



Variable Acceleration in Two Dimensions (Sheet 2)

Q1.

- (i) At time t seconds, where $t \geq 0$, a particle P moves so that its acceleration \mathbf{a} m s⁻² is given by

$$\mathbf{a} = (1 - 4t)\mathbf{i} + (3 - t^2)\mathbf{j}$$

At the instant when $t = 0$, the velocity of P is $36\mathbf{i}$ m s⁻¹

- (a) Find the velocity of P when $t = 4$

(3)

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

(3)

- (ii) At time t seconds, where $t \geq 0$, a particle Q moves so that its position vector \mathbf{r} metres, relative to a fixed origin O , is given by

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

Find the value of t at the instant when the speed of Q is 5 m s⁻¹

(6)

(Total for question = 12 marks)

Q2.

- At time t seconds, where $t \geq 0$, a particle P moves so that its acceleration \mathbf{a} m s⁻² is given by

$$\mathbf{a} = 5t\mathbf{i} - 15t^{\frac{1}{2}}\mathbf{j}$$

When $t = 0$, the velocity of P is $20\mathbf{i}$ m s⁻¹

Find the speed of P when $t = 4$

(6)

(Total for question = 6 marks)

Q3.

At time t seconds, where $t \geq 0$, a particle P is moving on a horizontal plane with acceleration $[(3t^2 - 4t)\mathbf{i} + (6t - 5)\mathbf{j}]$ m s⁻².

When $t = 3$ the velocity of P is $(11\mathbf{i} + 10\mathbf{j})$ m s⁻¹.

Find

- (a) the velocity of P at time t seconds,

(5)

- (b) the speed of P when it is moving parallel to the vector \mathbf{i} .

(4)

(Total 9 marks)

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Q4.

At time t seconds the velocity of a particle P is $[(4t - 5)\mathbf{i} + 3\mathbf{j}] \text{ m s}^{-1}$. When $t = 0$, the position vector of P is $(2\mathbf{i} + 5\mathbf{j}) \text{ m}$, relative to a fixed origin O .

(a) Find the value of t when the velocity of P is parallel to the vector \mathbf{j} .

(1)

(b) Find an expression for the position vector of P at time t seconds.

(4)

A second particle Q moves with constant velocity $(-2\mathbf{i} + c\mathbf{j}) \text{ m s}^{-1}$. When $t = 0$, the position vector of Q is $(11\mathbf{i} + 2\mathbf{j}) \text{ m}$. The particles P and Q collide at the point with position vector $(d\mathbf{i} + 14\mathbf{j}) \text{ m}$.

(c) Find

(i) the value of c ,

(ii) the value of d .

(5)

(Total 10 marks)

Q5.

A particle P of mass 0.5 kg moves under the action of a single force \mathbf{F} newtons. At time t seconds, the velocity $\mathbf{v} \text{ m s}^{-1}$ of P is given by

$$\mathbf{v} = 3t^2\mathbf{i} + (1 - 4t)\mathbf{j}.$$

Find

(a) the acceleration of P at time t seconds,

(2)

(b) the magnitude of \mathbf{F} when $t = 2$.

(4)

(Total 6 marks)

Q6.

A particle P moves with acceleration $(4\mathbf{i} - 5\mathbf{j}) \text{ m s}^{-2}$

At time $t = 0$, P is moving with velocity $(-2\mathbf{i} + 2\mathbf{j}) \text{ m s}^{-1}$

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

(2)

At time $t = 0$, P passes through the origin O .

At time $t = T$ seconds, where $T > 0$, the particle P passes through the point A .

The position vector of A is $(\lambda\mathbf{i} - 4.5\mathbf{j}) \text{ m}$ relative to O , where λ is a constant.

(b) Find the value of T .

(4)

(c) Hence find the value of λ

(2)



(Total for question = 8 marks)

Q7.

A particle P is moving in a plane. At time t seconds, P is moving with velocity \mathbf{v} m s⁻¹, where $\mathbf{v} = 2t\mathbf{i} - 3t^2\mathbf{j}$.

Find

(a) the speed of P when $t = 4$

(2)

(b) the acceleration of P when $t = 4$

(3)

Given that P is at the point with position vector $(-4\mathbf{i} + \mathbf{j})$ m when $t = 1$,

(c) find the position vector of P when $t = 4$

(5)

(Total 10 marks)

Q8.

[In this question \mathbf{i} and \mathbf{j} are perpendicular unit vectors in a horizontal plane.]

A particle P moves in such a way that its velocity \mathbf{v} m s⁻¹ at time t seconds is given by

$$\mathbf{v} = (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}$$

(5)

Given that, when $t = 0$, the position vector of P is \mathbf{i} metres,

(b) find the position vector of P when $t = 3$

(5)

(Total 10 marks)

Q9.

[In this question position vectors are given relative to a fixed origin O]

At time t seconds, where $t \geq 0$, a particle, P , moves so that its velocity \mathbf{v} m s⁻¹ is given by

$$\mathbf{v} = 6t\mathbf{i} - 5t^{\frac{3}{2}}\mathbf{j}$$

When $t = 0$, the position vector of P is $(-20\mathbf{i} + 20\mathbf{j})$ m.

(a) Find the acceleration of P when $t = 4$

(3)

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

(3)

(Total for question = 6 marks)