OXFORD AQA

INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL

MATHEMATICS

(9660/MA05) Unit M2 Mechanics

Friday 13 June 2025 07:00 GMT Time allowed: 1 hour 30 minutes

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

Materials

- For this paper you must have the OxfordAQA Booklet of Formulae and Statistical Tables (enclosed).
- You may use a graphical 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.

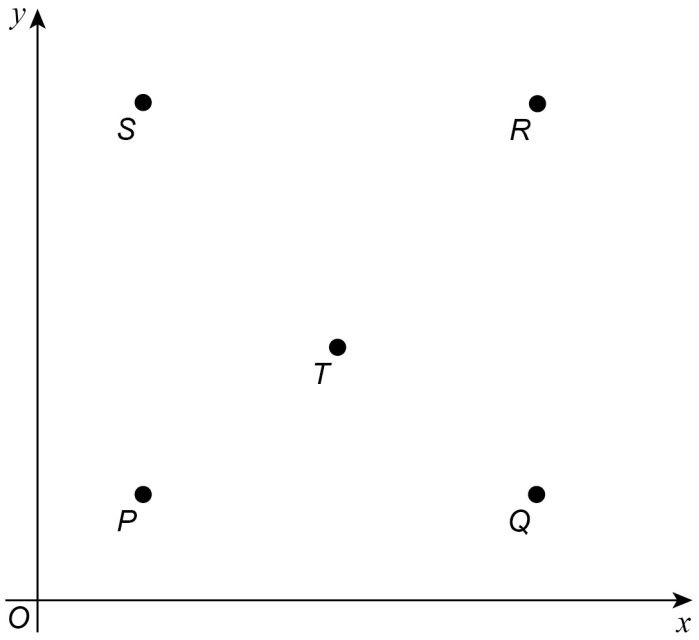
Advice

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

Do not write outside the box

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

1 A system of five fixed particles P, Q, R, S and T is shown in the diagram.



The table below shows the mass and the coordinates of the position for each particle, where k is a constant.

Particle	Mass (kg)	Coordinates (metres)
P	2	(3, 4)
Q	8	(9, 4)
R	6	(9, k)
S	10	(3, k)
T	7	(6, 10)

The coordinates, in metres, of the centre of mass of the system of particles are $(a, 14)$ where a is a constant.

Do not write outside the box

1 (a) Find the value of a

Give your answer as a fraction.

[2 marks]

Answer _____

1 (b) Find the value of k

[2 marks]

Answer _____

4

Turn over for the next question

Do not write outside the box

2 A body of mass 7.5 kg moves so that its position vector **r** metres relative to a fixed origin O at time t seconds is

$$\mathbf{r} = 30\cos(4t)\mathbf{i} - 30\sin(4t)\mathbf{j}$$

2 (a) (i) Show that the distance of the body from O is constant throughout its motion.

[2 marks]

2 (a) (ii) Hence describe the path that the body follows.

[1 mark]

Do not write outside the box

2 (b) Find the magnitude and the direction of the resultant force acting on the body.

[3 marks]

Magnitude _____

Direction _____

6

Turn over for the next question

Do not write outside the box

3 A tricycle is powered by a motor with a maximum power output of 250 W

The tricycle and its driver have a combined mass of 95 kg

When the tricycle is driven at a speed of v m s^{-1}, the total resistance force R newtons experienced is given by

$$R = cv^{1.06}$$

where c is a constant.

When the tricycle is driven along a straight, horizontal road, its maximum speed is 6.7 m s^{-1}

3 (a) (i) Show that $c = 5.0$ correct to two significant figures.

[3 marks]

3 (a) (ii) When the tricycle is driven at a speed of 2.1 m s^{-1} along a straight, horizontal road, the maximum magnitude of the tri-cycle and driver's acceleration is a m s^{-2}

Find the value of a

[2 marks]

Answer _____

Do not write outside the box

3 (b) State **one** modification that could be made to the tricycle to increase its maximum speed on the straight, horizontal road.

[1 mark]

3 (c) The tricycle is now driven along a straight road down a hill.

State with a reason the effect, if any, this would have on the maximum possible speed of the tricycle.

[2 marks]

8

Turn over for the next question

Do not write outside the box

4 A particle moves so that its velocity $\mathbf{v}$ m s^{-1} at time t seconds is given by

$$\mathbf{v} = \begin{bmatrix} (2+t)^{-1} \\ 2e^{\frac{t}{2}} \end{bmatrix}$$

4 (a) It is given that the position of the particle at time $t = 0$ is $\begin{bmatrix} 0 \\ 7 \end{bmatrix}$ metres relative to a fixed origin O

Find in terms of t the position of the body at time t seconds.

[4 marks]

Answer _____

Do not write outside the box

4 (b) Find the magnitude of the particle's acceleration at time $t = 0.05$

Give your answer to three decimal places.

[5 marks]

Answer _____

9

Do not write outside the box

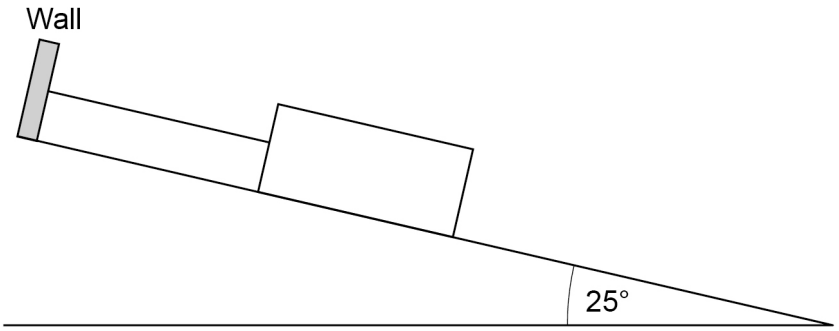
5 A block of mass 20 kg is at rest on a rough inclined plane.

The plane is inclined at an angle of 25° to the horizontal.

One end of a light inextensible string is attached to the block.

The other end of the string is attached to a fixed wall which is perpendicular to the inclined plane.

The string is parallel to the line of greatest slope of the inclined plane, as shown in the diagram.



The tension in the string is 50 newtons.

The coefficient of friction between the block and the inclined plane is μ

The magnitude of the friction acting on the block is maximum.

5 (a) Find the value of μ

Give your answer to three significant figures.

[4 marks]

Answer _____

Do not write outside the box

5 (b) The string is cut and the block starts to slide down the inclined plane.

Assume that the block experiences no resistance forces other than friction.

5 (b) (i) Find the work done against friction in the first 6 seconds of the motion of the block.

State the units of your answer.

[5 marks]

Answer _____ Units _____

5 (b) (ii) Find the loss in the block's gravitational potential energy in the first 6 seconds of the motion.

Give your answer to three significant figures.

[3 marks]

Answer _____

5 (b) (iii) Hence find the kinetic energy of the block 6 seconds after it started sliding.

[1 mark]

Answer _____

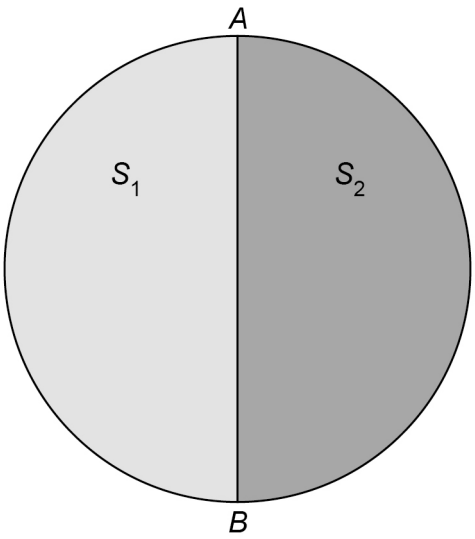
13

Turn over ►

Do not write outside the box

6 A circular board is made by joining two uniform semi-circular laminas S_1 and S_2 along their straight edges.

The straight edges of S_1 and S_2 form the diameter AB as shown in the diagram.



The length of the diameter AB is 6 metres.

The mass of S_1 is m kg

The mass of S_2 is $2m$ kg

You are given that the centre of mass of a uniform semi-circular lamina with radius r is located at a distance of $\frac{4r}{3\pi}$ from the straight edge, along the radius perpendicular to the straight edge.

The circular board is freely suspended from A and hangs in equilibrium.

Find the angle between the diameter AB and the vertical.

Give your answer to the nearest degree.

[5 marks]

Do not write outside the box

Answer _____

5

Turn over for the next question

Do not write outside the box

7 A light rod of length 1.6 metres has one of its ends attached to a fixed point A

The other end of the rod is attached to a particle P of mass 15 kg

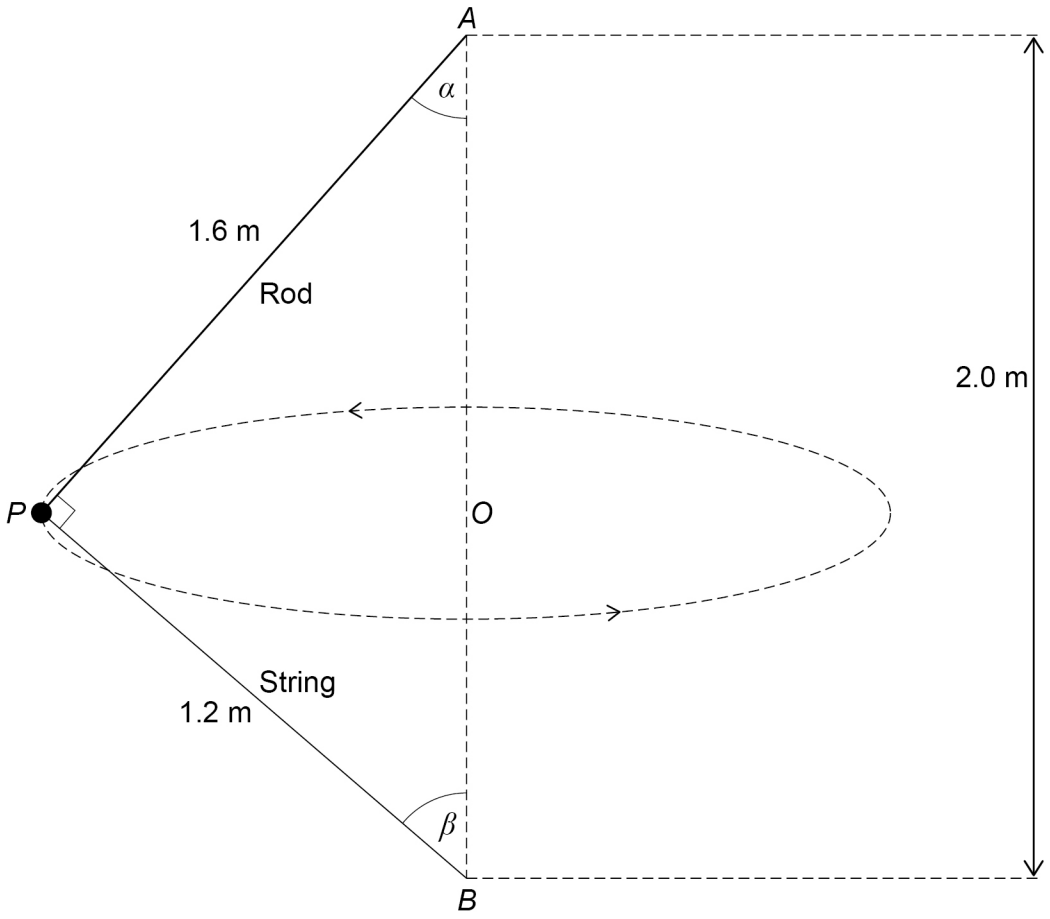
The particle P is also attached to one end of a light inextensible string of length 1.2 metres.

The other end of the string is attached to a fixed point B, where B is 2.0 metres vertically below A

The particle is set into motion so that it moves with constant speed 7 m s^{-1} in a horizontal circle about a centre O, where O is on the line AB, and the string is taut.

The rod and the string are perpendicular to each other throughout the motion.

The rod makes an angle α degrees with the downward vertical, and the string makes an angle β degrees with the upward vertical, as shown in the diagram.



7 (a) The rod is described as being light.

Explain what is meant by light in this context.

[1 mark]

Do not write outside the box

7 (b) (i) Find the distance *OP*

[2 marks]

Answer _____

7 (b) (ii) Find the angular speed of the particle.

[2 marks]

Answer _____

7 (b) (iii) Find the time taken for the particle to move once around the circumference of the horizontal circle.

[1 mark]

Answer _____

Question 7 continues on the next page

Do not write outside the box

7 (c) The tension in the rod is T_R newtons.

The tension in the string is T_S newtons.

Find the value of T_R and the value of T_S

Give your values to three significant figures.

[6 marks]

Do not write outside the box

$T_R =$ _____ $T_S =$ _____

12

Turn over for the next question

Do not write outside the box

8 At a theme park, players of a game throw a coin towards the top of a horizontal square platform. The top of the platform is rough.

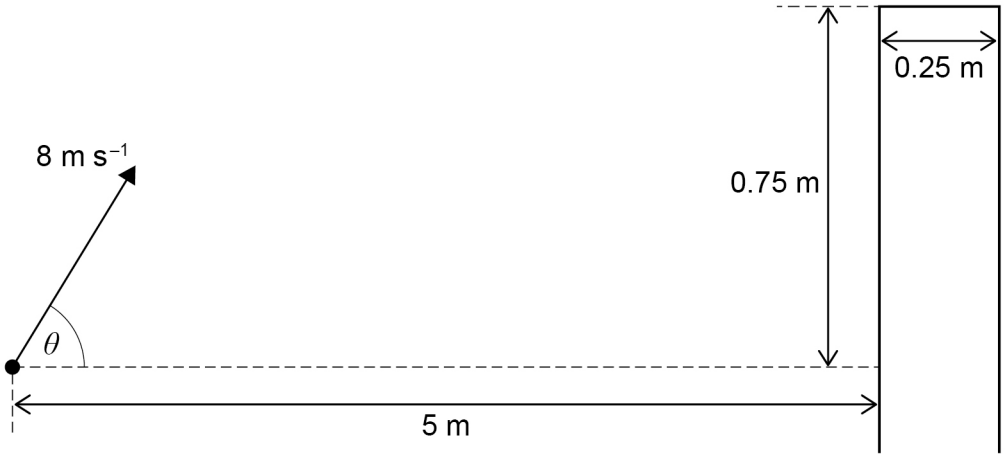
The game is won if the coin hits the top of the platform **and** comes to rest on the platform.

A child throws a coin so that the coin leaves their hand with a velocity of 8 m s^{-1} at an angle of θ degrees above the horizontal, where $\theta > 45$

The motion of the coin is in the vertical plane perpendicular to the front of the platform.

The platform has sides of length 0.25 metres.

The point at which the coin leaves the child's hand is 5 metres horizontally from the front of the platform and 0.75 metres vertically below the top of the platform, as shown in the diagram.



Model the coin as a particle and assume that the coin experiences no air resistance during its motion.

8 (a) The coin hits the top of the platform.

Find the range of values for θ

Give your values to three significant figures.

[10 marks]

Do not write outside the box

Answer _____

8 (b) Use your answer to **part (a)** to state with a reason the value of θ that gives the child the best chance of winning the game.

[2 marks]

$\theta =$ _____

Reason _____

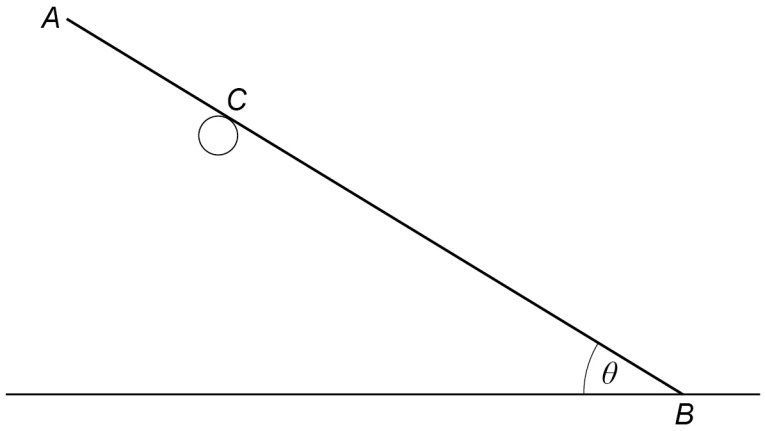
12

Turn over ►

Do not write outside the box

9 A **non-uniform** rod AB has one end on rough horizontal ground and is supported by a smooth horizontal circular peg at the point C, where BC is 6 metres.

The rod makes an angle of θ to the horizontal where $\theta < 45^\circ$, as shown in the diagram.



The mass of the rod is 14 kg

The centre of mass of the rod is 3 metres from B

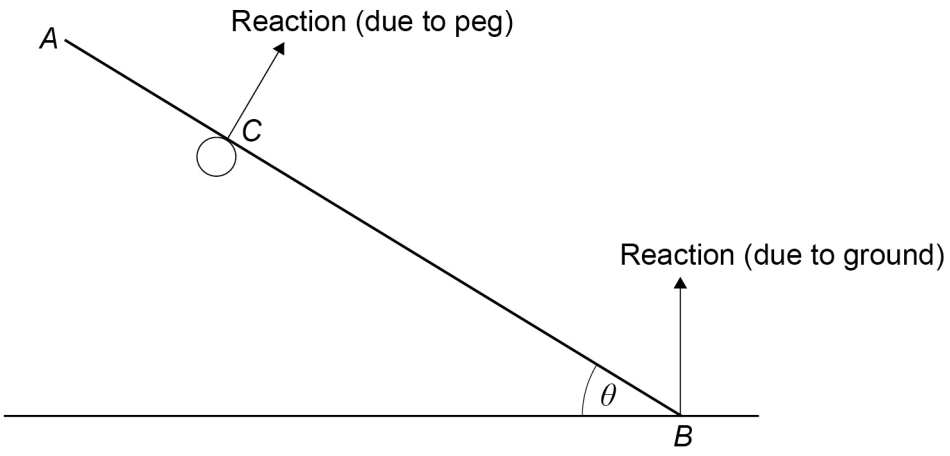
The coefficient of friction between the rod and the rough horizontal ground is μ

The rod is in equilibrium but is on the point of slipping at B

9 (a) Complete the diagram **below** to show all of the forces acting on the rod.

Write down the names of the forces on the diagram.

[1 mark]



Do not write outside the box

9 (b) (i) By taking moments about B, find in terms of θ an expression for the magnitude of the reaction force acting on the rod due to the peg.

[2 marks]

Answer _____

9 (b) (ii) Show that $\mu = \dfrac{\cos\theta \sin\theta}{2 - \cos^2\theta}$

[6 marks]

Question 9 continues on the next page

Do not write outside the box

9 (b) (iii) It is given that $\mu = 0.25$

Use a numerical method to verify that $16^\circ < \theta < 17^\circ$

[2 marks]

11

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED