M/J/2005/Q5

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]

O/N/2005/Q6

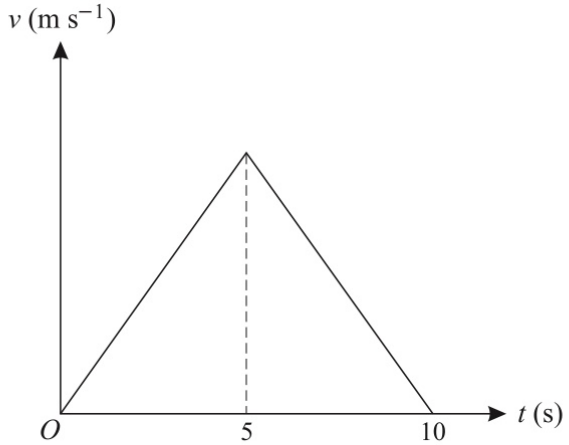
A particle P starts from rest at O and travels in a straight line. Its velocity $v\,\text{m s}^{-1}$ at time t s is given by $v = 8t - 2t^2$ for $0 \leqslant t \leqslant 3$, and $v = \dfrac{54}{t^2}$ for $t > 3$. Find

(i) the distance travelled by P in the first 3 seconds, [4]

(ii) an expression in terms of t for the displacement of P from O, valid for $t > 3$, [3]

(iii) the value of v when the displacement of P from O is 27 m. [3]

M/J/2007/Q6



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]

O/N/2007/Q6

(i) A man walks in a straight line from A to B with constant acceleration $0.004\,\text{m s}^{-2}$. His speed at A is $1.8\,\text{m s}^{-1}$ and his speed at B is $2.2\,\text{m s}^{-1}$. Find the time taken for the man to walk from A to B, and find the distance AB. [3]

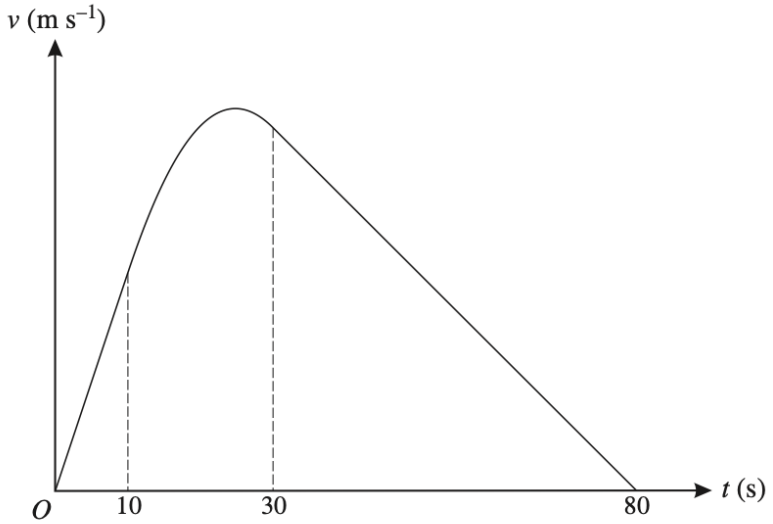
(ii) A woman cyclist leaves A at the same instant as the man. She starts from rest and travels in a straight line to B, reaching B at the same instant as the man. At time t s after leaving A the cyclist's speed is $k(200t - t^2)\,\text{m s}^{-1}$, where k is a constant. Find

(a) the value of k, [4]

(b) the cyclist's speed at B. [1]

(iii) Sketch, using the same axes, the velocity-time graphs for the man's motion and the woman's motion from A to B. [3]

M/J/2008/Q7



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 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]

M/J/2009/Q7

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 $(0.5t - 0.01t^2)\ \text{m s}^{-1}$, where t s is the time after leaving A.

(i) Given that the acceleration of P at B is $0.1\ \text{m s}^{-2}$, 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 $0.1\ \text{m s}^{-2}$.

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

P travels with constant deceleration $0.3\ \text{m s}^{-2}$ 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]

O/N/2009/Q7

A motorcyclist starts from rest at A and travels in a straight line. For the first part of the motion, the motorcyclist's displacement x metres from A after t seconds is given by $x = 0.6t^2 - 0.004t^3$.

(i) Show that the motorcyclist's acceleration is zero when $t = 50$ and find the speed $V\,\text{m s}^{-1}$ at this time. [5]

For $t \geqslant 50$, the motorcyclist travels at constant speed $V\,\text{m s}^{-1}$.

(ii) Find the value of t for which the motorcyclist's average speed is $27.5\,\text{m s}^{-1}$. [5]

M/J/2010/Q7

A vehicle is moving in a straight line. The velocity v 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]

O/N/2010/Q7

A particle P travels in a straight line. It passes through the point O of the line with velocity $5\ \text{m s}^{-1}$ at time $t = 0$, where t is in seconds. P's velocity after leaving O is given by

$$(0.002t^3 - 0.12t^2 + 1.8t + 5)\ \text{m s}^{-1}.$$

The velocity of P is increasing when $0 < t < T_1$ and when $t > T_2$, and the velocity of P is decreasing when $T_1 < t < T_2$.

(i) Find the values of T_1 and T_2 and the distance OP when $t = T_2$. [7]

(ii) Find the velocity of P when $t = T_2$ and sketch the velocity-time graph for the motion of P. [3]

M/J/2011/Q7

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]

M/J/2012/Q3

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

(i) Show that $t^{\frac{5}{3}} = \frac{5}{6}$ when the velocity of P is $3\,\text{m s}^{-1}$. [4]

(ii) Find the distance of P from O when the velocity of P is $3\,\text{m s}^{-1}$. [3]

O/N/2012/Q7

A particle P starts to move from a point O and travels in a straight line. The velocity of P is $k(60t^2 - t^3)\,\mathrm{m\,s^{-1}}$ at time t s after leaving O, where k is a constant. The maximum velocity of P is $6.4\,\mathrm{m\,s^{-1}}$.

(i) Show that $k = 0.0002$. [3]

P comes to instantaneous rest at a point A on the line. Find

(ii) the distance OA, [5]

(iii) the magnitude of the acceleration of P at A, [2]

(iv) the speed of P when it subsequently passes through O. [2]

M/J/2013/Q6

A particle P moves in a straight line. It starts from rest at a point O and moves towards a point A on the line. During the first 8 seconds P's speed increases to $8\,\mathrm{m\,s^{-1}}$ with constant acceleration. During the next 12 seconds P's speed decreases to $2\,\mathrm{m\,s^{-1}}$ with constant deceleration. P then moves with constant acceleration for 6 seconds, reaching A with speed $6.5\,\mathrm{m\,s^{-1}}$.

(i) Sketch the velocity-time graph for P's motion. [2]

The displacement of P from O, at time t seconds after P leaves O, is s metres.

(ii) Shade the region of the velocity-time graph representing s for a value of t where $20 \leqslant t \leqslant 26$. [1]

(iii) Show that, for $20 \leqslant t \leqslant 26$,

$$s = 0.375t^2 - 13t + 202.$$ [6]

O/N/2013/Q5

A particle P moves in a straight line. P starts from rest at O and travels to A where it comes to rest, taking 50 seconds. The speed of P at time t seconds after leaving O is $v\,\mathrm{m\,s^{-1}}$, where v is defined as follows.

$$\begin{aligned} \text{For } 0 \leqslant t \leqslant 5, &\quad v = t - 0.1t^2, \\ \text{for } 5 \leqslant t \leqslant 45, &\quad v \text{ is constant}, \\ \text{for } 45 \leqslant t \leqslant 50, &\quad v = 9t - 0.1t^2 - 200. \end{aligned}$$

(i) Find the distance travelled by P in the first 5 seconds. [3]

(ii) Find the total distance from O to A, and deduce the average speed of P for the whole journey from O to A. [6]

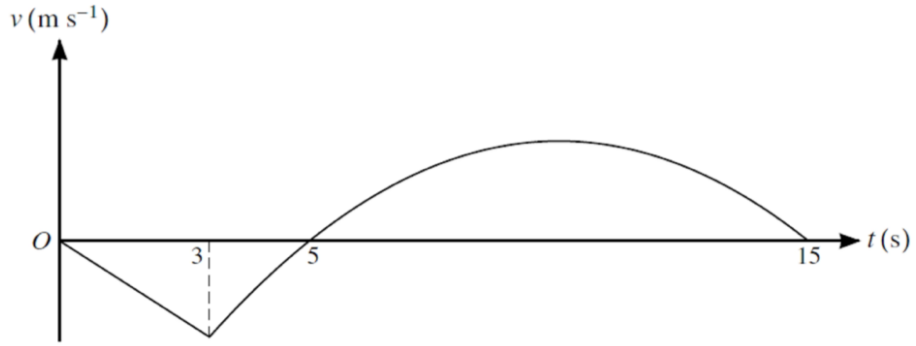
M/J/2014/Q4

A particle P moves on a straight line, starting from rest at a point O of the line. The time after P starts to move is t s, and the particle moves along the line with constant acceleration $\frac{1}{4}$ m s^{-2} until it passes through a point A at time $t = 8$. After passing through A the velocity of P is $\frac{1}{2}t^{\frac{2}{3}}$ m s^{-1}.

(i) Find the acceleration of P immediately after it passes through A. Hence show that the acceleration of P decreases by $\frac{1}{12}$ m s^{-2} as it passes through A. [4]

(ii) Find the distance moved by P from $t = 0$ to $t = 27$. [3]

O/N/2014/Q7



The diagram shows the velocity-time graph for the motion of a particle P which moves on a straight line BAC. It starts at A and travels to B taking 5 s. It then reverses direction and travels from B to C taking 10 s. For the first 3 s of P's motion its acceleration is constant. For the remaining 12 s the velocity of P is v m s^{-1} at time t s after leaving A, where

$$v = -0.2t^2 + 4t - 15 \quad \text{for } 3 \leqslant t \leqslant 15.$$

(i) Find the value of v when $t = 3$ and the magnitude of the acceleration of P for the first 3 s of its motion. [3]

(ii) Find the maximum velocity of P while it is moving from B to C. [3]

(iii) Find the average speed of P,

(a) while moving from A to B,

(b) for the whole journey. [6]

M/J/2015/Q4

A particle P moves in a straight line. At time t seconds after starting from rest at the point O on the line, the acceleration of P is $a\,\mathrm{m\,s^{-2}}$, where $a = 0.075t^2 - 1.5t + 5$.

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

(ii) Hence find the time taken for P to return to the point O. [3]

O/N/2015/Q3

A particle P moves along a straight line for 100 s. It starts at a point O and at time t seconds after leaving O the velocity of P is $v\,\mathrm{m\,s^{-1}}$, where

$$v = 0.000\,04t^3 - 0.006t^2 + 0.288t.$$

(i) Find the values of t at which the acceleration of P is zero. [3]

(ii) Find the displacement of P from O when $t = 100$. [3]

M/J/2017/Q3

A particle A moves in a straight line with constant speed $10\,\text{m s}^{-1}$. Two seconds after A passes a point O on the line, a particle B passes through O, moving along the line in the same direction as A. Particle B has speed $16\,\text{m s}^{-1}$ at O and has a constant deceleration of $2\,\text{m s}^{-2}$.

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

(ii) Find the distance between the particles when B comes to instantaneous rest. [3]

(iii) Find the minimum distance between the particles. [3]

O/N/2017/Q7

A particle starts from rest and moves in a straight line. The velocity of the particle at time t s after the start is v m s^{-1}, where

$$v = -0.01t^3 + 0.22t^2 - 0.4t.$$

(i) Find the two positive values of t for which the particle is instantaneously at rest. [2]

(ii) Find the time at which the acceleration of the particle is greatest. [3]

(iii) Find the distance travelled by the particle while its velocity is positive. [4]

M/J/2018/Q6

A particle P moves in a straight line passing through a point O. At time t s, the acceleration, a m s^{-2}, of P is given by $a = 6 - 0.24t$. The particle comes to instantaneous rest at time $t = 20$.

(i) Find the value of t at which the particle is again at instantaneous rest. [5]

(ii) Find the distance the particle travels between the times of instantaneous rest. [3]

O/N/2018/Q5

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

$$a = 1.2t^{\frac{1}{2}} - 0.6t.$$

(i) At time T s after leaving O the particle reaches its maximum velocity. Find the value of T. [2]

(ii) Find the velocity of the particle when its acceleration is maximum (you do not need to verify that the acceleration is a maximum rather than a minimum). [6]

M/J/2019/Q7

Particles P and Q leave a fixed point A at the same time and travel in the same straight line. The velocity of P after t seconds is $6t(t-3)\,\text{m s}^{-1}$ and the velocity of Q after t seconds is $(10-2t)\,\text{m s}^{-1}$.

(i) Sketch, on the same axes, velocity-time graphs for P and Q for $0 \leqslant t \leqslant 5$. [3]

(ii) Verify that P and Q meet after 5 seconds. [4]

(iii) Find the greatest distance between P and Q for $0 \leqslant t \leqslant 5$. [4]