6$ and find an expression, in terms of t, for the velocity of P for $4 \leqslant t \leqslant T$. [4]

(c) Given that P comes to instantaneous rest at $t = T$, find the exact value of T. [2]

(d) Find the total distance travelled between $t = 0$ and $t = T$. [4]

QUESTION – 7: QP_W22_42

40.

A particle P is projected vertically upwards with speed $u\,\mathrm{m\,s^{-1}}$ from a point on the ground. P reaches its greatest height after 3 s.

(a) Find u. [1]

(b) Find the greatest height of P above the ground. [2]

QUESTION – 1: QP_W22_43

41.

A particle P travels in the positive direction along a straight line with constant acceleration. P travels a distance of 52 m during the 2nd second of its motion and a distance of 64 m during the 4th second of its motion.

(a) Find the initial speed and the acceleration of P. [5]

(b) Find the distance travelled by P during the first 10 seconds of its motion. [2]

QUESTION – 4: QP_W22_43

42.

Particles X and Y move in a straight line through points A and B. Particle X starts from rest at A and moves towards B. At the same instant, Y starts from rest at B.

At time t seconds after the particles start moving

- the acceleration of X in the direction AB is given by $(12t + 12)\,\text{m s}^{-2}$,
- the acceleration of Y in the direction AB is given by $(24t - 8)\,\text{m s}^{-2}$.

(a) It is given that the velocities of X and Y are equal when they collide.

Calculate the distance AB. [6]

(b) It is given instead that $AB = 36\,\text{m}$.

Verify that X and Y collide after 3 s. [2]

QUESTION – 5: QP_W22_43

43.

A particle P is projected vertically upwards from horizontal ground with speed $15\,\text{m s}^{-1}$.

(a) Find the speed of P when it is 10 m above the ground. [2]

At the same instant that P is projected, a second particle Q is dropped from a height of 18 m above the ground in the same vertical line as P.

(b) Find the height above the ground at which the two particles collide. [3]

44. ***QUESTION – 2: QP_M23_42***

A particle moves in a straight line starting from rest from a point O. The acceleration of the particle at time t s after leaving O is $a\,\text{m s}^{-2}$, where $a = 4t^{\frac{1}{2}}$.

(a) Find the speed of the particle when $t = 9$. [2]

(b) Find the time after leaving O at which the speed (in metres per second) and the distance travelled (in metres) are numerically equal. [3]

QUESTION – 3: QP_M23_42

45.

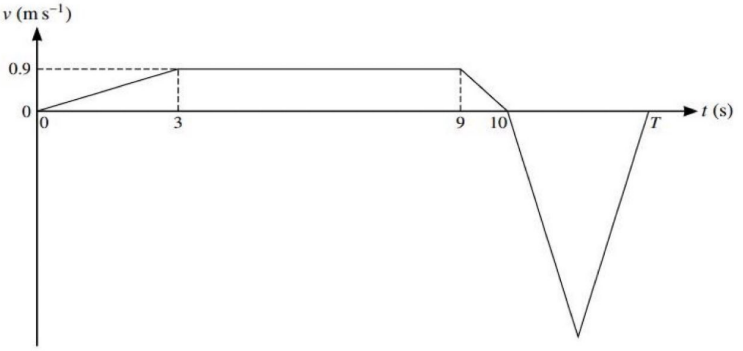
A particle moves in a straight line starting from rest. The displacement s m of the particle from a fixed point O on the line at time t s is given by

$$s = t^{\frac{5}{2}} - \frac{15}{4}t^{\frac{3}{2}} + 6.$$

Find the value of s when the particle is again at rest. [4]

QUESTION – 3: QP_S23_41

46.



The velocity of a particle at time t s after leaving a fixed point O is v m s^{-1}. The diagram shows a velocity-time graph which models the motion of the particle. The graph consists of 5 straight line segments. The particle accelerates to a speed of 0.9 m s^{-1} in a period of 3 s, then travels at constant speed for 6 s, and then comes instantaneously to rest 1 s later. The particle then moves back and returns to rest at O at time T s.

(a) Find the distance travelled by the particle in the first 10 s of its motion. [2]

(b) Given that $T = 12$, find the minimum velocity of the particle. [2]

(c) Given instead that the greatest speed of the particle is 3 m s^{-1}, find the value of T and hence find the average speed of the particle for the whole of the motion. [4]

QUESTION – 4: QP_S23_41

47.

A particle P starts at rest and moves in a straight line from a point O. At time t s after leaving O, the velocity of P, v m s^{-1}, is given by $v = bt + ct^{\frac{3}{2}}$, where b and c are constants. P has velocity 8 m s^{-1} when $t = 4$ and has velocity 13.5 m s^{-1} when $t = 9$.

(a) Show that $b = 3$ and $c = -0.5$. [1]

(b) Find the acceleration of P when $t = 1$. [2]

(c) Find the positive value of t when P is at instantaneous rest and find the distance of P from O at this instant. [5]

(d) Find the speed of P at the instant it returns to O. [3]

QUESTION – 6: QP_S23_42

48.

A particle starts from rest from a point O and moves in a straight line. The acceleration of the particle at time t s after leaving O is a m s^{-2}, where $a = kt^{\frac{1}{2}}$ for $0 \leqslant t \leqslant 9$ and where k is a constant. The velocity of the particle at $t = 9$ is 1.8 m s^{-1}.

(a) Show that $k = 0.1$. [3]

For $t > 9$, the velocity $v\,\text{m}\,\text{s}^{-1}$ of the particle is given by $v = 0.2(t-9)^2 + 1.8$.

(b) Show that the distance travelled in the first 9 seconds is one tenth of the distance travelled between $t = 9$ and $t = 18$. [4]

(c) Find the greatest acceleration of the particle during the first 10 seconds of its motion. [3]

QUESTION – 5: QP_S23_43

Answers

1. (a) $h = 20\ m$, (b) $4\ s$
2. (a) $k = 40$, (b) See the solution
   (c) $1 < t < 4$ (d) distance $= 644\ m$
3. (a) $0.5\ ms^{-2}$ (b) $18\ m$
4. (a) $1.5\ s$ (b) $-3.67\ ms^{-1}$ (c) $40.1\ m$
5. (a) $h = 4.05\ m$ (b) $T = 0.6\ s$
6. (a) $k = 0.05$; $s = 0.05\left(\frac{t^3}{3} - 5t^2 + 21t\right) + 1.5$
   (b) $s = 2.58\ m$
7. (a) For sketch see the solution.
   (b) $v = 15\ ms^{-1}$ (b) $a = 0.75\ ms^{-2}$
8. (a) See the solution (b) -6 (c) $84.15\ m$
9. (a) See the solution (b) $a = 4\ ms^{-2}$ (c) $t = 32.5\ s$
10. (a) $12.5\ ms^{-1}$ (b) $PQ = 81\ m$
11. $108\ m$
12. (a) $T = 10\ s$ (b) $v = 12\ ms^{-1}$
13. (a) $t = 4\ s$ (b) $s = 3.57\ m$
14. (a) $v = 30\ ms^{-1}$ (b) $h = 45\ m$
15. (a) $t = 1.5\ s$ and $3.5\ s$ (b) $a = -20\ ms^{-2}$
    (c) $v_{min} = -4\ ms^{-1}$ (d) $5.33\ m$
16. (a) $a_{rel} = \frac{4}{3}\ ms^{-2}$ (b) $1.7\ ms^{-1}$ (c) $T = 12000\ N$
17. (a) $2.13\ m$ (b) $-1.25\ ms^{-1}$
18. (a) $82.5\ m$ (b) $1.2\ ms^{-2}$
19. (a) $16\ s$ (b) $145.8\ m$
20. (a) $t = 5, 11$ (b) See solution (c) $341\frac{1}{3}\ m$
21. (a) $u = 22$ (b) $8\ m$
22. (a) $-0.125\ ms^{-1}$ (b) See solution (c) $0.0417\ m$
23. (a) $15\ ms^{-1}$ (b) $2.5\ ms^{-2}$
24. (a) $p = 3$, $q = 12$ (b) See solution (c) $208\ m$.
25. (a) $46.5\ s$ (b) $759.5\ m$
26. (a) $250\ m$ (b) $7.5\ ms^{-1}$
27. (a) ✓ (b) $-29.4\ ms^{-1}$ (c) $36\ m$.
28. 0.4
29. (a) $u = 20\ ms^{-1}$ (b) $2\ s$
30. (a) $k = 10\ s$ (b) $4.87\ ms^{-1}$ (c) $20.7\ m$
31. (a) $16\ s$ (b) See the solution (c) $17.9\ ms^{-1}$
32. (a) $t = 2\ s$ (b) $k = 3$, Distance $= 5.06\ m$
33. (a) $s_A = 32 + 8t$ (b) $t = 4; 8$ (c) See solution.
34. (a) Proof (b) $51\ m$
35. (a) $30\ ms^{-1}$ (b) $T = 4\ s$
36. (a) $20\ ms^{-1}$ (b) $a = 4\ ms^{-2}$ (c) $20\ ms^{-1}$
37. (a) $b = 9$, $c = 0.1$ (b) $31.8\ m$
38. (a) Pivot rest, $t = 2\ s$ and $t = 10\ s$
    (b) $123\ m$
39. (a) $1.6\ ms^{-1}$ (b) $v = 5.2t^{-\frac{1}{2}} - 1$
    (c) $T = 27.04\ s$ (d) $12.8\ m$
40. (a) $30\ ms^{-1}$ (b) $45\ m$
41. (a) $u = 43\ ms^{-1}$, $a = 6\ ms^{-2}$ (b) $730\ m$.
42. (a) $37\ m$ (b) Verify
43. (a) $5\ ms^{-1}$ (b) $10.8\ m$
44. (a) $72\ ms^{-1}$ (b) $\frac{5}{2}\ s$
45. $\frac{15}{16}\ m$ (or $0.9375\ m$)
46. (a) $7.2\ m$ (b) $-7.2\ ms^{-1}$ (c) $\frac{36}{37}\ ms^{-1}$
47. (a) ✓ (b) $2.25\ ms^{-2}$ (c) $388.8\ m$
    (d) $42.2\ ms^{-1}$
48. (a) $k = 0.1$ (b) ✓ (c) $a = 0.4\ ms^{-2}$,

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