MATHSAURUS

A Level Mathematics Year 2 Exam Questions by Topic
Chapter 18: Kinematics

These questions are taken from the Specimen Exam materials and the real 2018 papers for the new syllabus AS and A-level mathematics courses and arranged by chapter of the textbooks by Goldie et al (available here: `https://amzn.to/39umfr5` and `https://amzn.to/3hE8kBL`). There are a mixture of questions from OCR A, OCR B (MEI), Edexcel and AQA. Although the style of questions varies a little across the exam boards the content of the syllabus is almost identical so these are suitable for students preparing for any exam board.

Free problem sets for all other chapters, as well as video solutions, full past papers and other content for GCSE and A-level maths can be found at:

`https://mathsaurus.com/`

OCR B MEI Sample Paper 1 Question 12:

12 A model boat has velocity $\mathbf{v} = \left((2t-2)\mathbf{i}+(2t+2)\mathbf{j}\right)$ m s^{-1}, where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors east and north respectively and t is the time in seconds, where $t \geq 0$. The position vector of the boat is $(3\mathbf{i}+14\mathbf{j})$ m when $t=3$.

(i) Show that the boat is never instantaneously at rest. **[2]**

(ii) Determine any times at which the boat is moving directly northwards. **[2]**

(iii) Determine any times at which the boat is north-east of the origin. **[5]**

AQA Sample Paper 2 Question 15:

15 At time $t = 0$, a parachutist jumps out of an airplane that is travelling horizontally.

The velocity, $\mathbf{v}$ m s^{-1}, of the parachutist at time t seconds is given by:

$$\mathbf{v} = \left(40e^{-0.2t}\right)\mathbf{i} + 50\left(e^{-0.2t} - 1\right)\mathbf{j}$$

The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are horizontal and vertical respectively.

Assume that the parachutist is at the origin when $t = 0$

Model the parachutist as a particle.

15 (a) Find an expression for the position vector of the parachutist at time t.

[4 marks]

15 (b) The parachutist opens her parachute when she has travelled 100 metres horizontally.

Find the vertical displacement of the parachutist from the origin when she opens her parachute.

[4 marks]

15 (c) Carefully, explaining the steps that you take, deduce the value of g used in the formulation of this model.

[3 marks]

Edexcel 2018 Paper 3 Question 6:

6. At time t seconds, where $t \geqslant 0$, a particle P moves in the x-y plane in such a way that its velocity $\mathbf{v}$ m s^{-1} is given by

$$\mathbf{v} = t^{-\frac{1}{2}}\mathbf{i} - 4t\mathbf{j}$$

When $t = 1$, P is at the point A and when $t = 4$, P is at the point B.

Find the exact distance AB.

(6)

Edexcel 2018 Paper 3 Question 8:

8. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given relative to the fixed point O.*]

A particle P moves with constant acceleration.
At time $t = 0$, the particle is at O and is moving with velocity $(2\mathbf{i} - 3\mathbf{j})\,\text{m s}^{-1}$
At time $t = 2$ seconds, P is at the point A with position vector $(7\mathbf{i} - 10\mathbf{j})\,\text{m}$.

(a) Show that the magnitude of the acceleration of P is $2.5\,\text{m s}^{-2}$

(4)

At the instant when P leaves the point A, the acceleration of P changes so that P now moves with constant acceleration $(4\mathbf{i} + 8.8\mathbf{j})\,\text{m s}^{-2}$

At the instant when P reaches the point B, the direction of motion of P is north east.

(b) Find the time it takes for P to travel from A to B.

(4)

Edexcel Sample Paper 3 Question 6:

6. At time t seconds, where $t \geqslant 0$, a particle P moves so that its acceleration $\mathbf{a}\ \text{m s}^{-2}$ is given by

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

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

Find the speed of P when $t = 4$

(6)

OCR B MEI 2018 Paper 1 Question 5:

5 The position vector $\mathbf{r}$ metres of a particle at time t seconds is given by

$$\mathbf{r} = (1 + 12t - 2t^2)\mathbf{i} + (t^2 - 6t)\mathbf{j}.$$

(i) Find an expression for the velocity of the particle at time t. **[2]**

(ii) Determine whether the particle is ever stationary. **[2]**

Edexcel Sample Paper 3 Question 8:

8. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively*]

A radio controlled model boat is placed on the surface of a large pond.

The boat is modelled as a particle.

At time $t = 0$, the boat is at the fixed point O and is moving due north with speed 0.6 m s^{-1}.

Relative to O, the position vector of the boat at time t seconds is **r** metres.

At time $t = 15$, the velocity of the boat is $(10.5\mathbf{i} - 0.9\mathbf{j})$ m s^{-1}.

The acceleration of the boat is constant.

(a) Show that the acceleration of the boat is $(0.7\mathbf{i} - 0.1\mathbf{j})$ m s^{-2}.

(2)

(b) Find **r** in terms of t.

(2)

(c) Find the value of t when the boat is north-east of O.

(3)

(d) Find the value of t when the boat is moving in a north-east direction.

(3)

OCR A 2018 Paper 3 Question 8:

8 In this question $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ denote unit vectors which are horizontal and vertically upwards respectively.

A particle of mass 5 kg, initially at rest at the point with position vector $\begin{pmatrix}2\\45\end{pmatrix}$ m, is acted on by gravity and also by two forces $\begin{pmatrix}15\\-8\end{pmatrix}$ N and $\begin{pmatrix}-7\\-2\end{pmatrix}$ N.

(i) Find the acceleration vector of the particle. **[3]**

(ii) Find the position vector of the particle after 10 seconds. **[3]**

OCR A Sample Paper 3 Question 11:

11 In this question the unit vectors **i** and **j** are in the directions east and north respectively.

A particle of mass 0.12 kg is moving so that its position vector **r** metres at time t seconds is given by $\mathbf{r} = 2t^3\mathbf{i} + \left(5t^2 - 4t\right)\mathbf{j}$.

(i) Show that when $t = 0.7$ the bearing on which the particle is moving is approximately 044°. **[3]**

(ii) Find the magnitude of the resultant force acting on the particle at the instant when $t = 0.7$. **[4]**

(iii) Determine the times at which the particle is moving on a bearing of 045°. **[2]**