International A Level · Edexcel · Maths

56 mins 8 questions

1.2 Variable Acceleration - 2D

1.2.1 Using Calculus in 2D

Scan here for your answers
or visit savemyexams.com

Total Marks /56

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

1 (a) The position of a boat on a small lake, relative to a mooring point located at the origin, is given by the vector

$$\mathbf{r} = (-20\sin(\frac{t}{360}))\mathbf{i} + (20 - 20\cos(\frac{t}{360}))\mathbf{j}\ \text{m}$$

where time t is measured in seconds.

(i) Show that the boat is initially at the mooring point.

(ii) Show that the distance from the mooring point to the boat at time $t = 180\pi$ is $20\sqrt{2}$ m.

(3 marks)

(b) (i) Find the velocity, $\mathbf{v}$ m s^{-1}, of the boat, at time t seconds.

(ii) Show that the boat has a speed of $\frac{1}{18}$ m s^{-1} when it first returns to the mooring point.

(3 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

2 (a) A particle moving in the $x-y$ plane has velocity, $\mathbf{v}$ m s^{-1}, at time t seconds, given by

$$\mathbf{v} = (0.1t^3 - 3t^2)\mathbf{i} + (2t + 1)\mathbf{j}$$

(i) Find the acceleration, $\mathbf{a}$ m s^{-2}, of the particle at time t and explain how you can tell that the acceleration in the y-direction is constant.

(ii) Other than $t = 0$, find the time at which the acceleration in the $x-$direction is zero.

(4 marks)

(b) Find the position vector of the particle given that its initial position is at the point $(-3\ ,\ 5)$.

(3 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

3 (a) Once an aircraft reaches its cruising height (at time $t = 0$ hours) its acceleration is modelled by

$$\mathbf{a} = (4t^3 - 6t^2)\mathbf{i} + (0.9t^2 - 1)\mathbf{j} \text{ km h}^{-2}$$

Given that the velocity of the aircraft at $t = 5$ hours is $\mathbf{v} = 400\mathbf{i} + 40\mathbf{j} \text{ km h}^{-1}$, find the velocity of the aircraft in terms of t.

(3 marks)

(b) Find the speed of the aircraft when it first reaches its cruising height.

(2 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

4 (a) An ice skater moves across a straight section of a frozen river such that their position, at time t seconds relative to an origin is given by

$$\mathbf{r} = \left(\left(\frac{1}{3}t^2 + \frac{1}{5}t\right)\mathbf{i} + (2t^2 + 7t)\mathbf{j}\right) \text{m} \qquad t \geq 0$$

Find the initial speed of the ice skater giving your answer to three significant figures.

(3 marks)

(b) Show that the ice skater's acceleration is constant and find the magnitude of the acceleration, giving your answer to three significant figures.

(3 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

5 (a) A remote-controlled car is driven around a large playground with velocity, $\mathbf{v_c}$ m s^{-1}, at time t seconds, given by

$$\mathbf{v_c} = (0.45t^2 + 2t - 16)\mathbf{i} + (0.75t^2 - 1)\mathbf{j}$$

(i) The remote-controlled car is initially set in motion from position $(-6, 15)$. Find the position vector $\mathbf{r_c}$ of the car at time t seconds.

(ii) Find the distance of the remote-controlled car from the origin after 15 seconds.

(4 marks)

(b) At the same time as the remote-controlled car is started, a remote-controlled truck is also set into motion. The truck has position vector, $\mathbf{r_T}$ m, at time t seconds given by

$$\mathbf{r_T} = (0.15t^3 - 6)\mathbf{i} + (0.25t^3 - 1)\mathbf{j}$$

Determine the time(s) at which the car and the truck will collide, if at all.

(3 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

6 (a) A spider is crawling across the floor of a house such that is has acceleration

$$\mathbf{a} = (1.2t)\mathbf{i} + (0.5)\mathbf{j}\ \text{m s}^{-2}$$

at time t seconds after the spider emerged from under the skirting board.

After 3 seconds the spider's velocity is $\mathbf{v} = 5.4\mathbf{i} + 1.7\mathbf{j}\ \text{m s}^{-1}$.
Find the velocity of the spider at time t seconds.

(4 marks)

(b) After 3 seconds the spider's position, relative to an origin at a corner of the floor, is $(10.4, 5.15)$. Find the distance the spider is from the origin when it emerges from under the skirting board.

(4 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

7 (a) A particle's velocity is modelled by the equation

$$\dot{\mathbf{r}} = ((0.75e^{1.5t} + 2t)\mathbf{i} + (5t - (t+1)^{-1})\mathbf{j}) \text{ m s}^{-1} \qquad t \geq 0$$

where t is the time in seconds.

The particle's initial displacement is $(0\mathbf{i} + 0\mathbf{j})$ m.

Find the position vector of the particle, $\mathbf{r}$ m, at time t seconds.

(3 marks)

(b) Find the magnitude of the acceleration of the particle after 1 second.

(3 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers

8 (a) At time t seconds, a particle P has acceleration $\mathbf{a}$ m s^{-2}, where

$$\mathbf{a} = (4t - 3)\mathbf{i} + (4t + 5)\mathbf{j} \qquad t \geq 0.$$

Initially P starts at the origin O and moves with velocity $(-5\mathbf{j})$ m s^{-1}.

Find the distance between the origin and the position of P when $t = 6$.

(6 marks)

(b) Find the value of t at the instant when P is moving in the direction of $\mathbf{i} + 2\mathbf{j}$.

(5 marks)

© 2015–2024 Save My Exams, Ltd. · Revision Notes, Topic Questions, Past Papers