Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Kinematics

Time allowed: 2 hours

Subject code **0606**

Additional Mathematics

Questions from Paper 1 and Paper 2

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.
Questions 1-3, 7-9 (Paper 1): no calculator.
Questions 4-6, 10 (Paper 2): calculator allowed.

Total marks

/ 77

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.
- Unless a question says otherwise, give answers that are not exact to 3 significant figures, and angles in degrees to 1 decimal place.

Information

- This paper has 10 questions worth 77 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

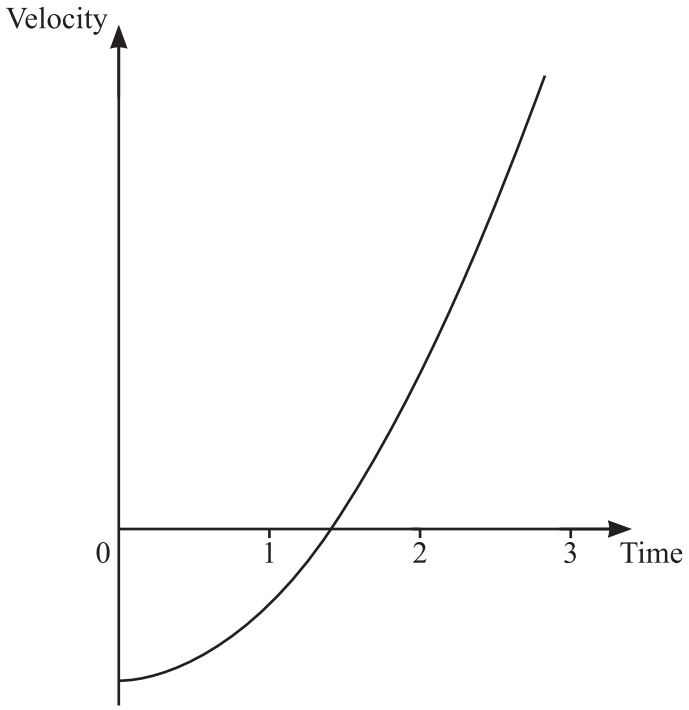
Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

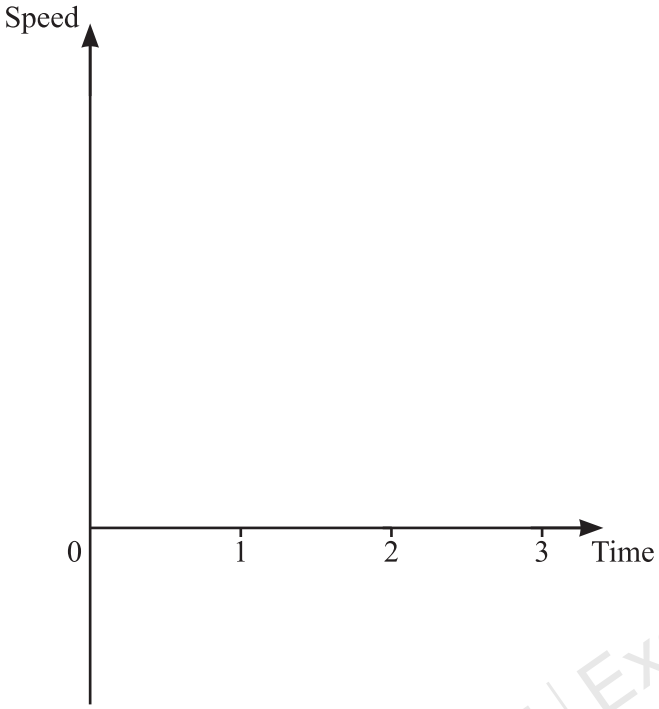
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Print at 100% (Actual size) so diagrams keep their real measurements.

1 The diagram shows the velocity–time graph for a particle moving in a straight line.



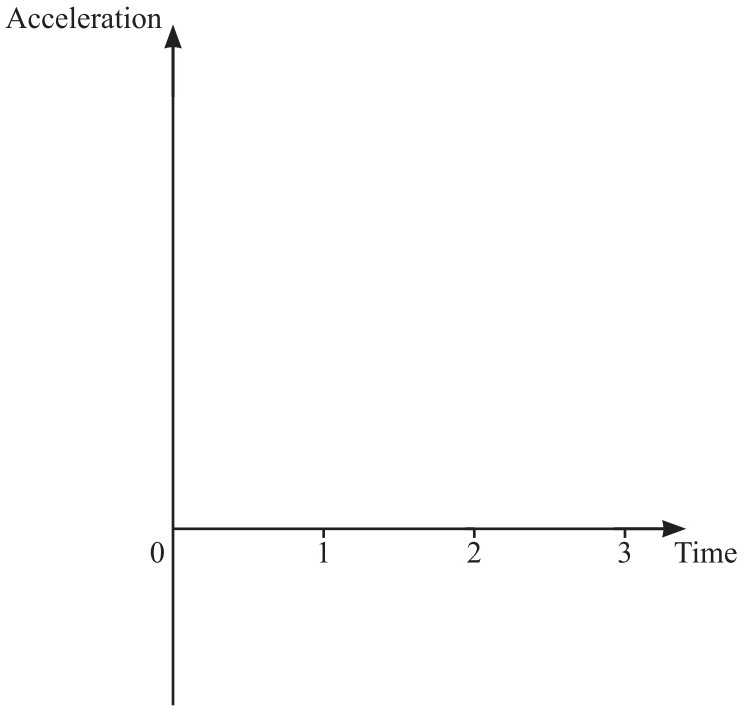
(a) On the diagram below, sketch the speed–time graph for the motion of this particle. [1]



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It is given that the velocity–time graph is part of a quadratic curve.
The curve has gradient 0 when time is 0.

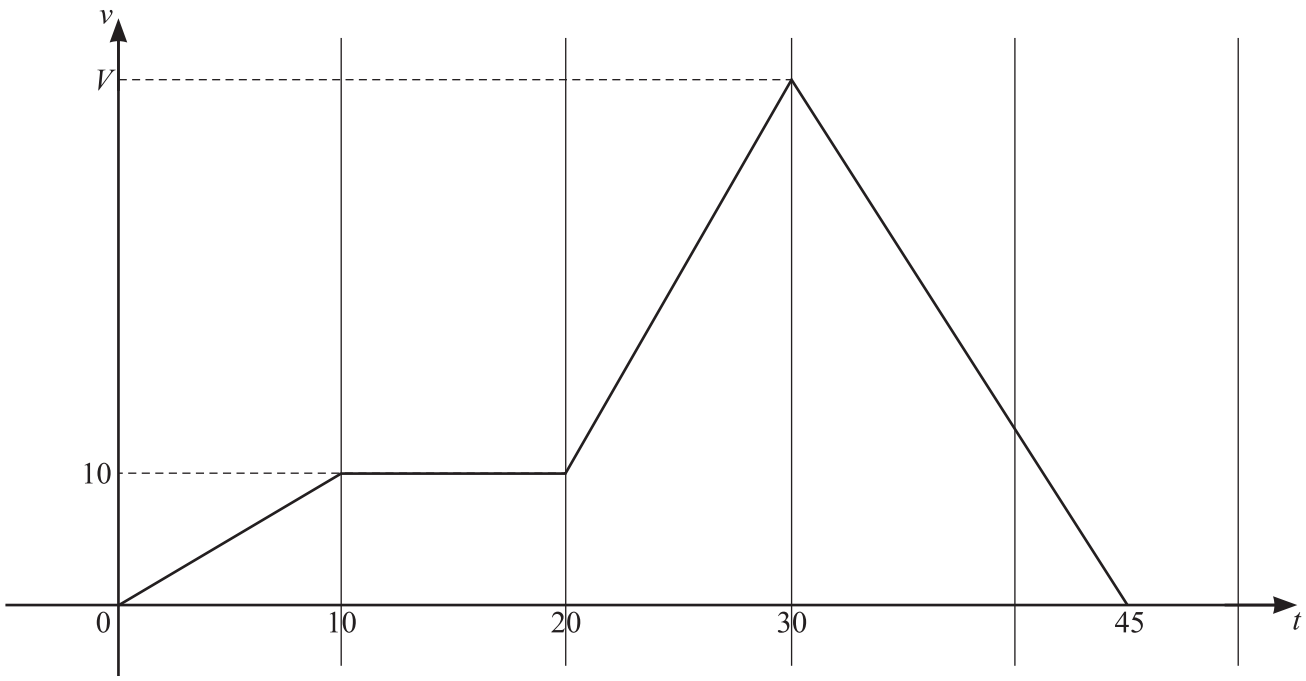
(b) On the diagram below sketch a possible acceleration–time graph for the motion of the particle. [2]



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2



The diagram shows the velocity–time graph for a particle travelling in a straight line with velocity, $v\,\text{ms}^{-1}$, at time t seconds. When $t = 30$ the velocity of the particle is $V\,\text{ms}^{-1}$. The particle travels 800 metres in 45 seconds.

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

(b) Find the acceleration of the particle when $t = 35$. [2]

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3 A particle moves in a straight line such that its displacement, s metres, from a fixed point, at time t seconds, $t \geqslant 0$, is given by $s = \left(1 + 3t\right)^{-\frac{1}{2}}$.

(a) Find the exact speed of the particle when $t = 1$. [3]

(b) Show that the acceleration of the particle will never be zero. [2]

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4 A particle moves in a straight line so that, t seconds after passing through a fixed point O, its velocity, $v\,\text{ms}^{-1}$, is given by $v = 3t^2 - 30t + 72$.

(a) Find the distance between the particle's two positions of instantaneous rest. [6]

(b) Find the acceleration of the particle when $t = 2$. [2]

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5 The acceleration, $a\,\text{ms}^{-2}$, of a particle at time t seconds is given by $a = -\dfrac{45}{(t+1)^2}$. When $t = 0$ the velocity of the particle is $50\,\text{ms}^{-1}$.

(a) Find an expression for the velocity of the particle in terms of t. [4]

(b) Find the distance travelled by the particle between $t = 1$ and $t = 10$. [4]

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6 A particle moves in a straight line such that its displacement, s metres, from a fixed point O at time t seconds, is given by $s = 2 + t - 2\cos t$, for $t \geqslant 0$.

(a) Find the displacement of the particle from O at the time when it first comes to instantaneous rest. [5]

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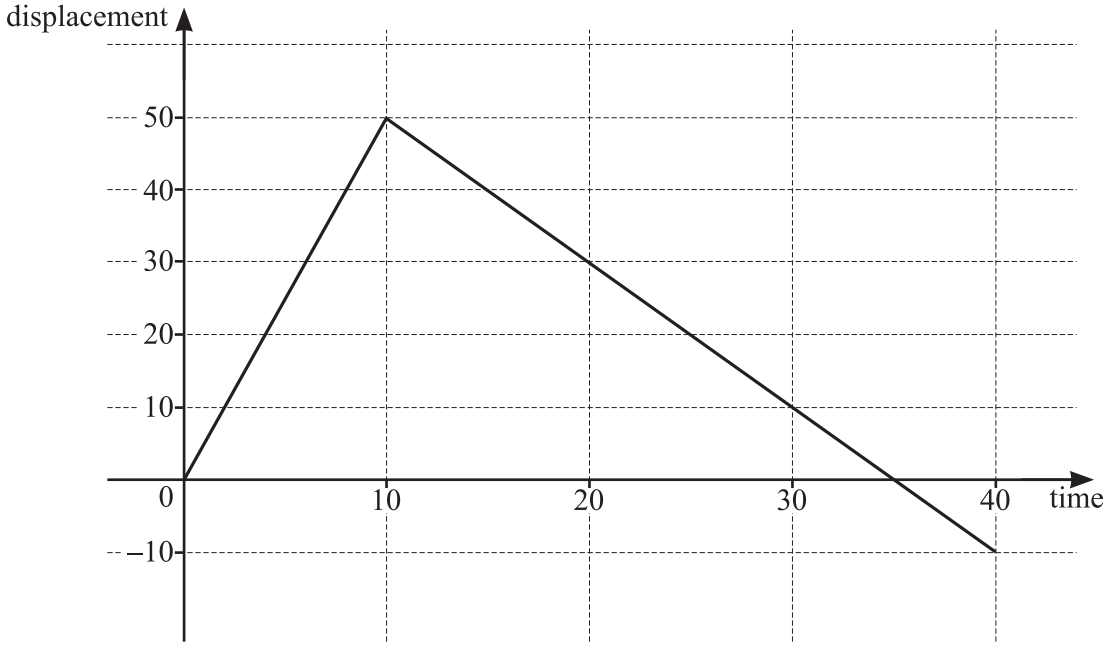
(b) Find the time when the particle next comes to rest. [1]

(c) Find the distance travelled by the particle for $0 \leqslant t \leqslant \frac{3\pi}{2}$. [2]

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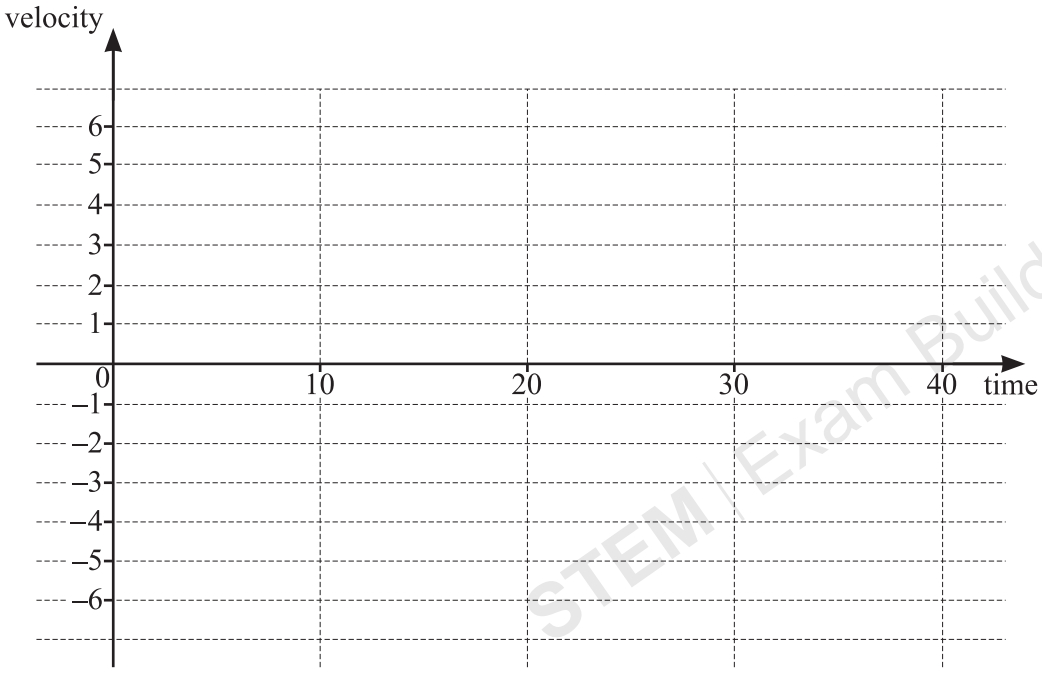
7 **(a)** In this question, all lengths are in metres and time, t, is in seconds.



The diagram shows the displacement–time graph for a runner, for $0 \leqslant t \leqslant 40$.

(i) Find the distance the runner has travelled when $t = 40$. [1]

(ii) On the axes, draw the corresponding velocity–time graph for the runner, for $0 \leqslant t \leqslant 40$. [2]



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(b) A particle, P, moves in a straight line such that its displacement from a fixed point at time t is s.

The acceleration of P is given by $(2t+4)^{-\frac{1}{2}}$, for $t > 0$.

(i) Given that P has a velocity of 9 when $t = 6$, find the velocity of P at time t. [3]

(ii) Given that $s = \frac{1}{3}$ when $t = 6$, find the displacement of P at time t. [3]

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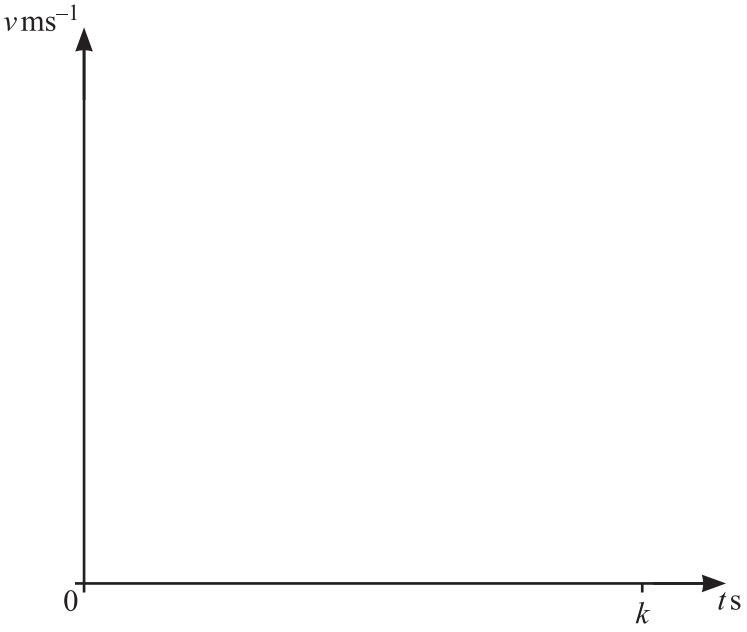
8 A particle P moves in a straight line and passes through a fixed point O.
At time t seconds, its displacement from O, s metres, is given by

$$s = t + 6t^2 - t^3 \qquad \text{for } 0 \leqslant t \leqslant 3$$

$$s = 12t - \frac{1}{3}t^2 - 3 \qquad \text{for } 3 \leqslant t \leqslant k \qquad \text{where } k \text{ is a constant.}$$

It is given that, for $3 \leqslant t \leqslant k$, the velocity of P is positive and its acceleration is negative.

(a) The maximum velocity of P occurs when $t = 2$.
On the axes below, sketch a velocity–time graph for the first k seconds of the motion of P. [4]



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(b) The total distance travelled by P for $0 \leqslant t \leqslant k$ is 57 metres.

Given that when $t = 3$ the distance and displacement of P from O are equal, find the value of k. [6]

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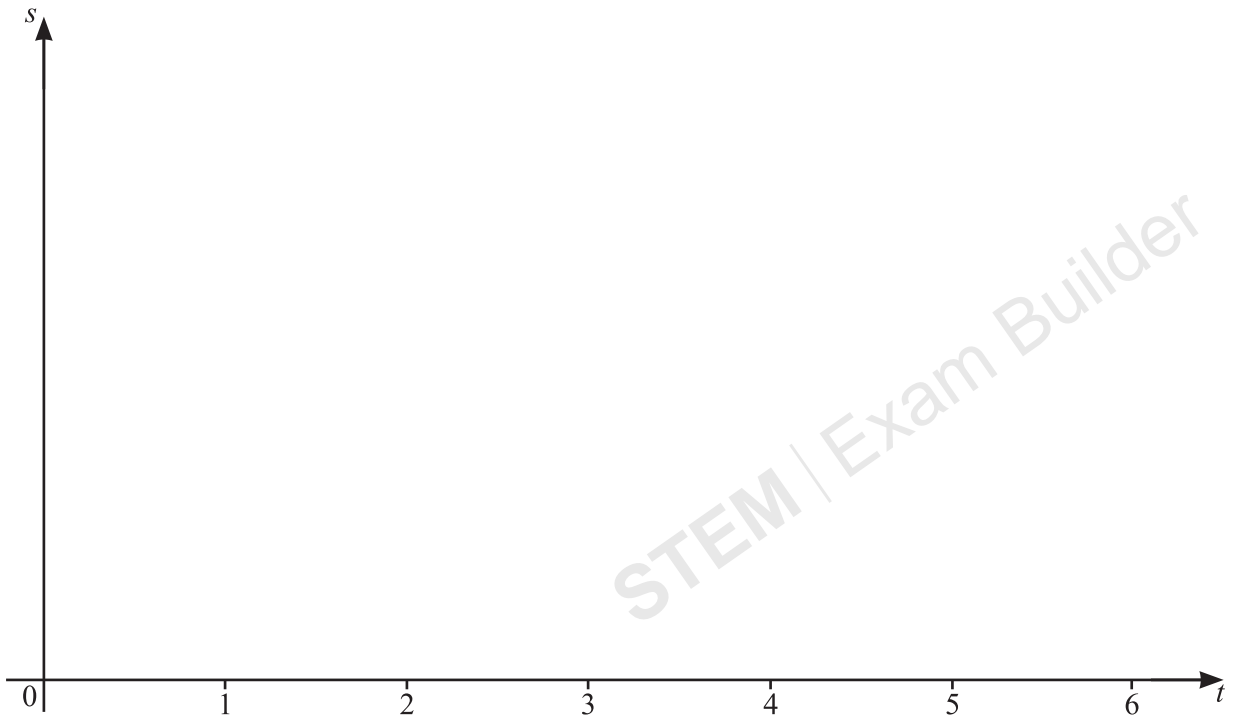
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9 In this question all lengths are in kilometres and time is in hours.

A particle P moves in a straight line such that its displacement, s, from a fixed point at time t is given by $s = (t+2)(t-5)^2$, for $t \geqslant 0$.

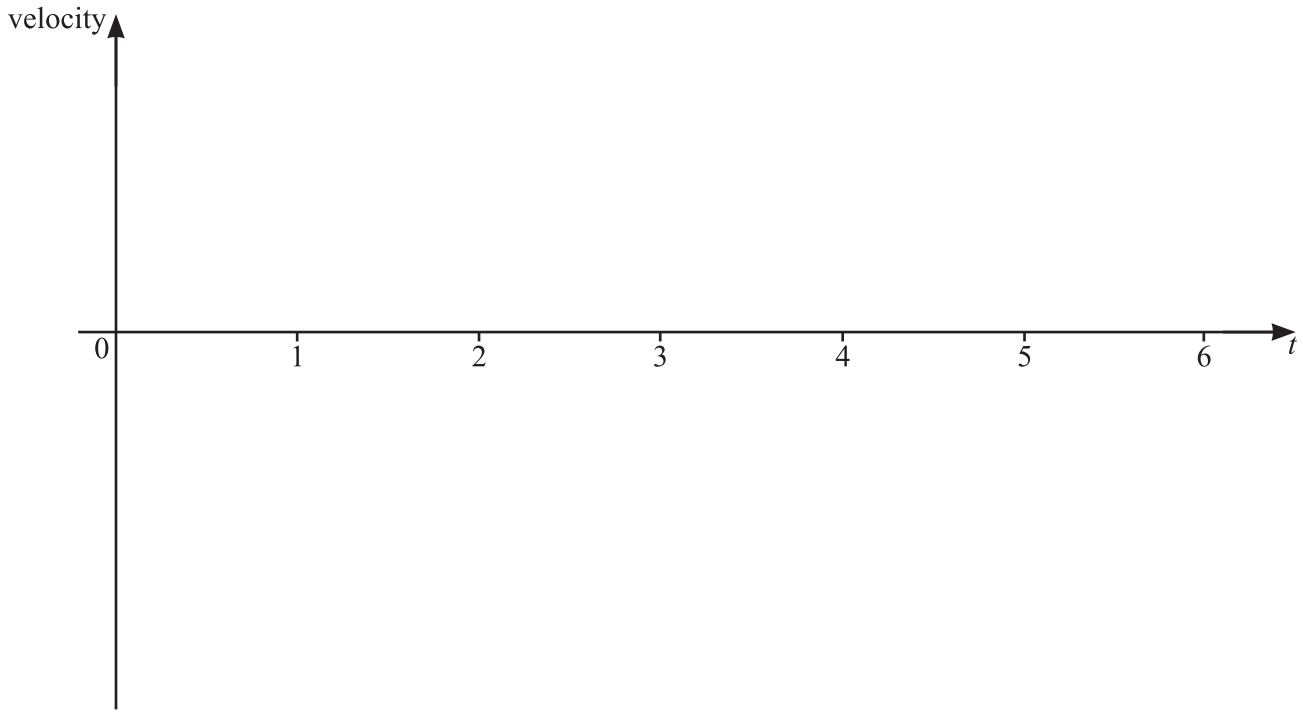
(a) Find the values of t for which the velocity of P is zero. [4]

(b) On the axes, draw the displacement–time graph for P for $0 \leqslant t \leqslant 6$, stating the coordinates of the points where the graph meets the coordinate axes. [2]



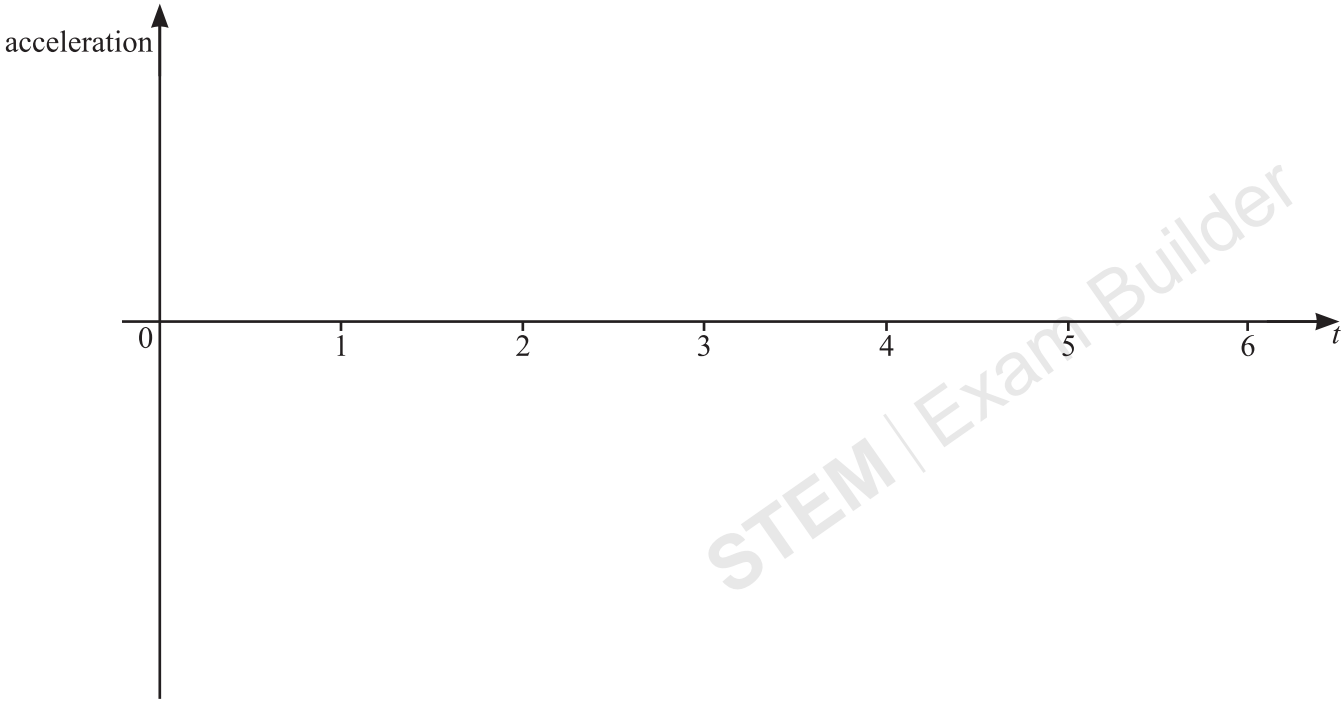
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(c) On the axes below, draw the velocity–time graph for P for $0 \leqslant t \leqslant 6$, stating the coordinates of the points where the graph meets the coordinate axes. [2]



(d) **(i)** Write down an expression for the acceleration of P at time t. [1]

(ii) Hence, on the axes below, draw the acceleration–time graph for P for $0 \leqslant t \leqslant 6$, stating the coordinates of the points where the graph meets the coordinate axes. [2]



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10 In this question, all lengths are in metres and time is in seconds.

A particle, P, moves in a straight line such that t seconds after passing through a fixed point O its displacement, s, is given by $s = 5\ln(2t+1) - 5t$.

(a) Find the value of t for which P is instantaneously at rest. [4]

(b) Find the distance P travels between $t = 0$ and $t = 2$. [4]

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(c) Find an expression for the acceleration of P in terms of t. [2]

(d) Find the acceleration when $t = 4.5$. [1]

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