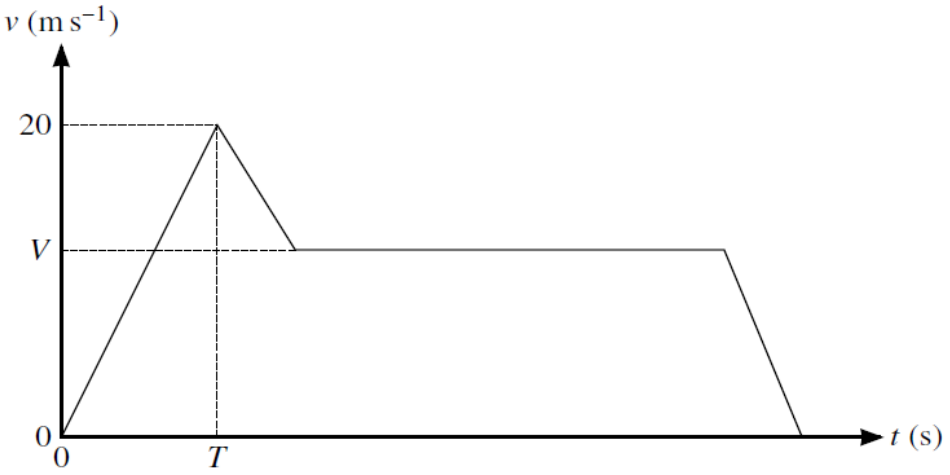
Kinematics – 2020 AS

1. Nov/2020/Paper_9709/41/No.4

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 m s^{-2}, where $a = 6t - 18$.

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

2. Nov/2020/Paper_9709/42/No.4



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]

3. Nov/2020/Paper_9709/42/No.5

A particle is projected vertically upwards with speed $40\,\text{m s}^{-1}$ alongside a building of height h m.

(a) Given that the particle is above the level of the top of the building for 4 s, find h. [4]

(b) One second after the first particle is projected, a second particle is projected vertically upwards from the top of the building with speed $20\,\text{m s}^{-1}$.

Denoting the time after projection of the first particle by t s, find the value of t for which the two particles are at the same height above the ground. [4]

4. Nov/2020/Paper_9709/42/No.7

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]

5. Nov/2020/Paper_9709/43/No.1

A particle P is projected vertically upwards with speed v 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]

6. Nov/2020/Paper_9709/43/No.5

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 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]

7. June/2020/Paper_9709/41/No.3

A particle P is projected vertically upwards with speed $5\,\text{m}\,\text{s}^{-1}$ 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]

8. June/2020/Paper_9709/41/No.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]

9. June/2020/Paper_9709/42/No.1

A tram starts from rest and moves with uniform acceleration for 20 s. The tram then travels at a constant speed, V 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. [2]

(c) Find the magnitude of the acceleration. [2]

10. June/2020/Paper_9709/42/No.6

A particle P moves in a straight line. The velocity v 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]

11. June/2020/Paper_9709/43/No.4

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]

12. June/2020/Paper_9709/43/No.6

A particle travels in a straight line PQ. The velocity of the particle t s after leaving P is v 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]

13. March/2020/Paper_9709/42/No.4

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]

14. March/2020/Paper_9709/42/No.7

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

$$s = t^2 - 3t + 2 \qquad \text{for } 0 \leqslant t \leqslant 6,$$

$$s = \frac{24}{t} - \frac{t^2}{4} + 25 \qquad \text{for } t \geqslant 6.$$

(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]