

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Level Examination
January 2013

Mathematics

MM2B

Unit Mechanics 2B

Monday 28 January 2013 9.00 am to 10.30 am

For this paper you must have:

- the blue AQA booklet of formulae and statistical tables.
- You may use a graphics calculator.

Time allowed

- 1 hour 30 minutes

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8 \text{ m s}^{-2}$, unless stated otherwise.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	



J A N 1 3 M M 2 B 0 1

Answer **all** questions.

Answer each question in the space provided for that question.

- 1** Tim is playing cricket. He hits a ball at a point A . The speed of the ball immediately after being hit is 11 m s^{-1} .
- The ball strikes a tree at a point B . The height of B is 5 metres above the height of A .
- The ball is to be modelled as a particle of mass 0.16 kg being acted upon only by gravity.
- (a) Calculate the initial kinetic energy of the ball. (2 marks)
- (b) Calculate the potential energy gained by the ball as it moves from the point A to the point B . (2 marks)
- (c) (i) Find the kinetic energy of the ball immediately before it strikes the tree. (2 marks)
- (ii) Hence find the speed of the ball immediately before it strikes the tree. (2 marks)

QUESTION
PART
REFERENCE

Answer space for question 1



QUESTION
PART
REFERENCE**Answer space for question 1****Turn over ►**

- 2** A particle moves in a horizontal plane. The vectors $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in the horizontal plane. At time t seconds, the velocity of the particle, $\mathbf{v} \text{ m s}^{-1}$, is given by

$$\mathbf{v} = 12 \cos\left(\frac{\pi}{3}t\right)\mathbf{i} - 9t^2\mathbf{j}$$

- (a) Find an expression for the acceleration of the particle at time t . (2 marks)
- (b) The particle, which has mass 4 kg, moves under the action of a single force, $\mathbf{F}$ newtons.
- (i) Find an expression for the force $\mathbf{F}$ in terms of t . (2 marks)
- (ii) Find the magnitude of $\mathbf{F}$ when $t = 3$. (2 marks)
- (c) When $t = 3$, the particle is at the point with position vector $(4\mathbf{i} - 2\mathbf{j}) \text{ m}$.
Find the position vector, $\mathbf{r}$ metres, of the particle at time t . (5 marks)

QUESTION
PART
REFERENCE

Answer space for question 2



Answer space for question 2

[illegible]

- 3** A van, of mass 1500 kg, travels at a constant speed of 22 m s^{-1} up a slope inclined at an angle θ to the horizontal, where $\sin \theta = \frac{1}{25}$.

The van experiences a resistance force of 8 000 N.

Find the power output of the van's engine, giving your answer in kilowatts.

(5 marks)

QUESTION
PART
REFERENCE

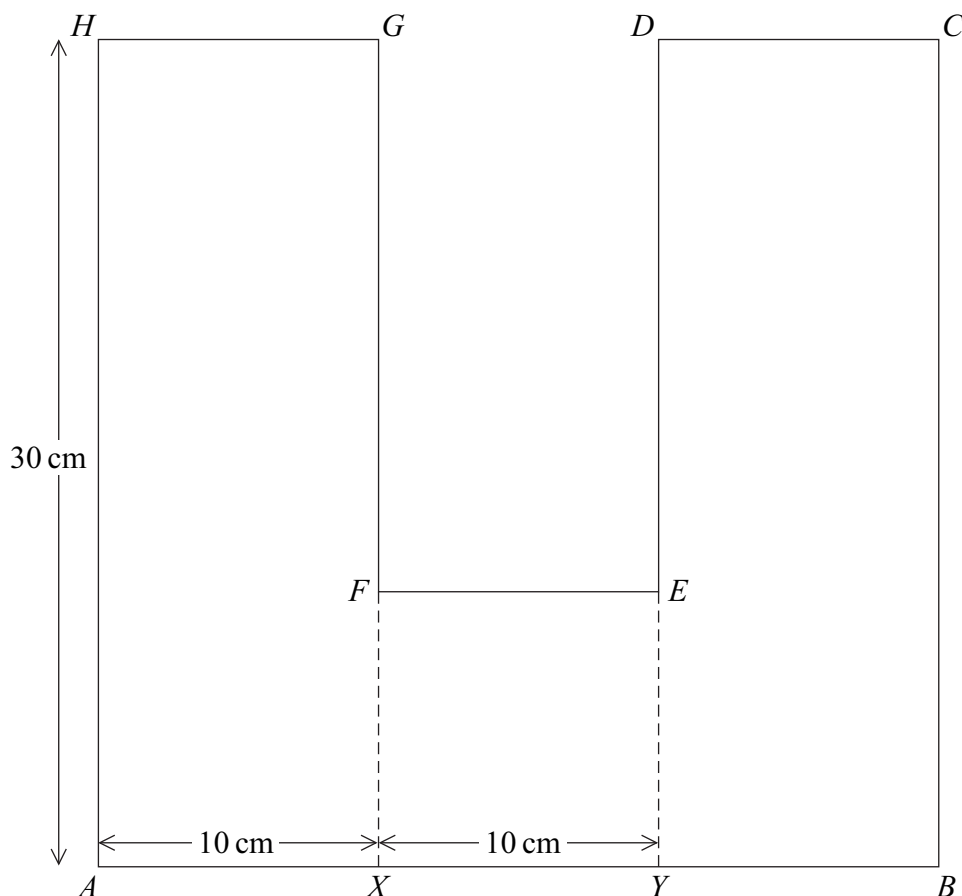
Answer space for question 3



QUESTION
PART
REFERENCE**Answer space for question 3****Turn over ►**

- 4** The diagram shows a uniform lamina which is in the shape of two identical rectangles $AXGH$ and $YBCD$ and a square $XYEF$, arranged as shown.

The length of AX is 10 cm, the length of XY is 10 cm and the length of AH is 30 cm.



- (a) Explain why the centre of mass of the lamina is 15 cm from AH . (1 mark)
- (b) Find the distance of the centre of mass of the lamina from AB . (3 marks)
- (c) The lamina is freely suspended from the point H .

Find, to the nearest degree, the angle between HG and the horizontal when the lamina is in equilibrium. (4 marks)



Answer space for question 4

This image shows a blank sheet of white paper designed for writing. It features a series of evenly spaced horizontal blue lines across its entire width. A single vertical red line runs down the left side, creating a narrow margin. The paper is otherwise completely empty, with no text or markings.

Answer space for question 4

This image shows a full page of primary-ruled paper. It features a vertical solid line on the left side, creating a narrow margin. The rest of the page is filled with horizontal dashed lines, providing a guide for handwriting practice. There are no other markings or text on the page.

QUESTION
PART
REFERENCE**Answer space for question 4****Turn over ►**

- 5** A particle, of mass 12 kg, is moving along a straight horizontal line. At time t seconds, the particle has speed $v \text{ m s}^{-1}$. As the particle moves, it experiences a resistance force of magnitude $4v^{\frac{1}{3}}$. No other horizontal force acts on the particle.

The initial speed of the particle is 8 m s^{-1} .

- (a)** Show that

$$v = \left(4 - \frac{2}{9}t\right)^{\frac{3}{2}} \quad (6 \text{ marks})$$

- (b)** Find the value of t when the particle comes to rest. (1 mark)

QUESTION
PART
REFERENCE

Answer space for question 5



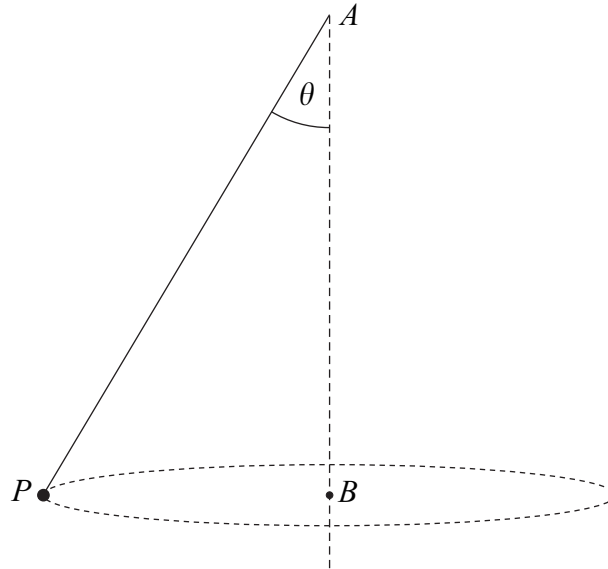
Answer space for question 5

[illegible]

6

A light inextensible string has one end attached to a particle, P , of mass 2 kg . The other end of the string is attached to the fixed point A . The point A is vertically above the point B . The particle moves at a constant speed in a horizontal circle of radius 0.8 m and centre B . The tension in the string is 34 N .

The string is inclined at an angle θ to the vertical, as shown in the diagram.



- (a) Find the angle θ . (3 marks)
- (b) Find the speed of the particle. (3 marks)
- (c) Find the time taken for the particle to make one complete revolution. (2 marks)

QUESTION
PART
REFERENCE

Answer space for question 6



Answer space for question 6

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A small ball, of mass 3 kg, is suspended from a fixed point O by a light inextensible string of length 1.2 m. Initially, the string is taut and the ball is at the point P , vertically below O . The ball is then set into motion with an initial horizontal velocity of 4 m s^{-1} .

A diagram showing a particle moving in a circular path. The center of the circle is labeled O . A vertical line segment of length 1.2 m connects O to a point P on the circumference. A horizontal line segment extends from P to the right, with an arrow indicating a velocity of 4 m s^{-1} . A point A is on the circumference in the first quadrant. A line segment connects O to A . The angle between the vertical line OP and the line OA is labeled 25° . A dashed circle represents the path.

- (a) Find the speed of the ball at the point A . (4 marks)
- (b) Find the tension in the string when the ball is at the point A . (3 marks)

Answer space for question 7

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Answer space for question 7

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- 8 (a)** An elastic string has natural length l and modulus of elasticity λ . The string is stretched from length l to length $l + e$.

Show, by integration, that the work done in stretching the string is $\frac{\lambda e^2}{2l}$. (3 marks)

- (b)** A particle, of mass 5 kg, is attached to one end of a light elastic string. The other end of the string is attached to a fixed point O .

The string has natural length 1.6 m and modulus of elasticity 392 N.

- (i)** Find the extension of the string when the particle hangs in equilibrium. (2 marks)

- (ii)** The particle is pulled down to a point A , which is 2.2 m below the point O .

Calculate the elastic potential energy in the string. (3 marks)

- (iii)** The particle is released when it is at rest at the point A .

Calculate the distance of the particle from the point A when its speed first reaches 0.8 m s^{-1} . (5 marks)

QUESTION
PART
REFERENCE

Answer space for question 8



Answer space for question 8

[illegible]

Answer space for question 8

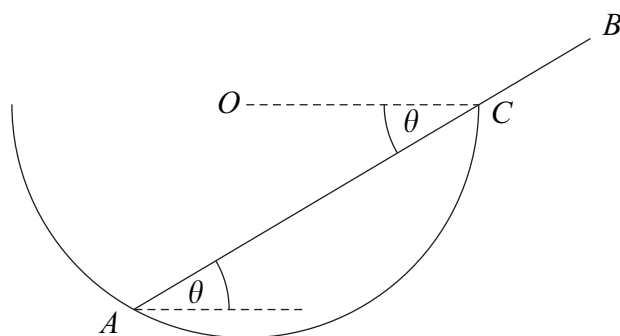
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Answer space for question 8

This image shows a full page of primary-ruled paper. It features a vertical solid line on the left side, creating a narrow margin. The rest of the page is filled with horizontal dashed lines, providing a guide for handwriting practice. There are no other markings or text on the page.

9

A smooth hollow hemisphere, of radius a and centre O , is fixed so that its rim is in a horizontal plane. A smooth uniform rod AB , of mass m , is in equilibrium, with one end A resting on the inside of the hemisphere and the point C on the rod being in contact with the rim of the hemisphere. The rod, of length l , is inclined at an angle θ to the horizontal, as shown in the diagram.



- (a) Explain why the reaction between the rod and the hemisphere at point A acts through O . (1 mark)
- (b) Draw a diagram to show the forces acting on the rod. (2 marks)
- (c) Show that $l = \frac{4a \cos 2\theta}{\cos \theta}$. (5 marks)

QUESTION
PART
REFERENCE

Answer space for question 9



Answer space for question 9

[illegible]

QUESTION
PART
REFERENCE**Answer space for question 9****END OF QUESTIONS**

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