

Kinematics 1 [88 marks]

1. [Maximum mark: 8]

23N.1.AHL.TZ0.13

The velocity v of a particle at time t , as it moves along a straight line, can be modelled by the piecewise function

$$v(t) = \begin{cases} u_1(t), & 0 \leq t \leq T \\ u_2(t), & t \geq T \end{cases}$$

where $u_1(t) = 2t^2 - t^3$ and $u_2(t) = 8 - 4t$. It is required that $u_1(T) = u_2(T)$.

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

(b) Show that $u_1'(T) = u_2'(T)$. [2]

The displacement of the particle at time $t = 0$ is zero.

(c) Find the time when the particle returns to its initial position. [4]

2. [Maximum mark: 9]

22N.1.AHL.TZ0.14

A particle moves such that its velocity, v metres per second, at time t seconds, is given by $v = t \sin(t^2)$.

(a) Find an expression for the acceleration of the particle. [2]

(b) Hence, or otherwise, find its greatest acceleration for $0 \leq t \leq 8$. [2]

The particle starts at the origin.

(c) Find an expression for the displacement of the particle. [3]

- (d) Hence show that the particle never has a negative displacement. [2]

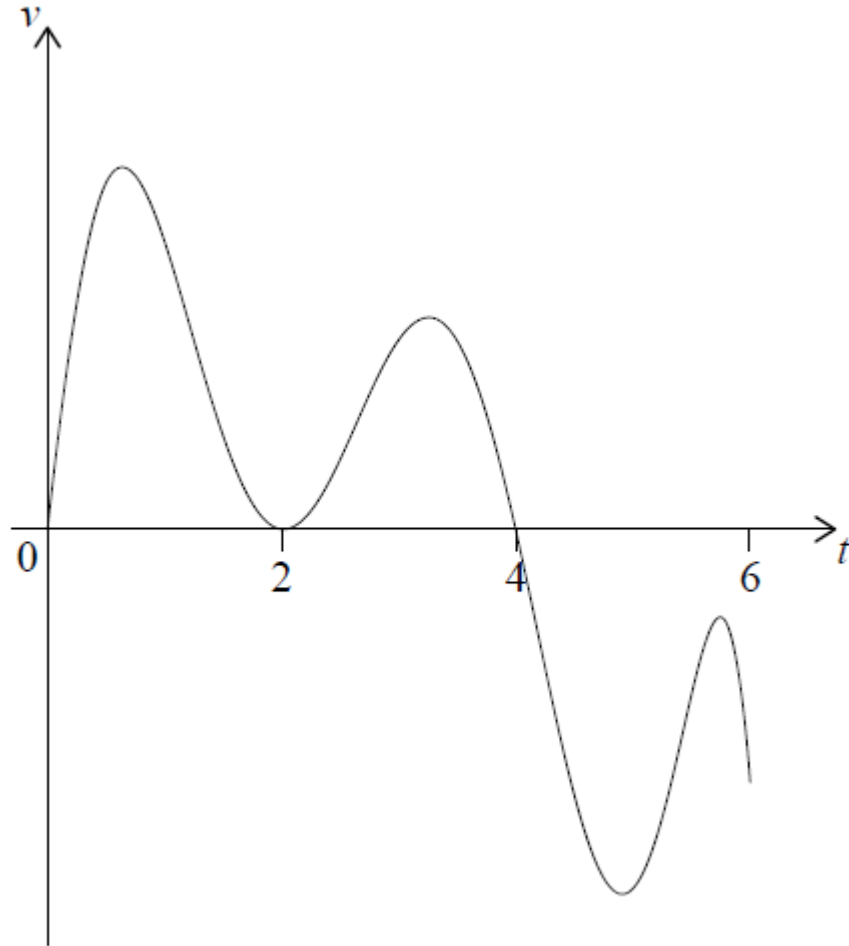
3. [Maximum mark: 15] 21M.2.AHL.TZ2.6

A particle **P** moves along the x -axis. The velocity of **P** is $v \text{ ms}^{-1}$ at time t seconds, where $v = -2t^2 + 16t - 24$ for $t \geq 0$.

- (a) Find the times when **P** is at instantaneous rest. [2]
- (b) Find the magnitude of the particle's acceleration at 6 seconds. [4]
- (c) Find the greatest speed of **P** in the interval $0 \leq t \leq 6$. [2]
- (d) The particle starts from the origin **O**. Find an expression for the displacement of **P** from **O** at time t seconds. [4]
- (e) Find the total distance travelled by **P** in the interval $0 \leq t \leq 4$. [3]

4. [Maximum mark: 7] 19M.1.SL.TZ1.S_7

A particle **P** starts from point **O** and moves along a straight line. The graph of its velocity, $v \text{ ms}^{-1}$ after t seconds, for $0 \leq t \leq 6$, is shown in the following diagram.



The graph of v has t -intercepts when $t = 0, 2$ and 4 .

The function $s(t)$ represents the displacement of P from O after t seconds.

It is known that P travels a distance of 15 metres in the first 2 seconds. It is also known that $s(2) = s(5)$ and $\int_2^4 v dt = 9$.

(a) Find the value of $s(4) - s(2)$. [2]

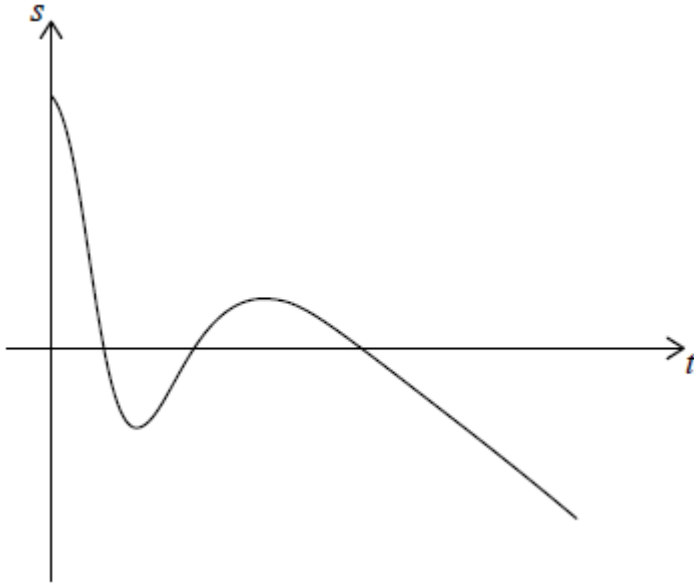
(b) Find the total distance travelled in the first 5 seconds. [5]

5. [Maximum mark: 16]

19M.2.SL.TZ2.S_8

In this question distance is in centimetres and time is in seconds.

Particle A is moving along a straight line such that its displacement from a point P, after t seconds, is given by $s_A = 15 - t - 6t^3e^{-0.8t}$, $0 \leq t \leq 25$. This is shown in the following diagram.



- (a) Find the initial displacement of particle A from point P. [2]
- (b) Find the value of t when particle A first reaches point P. [2]
- (c) Find the value of t when particle A first changes direction. [2]
- (d) Find the total distance travelled by particle A in the first 3 seconds. [3]

Another particle, B, moves along the same line, starting at the same time as particle A. The velocity of particle B is given by $v_B = 8 - 2t$, $0 \leq t \leq 25$.

- (e.i) Given that particles A and B start at the same point, find the displacement function s_B for particle B. [5]
- (e.ii) Find the other value of t when particles A and B meet. [2]

A particle moves along a horizontal line such that at time t seconds, $t \geq 0$, its acceleration a is given by $a = 2t - 1$. When $t = 6$, its displacement s from a fixed origin O is 18.25 m. When $t = 15$, its displacement from O is 922.75 m. Find an expression for s in terms of t . [6]

7. [Maximum mark: 7] 18N.2.SL.TZ0.S_4

A particle moves along a straight line so that its velocity, $v \text{ m s}^{-1}$, after t seconds is given by $v(t) = 1.4^t - 2.7$, for $0 \leq t \leq 5$.

(a) Find when the particle is at rest. [2]

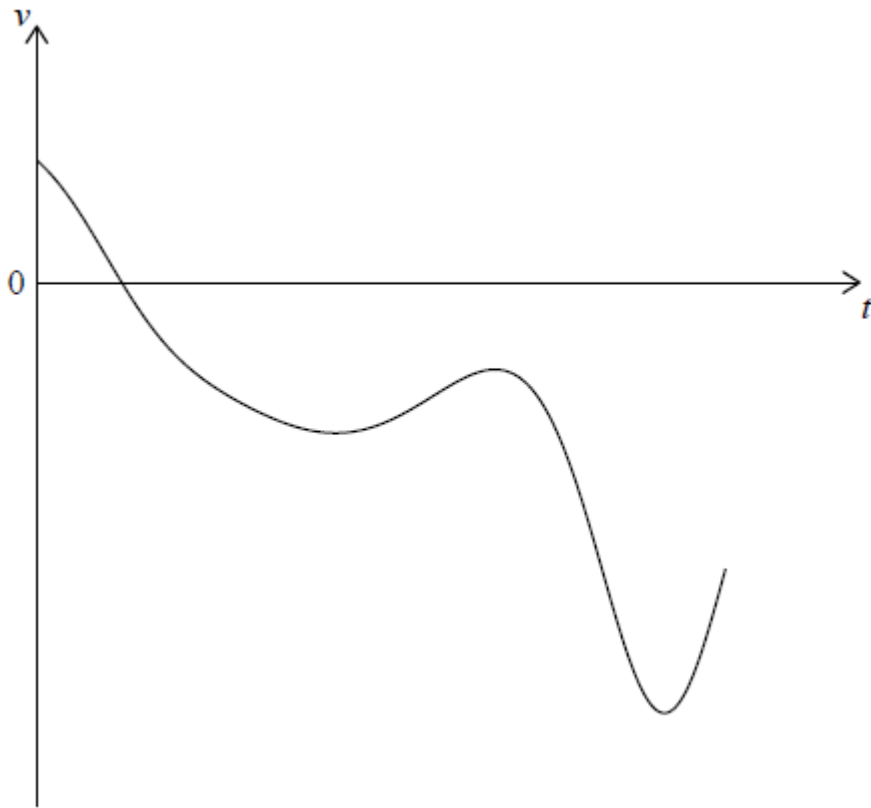
(b) Find the acceleration of the particle when $t = 2$. [2]

(c) Find the total distance travelled by the particle. [3]

8. [Maximum mark: 15] 18M.2.SL.TZ2.S_9

A particle P moves along a straight line. The velocity $v \text{ m s}^{-1}$ of P after t seconds is given by $v(t) = 7 \cos t - 5t^{\cos t}$, for $0 \leq t \leq 7$.

The following diagram shows the graph of v .



- (a) Find the initial velocity of P. [2]
- (b) Find the maximum speed of P. [3]
- (c) Write down the number of times that the acceleration of P is 0 m s^{-2} . [3]
- (d) Find the acceleration of P when it changes direction. [4]
- (e) Find the total distance travelled by P. [3]

9. [Maximum mark: 5]

18M.2.AHL.TZ2.H_7

A point P moves in a straight line with velocity $v \text{ ms}^{-1}$ given by $v(t) = e^{-t} - 8t^2e^{-2t}$ at time t seconds, where $t \geq 0$.

- (a) Determine the first time t_1 at which P has zero velocity. [2]
- (b.i) Find an expression for the acceleration of P at time t . [2]

(b.ii) Find the value of the acceleration of P at time t_1 .

[1]