# Kinematics 2 [84 marks]

**1.** [Maximum mark: 7]

The displacement, in centimetres, of a particle from an origin, O, at time $t$ seconds, is given by $s(t) = t^2 \cos t + 2t \sin t$, $0 \le t \le 5$.

(a) Find the maximum distance of the particle from O. [3]

(b) Find the acceleration of the particle at the instant it first changes direction. [4]

**2.** [Maximum mark: 5]

A particle moves in a straight line such that its velocity, $v \text{ ms}^{-1}$, at time $t$ seconds is given by

$$v = 4t^2 - 6t + 9 - 2\sin(4t),\ 0 \le t \le 1.$$

The particle's acceleration is zero at $t = T$.

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

(b) Let $s_1$ be the distance travelled by the particle from $t = 0$ to $t = T$ and let $s_2$ be the distance travelled by the particle from $t = T$ to $t = 1$.

Show that $s_2 > s_1$. [3]

**3.** [Maximum mark: 5]

A particle moves along a straight line. Its displacement, $s$ metres, from a fixed point $O$ after time $t$ seconds is given by $s(t) = 4.3 \sin\left(\sqrt{3t+5}\right)$, where $0 \le t \le 10$.

The particle first comes to rest after $q$ seconds.

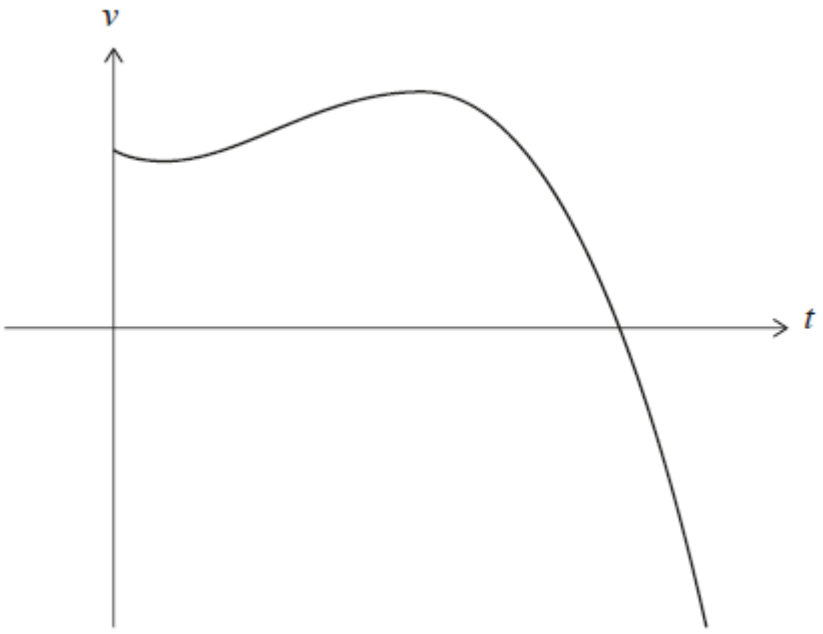
(a) Find the value of $q$. [2]

(b) Find the total distance that the particle travels in the first $q$ seconds. [3]

**4.** [Maximum mark: 17]

An object moves along a straight line. Its velocity, $v\,\mathrm{m\,s^{-1}}$, at time $t$ seconds is given by $v(t) = -t^3 + \frac{7}{2}t^2 - 2t + 6$, for $0 \leq t \leq 4$. The object first comes to rest at $t = k$.

The graph of $v$ is shown in the following diagram.




At $t = 0$, the object is at the origin.

(a) Find the displacement of the object from the origin at $t = 1$. [5]

(b) Find an expression for the acceleration of the object. [2]

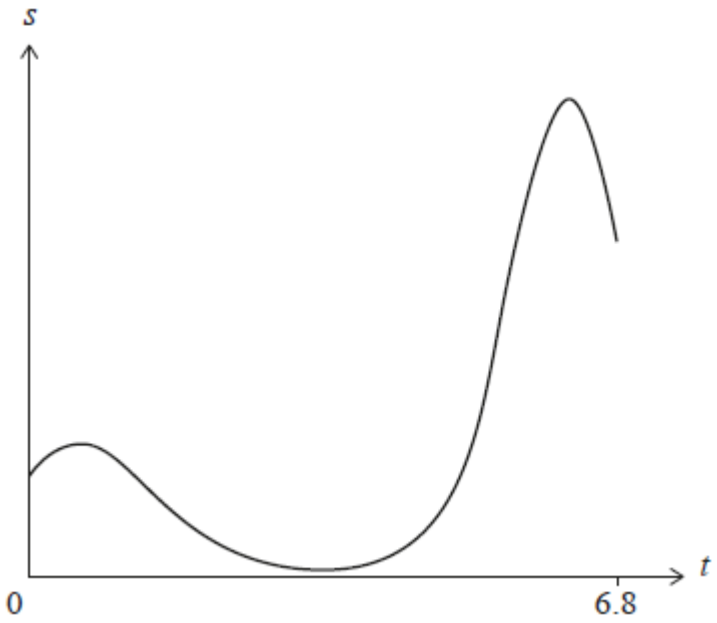
(c) Hence, find the greatest speed reached by the object before it comes to rest. [5]

(d) Find the greatest speed reached by the object for $0 \leq t \leq 4$. [2]

(e) Write down an expression that represents the distance travelled by the object while its speed is increasing. Do not evaluate the expression. [3]

**5.** [Maximum mark: 16]

A particle moves in a straight line. Its displacement, $s$ metres, from a fixed point $\mathrm{P}$ at time $t$ seconds is given by $s\left(t\right) = 3(t+2)^{\cos t}$, for $0 \leq t \leq 6.8$, as shown in the following graph.




(a) Find the particle's initial displacement from the point $\mathrm{P}$. [2]

(b) Find the particle's velocity when $t = 2$. [2]

(c) Determine the intervals of time when the particle is moving away from the point $\mathrm{P}$.

[5]

The acceleration of the particle is zero when $t = b$ and $t = c$, where $b < c$.

(d) Find the value of $b$ and the value of $c$. [4]

(e) Find the total distance travelled by the particle for $b \leq t \leq c$. [3]

**6.** [Maximum mark: 7]

A particle moves along a straight line so that its velocity, $v\,\mathrm{m\,s^{-1}}$, after $t$ seconds is given by $v(t) = \mathrm{e}^{\sin t} + 4 \sin t$ for $0 \leq t \leq 6$.

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

(b) Find the acceleration of the particle when it changes direction. [3]

(c) Find the total distance travelled by the particle. [2]

**7.** [Maximum mark: 7]

A particle moves in a straight line such that its velocity, $v\,\mathrm{m\,s^{-1}}$, at time $t$ seconds is given by $v = \frac{(t^2+1)\cos t}{4},\ 0 \leq t \leq 3$.

(a) Determine when the particle changes its direction of motion. [2]

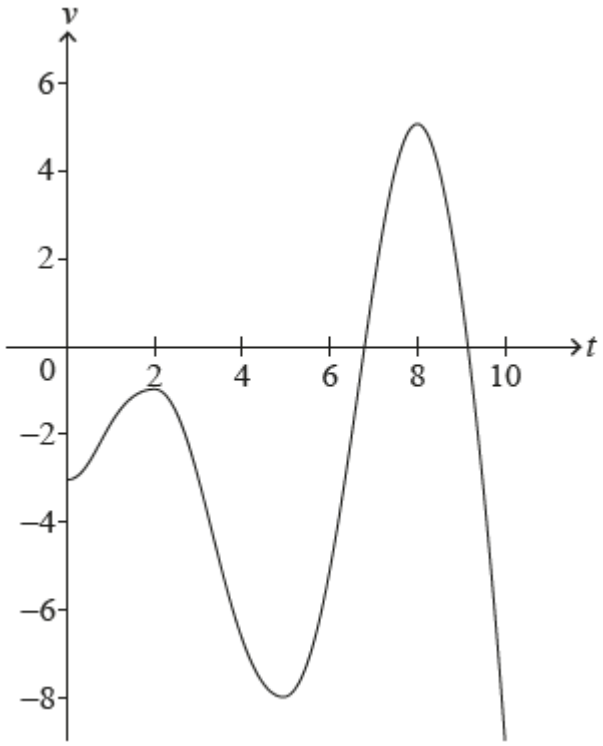
(b) Find the times when the particle's acceleration is $-1.9\,\mathrm{m\,s^{-2}}$. [3]

(c) Find the particle's acceleration when its speed is at its greatest. [2]

**8.** [Maximum mark: 6]

A particle moves in a straight line. The velocity, $v\,\text{ms}^{-1}$, of the particle at time $t$ seconds is given by $v(t) = t \sin t - 3$, for $0 \leq t \leq 10$.

The following diagram shows the graph of $v$.




(a) Find the smallest value of $t$ for which the particle is at rest. [2]

(b) Find the total distance travelled by the particle. [2]

(c) Find the acceleration of the particle when $t = 7$. [2]

**9.** [Maximum mark: 14]

A rocket is travelling in a straight line, with an initial velocity of $140$ m s$^{-1}$. It accelerates to a new velocity of $500$ m s$^{-1}$ in two stages.

During the first stage its acceleration, $a$ m s$^{-2}$, after $t$ seconds is given by $a(t) = 240 \sin(2t)$, where $0 \leqslant t \leqslant k$.

(a) Find an expression for the velocity, $v$ m s$^{-1}$, of the rocket during the first stage. [4]

The first stage continues for $k$ seconds until the velocity of the rocket reaches $375$ m s$^{-1}$.

(b) Find the distance that the rocket travels during the first stage. [4]

(c) During the second stage, the rocket accelerates at a constant rate. The distance which the rocket travels during the second stage is the same as the distance it travels during the first stage.

Find the total time taken for the two stages. [6]