

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL A-LEVEL MATHEMATICS

(9660/MA05) Unit M2 Mechanics

Time allowed: 1 hour 30 minutes

Materials

- For this paper you must have the Oxford International AQA booklet of formulae and statistical tables (enclosed).
- You may use a graphic calculator.

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.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to two significant figures, unless stated otherwise.
- Unless stated otherwise, the acceleration due to gravity, g , should be taken as 9.8 m s^{-2}

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- Show all necessary working; otherwise marks may be lost.

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



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1B/G/Jun22/E8

MA05

Answer **all** questions in the spaces provided.

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- 1** A particle moves in a horizontal plane so that its position vector, $\mathbf{r}$ metres, at time t seconds is given by

$$\mathbf{r} = \begin{bmatrix} 5 \sin\left(\frac{\pi t}{6}\right) \\ 5 \cos\left(\frac{\pi t}{6}\right) \end{bmatrix}$$

- 1 (a) (i)** Find the velocity of the particle at time t seconds.

[2 marks]

Answer _____

- 1 (a) (ii)** Find the acceleration of the particle at time t seconds.

[1 mark]

Answer _____



- 1 (b)** Using your answers to **part (a)**, show that the velocity of the particle is always perpendicular to the acceleration of the particle.

[3 marks]

- 1 (c)** Describe the path that the particle follows.

[1 mark]

7

Turn over for the next question

Turn over ►



The table below shows the mass and coordinates of each particle.

Particle	Mass (kg)	Coordinates
A	1.25	(3, 1)
B	2.5	(4, 2)
C	3.75	(5, 3)
D	2.5	(1, 2)
E	1.25	(2, 1)

[3 marks]

[illegible]

Answer



- 3** A body, of mass 2 kg is acted upon by the three forces $\mathbf{F}_1$ newtons, $\mathbf{F}_2$ newtons and $\mathbf{F}_3$ newtons, where

$$\mathbf{F}_1 = \begin{bmatrix} 2 \\ -1 \\ 5 \end{bmatrix}$$

$$\mathbf{F}_2 = \begin{bmatrix} 3 \\ 0 \\ 2 \end{bmatrix}$$

$$\mathbf{F}_3 = \begin{bmatrix} 7 \\ 3 \\ -3 \end{bmatrix}$$

- 3 (a)** Find the acceleration of the body.

[3 marks]

Answer _____

- 3 (b)** Another force, $\mathbf{F}_4$ newtons, now acts on the body so that the body is in equilibrium.

Find $\mathbf{F}_4$

[1 mark]

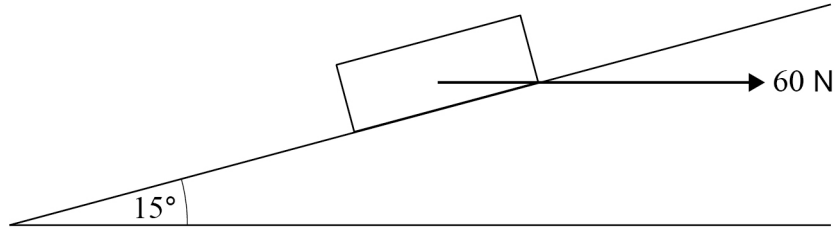
Answer _____

Turn over ►



- 4** A block, of weight 500 newtons, is at rest on a rough slope and is prevented from moving down the slope by a horizontal force of 60 newtons, as shown in the diagram.

The slope is inclined at an angle of 15° to the horizontal.



Throughout this question you may use the following results:

$$\sin 15^\circ = \frac{\sqrt{6} - \sqrt{2}}{4} \quad \text{and} \quad \cos 15^\circ = \frac{\sqrt{6} + \sqrt{2}}{4}$$

- 4 (a)** The magnitude of the frictional force which acts on the block is F newtons.

Find F , giving your answer in the form $a\sqrt{6} + b\sqrt{2}$ where a and b are constants.

[4 marks]

Answer _____



Find the range of possible values for μ

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Answer _____

3

Turn over ►



- 5** A pebble is projected with a speed of 15 m s^{-1} at an angle of 39° above the horizontal from a point O on horizontal ground.

- 5 (a) (i)** Find the time of flight of the pebble, giving your answer to three significant figures.

[3 marks]

Answer _____

- 5 (a) (ii)** Find the range of the pebble.

[2 marks]

Answer _____



5 (a) (iii) State an assumption you have made in **part (a)(ii)**

[1 mark]

5 (b) (i) Find the maximum height of the pebble.

[2 marks]

Answer _____

5 (b) (ii) State the horizontal displacement of the pebble from O when it is at its maximum height.

[1 mark]

Answer _____

9

Turn over for the next question

Turn over ►



- 6** A cyclist is riding her bicycle at a constant speed of 6.0 m s^{-1} along a straight horizontal road.

The combined mass of the cyclist and her bicycle is 70 kg

- 6 (a)** Calculate the kinetic energy of the cyclist and her bicycle.

[2 marks]

Answer _____

- 6 (b)** The cyclist's constant power output is 150 W

- 6 (b) (i)** Explain why the total resistive force acting on the cyclist and her bicycle must be 25 N

[2 marks]

- 6 (b) (ii)** State, with a reason, the work done each second by the cyclist against the total resistive force which acts on the cyclist and her bicycle.

[2 marks]



- 6 (c)** The cyclist begins to ride up a 100 metre section of straight road which is inclined at 1.5° to the horizontal.

The total resistive force which acts on the cyclist and her bicycle along the 100 metre section of road is constant and has magnitude 25 N

The speed of the cyclist and bicycle at the start of this section of road is 6.0 m s^{-1} and she now produces a constant driving force of 40 N

- 6 (c) (i)** Find the acceleration of the cyclist and her bicycle on the 100 metre section of road.

[4 marks]

Answer _____

- 6 (c) (ii)** Find the speed of the cyclist and her bicycle at the end of the 100 metre section of road.

[2 marks]

Answer _____

- 6 (c) (iii)** Calculate the change in gravitational potential energy of the cyclist and her bicycle by riding up the 100 metre section of road.

[2 marks]

Answer _____



- 7** A particle is projected with speed $u \text{ m s}^{-1}$ at an angle α degrees above the horizontal from a point O on horizontal ground.

The horizontal displacement of the particle from O at time t seconds is x metres.

The vertical displacement of the particle from O at time t seconds is y metres.

- 7 (a) (i)** Write down an expression for x in terms of u , α and t

[1 mark]

Answer _____

- 7 (a) (ii)** Write down an expression for y in terms of u , α , g and t

[1 mark]

Answer _____



7 (b)

[4 marks]

[illegible]

Turn over ►



- 7 (c) (i) Find an expression for the maximum height reached by the particle in terms of u , α and g
[3 marks]

Answer _____

- 7 (c) (ii) The particle reaches a maximum height of 16 metres when it is projected with speed 20 m s^{-1}

Find the value of α

[2 marks]

Answer _____



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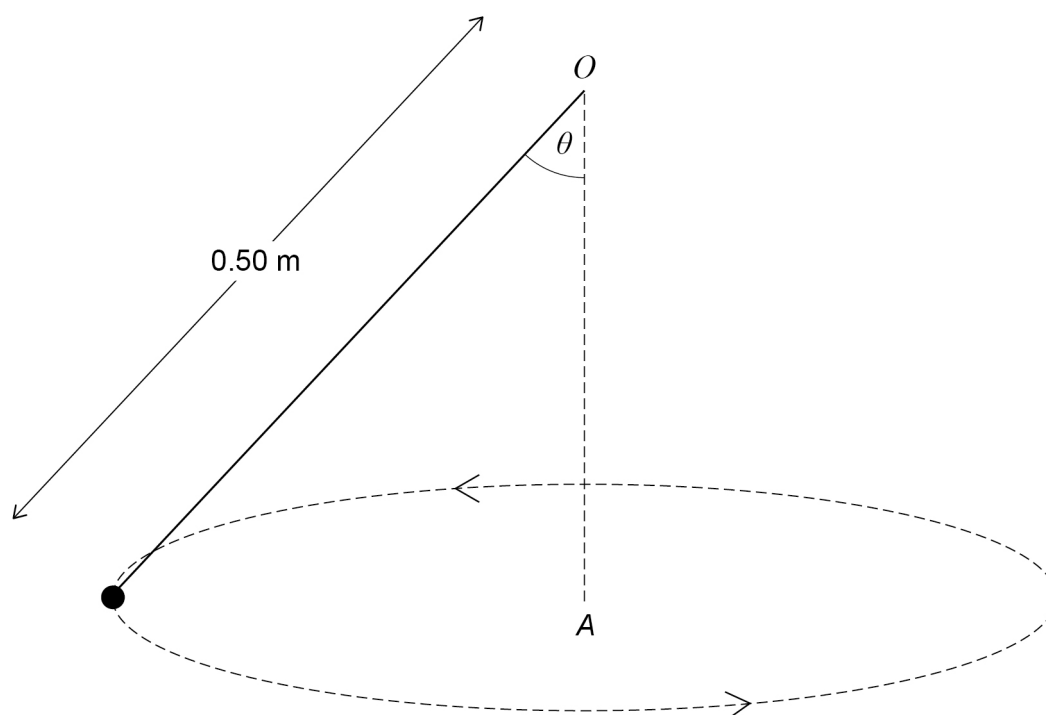


8 A light inextensible string of length 0.50 metres has one of its ends attached to a fixed point O

The other end of the string is attached to a particle of mass m kg

The particle is set into motion so that it moves with constant speed v m s⁻¹ in a horizontal circle about a centre A , where A is directly below O

The string makes an angle θ degrees to the vertical, where $0 \leq \theta \leq 90$ as shown in the diagram.



8 (a) The string is described as light.

Explain what is meant by light in this context.

[1 mark]



8 (b)

[6 marks]

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[4 marks]

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Answer _____



[2 marks]

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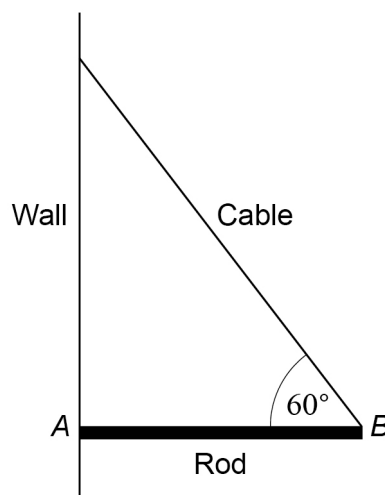
Answer _____

13

Turn over ►



- 9** A **non-uniform** rod AB is attached to a vertical wall by a smooth hinge at A
- A light inextensible cable is attached to the rod at B
- The cable makes an angle of 60° to the horizontal.
- The other end of the cable is attached to the vertical wall directly above A
- The rod is held in equilibrium in a horizontal position, as shown in the diagram.



The rod has mass 8.0 kg and length 1.2 metres .

The centre of mass of the rod is 0.7 metres from A

- 9 (a)** Explain what is meant by equilibrium.

[2 marks]

- 9 (b)** Find the tension in the cable, giving your answer to three significant figures.

[3 marks]



Answer _____

- 9 (c)** Calculate the magnitude and direction of the reaction force which acts on the rod at A, showing the direction of the reaction force on a labelled diagram.

[6 marks]

Answer

11

END OF QUESTIONS



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