Kinematics of motion in a straight line 1

Q1.

A vehicle is moving in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t s after the vehicle starts is given by

$$v = A(t - 0.05t^2) \quad \text{for } 0 \leqslant t \leqslant 15,$$

$$v = \frac{B}{t^2} \quad \text{for } t \geqslant 15,$$

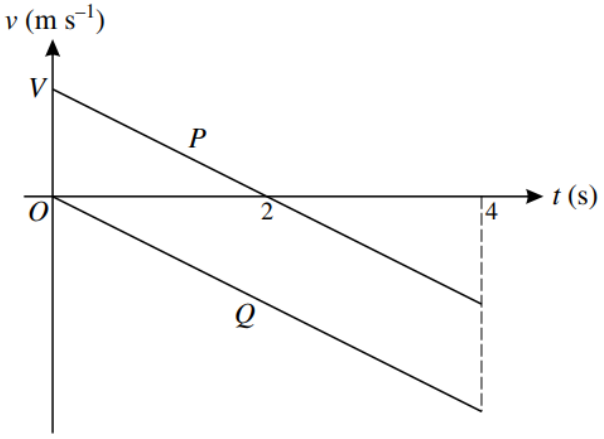
where A and B are constants. The distance travelled by the vehicle between $t = 0$ and $t = 15$ is 225 m.

(i) Find the value of A and show that $B = 3375$. [5]

(ii) Find an expression in terms of t for the total distance travelled by the vehicle when $t \geqslant 15$. [3]

(iii) Find the speed of the vehicle when it has travelled a total distance of 315 m. [3]

Q2.



Two particles P and Q move vertically under gravity. The graphs show the upward velocity $v\,\text{m s}^{-1}$ of the particles at time t s, for $0 \leqslant t \leqslant 4$. P starts with velocity $V\,\text{m s}^{-1}$ and Q starts from rest.

(i) Find the value of V. [2]

Given that Q reaches the horizontal ground when $t = 4$, find

(ii) the speed with which Q reaches the ground, [1]

(iii) the height of Q above the ground when $t = 0$. [2]

Q3.

A particle starts at a point O and moves along a straight line. Its velocity t s after leaving O is $(1.2t - 0.12t^2)\,\text{m s}^{-1}$. Find the displacement of the particle from O when its acceleration is $0.6\,\text{m s}^{-2}$. [5]

Kinematics of motion in a straight line 1

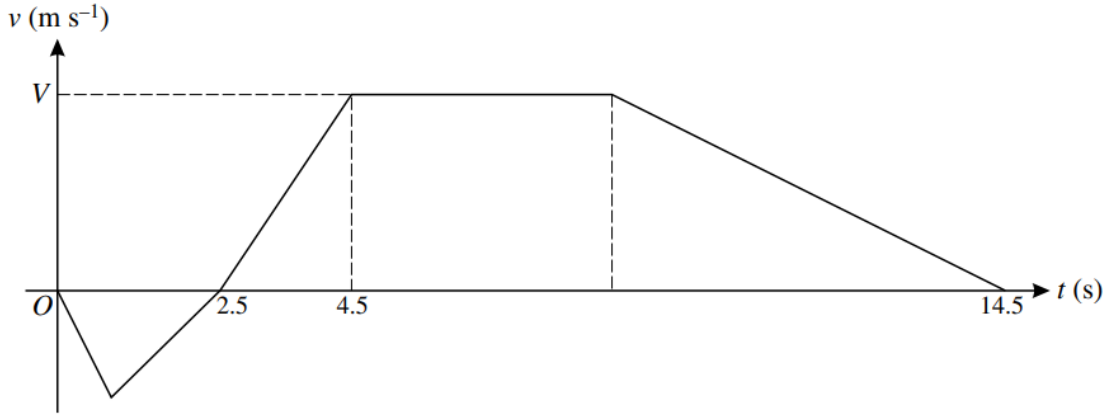
Q4.

Particles P and Q are projected vertically upwards, from different points on horizontal ground, with velocities of $20\,\text{m s}^{-1}$ and $25\,\text{m s}^{-1}$ respectively. Q is projected 0.4 s later than P. Find

(i) the time for which P's height above the ground is greater than 15 m, [3]

(ii) the velocities of P and Q at the instant when the particles are at the same height. [5]

Q5.



The diagram shows the velocity-time graph for a particle P which travels on a straight line AB, where $v\,\text{m s}^{-1}$ is the velocity of P at time t s. The graph consists of five straight line segments. The particle starts from rest when $t = 0$ at a point X on the line between A and B and moves towards A. The particle comes to rest at A when $t = 2.5$.

(i) Given that the distance XA is 4 m, find the greatest speed reached by P during this stage of the motion. [2]

In the second stage, P starts from rest at A when $t = 2.5$ and moves towards B. The distance AB is 48 m. The particle takes 12 s to travel from A to B and comes to rest at B. For the first 2 s of this stage P accelerates at $3\,\text{m s}^{-2}$, reaching a velocity of $V\,\text{m s}^{-1}$. Find

(ii) the value of V, [2]

(iii) the value of t at which P starts to decelerate during this stage, [3]

(iv) the deceleration of P immediately before it reaches B. [2]

Kinematics of motion in a straight line 1

Q6.

A particle starts from rest at a point X and moves in a straight line until, 60 seconds later, it reaches a point Y. At time t s after leaving X, the acceleration of the particle is

$$\begin{aligned} 0.75\,\text{m s}^{-2} &\quad \text{for} \quad 0 < t < 4, \\ 0\,\text{m s}^{-2} &\quad \text{for} \quad 4 < t < 54, \\ -0.5\,\text{m s}^{-2} &\quad \text{for} \quad 54 < t < 60. \end{aligned}$$

(i) Find the velocity of the particle when $t = 4$ and when $t = 60$, and sketch the velocity-time graph. [5]

(ii) Find the distance XY. [2]

Q7.

The velocity-time graph shown models the motion of a parachutist falling vertically. There are four stages in the motion:

- falling freely with the parachute closed,
- decelerating at a constant rate with the parachute open,
- falling with constant speed with the parachute open,
- coming to rest instantaneously on hitting the ground.

(i) Show that the total distance fallen is 1048 m. [2]

The weight of the parachutist is 850 N.

(ii) Find the upward force on the parachutist due to the parachute, during the second stage. [5]

Kinematics of motion in a straight line 1

Q8.

A walker travels along a straight road passing through the points A and B on the road with speeds $0.9\,\text{m s}^{-1}$ and $1.3\,\text{m s}^{-1}$ respectively. The walker's acceleration between A and B is constant and equal to $0.004\,\text{m s}^{-2}$.

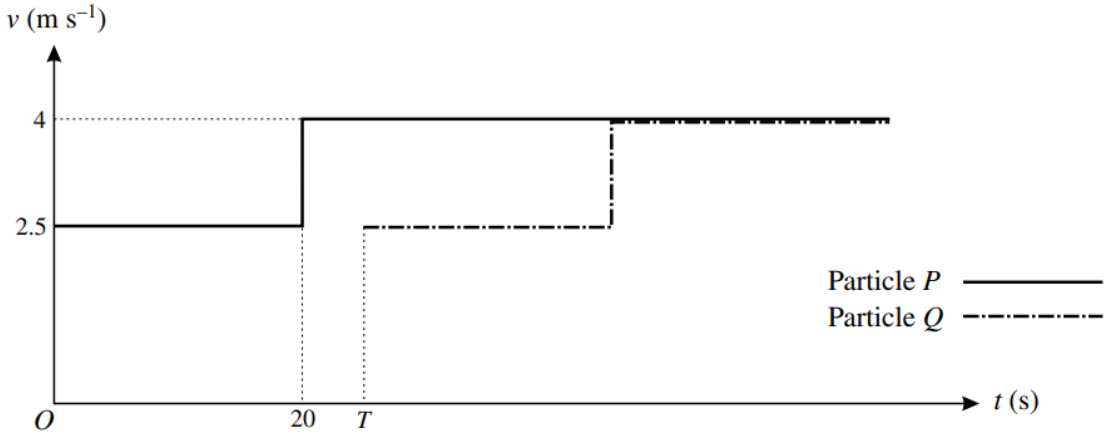
(i) Find the time taken by the walker to travel from A to B, and find the distance AB. [3]

A cyclist leaves A at the same instant as the walker. She starts from rest and travels along the straight road, passing through B at the same instant as the walker. At time t s after leaving A the cyclist's speed is $kt^3\,\text{m s}^{-1}$, where k is a constant.

(ii) Show that when $t = 64.05$ the speed of the walker and the speed of the cyclist are the same, correct to 3 significant figures. [5]

(ii) Find the cyclist's acceleration at the instant she passes through B. [2]

Q9.



The diagram shows the velocity-time graphs for the motion of two particles P and Q, which travel in the same direction along a straight line. P and Q both start at the same point X on the line, but Q starts to move T s later than P. Each particle moves with speed $2.5\,\text{m s}^{-1}$ for the first 20 s of its motion. The speed of each particle changes instantaneously to $4\,\text{m s}^{-1}$ after it has been moving for 20 s and the particle continues at this speed.

(i) Make a rough copy of the diagram and shade the region whose area represents the displacement of P from X at the instant when Q starts. [1]

It is given that P has travelled 70 m at the instant when Q starts.

(ii) Find the value of T. [2]

(iii) Find the distance between P and Q when Q's speed reaches $4\,\text{m s}^{-1}$. [2]

(iv) Sketch a single diagram showing the displacement-time graphs for both P and Q, with values shown on the t-axis at which the speed of either particle changes. [2]