Chapter 2 Kinematics of motion along a straight line

May/June 2002

5 **(i)** A cyclist travels in a straight line from A to B with constant acceleration $0.06\,\text{m s}^{-2}$. His speed at A is $3\,\text{m s}^{-1}$ and his speed at B is $6\,\text{m s}^{-1}$. Find

(a) the time taken by the cyclist to travel from A to B, [2]

(b) the distance AB. [2]

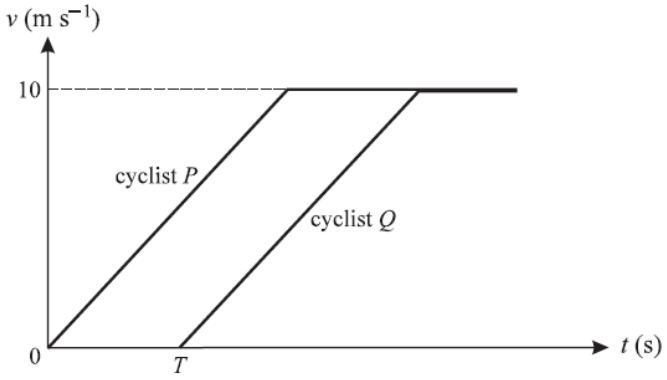
(ii) A car leaves A at the same instant as the cyclist. The car starts from rest and travels in a straight line to B. The car reaches B at the same instant as the cyclist. At time t s after leaving A the speed of the car is $kt^2\,\text{m s}^{-1}$, where k is a constant. Find

(a) the value of k, [4]

(b) the speed of the car at B. [1]

May/June 2003

3



The diagram shows the velocity-time graphs for the motion of two cyclists P and Q, who travel in the same direction along a straight path. Both cyclists start from rest at the same point O and both accelerate at $2\,\text{m s}^{-2}$ up to a speed of $10\,\text{m s}^{-1}$. Both then continue at a constant speed of $10\,\text{m s}^{-1}$. Q starts his journey T seconds after P.

(i) Show in a sketch of the diagram the region whose area represents the displacement of P, from O, at the instant when Q starts. [1]

Given that P has travelled 16 m at the instant when Q starts, find

(ii) the value of T, [3]

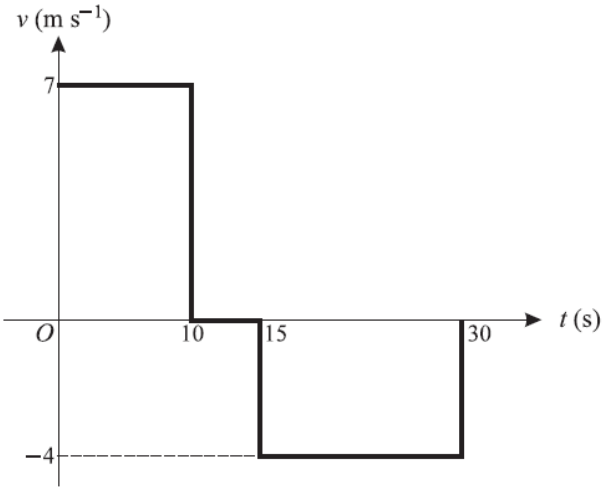
(iii) the distance between P and Q when Q's speed reaches $10\,\text{m s}^{-1}$. [2]

4 A particle moves in a straight line. Its displacement t seconds after leaving the fixed point O is x metres, where $x = \frac{1}{2}t^2 + \frac{1}{30}t^3$. Find

(i) the speed of the particle when $t = 10$, [3]

(ii) the value of t for which the acceleration of the particle is twice its initial acceleration. [3]

May/June 2004



A boy runs from a point A to a point C. He pauses at C and then walks back towards A until reaching the point B, where he stops. The diagram shows the graph of v against t, where v m s^{-1} is the boy's velocity at time t seconds after leaving A. The boy runs and walks in the same straight line throughout.

(i) Find the distances AC and AB. [3]

(ii) Sketch the graph of x against t, where x metres is the boy's displacement from A. Show clearly the values of t and x when the boy arrives at C, when he leaves C, and when he arrives at B. [3]

5 A particle P moves in a straight line that passes through the origin O. The velocity of P at time t seconds is v m s^{-1}, where $v = 20t - t^3$. At time $t = 0$ the particle is at rest at a point whose displacement from O is -36 m.

(i) Find an expression for the displacement of P from O in terms of t. [3]

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

(iii) Find the values of t for which the particle is at O. [3]

7 A particle P_1 is projected vertically upwards, from horizontal ground, with a speed of 30 m s^{-1}. At the same instant another particle P_2 is projected vertically upwards from the top of a tower of height 25 m, with a speed of 10 m s^{-1}. Find

(i) the time for which P_1 is higher than the top of the tower, [3]

(ii) the velocities of the particles at the instant when the particles are at the same height, [5]

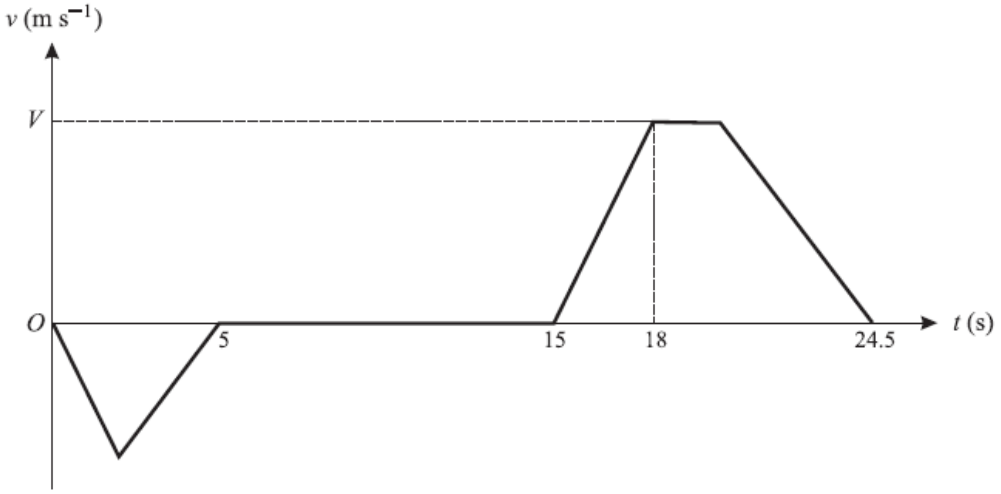
(iii) the time for which P_1 is higher than P_2 and is moving upwards. [3]

May/June 2005

5 A particle P moves along the x-axis in the positive direction. The velocity of P at time t s is $0.03t^2$ m s^{-1}. When $t = 5$ the displacement of P from the origin O is 2.5 m.

(i) Find an expression, in terms of t, for the displacement of P from O. [4]

(ii) Find the velocity of P when its displacement from O is 11.25 m. [3]



The diagram shows the velocity-time graph for a lift moving between floors in a building. The graph consists of straight line segments. In the first stage the lift travels downwards from the ground floor for 5 s, coming to rest at the basement after travelling 10 m.

(i) Find the greatest speed reached during this stage. [2]

The second stage consists of a 10 s wait at the basement. In the third stage, the lift travels upwards until it comes to rest at a floor 34.5 m above the basement, arriving 24.5 s after the start of the first stage. The lift accelerates at $2\,\text{m s}^{-2}$ for the first 3 s of the third stage, reaching a speed of $V\,\text{m s}^{-1}$. Find

(ii) the value of V, [2]

(iii) the time during the third stage for which the lift is moving at constant speed, [3]

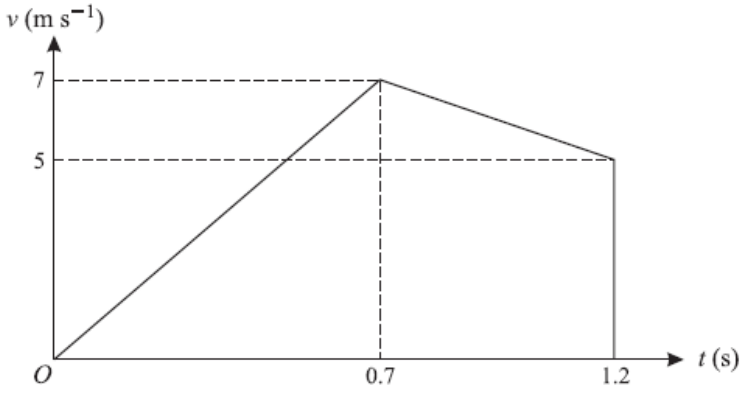
(iv) the deceleration of the lift in the final part of the third stage. [2]

May/June 2006

2 A motorcyclist starts from rest at A and travels in a straight line until he comes to rest again at B. The velocity of the motorcyclist t seconds after leaving A is $v\,\text{m s}^{-1}$, where $v = t - 0.01t^2$. Find

(i) the time taken for the motorcyclist to travel from A to B, [2]

(ii) the distance AB. [3]



The diagram shows the velocity-time graph for the motion of a small stone which falls vertically from rest at a point A above the surface of liquid in a container. The downward velocity of the stone t s after leaving A is v m s^{-1}. The stone hits the surface of the liquid with velocity 7 m s^{-1} when $t = 0.7$. It reaches the bottom of the container with velocity 5 m s^{-1} when $t = 1.2$.

(i) Find

(a) the height of A above the surface of the liquid,

(b) the depth of liquid in the container.

[3]

(ii) Find the deceleration of the stone while it is moving in the liquid. [2]

(iii) Given that the resistance to motion of the stone while it is moving in the liquid has magnitude 0.7 N, find the mass of the stone. [3]

7 Two particles P and Q move on a line of greatest slope of a smooth inclined plane. The particles start at the same instant and from the same point, each with speed 1.3 m s^{-1}. Initially P moves down the plane and Q moves up the plane. The distance between the particles t seconds after they start to move is d m.

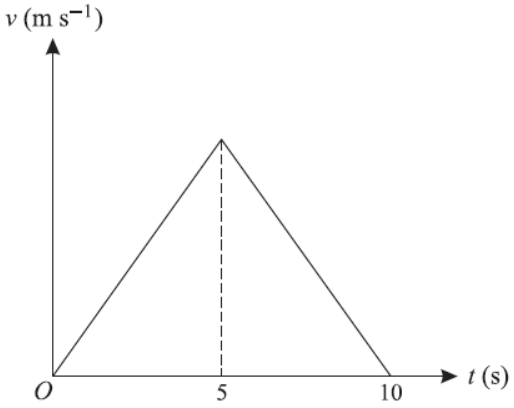
(i) Show that $d = 2.6t$. [4]

When $t = 2.5$ the difference in the vertical height of the particles is 1.6 m. Find

(ii) the acceleration of the particles down the plane, [3]

(iii) the distance travelled by P when Q is at its highest point. [3]

May/June 2007



A particle P starts from rest at the point A and travels in a straight line, coming to rest again after 10 s. The velocity-time graph for P consists of two straight line segments (see diagram). A particle Q starts from rest at A at the same instant as P and travels along the same straight line as P. The velocity of Q is given by $v = 3t - 0.3t^2$ for $0 \leqslant t \leqslant 10$. The displacements from A of P and Q are the same when $t = 10$.

(i) Show that the greatest velocity of P during its motion is $10\,\text{m s}^{-1}$. [6]

(ii) Find the value of t, in the interval $0 < t < 5$, for which the acceleration of Q is the same as the acceleration of P. [3]

May/June 2008

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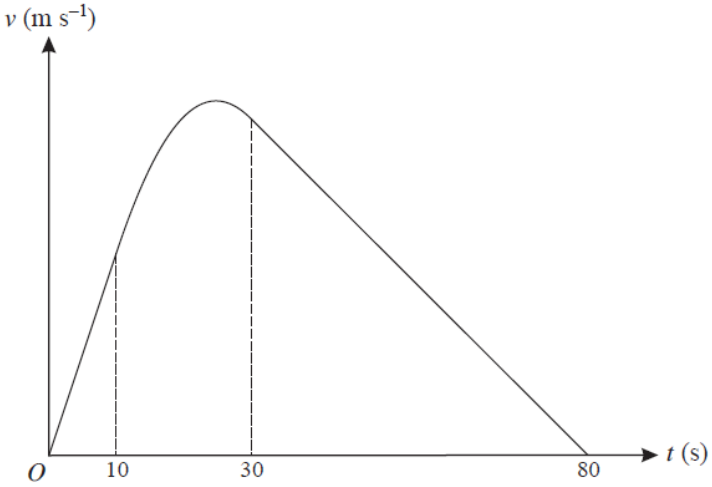

An object P travels from A to B in a time of 80 s. The diagram shows the graph of v against t, where $v\,\text{m s}^{-1}$ is the velocity of P at time t s after leaving A. The graph consists of straight line segments for the intervals $0 \leqslant t \leqslant 10$ and $30 \leqslant t \leqslant 80$, and a curved section whose equation is $v = -0.01t^2 + 0.5t - 1$ for $10 \leqslant t \leqslant 30$. Find

(i) the maximum velocity of P, [4]

(ii) the distance AB. [9]

May/June 2009

7 A particle P travels in a straight line from A to D, passing through the points B and C. For the section AB the velocity of the particle is $(0.5t - 0.01t^2)$ m s^{-1}, where t s is the time after leaving A.

(i) Given that the acceleration of P at B is 0.1 m s^{-2}, find the time taken for P to travel from A to B. [3]

The acceleration of P from B to C is constant and equal to 0.1 m s^{-2}.

(ii) Given that P reaches C with speed 14 m s^{-1}, find the time taken for P to travel from B to C. [3]

P travels with constant deceleration 0.3 m s^{-2} from C to D. Given that the distance CD is 300 m, find

(iii) the speed with which P reaches D, [2]

(iv) the distance AD. [6]