Cambridge International AS & A Level

MATHEMATICS (9709) P4

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS

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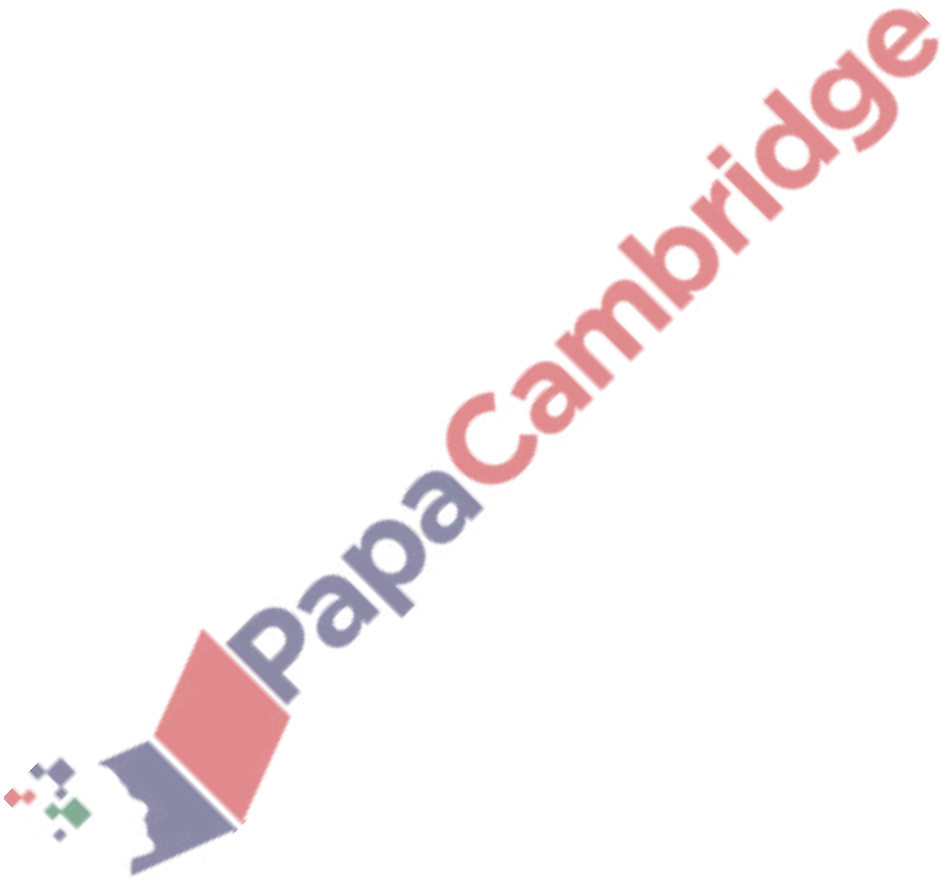
Chapter 2

Kinematics of motion in a straight line



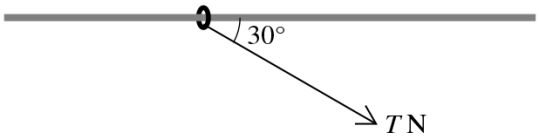
53. 9709_s20_qp_41 Q: 3

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]

54. 9709_s20_qp_41 Q: 4



The diagram shows a ring of mass 0.1 kg threaded on a fixed horizontal rod. The rod is rough and the coefficient of friction between the ring and the rod is 0.8. A force of magnitude T N acts on the ring in a direction at 30° to the rod, downwards in the vertical plane containing the rod. Initially the ring is at rest.

(a) Find the greatest value of T for which the ring remains at rest. [4]

(b) Find the acceleration of the ring when $T = 3$. [3]

55. 9709_s20_qp_41 Q: 6

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

56. 9709_s20_qp_42 Q: 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]

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(b) Find V. [2]

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

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57. 9709_s20_qp_42 Q: 6

A particle P moves in a straight line. The velocity v m s^{-1} at time t s is given by

$$v = 2t + 1 \qquad \text{for } 0 \leqslant t \leqslant 5,$$
$$v = 36 - t^2 \qquad \text{for } 5 \leqslant t \leqslant 7,$$
$$v = 2t - 27 \qquad \text{for } 7 \leqslant t \leqslant 13.5.$$

(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]

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(c) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 13.5$. [5]

58. 9709_s20_qp_43 Q: 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]

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(c) Find the total time for which the car is in motion. [3]

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59. 9709_s20_qp_43 Q: 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.

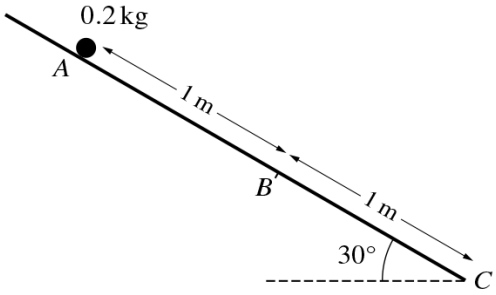
(b) Find the distance PQ. [6]

60. 9709_W20_qp_41 Q: 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]

61. 9709_W20_qp_41 Q: 7

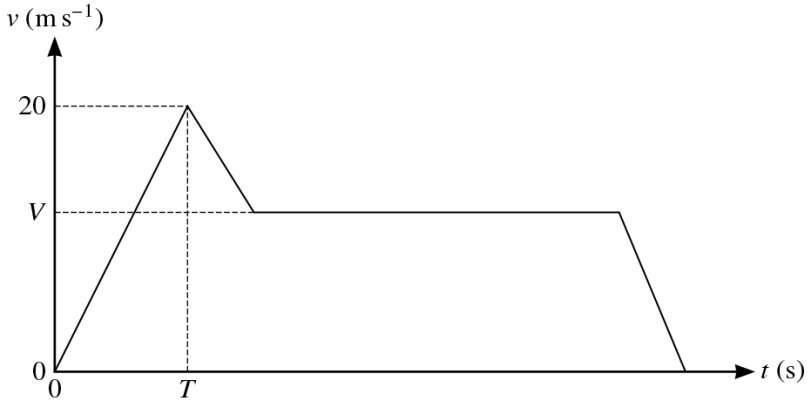


Three points A, B and C lie on a line of greatest slope of a plane inclined at an angle of 30° to the horizontal, with $AB = 1$ m and $BC = 1$ m, as shown in the diagram. A particle of mass 0.2 kg is released from rest at A and slides down the plane. The part of the plane from A to B is smooth. The part of the plane from B to C is rough, with coefficient of friction μ between the plane and the particle.

(a) Given that $\mu = \frac{1}{2}\sqrt{3}$, find the speed of the particle at C. [8]

(b) Given instead that the particle comes to rest at C, find the exact value of μ. [4]

62. 9709_W20_qp_42 Q: 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]

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(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]

63. 9709_W20_qp_42 Q: 5

A particle is projected vertically upwards with speed $40\,\text{m}\,\text{s}^{-1}$ 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 $20\,\text{m}\,\text{s}^{-1}$.

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]

64. 9709_W20_qp_42 Q: 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]

65. 9709_W20_qp_43 Q: 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]

66. 9709_W20_qp_43 Q: 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]

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(b) Find the initial acceleration of P. [2]

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(c) Find the minimum velocity of P. [2]

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(d) Find the distance travelled by P during the time when its velocity is negative. [4]

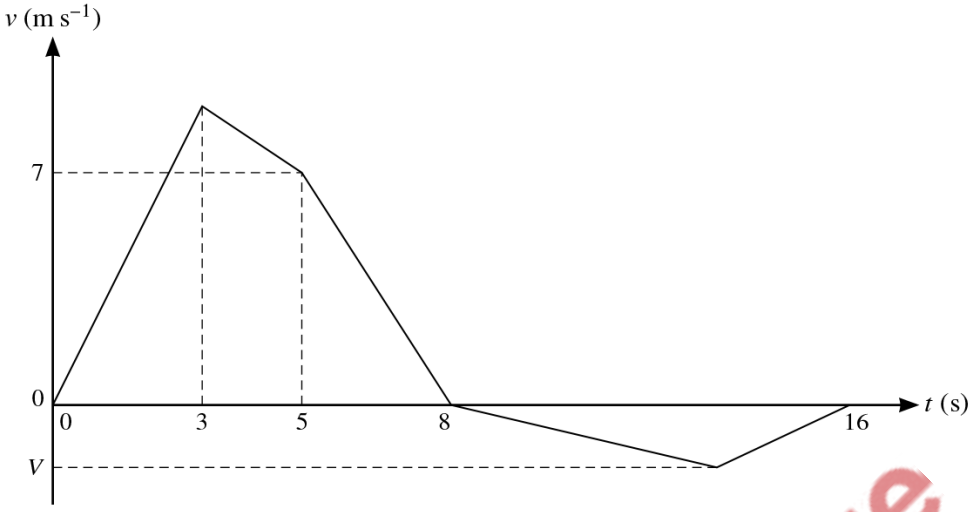
67. 9709_m19_qp_42 Q: 2

A particle is projected vertically upwards with speed $30\,\text{m}\,\text{s}^{-1}$ from a point on horizontal ground.

(i) Show that the maximum height above the ground reached by the particle is 45 m. [2]

(ii) Find the time that it takes for the particle to reach a height of 33.75 m above the ground for the first time. Find also the speed of the particle at this time. [4]

68. 9709_m19_qp_42 Q: 5



The velocity of a particle moving in a straight line is v m s^{-1} at time t seconds after leaving a fixed point O. The diagram shows a velocity-time graph which models the motion of the particle from $t = 0$ to $t = 16$. The graph consists of five straight line segments. The acceleration of the particle from $t = 0$ to $t = 3$ is 3 m s^{-2}. The velocity of the particle at $t = 5$ is 7 m s^{-1} and it comes to instantaneous rest at $t = 8$. The particle then comes to rest again at $t = 16$. The minimum velocity of the particle is V m s^{-1}.

(i) Find the distance travelled by the particle in the first 8 s of its motion. [3]

(ii) Given that when the particle comes to rest at $t = 16$ its displacement from O is 32 m, find the value of V. [4]

69. 9709_m19_qp_42 Q: 6

A particle moves in a straight line. It starts from rest at a fixed point O on the line. Its acceleration at time t s after leaving O is a m s^{-2}, where $a = 0.4t^3 - 4.8t^{\frac{1}{2}}$.

(i) Show that, in the subsequent motion, the acceleration of the particle when it comes to instantaneous rest is 16 m s^{-2}. [6]

(ii) Find the displacement of the particle from O at $t = 5$. [3]

70. 9709_s19_qp_41 Q: 2

A particle P is projected vertically upwards with speed $25\,\text{m}\,\text{s}^{-1}$ from a point 3 m above horizontal ground.

(i) Find the time taken for P to reach its greatest height. [2]

(ii) Find the length of time for which P is higher than 23 m above the ground. [3]

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(iii) P is higher than h m above the ground for 1 second. Find h. [2]

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71. 9709_s19_qp_41 Q: 5

A particle P moves in a straight line from a fixed point O. The velocity v m s^{-1} of P at time t s is given by

$$v = t^2 - 8t + 12 \quad \text{for } 0 \leqslant t \leqslant 8.$$

(i) Find the minimum velocity of P. [3]

(ii) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 8$. [7]

72. 9709_s19_qp_42 Q: 2

A car moves in a straight line with initial speed u m s^{-1} and constant acceleration a 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]

73. 9709_s19_qp_42 Q: 7

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]

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

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74. 9709_s19_qp_43 Q: 1

A bus moves in a straight line between two bus stops. The bus starts from rest and accelerates at $2.1\,\text{m s}^{-2}$ for 5 s. The bus then travels for 24 s at constant speed and finally slows down, with a constant deceleration, stopping in a further 6 s. Sketch a velocity-time graph for the motion and hence find the distance between the two bus stops. [5]

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75. 9709_s19_qp_43 Q: 6

A particle P moves in a straight line. The acceleration a m s^{-2} of P at time t s is given by $a = 6t - 12$. The displacement of P from a fixed point O on the line is s m. It is given that $s = 5$ when $t = 1$ and $s = 1$ when $t = 3$.

(i) Show that $s = t^3 - 6t^2 + pt + q$, where p and q are constants to be found. [4]

(ii) Find the values of t when P is at instantaneous rest. [2]

(iii) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 4$. [4]

76. 9709_w19_qp_41 Q: 7

A particle moves in a straight line, starting from rest at a point O, and comes to instantaneous rest at a point P. The velocity of the particle at time t s after leaving O is v m s^{-1}, where

$$v = 0.6t^2 - 0.12t^3.$$

(i) Show that the distance OP is 6.25 m. [5]

On another occasion, the particle also moves in the same straight line. On this occasion, the displacement of the particle at time t s after leaving O is s m, where

$$s = kt^3 + ct^5.$$

It is given that the particle passes point P with velocity $1.25\ \text{m s}^{-1}$ at time $t = 5$.

(ii) Find the values of the constants k and c. [5]

(iii) Find the acceleration of the particle at time $t = 5$. [2]

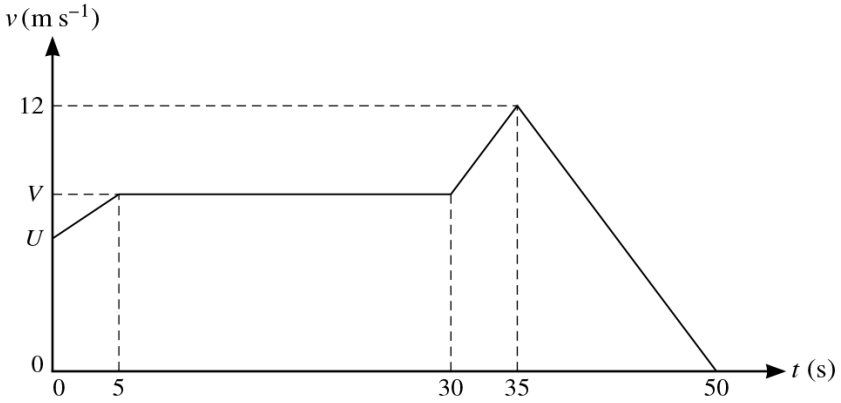
77. 9709_w19_qp_42 Q: 1

A particle moves in a straight line. The displacement of the particle at time t s is s m, where

$$s = t^3 - 6t^2 + 4t.$$

Find the velocity of the particle at the instant when its acceleration is zero. [4]

78. 9709_w19_qp_42 Q: 2



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]

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(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]

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79. 9709_w19_qp_42 Q: 5

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]

80. 9709_w19_qp_43 Q: 4

A car travels along a straight road with constant acceleration. It passes through points P, Q, R and S. The times taken for the car to travel from P to Q, Q to R and R to S are each equal to 10 s. The distance QR is 1.5 times the distance PQ. At point Q the speed of the car is 20 m s^{-1}.

(i) Show that the acceleration of the car is 0.8 m s^{-2}. [3]

(ii) Find the distance QS and hence find the average speed of the car between Q and S. [3]

81. 9709_w19_qp_43 Q: 6

Particle P travels in a straight line from A to B. The velocity of P at time t s after leaving A is denoted by v m s^{-1}, where

$$v = 0.04t^3 + ct^2 + kt.$$

P takes 5 s to travel from A to B and it reaches B with speed 10 m s^{-1}. The distance AB is 25 m.

(i) Find the values of the constants c and k. [6]

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(ii) Show that the acceleration of P is a minimum when $t = 2.5$. [3]

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82. 9709_m18_qp_42 Q: 5

A small rocket is fired vertically upwards, starting from rest at ground level, and moves with constant acceleration. The rocket reaches a height of 200 m after 10 s.

(i) Show that the speed of the rocket after 10 s is 40 m s^{-1} and find the acceleration of the rocket during the first 10 s. [4]

(ii) After 10 s, the rocket's fuel stops burning and there is no upward force acting on the rocket. Find the maximum height above ground level reached by the rocket. [2]

(iii) Find the total time from the instant the rocket is fired until it returns to the ground. [4]

83. 9709_m18_qp_42 Q: 7

A particle P moves in a straight line. The velocity v m s^{-1} at time t s is given by

$$v = 4 + 0.2t \qquad \text{for } 0 \leqslant t \leqslant 10,$$

$$v = -2 + \frac{800}{t^2} \qquad \text{for } 10 \leqslant t \leqslant 20.$$

(i) Find the acceleration of P during the first 10 s. [1]

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(ii) Find the acceleration of P when $t = 20$. [2]

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(iii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 20$. [3]

(iv) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 20$. [5]

84. 9709_s18_qp_41 Q: 1

A particle P is projected vertically upwards with speed $24\,\text{m}\,\text{s}^{-1}$ from a point 5 m above ground level. Find the time from projection until P reaches the ground. [3]

85. 9709_s18_qp_41 Q: 4

A particle P moves in a straight line starting from a point O. At time t s after leaving O, the displacement s m from O is given by $s = t^3 - 4t^2 + 4t$ and the velocity is v m s^{-1}.

(i) Find an expression for v in terms of t. [2]

(ii) Find the two values of t for which P is at instantaneous rest. [2]

(iii) Find the minimum velocity of P. [3]

86. 9709_s18_qp_41 Q: 5

A sprinter runs a race of 200 m. His total time for running the race is 20 s. He starts from rest and accelerates uniformly for 6 s, reaching a speed of 12 m s^{-1}. He maintains this speed for the next 10 s, before decelerating uniformly to cross the finishing line with speed V m s^{-1}.

(i) Find the distance travelled by the sprinter in the first 16 s of the race. Hence sketch a displacement-time graph for the 20 s of the sprinter's race. [6]

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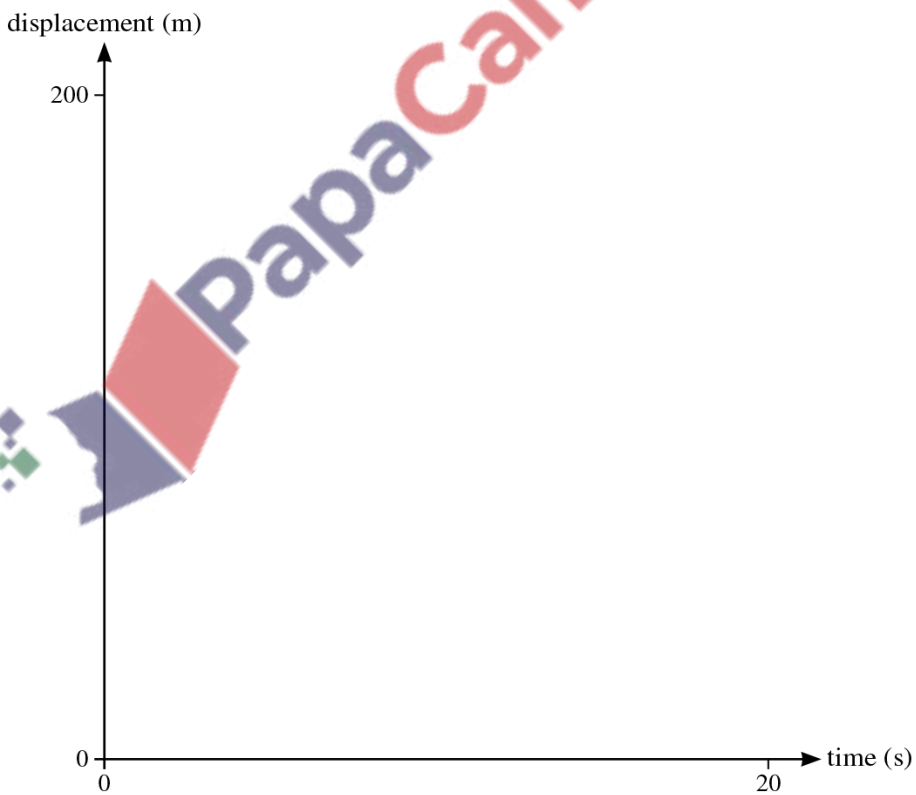


(ii) Find the value of V. [2]

87. 9709_s18_qp_42 Q: 4

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 m s^{-2} and find the speed of P at A. [6]

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

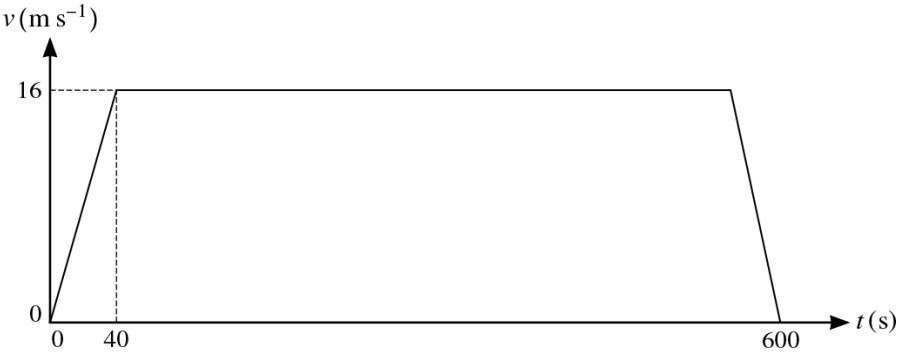
88. 9709_s18_qp_42 Q: 6

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]

89. 9709_s18_qp_43 Q: 1



The diagram shows the velocity-time graph for a train which travels from rest at one station to rest at the next station. The graph consists of three straight line segments. The distance between the two stations is 9040 m.

(i) Find the acceleration of the train during the first 40 s. [1]

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(ii) Find the length of time for which the train is travelling at constant speed. [2]

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(iii) Find the distance travelled by the train while it is decelerating. [2]

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90. 9709_s18_qp_43 Q: 2

A small ball is projected vertically downwards with speed $5\,\text{m s}^{-1}$ from a point A at a height of 7.2 m above horizontal ground. The ball hits the ground with speed $V\,\text{m s}^{-1}$ and rebounds vertically upwards with speed $\frac{1}{2}V\,\text{m s}^{-1}$. The highest point the ball reaches after rebounding is B. Find V and hence find the total time taken for the ball to reach the ground from A and rebound to B. [5]

91. 9709_s18_qp_43 Q: 7

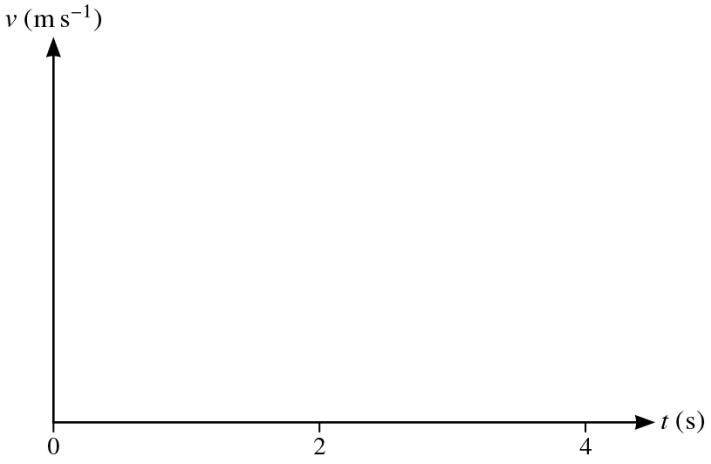
A particle P moves in a straight line starting from a point O. The velocity $v\,\text{m s}^{-1}$ of P at time t s is given by

$$v = 12t - 4t^2 \quad \text{for } 0 \leqslant t \leqslant 2,$$
$$v = 16 - 4t \quad \text{for } 2 \leqslant t \leqslant 4.$$

(i) Find the maximum velocity of P during the first 2 s. [3]

(ii) Determine, with justification, whether there is any instantaneous change in the acceleration of P when $t = 2$. [2]

(iii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 4$. [3]



(iv) Find the distance travelled by P in the interval $0 \leqslant t \leqslant 4$. [5]

92. 9709_w18_qp_41 Q: 7

A particle moves in a straight line starting from rest from a point O. The acceleration of the particle at time t s after leaving O is a m s^{-2}, where

$$a = 5.4 - 1.62t.$$

(i) Find the positive value of t at which the velocity of the particle is zero, giving your answer as an exact fraction. [4]

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(ii) Find the velocity of the particle at $t = 10$ and sketch the velocity-time graph for the first ten seconds of the motion. [3]

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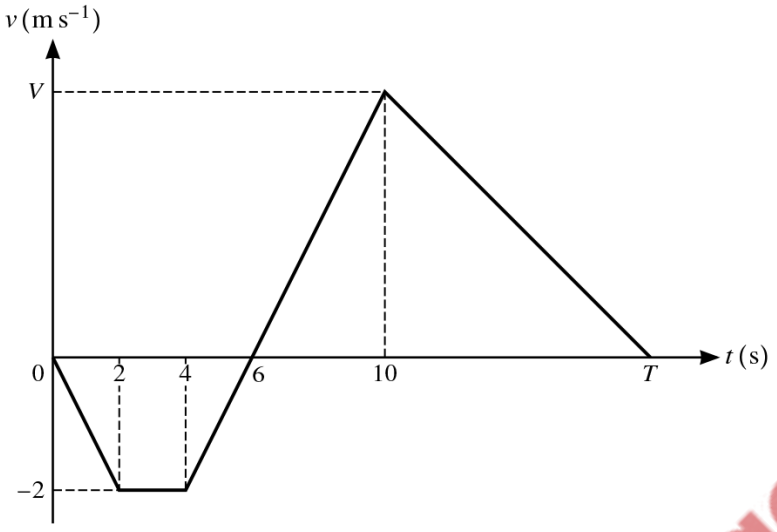
(iii) Find the total distance travelled during the first ten seconds of the motion. [5]

93. 9709_w18_qp_42 Q: 3



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]

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

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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]

94. 9709_w18_qp_42 Q: 5

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

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

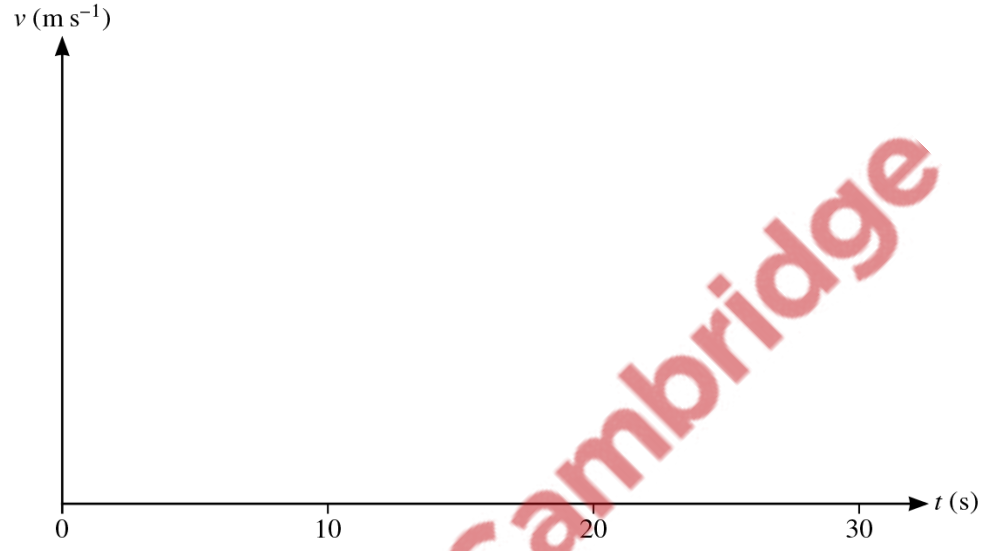
(i) At time T s after leaving O the particle reaches its maximum velocity. Find the value of T. [2]

(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]

95. 9709_w18_qp_43 Q: 4

A runner sets off from a point P at time $t = 0$, where t is in seconds. The runner starts from rest and accelerates at $1.2\,\text{m s}^{-2}$ for 5 s. For the next 12 s the runner moves at constant speed before decelerating uniformly over a period of 3 s, coming to rest at Q. A cyclist sets off from P at time $t = 10$ and accelerates uniformly for 10 s, before immediately decelerating uniformly to rest at Q at time $t = 30$.

(i) Sketch the velocity-time graph for the runner and show that the distance PQ is 96 m. [4]



(ii) Find the magnitude of the acceleration of the cyclist. [3]

96. 9709_w18_qp_43 Q: 7

A particle moves in a straight line. The particle is initially at rest at a point O on the line. At time t s after leaving O, the acceleration a m s^{-2} of the particle is given by $a = 25 - t^2$ for $0 \leqslant t \leqslant 9$.

(i) Find the maximum velocity of the particle in this time period. [4]

(ii) Find the total distance travelled until the maximum velocity is reached. [2]

The acceleration of the particle for $t > 9$ is given by $a = -3t^{-\frac{1}{2}}$.

(iii) Find the velocity of the particle when $t = 25$. [4]

97. 9709_m17_qp_42 Q: 5

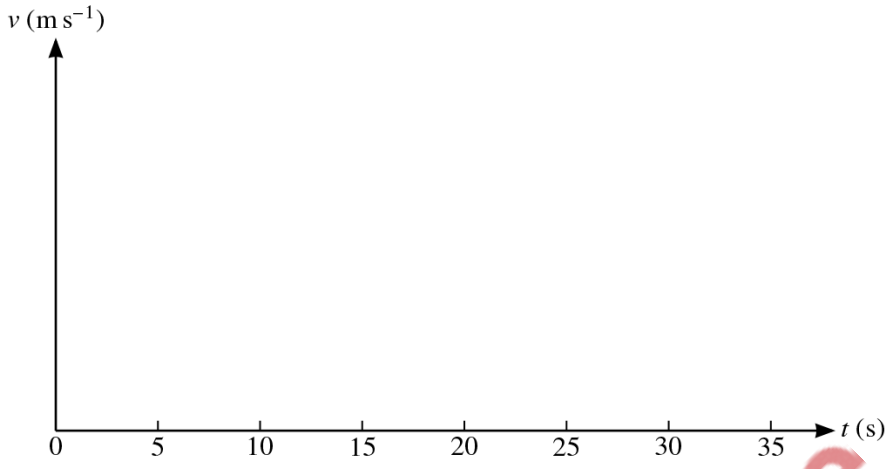
A particle P moves in a straight line starting from a point O and comes to rest 35 s later. At time t s after leaving O, the velocity v m s^{-1} of P is given by

$$v = \tfrac{4}{5}t^2 \qquad 0 \leqslant t \leqslant 5,$$
$$v = 2t + 10 \qquad 5 \leqslant t \leqslant 15,$$
$$v = a + bt^2 \qquad 15 \leqslant t \leqslant 35,$$

where a and b are constants such that $a > 0$ and $b < 0$.

(i) Show that the values of a and b are 49 and –0.04 respectively. [3]

(ii) Sketch the velocity-time graph. [4]



(iii) Find the total distance travelled by P during the 35 s. [5]

98. 9709_s17_qp_41 Q: 5

A particle P moves in a straight line $ABCD$ with constant deceleration. The velocities of P at A, B and C are $20\,\text{m s}^{-1}$, $12\,\text{m s}^{-1}$ and $6\,\text{m s}^{-1}$ respectively.

(i) Find the ratio of distances $AB : BC$. [4]

(ii) The particle comes to rest at D. Given that the distance AD is 80 m, find the distance BC. [3]

99. 9709_s17_qp_41 Q: 6

A particle P moves in a straight line passing through a point O. At time t s, the velocity of P, v m s^{-1}, is given by $v = qt + rt^2$, where q and r are constants. The particle has velocity 4 m s^{-1} when $t = 1$ and when $t = 2$.

(i) Show that, when $t = 0.5$, the acceleration of P is 4 m s^{-2}. [4]

(ii) Find the values of t when P is at instantaneous rest. [2]

(iii) The particle is at O when $t = 3$. Find the distance of P from O when $t = 0$. [4]

100. 9709_s17_qp_42 Q: 3

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]

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

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

101. 9709_s17_qp_43 Q: 3

A train travels between two stations, A and B. The train starts from rest at A and accelerates at a constant rate for T s until it reaches a speed of 25 m s^{-1}. It then travels at this constant speed before decelerating at a constant rate, coming to rest at B. The magnitude of the train's deceleration is twice the magnitude of its acceleration. The total time taken for the journey is 180 s.

(i) Sketch the velocity-time graph for the train's journey from A to B. [1]

(ii) Find an expression, in terms of T, for the length of time for which the train is travelling with constant speed. [2]

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(iii) The distance from A to B is 3300 m. Find how far the train travels while it is decelerating. [3]

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102. 9709_s17_qp_43 Q: 4

A particle P moves in a straight line starting from a point O. At time t s after leaving O, the velocity, v m s^{-1}, of P is given by $v = (2t - 5)^3$.

(i) Find the values of t when the acceleration of P is 54 m s^{-2}. [3]

(ii) Find an expression for the displacement of P from O at time t s. [3]

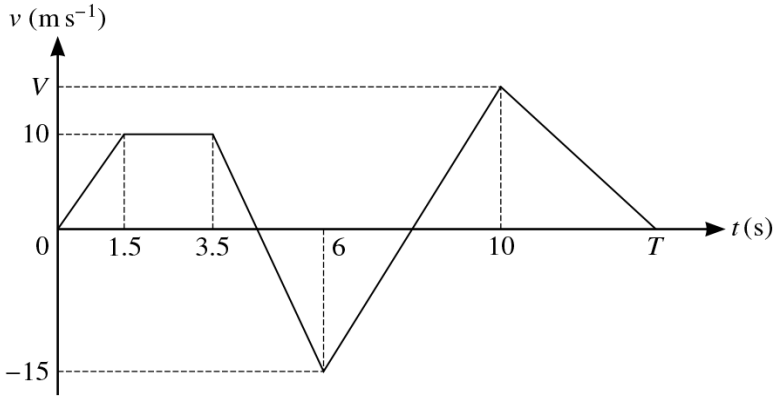
103. 9709_s17_qp_43 Q: 5

A particle is projected vertically upwards from a point O with a speed of $12\,\text{m}\,\text{s}^{-1}$. Two seconds later a second particle is projected vertically upwards from O with a speed of $20\,\text{m}\,\text{s}^{-1}$. At time t s after the second particle is projected, the two particles collide.

(i) Find t. [5]

(ii) Hence find the height above O at which the particles collide. [1]

104. 9709_w17_qp_41 Q: 4



The diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

(i) Show that the acceleration of the particle between $t = 3.5$ and $t = 6$ is $-10\,\text{m s}^{-2}$. [1]

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(ii) The acceleration of the particle between $t = 6$ and $t = 10$ is $7.5\,\text{m s}^{-2}$. When $t = 10$ the velocity of the particle is $V\,\text{m s}^{-1}$. Find the value of V. [2]

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(iii) The particle comes to rest at B at time T s. Given that the total distance travelled by the particle between $t = 0$ and $t = T$ is 100 m, find the value of T. [4]

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105. 9709_w17_qp_41 Q: 5

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

$$v = 1.5 + 0.4t \quad \text{for } 0 \leqslant t \leqslant 5,$$
$$v = \frac{100}{t^2} - 0.1t \quad \text{for } t \geqslant 5.$$

(i) Find the acceleration of the particle during the first 5 seconds of motion. [1]

(ii) Find the value of t when the particle is instantaneously at rest. [2]

(iii) Find the total distance travelled by the particle in the first 10 seconds of motion. [5]

106. 9709_w17_qp_42 Q: 3

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 $14\,\text{m s}^{-1}$. 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 $4\,\text{m s}^{-2}$. [4]

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

107. 9709_w17_qp_42 Q: 4

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

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

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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 $10\,\text{m s}^{-1}$ 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]

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108. 9709_w17_qp_42 Q: 7

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]

109. 9709_w17_qp_43 Q: 5

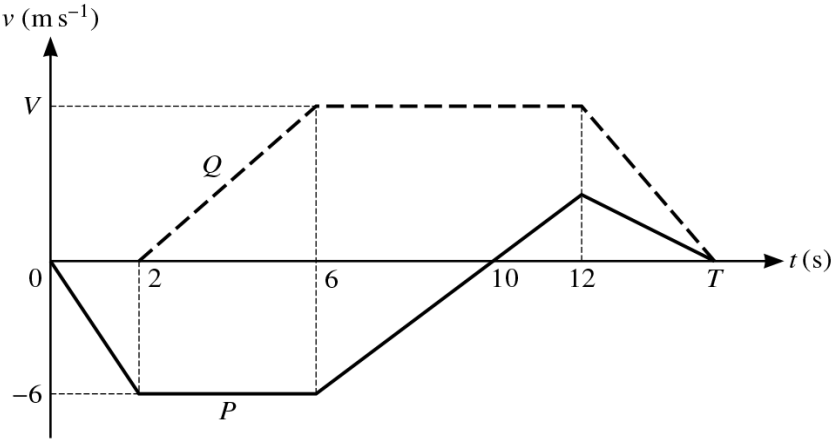
A particle starts from a fixed origin with velocity $0.4\,\text{m s}^{-1}$ and moves in a straight line. The acceleration $a\,\text{m s}^{-2}$ of the particle t s after it leaves the origin is given by $a = k(3t^2 - 12t + 2)$, where k is a constant. When $t = 1$, the velocity of P is $0.1\,\text{m s}^{-1}$.

(i) Show that the value of k is 0.1. [5]

(ii) Find an expression for the displacement of the particle from the origin in terms of t. [2]

(iii) Hence verify that the particle is again at the origin at $t = 2$. [1]

110. 9709_w17_qp_43 Q: 6



The diagram shows the velocity-time graphs for two particles, P and Q, which are moving in the same straight line. The graph for P consists of four straight line segments. The graph for Q consists of three straight line segments. Both particles start from the same initial position O on the line. Q starts 2 seconds after P and both particles come to rest at time $t = T$. The greatest velocity of Q is V m s^{-1}.

(i) Find the displacement of P from O at $t = 10$. [1]

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(ii) Find the velocity of P at $t = 12$. [2]

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(iii) Given that the total distance covered by P during the T seconds of its motion is 49.5 m, find the value of T. [3]

(iv) Given also that the acceleration of Q from $t = 2$ to $t = 6$ is $1.75\,\text{m s}^{-2}$, find the value of V and hence find the distance between the two particles when they both come to rest at $t = T$. [3]

111. 9709_m16_qp_42 Q: 7

A particle P moves in a straight line. The velocity v m s^{-1} at time t s is given by

$$\begin{aligned} v &= 5t(t-2) && \text{for } 0 \leqslant t \leqslant 4, \\ v &= k && \text{for } 4 \leqslant t \leqslant 14, \\ v &= 68 - 2t && \text{for } 14 \leqslant t \leqslant 20, \end{aligned}$$

where k is a constant.

(i) Find k. [1]

(ii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 20$. [3]

(iii) Find the set of values of t for which the acceleration of P is positive. [2]

(iv) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 20$. [5]

112. 9709_s16_qp_41 Q: 1

A lift moves upwards from rest and accelerates at $0.9\,\text{m}\,\text{s}^{-2}$ for 3 s. The lift then travels for 6 s at constant speed and finally slows down, with a constant deceleration, stopping in a further 4 s.

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

(ii) Find the total distance travelled by the lift. [2]

113. 9709_s16_qp_41 Q: 6

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 a velocity v m s^{-1}, where $v = 6t^2 - 30t + 24$.

(i) Find the set of values of t for which the acceleration of the particle is negative. [2]

(ii) Find the distance between the two positions at which P is at instantaneous rest. [4]

(iii) Find the two positive values of t at which P passes through O. [3]

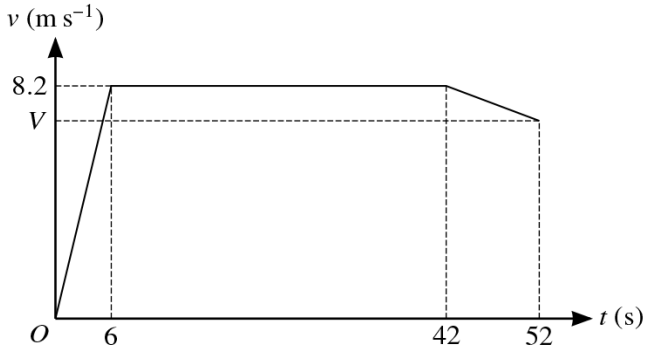
114. 9709_s16_qp_42 Q: 2

A particle P moves in a straight line, starting from a point O. At time t s after leaving O, the velocity of P, v m s^{-1}, is given by $v = 4t^2 - 8t + 3$.

(i) Find the two values of t at which P is at instantaneous rest. [2]

(ii) Find the distance travelled by P between these two times. [3]

115. 9709_s16_qp_42 Q: 4



A sprinter runs a race of 400 m. His total time for running the race is 52 s. The diagram shows the velocity-time graph for the motion of the sprinter. He starts from rest and accelerates uniformly to a speed of 8.2 m s^{-1} in 6 s. The sprinter maintains a speed of 8.2 m s^{-1} for 36 s, and he then decelerates uniformly to a speed of V m s^{-1} at the end of the race.

(i) Calculate the distance covered by the sprinter in the first 42 s of the race. [2]

(ii) Show that $V = 7.84$. [3]

(iii) Calculate the deceleration of the sprinter in the last 10 s of the race. [2]

116. 9709_s16_qp_43 Q: 2

Alan starts walking from a point O, at a constant speed of $4\,\text{m}\,\text{s}^{-1}$, along a horizontal path. Ben walks along the same path, also starting from O. Ben starts from rest 5 s after Alan and accelerates at $1.2\,\text{m}\,\text{s}^{-2}$ for 5 s. Ben then continues to walk at a constant speed until he is at the same point, P, as Alan.

(i) Find how far Ben has travelled when he has been walking for 5 s and find his speed at this instant. [2]

(ii) Find the distance OP. [3]

117. 9709_s16_qp_43 Q: 7

A particle P moves in a straight line. At time t s, the displacement of P from O is s m and the acceleration of P is a m s^{-2}, where $a = 6t - 2$. When $t = 1$, $s = 7$ and when $t = 3$, $s = 29$.

(i) Find the set of values of t for which the particle is decelerating. [2]

(ii) Find s in terms of t. [5]

(iii) Find the time when the velocity of the particle is 10 m s^{-1}. [3]

118. 9709_w16_qp_41 Q: 1

Two particles P and Q, of masses 0.6 kg and 0.4 kg respectively, are connected by a light inextensible string. The string passes over a small smooth light pulley fixed at the edge of a smooth horizontal table. Initially P is held at rest on the table and Q hangs vertically (see diagram). P is then released. Find the tension in the string and the acceleration of Q. [4]

119. 9709_w16_qp_41 Q: 3

A particle P is projected vertically upwards from a point O. When the particle is at a height of 0.5 m, its speed is $6\,\mathrm{m\,s^{-1}}$. Find

(i) the greatest height reached by the particle above O, [3]

(ii) the time after projection at which the particle returns to O. [3]

120. 9709_w16_qp_41 Q: 7

A racing car is moving in a straight line. The acceleration a m s^{-2} at time t s after the car starts from rest is given by

$$a = 15t - 3t^2 \qquad \text{for } 0 \leqslant t \leqslant 5,$$

$$a = -\frac{625}{t^2} \qquad \text{for } 5 < t \leqslant k,$$

where k is a constant.

(i) Find the maximum acceleration of the car in the first five seconds of its motion. [3]

(ii) Find the distance of the car from its starting point when $t = 5$. [3]

(iii) The car comes to rest when $t = k$. Find the value of k. [5]

121. 9709_w16_qp_42 Q: 2

A particle moves in a straight line. Its displacement t s after leaving a fixed point O on the line is s m, where $s = 2t^2 - \frac{80}{3}t^{\frac{3}{2}}$.

(i) Find the time at which the acceleration of the particle is zero. [4]

(ii) Find the displacement and velocity of the particle at this instant. [2]

122. 9709_w16_qp_42 Q: 7

A car starts from rest and moves in a straight line from point A with constant acceleration $3\,\text{m s}^{-2}$ for 10 s. The car then travels at constant speed for 30 s before decelerating uniformly, coming to rest at point B. The distance AB is 1.5 km.

(i) Find the total distance travelled in the first 40 s of motion. [3]

When the car has been moving for 20 s, a motorcycle starts from rest and accelerates uniformly in a straight line from point A to a speed $V\,\text{m s}^{-1}$. It then maintains this speed for 30 s before decelerating uniformly to rest at point B. The motorcycle comes to rest at the same time as the car.

(ii) Given that the magnitude of the acceleration $a\,\text{m s}^{-2}$ of the motorcycle is three times the magnitude of its deceleration, find the value of a. [6]

(iii) Sketch the displacement-time graph for the motion of the car. [3]

123. 9709_w16_qp_43 Q: 4

A ball A is released from rest at the top of a tall tower. One second later, another ball B is projected vertically upwards from ground level near the bottom of the tower with a speed of $20\,\text{m}\,\text{s}^{-1}$. The two balls are at the same height 1.5 s after ball B is projected.

(i) Show that the height of the tower is 50 m. [3]

(ii) Find the length of time for which ball B has been in motion when ball A reaches the ground. Hence find the total distance travelled by ball B up to the instant when ball A reaches the ground. [5]

124. 9709_w16_qp_43 Q: 5

A particle P starts from a fixed point O and moves in a straight line. At time t s after leaving O, the velocity v m s^{-1} of P is given by $v = 6t - 0.3t^2$. The particle comes to instantaneous rest at point X.

(i) Find the distance OX. [4]

A second particle Q starts from rest from O, at the same instant as P, and also travels in a straight line. The acceleration a m s^{-2} of Q is given by $a = k - 12t$, where k is a constant. The displacement of Q from O is 400 m when $t = 10$.

(ii) Find the value of k. [4]

125. 9709_s15_qp_41 Q: 6

Two particles A and B start to move at the same instant from a point O. The particles move in the same direction along the same straight line. The acceleration of A at time t s after starting to move is a m s^{-2}, where $a = 0.05 - 0.0002t$.

(i) Find A's velocity when $t = 200$ and when $t = 500$. [4]

B moves with constant acceleration for the first 200 s and has the same velocity as A when $t = 200$. B moves with constant retardation from $t = 200$ to $t = 500$ and has the same velocity as A when $t = 500$.

(ii) Find the distance between A and B when $t = 500$. [6]

126. 9709_s15_qp_42 Q: 4

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 $a\,\text{m s}^{-2}$, 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]

127. 9709_s15_qp_42 Q: 5

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]

128. 9709_s15_qp_43 Q: 7

A particle P moves on a straight line. It starts at a point O on the line and returns to O 100 s later. The velocity of P is v m s^{-1} at time t s after leaving O, where

$$v = 0.0001t^3 - 0.015t^2 + 0.5t.$$

(i) Show that P is instantaneously at rest when $t = 0$, $t = 50$ and $t = 100$. [2]

(ii) Find the values of v at the times for which the acceleration of P is zero, and sketch the velocity-time graph for P's motion for $0 \leqslant t \leqslant 100$. [7]

(iii) Find the greatest distance of P from O for $0 \leqslant t \leqslant 100$. [4]

129. 9709_w15_qp_41 Q: 6

A particle P moves in a straight line, starting from a point O. The velocity of P, measured in $\mathrm{m\,s^{-1}}$, at time t s after leaving O is given by

$$v = 0.6t - 0.03t^2.$$

(i) Verify that, when $t = 5$, the particle is 6.25 m from O. Find the acceleration of the particle at this time. [4]

(ii) Find the values of t at which the particle is travelling at half of its maximum velocity. [6]

130. 9709_w15_qp_41 Q: 7

A cyclist starts from rest at point A and moves in a straight line with acceleration $0.5\,\text{m s}^{-2}$ for a distance of 36 m. The cyclist then travels at constant speed for 25 s before slowing down, with constant deceleration, to come to rest at point B. The distance AB is 210 m.

(i) Find the total time that the cyclist takes to travel from A to B. [5]

24 s after the cyclist leaves point A, a car starts from rest from point A, with constant acceleration $4\,\text{m s}^{-2}$, towards B. It is given that the car overtakes the cyclist while the cyclist is moving with constant speed.

(ii) Find the time that it takes from when the cyclist starts until the car overtakes her. [5]

131. 9709_w15_qp_42 Q: 2

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]

132. 9709_w15_qp_42 Q: 3

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 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]

133. 9709_w15_qp_43 Q: 6

A particle P starts from rest at a point O of a straight line and moves along the line. The displacement of the particle at time t s after leaving O is x m, where

$$x = 0.08t^2 - 0.0002t^3.$$

(i) Find the value of t when P returns to O and find the speed of P as it passes through O on its return. [4]

(ii) For the motion of P until the instant it returns to O, find

(a) the total distance travelled, [3]

(b) the average speed. [2]