Kinematics

O/N/2007/Q2

A particle is projected vertically upwards from a point O with initial speed $12.5\,\mathrm{m\,s^{-1}}$. At the same instant another particle is released from rest at a point 10 m vertically above O. Find the height above O at which the particles meet. [5]

O/N/2012/Q3

A car travels along a straight road with constant acceleration $a\,\mathrm{m\,s^{-2}}$. It passes through points A, B and C; the time taken from A to B and from B to C is 5 s in each case. The speed of the car at A is $u\,\mathrm{m\,s^{-1}}$ and the distances AB and BC are 55 m and 65 m respectively. Find the values of a and u. [6]

M/J/2008/Q6

A particle P of mass 0.6 kg is projected vertically upwards with speed $5.2\,\mathrm{m\,s^{-1}}$ from a point O which is 6.2 m above the ground. Air resistance acts on P so that its deceleration is $10.4\,\mathrm{m\,s^{-2}}$ when P is moving upwards, and its acceleration is $9.6\,\mathrm{m\,s^{-2}}$ when P is moving downwards. Find

(i) the greatest height above the ground reached by P, [3]

(ii) the speed with which P reaches the ground, [2]

M/J/2014/Q2

A and B are two points which are 10 m apart on the same horizontal plane. A particle P starts to move from rest at A, directly towards B, with constant acceleration $0.5\,\mathrm{m\,s^{-2}}$. Another particle Q is moving directly towards A with constant speed $0.75\,\mathrm{m\,s^{-1}}$, and passes through B at the instant that P starts to move. At time T s after this instant, particles P and Q collide. Find

(i) the value of T, [4]

(ii) the speed of P immediately before the collision. [1]

O/N/2014/Q1

A particle P is projected vertically upwards with speed $11\,\mathrm{m\,s^{-1}}$ from a point on horizontal ground. At the same instant a particle Q is released from rest at a point h m above the ground. P and Q hit the ground at the same instant, when Q has speed $V\,\mathrm{m\,s^{-1}}$.

(i) Find the time after projection at which P hits the ground. [2]

(ii) Hence find the values of h and V. [2]

M/J/2015/Q5

A particle P starts from rest at a point O on a horizontal straight line. P moves along the line with constant acceleration and reaches a point A on the line with a speed of $30\,\mathrm{m\,s^{-1}}$. At the instant that P leaves O, a particle Q is projected vertically upwards from the point A with a speed of $20\,\mathrm{m\,s^{-1}}$. Subsequently P and Q collide at A. Find

(i) the acceleration of P, [4]

(ii) the distance OA. [2]

O/N/2015/Q2

A particle is released from rest at a point H m above horizontal ground and falls vertically. The particle passes through a point 35 m above the ground with a speed of $(V - 10)\,\mathrm{m\,s^{-1}}$ and reaches the ground with a speed of $V\,\mathrm{m\,s^{-1}}$. Find

(i) the value of V, [3]

(ii) the value of H. [2]

O/N/2017/Q3

A car travels along a straight road with constant acceleration. It passes through points A, B and C. The car passes point A with velocity $14\,\mathrm{m\,s^{-1}}$. The two sections AB and BC are of equal length. The times taken to travel along AB and BC are 5 s and 3 s respectively.

(i) Write down an expression for the distance AB in terms of the acceleration of the car. Write down a similar expression for the distance AC. Hence show that the acceleration of the car is $4\,\mathrm{m\,s^{-2}}$. [4]

(ii) Find the speed of the car as it passes point C. [2]

O/N/2017/Q4

A particle P is projected vertically upwards from horizontal ground with speed $12\,\text{m}\,\text{s}^{-1}$.

(i) Find the time taken for P to return to the ground. [2]

The time in seconds after P is projected is denoted by t. When $t = 1$, a second particle Q is projected vertically upwards with speed $10\,\text{m}\,\text{s}^{-1}$ from a point which is 5 m above the ground. Particles P and Q move in different vertical lines.

(ii) Find the set of values of t for which the two particles are moving in the same direction. [4]

M/J/2018/Q4

A particle P moves in a straight line $ABCD$ with constant acceleration. The distances AB and BC are 100 m and 148 m respectively. The particle takes 4 s to travel from A to B and also takes 4 s to travel from B to C.

(i) Show that the acceleration of P is $3\,\text{m s}^{-2}$ and find the speed of P at A. [6]

(ii) P reaches D with a speed of $61\,\text{m s}^{-1}$. Find the distance CD. [3]

M/J/2019/Q2

A car moves in a straight line with initial speed $u\,\text{m s}^{-1}$ and constant acceleration $a\,\text{m s}^{-2}$. The car takes 5 s to travel the first 80 m and it takes 8 s to travel the first 160 m. Find a and u. [6]

O/N/2019/Q5

Two particles A and B move in the same vertical line. Particle A is projected vertically upwards from the ground with speed $20\,\text{m}\,\text{s}^{-1}$. One second later particle B is dropped from rest from a height of 40 m.

(i) Find the height above the ground at which the two particles collide. [4]

(ii) Find the difference in the speeds of the two particles at the instant when the collision occurs. [3]

O/N/2010/Q5

Particles P and Q are projected vertically upwards, from different points on horizontal ground, with velocities of $20\,\text{m}\,\text{s}^{-1}$ and $25\,\text{m}\,\text{s}^{-1}$ 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]

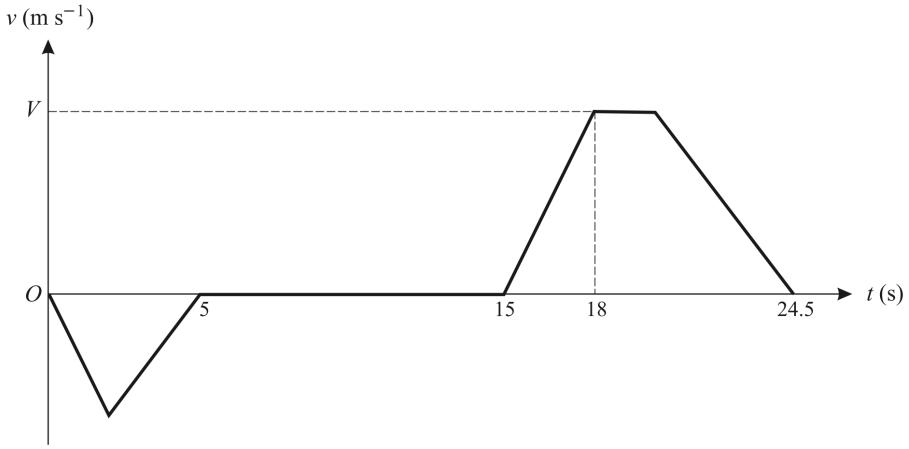
M/J/2011/Q5

Two particles P and Q are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of P and Q are $12\,\text{m s}^{-1}$ and $7\,\text{m s}^{-1}$ respectively and the heights of P and Q above the ground, t seconds after projection, are h_P m and h_Q m respectively. Each particle comes to rest on returning to the ground.

(i) Find the set of values of t for which the particles are travelling in opposite directions. [3]

(ii) At a certain instant, P and Q are above the ground and $3h_P = 8h_Q$. Find the velocities of P and Q at this instant. [5]

M/J/2005/Q6



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]

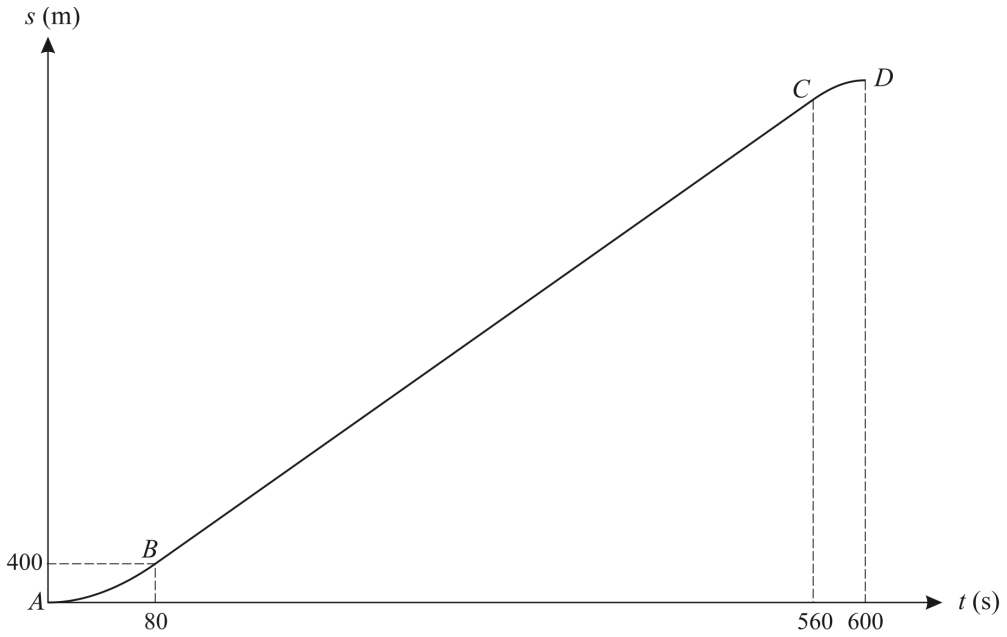
The second stage consists of a 10 s wait at the basement. In the third stage, the lift travels upwards until it comes to rest at a floor 34.5 m above the basement, arriving 24.5 s after the start of the first stage. The lift accelerates at $2\,\text{m s}^{-2}$ for the first 3 s of the third stage, reaching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

O/N/2005/Q5



The diagram shows the displacement-time graph for a car's journey. The graph consists of two curved parts AB and CD, and a straight line BC. The line BC is a tangent to the curve AB at B and a tangent to the curve CD at C. The gradient of the curves at $t = 0$ and $t = 600$ is zero, and the acceleration of the car is constant for $0 < t < 80$ and for $560 < t < 600$. The displacement of the car is 400 m when $t = 80$.

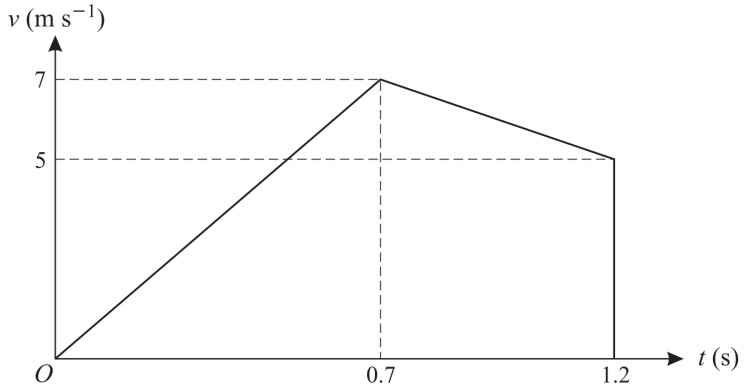
(i) Sketch the velocity-time graph for the journey. [3]

(ii) Find the velocity at $t = 80$. [2]

(iii) Find the total distance for the journey. [2]

(iv) Find the acceleration of the car for $0 < t < 80$. [2]

M/J/2006/Q4



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,

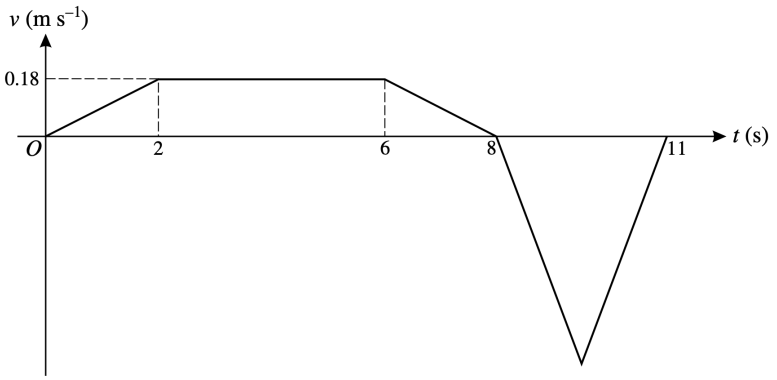
(b) the depth of liquid in the container.

[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]

M/J/2010/Q2



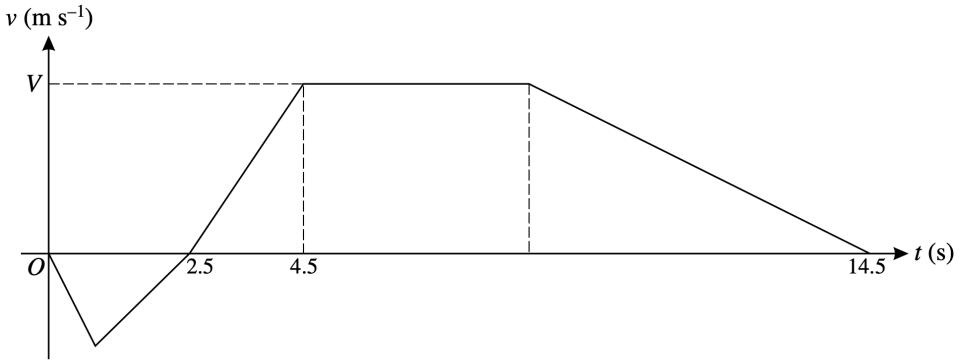
The diagram shows the velocity-time graph for the motion of a machine's cutting tool. The graph consists of five straight line segments. The tool moves forward for 8 s while cutting and then takes 3 s to return to its starting position. Find

(i) the acceleration of the tool during the first 2 s of the motion, [1]

(ii) the distance the tool moves forward while cutting, [2]

(iii) the greatest speed of the tool during the return to its starting position. [2]

O/N/2010/Q6



The diagram shows the velocity-time graph for a particle P which travels on a straight line AB, where v 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 m s^{-2}, reaching a velocity of V m s^{-1}. Find

(ii) the value of V, [2]

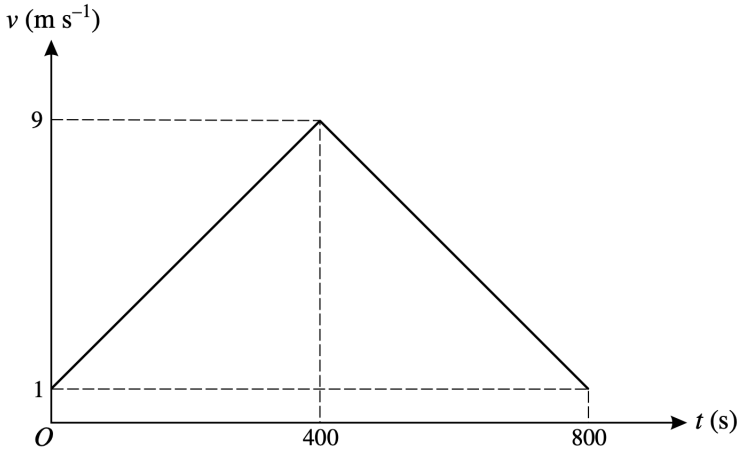
(iii) the value of t at which P starts to decelerate during this stage, [3]

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

O/N/2011/Q7

A tractor travels in a straight line from a point A to a point B. The velocity of the tractor is v m s^{-1} at time t s after leaving A.

(i)



The diagram shows an approximate velocity-time graph for the motion of the tractor. The graph consists of two straight line segments. Use the graph to find an approximation for

(a) the distance AB, [2]

(b) the acceleration of the tractor for $0 < t < 400$ and for $400 < t < 800$. [2]

(ii) The actual velocity of the tractor is given by $v = 0.04t - 0.000\,05t^2$ for $0 \leqslant t \leqslant 800$.

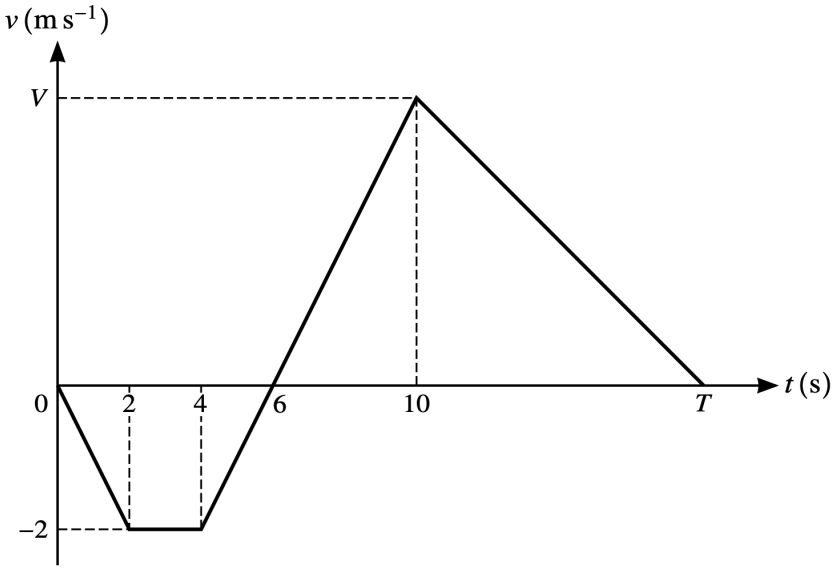
(a) Find the values of t for which the actual acceleration of the tractor is given correctly by the approximate velocity-time graph in part **(i)**. [3]

For the interval $0 \leqslant t \leqslant 400$, the approximate velocity of the tractor in part **(i)** is denoted by v_1 m s^{-1}.

(b) Express v_1 in terms of t and hence show that $v_1 - v = 0.000\,05(t - 200)^2 - 1$. [2]

(c) Deduce that $-1 \leqslant v_1 - v \leqslant 1$. [2]

O/N/2018/Q3



The velocity of a particle moving in a straight line is v m s^{-1} at time t seconds. The diagram shows a velocity-time graph which models the motion of the particle from $t = 0$ to $t = T$. The graph consists of four straight line segments. The particle reaches its maximum velocity V m s^{-1} at $t = 10$.

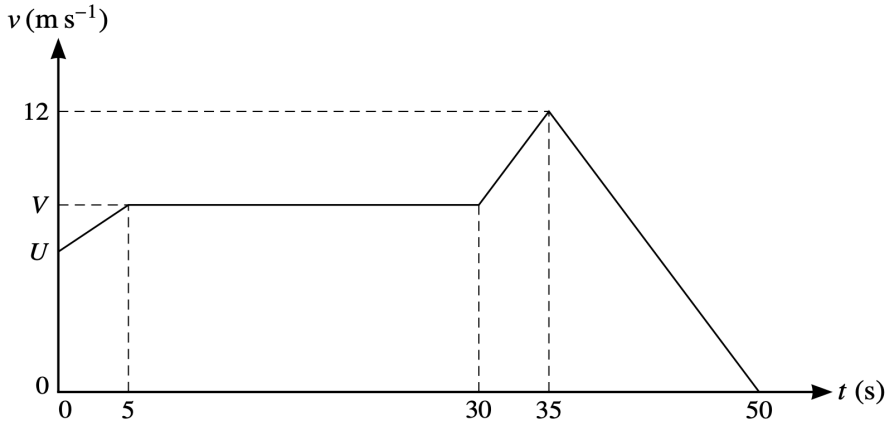
(i) Find the acceleration of the particle during the first 2 seconds. [1]

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

At $t = 6$, the particle is instantaneously at rest at the point A. At $t = T$, the particle comes to rest at the point B. At $t = 0$ the particle starts from rest at a point one third of the way from A to B.

(iii) Find the distance AB and hence find the value of T. [4]

O/N/2019/Q2



The diagram shows a velocity-time graph which models the motion of a tractor. The graph consists of four straight line segments. The tractor passes a point O at time $t = 0$ with speed U m s^{-1}. The tractor accelerates to a speed of V m s^{-1} over a period of 5 s, and then travels at this speed for a further 25 s. The tractor then accelerates to a speed of 12 m s^{-1} over a period of 5 s. The tractor then decelerates to rest over a period of 15 s.

(i) Given that the acceleration of the tractor between $t = 30$ and $t = 35$ is 0.8 m s^{-2}, find the value of V. [2]

(ii) Given also that the total distance covered by the tractor in the 50 seconds of motion is 375 m, find the value of U. [3]