1. At time t seconds, a particle P has velocity $\mathbf{v}\,\mathrm{m\,s^{-1}}$, where

$$\mathbf{v} = 3t^{\frac{1}{2}}\,\mathbf{i} - 2t\,\mathbf{j} \qquad t > 0$$

(a) Find the acceleration of P at time t seconds, where $t > 0$

(2)

(b) Find the value of t at the instant when P is moving in the direction of $\mathbf{i} - \mathbf{j}$

(3)

At time t seconds, where $t > 0$, the position vector of P, relative to a fixed origin O, is $\mathbf{r}$ metres.

When $t = 1$, $\mathbf{r} = -\mathbf{j}$

(c) Find an expression for $\mathbf{r}$ in terms of t.

(3)

(d) Find the exact distance of P from O at the instant when P is moving with speed $10\,\mathrm{m\,s^{-1}}$

(6)

2. [*In this question, position vectors are given relative to a fixed origin.*]

At time t seconds, where $t > 0$, a particle P has velocity $\mathbf{v}\,\mathrm{m\,s^{-1}}$ where

$$\mathbf{v} = 3t^2\mathbf{i} - 6t^{\frac{1}{2}}\mathbf{j}$$

(a) Find the speed of P at time $t = 2$ seconds.

(2)

(b) Find an expression, in terms of t, $\mathbf{i}$ and $\mathbf{j}$, for the acceleration of P at time t seconds, where $t > 0$

(2)

At time $t = 4$ seconds, the position vector of P is $(\mathbf{i} - 4\mathbf{j})\,\mathrm{m}$.

(c) Find the position vector of P at time $t = 1$ second.

(4)

3. At time t seconds, where $t \geqslant 0$, a particle P has velocity $\mathbf{v}\,\mathrm{m\,s^{-1}}$ where

$$\mathbf{v} = (t^2 - 3t + 7)\mathbf{i} + (2t^2 - 3)\mathbf{j}$$

Find

(a) the speed of P at time $t = 0$

(3)

(b) the value of t when P is moving parallel to $(\mathbf{i} + \mathbf{j})$

(2)

(c) the acceleration of P at time t seconds

(2)

(d) the value of t when the direction of the acceleration of P is perpendicular to $\mathbf{i}$

(2)

4. **In this question you must show all stages of your working.**

Solutions relying entirely on calculator technology are not acceptable.

[*In this question,* **i** *is a unit vector due east and* **j** *is a unit vector due north. Position vectors are given relative to a fixed origin O.*]

At time t seconds, $t \geqslant 1$, the position vector of a particle P is $\mathbf{r}$ metres, where

$$\mathbf{r} = ct^{\frac{1}{2}}\mathbf{i} - \frac{3}{8}t^2\mathbf{j}$$

and c is a constant.

When $t = 4$, the bearing of P from O is 135°

(a) Show that $c = 3$

(3)

(b) Find the speed of P when $t = 4$

(4)

When $t = T$, P is accelerating in the direction of $(-\mathbf{i} - 27\mathbf{j})$.

(c) Find the value of T.

(4)