A Level · Edexcel · Maths

3 hours 38 questions

2.5 Constant Acceleration - 2D (A Level only)

Easy (11 questions)	/44
Medium (9 questions)	/47
Hard (9 questions)	/55
Very Hard (9 questions)	/57
Total Marks	**/203**

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Easy Questions

1 A particle moves from rest and 8 seconds later has velocity $(3\mathbf{i} + 7\mathbf{j})\ \text{m s}^{-1}$.Find the displacement of the particle.

(3 marks)

2 (a) A ball is thrown from the top of a tall building with a velocity of $(2\mathbf{i} + 29.4\mathbf{j})\ \text{m s}^{-1}$.

Write down the vector $\mathbf{g}\ \text{m s}^{-2}$ - the vector for acceleration due to gravity.

(1 mark)

(b) How long does it take for the ball to reach a velocity of $(2\mathbf{i} + 4.9\mathbf{j})\ \text{m s}^{-1}$?

(3 marks)

3 (a) A particle travels $(-6\mathbf{i} + 6\mathbf{j})$ m in 12 seconds with constant acceleration $(2\mathbf{i} + \mathbf{j})$ m s^{-2}.

Find the velocity of the particle at the end of this motion.

(3 marks)

(b) Use Pythagoras' theorem to find the speed of the particle at the end of this motion, giving your answer to three significant figures.

(2 marks)

4 (a) A particle passes point A with velocity $(8\mathbf{i} - 3\mathbf{j})\text{m s}^{-1}$ and 12 seconds later passes point B with velocity $(-4\mathbf{i} + 18\mathbf{j})\text{ m s}^{-1}$.

Given that it is constant, find the acceleration of the particle between the points A and B.

(3 marks)

(b) Use Pythagoras' theorem to find the magnitude of the acceleration of the particle between the points A and B, giving your answer to three significant figures.

(2 marks)

5 A particle moves with acceleration $\begin{pmatrix} -3 \\ 4 \end{pmatrix}\text{m s}^{-2}$ and after 7 seconds of motion has velocity $\begin{pmatrix} 5 \\ 3 \end{pmatrix}\text{m s}^{-1}$. Find the displacement of the particle in this time.

(3 marks)

6 (a) A ball is projected from the top of a tall building. 9 seconds later it has displacement $\begin{pmatrix} 6 \\ -8 \end{pmatrix}$ m from its starting position.

Use Pythagoras' theorem to find the distance the ball is from its starting point after 9 seconds.

(1 mark)

(b) Find the velocity with which the ball is projected.

(3 marks)

7 A particle passes a fixed point, O, with velocity $\begin{pmatrix} 2.3 \\ 1.8 \end{pmatrix}$ m s^{-1} and accelerates at a constant $\begin{pmatrix} 0.3 \\ -0.1 \end{pmatrix}$ m s^{-2}. Find the displacement of the particle from O 4.8 seconds later.

(3 marks)

8 (a) In two minutes, a particle travels $\begin{pmatrix} 1200 \\ 2400 \end{pmatrix}$ m. It's velocity at this point is $\begin{pmatrix} 40 \\ 60 \end{pmatrix}$ m s^{-1}.

Assuming it is constant during this motion, find the acceleration of the particle.

(3 marks)

(b) Use Pythagoras' theorem to find the magnitude of the acceleration.

(2 marks)

9 A particle travels $(10.6\mathbf{i} - 21.2\mathbf{j})$ m in 10.6 seconds, at which point it has velocity $(2\mathbf{i} - 4\mathbf{j})$ m s^{-1}. Show that the particle was initially at rest.

(3 marks)

10 (a) A particle is projected from ground level such that after 1.8 seconds its displacement is $(2.7\mathbf{i} + 3.6\mathbf{j})$ m.

Find the velocity of the particle after 1.8 seconds.

(3 marks)

(b) Use Pythagoras' theorem to find the speed of the particle after 1.8 seconds, giving your answer to three significant figures.

(2 marks)

11 A particle is travelling with constant acceleration $\begin{pmatrix} 3 \\ -2 \end{pmatrix}$ m s^{-2}. After it has been displaced by $\begin{pmatrix} -42 \\ 6 \end{pmatrix}$ m the particle has velocity $\begin{pmatrix} 2 \\ -5 \end{pmatrix}$ m s^{-1}. Find the time it takes for this motion to occur.

(4 marks)

Medium Questions

1 Starting from rest a toy boat experiencing a constant acceleration of $(0.5\mathbf{i} + 0.2\mathbf{j})\ \text{m s}^{-2}$ takes 12 seconds to sail across a pond. Find the distance the toy boat sails across the pond, giving your answer to three significant figures.

(4 marks)

2 (a) A ball is thrown from the top of a tall building with a velocity of $\begin{pmatrix} 0.8 \\ 0.2 \end{pmatrix} \text{m s}^{-1}$.

Find the velocity of the ball 5 seconds after it is thrown.

(3 marks)

(b) Find the speed of the ball 5 seconds after it is thrown.

(2 marks)

3 (a) A particle experiences a constant acceleration of $(3p\mathbf{i} + 2\mathbf{j})\ \text{m s}^{-2}$ where p is a constant.

In 7 seconds the particle travels $(-91\mathbf{i} + 7\mathbf{j})\ \text{m}$.

Given that the particle's velocity after the 7 seconds is $(4p\mathbf{i} + 8\mathbf{j})\ \text{m s}^{-1}$ find the value of the constant p.

(3 marks)

(b) Find the magnitude of the acceleration during this motion.

(2 marks)

4 (a) Two stones are slid across a large icy pond. Both are released from rest at the origin. The first stone experiences a constant acceleration of $(3\mathbf{i} - \mathbf{j})\ \text{m s}^{-2}$. The second stone experiences a constant acceleration of $(-2\mathbf{i} + \mathbf{j})\ \text{m s}^{-2}$.

(i) Find the displacement of both stones after 8 seconds.

(ii) Find the distance between the two stones after 8 seconds.

(5 marks)

(b) If the second stone had been released from the point with coordinates $(10\ ,\ 30)$ rather than the origin, what would its position vector (rather than displacement from starting point) be at time t?

(2 marks)

5 (a) A horse running across a large area of open countryside starts to gallop with constant acceleration $(0.25\mathbf{i} + 0.45\mathbf{j})\ \text{m s}^{-2}$. After 16 seconds of galloping the horse has velocity $(12\mathbf{i} + 6\mathbf{j})\ \text{m s}^{-1}$.

Find the displacement of the horse from its starting position at the end of the 16 second gallop.

(2 marks)

(b) Find the average velocity of the horse during the gallop.

(3 marks)

6 It takes four minutes for a particle to travel $\begin{pmatrix} 0.96 \\ 1.2 \end{pmatrix}$ km with constant acceleration. The velocity of the particle at the end of the four minutes is triple the velocity of the particle at the start. Find the initial and final velocities, giving your answers in metres per second.

(4 marks)

7 (a) A football is kicked from the top of a hill and its motion is modelled as that of a particle moving in a 2D vertical plane with constant acceleration. The initial velocity of the football is $(18\mathbf{i} + 23\mathbf{j})\ \text{m s}^{-1}$ and it lands at ground level with velocity $(18\mathbf{i} - 26\mathbf{j})\ \text{m s}^{-1}$, where $\mathbf{i}$ is a unit vector in the horizontal direction and $\mathbf{j}$ is a unit vector in the upwards vertical direction.

Find the time it takes the football to first hit ground level.

(3 marks)

(b) (i) Find the displacement of the football when it first hits ground level.

(ii) Give an interpretation of the values of the components of the vector from part (b) (i).

(3 marks)

8 (a) A particle moves under constant acceleration. In a 9 second time period the particle has initial velocity $\begin{pmatrix} 2q - 1 \\ q \end{pmatrix} \text{m s}^{-1}$ and final velocity $\begin{pmatrix} p \\ 1 - 8p \end{pmatrix} \text{m s}^{-1}$, where p and q are constants. The displacement of the particle in these 9 seconds is $\begin{pmatrix} -22.5 \\ -81 \end{pmatrix} \text{m}$.

Show that

$$\begin{pmatrix} -22.5 \\ -81 \end{pmatrix} = 4.5 \begin{pmatrix} p + 2q - 1 \\ 1 - 8p + q \end{pmatrix}$$

(2 marks)

(b) Show that the two simultaneous equations

$$p + 2q = -4 \qquad \textit{and} \qquad 8p - q = 19$$

must be satisfied and hence find the values of p and q.

(3 marks)

9 (a) A train leaves station O from rest with constant acceleration $\mathbf{a} = (0.3\mathbf{i} + 0.7\mathbf{j})\ \text{m s}^{-2}$. 80 seconds later it passes through (but does not stop at) station A at which point its acceleration changes to $\mathbf{a} = (0.5\mathbf{i} + 0.3\mathbf{j})\ \text{m s}^{-2}$. 180 seconds later the train passes through station B.

Find the displacement of the train from station O when it passes through station A.

(2 marks)

(b) Find the velocity of the train as it passes through station A.

(2 marks)

(c) Find the displacement of the train between stations A and B.

(2 marks)

Hard Questions

1 (a) Starting from rest a toy boat sails across a pond such that for the first 10 seconds of its motion it has constant acceleration $(0.1\mathbf{i} + 0.3\mathbf{j})$ m s^{-2}. It then sails with a constant velocity until it reaches the other side of the pond, 6 seconds later.

Find the distance between the toy boat's starting position and its position once it has reached the other side of the pond. Give your answer to three significant figures.

(4 marks)

(b) Briefly explain why your answer to part (a) is not necessarily the length nor width of the pond.

(1 mark)

2 (a) A ball is thrown from the top of a tall building with a velocity of $\begin{pmatrix} 3.5 \\ 6 \end{pmatrix}$ m s^{-1}.

(i) Find the velocity of the ball 3 seconds after it is thrown.

(ii) Find the speed of the ball 3 seconds after it is thrown.

(4 marks)

(b) The ball first strikes the ground after 6 seconds.
Find the displacement of the ball when it first strikes the ground.

(3 marks)

3 (a) A particle travels $(16\mathbf{i} + 96\mathbf{j})$ m in 8 seconds with a constant acceleration of $(a\mathbf{i} - 4\mathbf{j})$ m s^{-2}.

Given that the particle's velocity after the 8 seconds is $(14\mathbf{i} + b\mathbf{j})$ m s^{-1} find the values of the constants a and b.

(3 marks)

(b) Find the velocity of the particle at the start of these 8 seconds.

(2 marks)

4 (a) Two stones are slid across a large icy pond. The first stone is released from rest at the origin with constant acceleration $(2\mathbf{i} + 3\mathbf{j})\ \text{m s}^{-2}$. The second stone is released from rest from the position with coordinates $(50, -100)$ with constant acceleration $(\mathbf{i} + 5\mathbf{j})\ \text{m s}^{-2}$.

(i) Find the position vectors of both stones after 5 seconds.

(ii) Find the distance between the two stones after 5 seconds.

(5 marks)

(b) Show that the two stones collide after 10 seconds.

(2 marks)

5 (a) A horse running across a large area of open countryside starts to gallop with constant acceleration $(0.6\mathbf{i} + 0.4\mathbf{j})$ m s^{-2}. After 12 seconds of galloping the horse has velocity $(8\mathbf{i} + 10\mathbf{j})$ m s^{-1}.

Find the displacement of the horse at the end of its 12 second gallop.

(2 marks)

(b) Find the change in speed of the horse between the start and end of its 12 second gallop.

(4 marks)

6 It takes 6 minutes for a particle to travel $\begin{pmatrix} 5.94 \\ 13.86 \end{pmatrix}$ km with constant acceleration. The particle's velocity at the start of the 6 minutes is one-tenth of its velocity at the end. Find the acceleration of the particle.

(6 marks)

7 (a) A football is kicked from the top of a hill and its motion modelled as moving in a 2D plane under the force of gravity only. The ball is kicked such that its initial velocity is $(15\mathbf{i} + 24\mathbf{j})\ \text{m s}^{-1}$.

(i) Given the top of the hill is $6\ \text{m}$ above ground level, find the time it takes the football to first hit the ground.

(ii) Find the horizontal ground covered by the football at the time it first hits ground level.

(4 marks)

(b) Find the speed with which the football first hits the ground.

(3 marks)

8 (a) A particle moves under constant acceleration $\begin{pmatrix} 2q + 1 \\ q - 1 \end{pmatrix} \text{m s}^{-2}$. In a 6 second time period, the particle has initial velocity $\begin{pmatrix} 5.2 \\ 1 - 2p \end{pmatrix} \text{m s}^{-1}$ and final velocity $\begin{pmatrix} 27p + 4 \\ 5.2 \end{pmatrix} \text{m s}^{-1}$. p and q are constants.

Show that

$$27p - 12q = 7.2 \text{ and}$$

$$2p - 6q = -10.2$$

(3 marks)

(b) Find the values of p and q.

(2 marks)

9 (a) A train leaves station O from rest with constant acceleration $\boldsymbol{a} = (0.5\mathbf{i} + 0.2\mathbf{j})\ \text{m s}^{-2}$. 60 seconds later it passes (but does not stop at) station A at which point its acceleration changes to $\boldsymbol{a} = (0.8\mathbf{i} + 0.1\mathbf{j})\ \text{m s}^{-2}$. 90 seconds later the train passes through station B.

(i) Find the displacement of the train between station O and station B.

(ii) Find the distance between station O and station B.

(4 marks)

(b) Find the average acceleration of the train between station O and station B.

(3 marks)

Very Hard Questions

1 Starting from rest a toy boat sails across a pond such that for the first 15 seconds of its motion it has constant acceleration $(0.12\mathbf{i} + 0.05\mathbf{j})\ \text{m s}^{-2}$. It then decelerates uniformly until it comes to rest 8 seconds later on the other side of the pond.

Find the distance between the toy boat's initial and final positions.

(5 marks)

2 (a) A ball is thrown from the top of a tall building with velocity $\begin{pmatrix} 4 \\ 8.5 \end{pmatrix} \text{m s}^{-1}$.

Find the speed of the ball 2 seconds after it is thrown.

(3 marks)

(b) (i) The ball first strikes the ground after 5 seconds. Find the height of the building and the distance from the building the ball is when it first strikes the ground.

(ii) Find the distance between the point where the ball first strikes the ground and its starting point at the top of the building.

(5 marks)

3 A particle travels $(464\mathbf{i} - 272\mathbf{j})$ m in 16 seconds with constant acceleration $\left(-\frac{p}{q}\mathbf{i} + \frac{2p}{q}\mathbf{j}\right) \text{m s}^{-2}$. p and q are positive constants.

Given that the particle's velocity after the 16 seconds is $((2q+3)\mathbf{i} + (p+5)\mathbf{j}) \text{ m s}^{-1}$ find the values of p and q.

(5 marks)

4 Two stones are slid across a large icy pond.

At time $t = 0$ seconds, the first stone is located at the point with coordinates $(2\ ,\ -8)$, has initial velocity $(5.4\mathbf{i} + 7.2\mathbf{j})\ \text{m s}^{-1}$ and moves with constant acceleration $(0.4\mathbf{i} + 0.6\mathbf{j})\ \text{m s}^{-2}$.

At time $t = 0$ seconds, the second stone is located at the point with coordinates $(50\ ,\ 40)$, has initial velocity $(-4.6\mathbf{i} - 2.8\mathbf{j})\ \text{m s}^{-1}$ and moves with constant acceleration $(1.4\mathbf{i} + 1.6\mathbf{j})\ \text{m s}^{-2}$.

Determine the two times at which the stones collide, and their distance from the origin at these times. Suggest a reason why the stones may not collide at the later time.

(7 marks)

5 (a) A horse running across a large area of open countryside starts to gallop with constant acceleration $(0.3\mathbf{i} + 0.2\mathbf{j})\ \text{m s}^{-2}$. After 9 seconds of galloping the horse has velocity $(10\mathbf{i} - 7\mathbf{j})\ \text{m s}^{-1}$.

Find the displacement of the horse at the end of the 9 second gallop.

(2 marks)

(b) (i) Find the average velocity of the horse during the gallop.

(ii) Find the average speed of the horse during the gallop.

(iii) Write down the magnitude of the average velocity and justify why you can do this without making any further calculations.

(4 marks)

6 It takes three minutes for a particle to travel $\begin{pmatrix} 1.62 \\ 2.16 \end{pmatrix}\ \text{km}$ with constant acceleration. The particle's velocity at the start of the three minutes is half of its velocity at the end. Find the magnitude of the acceleration giving your answer as a fraction, in metres per square second.

(6 marks)

7 (a) A football is kicked from the top of a hill and its motion modelled as moving in a 2D plane under gravity. Its initial velocity is $(12\mathbf{i} + 7\mathbf{j})\ \text{m s}^{-1}$ and it first hits ground level with velocity $(12\mathbf{i} - 20\mathbf{j})\ \text{m s}^{-1}$.

Find the height of the hill at the point from which the football was kicked.

(3 marks)

(b) Find the distance between the point from which the football was kicked and the point at which it first hits the ground.

(4 marks)

8 A particle passes a fixed point O at time $t = 0$ seconds. T seconds later the particle has velocity $\begin{pmatrix} 2T + 4 \\ 1 - T \end{pmatrix}\ \text{m s}^{-1}$. The acceleration of the particle is constant throughout this motion at $\begin{pmatrix} T - 3 \\ T - 9 \end{pmatrix}\ \text{m s}^{-2}$. The displacement of the particle from O T seconds after it passes O is $\begin{pmatrix} 4T \\ T \end{pmatrix}\ \text{m}$. Show that the initial velocity is $\begin{pmatrix} -10 \\ 8 \end{pmatrix}\ \text{m s}^{-1}$.

(6 marks)

9 A train leaves station O from rest with constant acceleration $\mathbf{a} = (0.4\mathbf{i} + 0.1\mathbf{j})\ \text{m s}^{-2}$. 2.5 minutes later it passes (but does not stop at) station A at which point its acceleration changes to $\mathbf{a} = (0.2\mathbf{i} + 0.3\mathbf{j})\ \text{m s}^{-2}$. 5 minutes later the train passes through station B.

Find the average velocity and the average acceleration of the train between station O and station B.

(7 marks)