OXFORD AQA

INTERNATIONAL QUALIFICATIONS

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INTERNATIONAL A-LEVEL

MATHEMATICS

(9660/MA05) Unit M2 Mechanics

Thursday 4 June 2026 08:00 UK Time Time allowed: 1 hour 30 minutes

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}

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

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.

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

1 Four particles P, Q, R and S are fixed on a uniform rectangular lamina $OABC$ to create a system. The system is shown in **Figure 1**

Figure 1

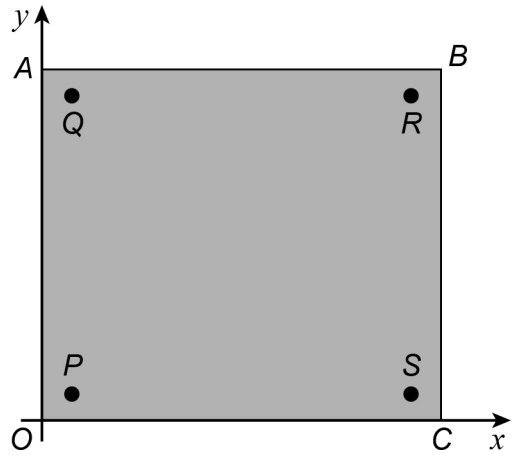

Figure 2 shows the mass of each particle and the coordinates of the points at which they are fixed to the lamina.

Figure 2

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

The mass of the uniform rectangular lamina $OABC$ is 11 kg

The coordinates of the point A are $(0, 10)$

The coordinates of the point C are $(12, 0)$

1 (a) State, with a reason, the coordinates of the centre of mass of the **uniform rectangular lamina**.

[2 marks]

Coordinates _____

Reason _____

_____

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1 (b) Find the coordinates of the centre of mass of the **system**.

Give your answer in an exact form.

[4 marks]

Answer _____

1 (c) The **system** is freely suspended from A and hangs in equilibrium.

Find the angle between the vertical and the straight line through A and B

Give your answer to the nearest degree.

[3 marks]

Answer _____

9

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2 A particle of mass 4 kg is moving up a smooth inclined plane.

The plane is inclined at an angle θ to the horizontal.

The particle passes through the points X and Y

As the particle passes through X it is moving with speed 3.2 m s^{-1} up the plane.

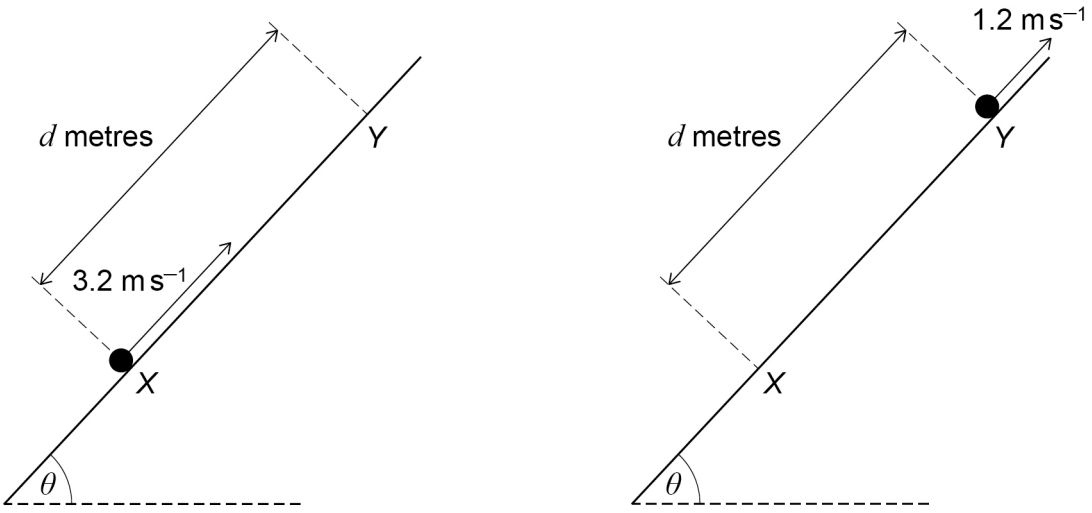
As the particle passes through Y it is moving with speed 1.2 m s^{-1} up the plane.

The line through X and Y is a line of greatest slope on the inclined plane.

The distance between X and Y is d metres.

The inclined plane is shown in **Figure 3**

Figure 3



Assume that the particle experiences no resistance forces or friction forces.

2 (a) Show that the loss in the particle's kinetic energy between X and Y is 17.6 J

[1 mark]

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2 (b) It is given that the particle experiences a normal reaction force of magnitude 25 newtons due to its contact with the plane.

2 (b) (i) Find the value of θ

Give your answer to the nearest degree.

[2 marks]

$\theta =$ _____

2 (b) (ii) Hence use an energy method to find the value of d

[3 marks]

$d =$ _____

2 (c) The particle continues to move up the plane until it momentarily comes to rest.

The particle then begins to move down the plane.

The total time that the particle is between X and Y during its entire motion on the plane is T seconds.

Find the value of T

[2 marks]

$T =$ _____

8

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3 A straight road is inclined at an angle of $3°$ to the horizontal.

A van of mass 2900 kg is moving downhill along the road.

When the van is moving at a speed of 15 m s^{-1} the van experiences a resistance force of magnitude 3000 newtons.

3 (a) When the van is moving at a constant speed of 15 m s^{-1} the power output from the van's engine is P watts.

Find the value of P

[4 marks]

$P =$ _____

3 (b) It is given that the maximum power output of the van's engine is $95\,000$ watts.

Find the magnitude of the maximum acceleration of the van when it is traveling at 15 m s^{-1} downhill along the road.

[2 marks]

Answer _____

6

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4 A car of mass 1200 kg moves at constant speed v m s^{-1} around a roundabout, which is a circular section of road of radius 50 metres.

The position vector of the car **r** metres relative to the centre of the roundabout at time t seconds is given by

$$\mathbf{r} = \begin{bmatrix} 50\cos(0.24t) \\ 50\sin(0.24t) \end{bmatrix}$$

The road on the roundabout is horizontal and **dry**.

The coefficient of friction between the car's tyres and the **dry** road is μ

4 (a) (i) Write down the angular speed of the car as it moves around the roundabout.

Include units in your answer.

[2 marks]

Answer _____ units _____

4 (a) (ii) Find the value of v

[2 marks]

$v =$ _____

4 (a) (iii) Find the range of values of μ for which the car can move with constant speed v m s^{-1} around the roundabout in a circle of radius 50 metres.

[2 marks]

Answer _____

Do not write outside the box

4 (b) A rain shower makes the road on the roundabout **wet**.

It is given that the coefficient of friction between the car's tyres and the **wet** road is 0.18

State, with a reason, whether the car can still move around the roundabout in a circle of radius 50 metres with the same constant speed v m s^{-1}

[2 marks]

8

Turn over for the next question

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5 A variable force **F** newtons acts on a body of mass 2 kg such that at time t seconds

$$\mathbf{F} = \begin{bmatrix} 4e^{2t} \\ 16\cos 4t \\ -12\sin 3t \end{bmatrix}$$

Assume that no other forces act on the body.

5 (a) It is given that the initial velocity of the body is $\begin{bmatrix} 2 \\ -5 \\ 3 \end{bmatrix}$ m s^{-1}

At time t seconds, the velocity of the body is **v** m s^{-1}

Find **v** in terms of t

[6 marks]

Answer _____

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5 (b) Hence find the speed of the body when $t = \frac{\pi}{12}$

[2 marks]

Answer _____

8

Turn over for the next question

Do not write outside the box

6 A small ball is kicked so that it has an initial velocity of u m s^{-1} at an angle θ degrees above the horizontal from a point O on horizontal ground.

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

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

Assume that the only force the ball experiences whilst it is in the air is its weight.

6 (a) Show that

$$\frac{gx^2}{2u^2}\tan^2\theta - x\tan\theta + y + \frac{gx^2}{2u^2} = 0$$

[6 marks]

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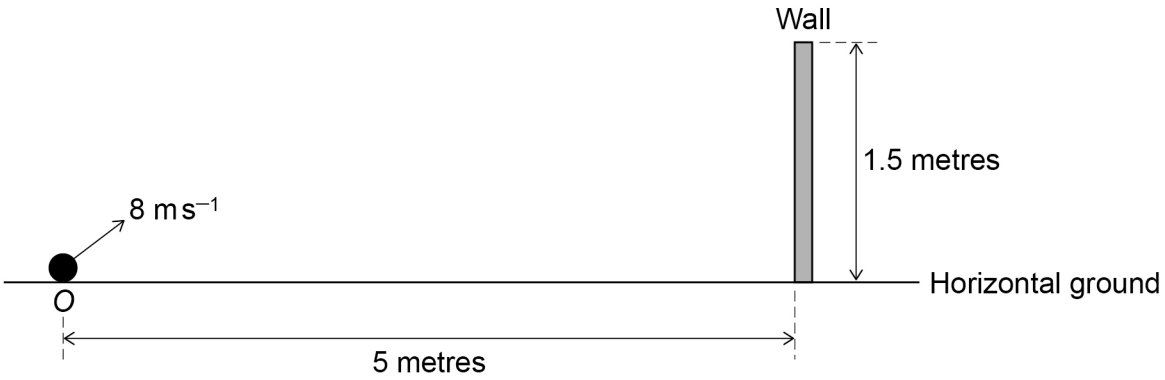
6 (b) A child is trying to kick a small ball from a point O on horizontal ground to make it pass over a vertical wall.

The child kicks the ball so its initial speed as it leaves their foot is $8\ \text{m s}^{-1}$

The horizontal displacement from O to the bottom of the wall is 5 metres.

The top of the wall is 1.5 metres vertically above the ground as shown in **Figure 4**

Figure 4



Use the result in **part (a)** to determine whether the child can kick the ball to make it pass over the wall.

[4 marks]

10

Turn over ►

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7 Two rough fixed planes are both inclined at 25° to the horizontal.

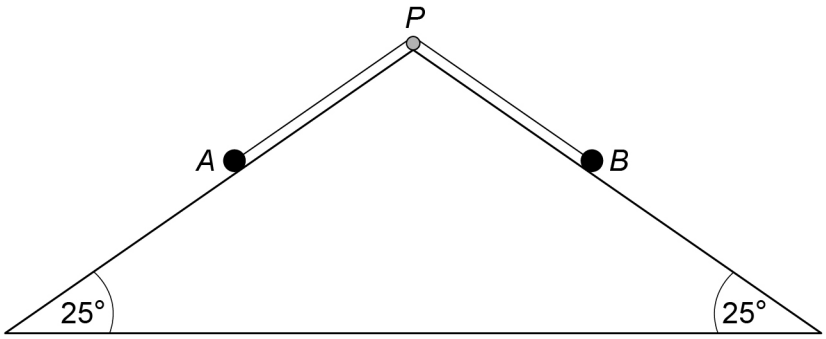
A smooth peg is located at P where the planes meet.

Two particles A and B are connected by a light inextensible string which passes over the peg.

Particle A has mass 5 kg and particle B has mass 11 kg

The particles are held at rest with the string taut and parallel to the line of greatest slope of each plane as shown in **Figure 5**

Figure 5



The coefficient of friction between the particles and each plane is μ

Both particles are released at the same time.

Exactly 4 seconds after being released, A has travelled a distance of 3 metres up the plane towards P

7 (a) (i) Find the magnitude of the acceleration of A

[1 mark]

Answer _____

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7 (a) (ii) State with a reason the magnitude of the acceleration of B

[2 marks]

Magnitude _____

Reason _____

_____

7 (b) Show that the value of μ is 0.133 correct to three significant figures.

[5 marks]

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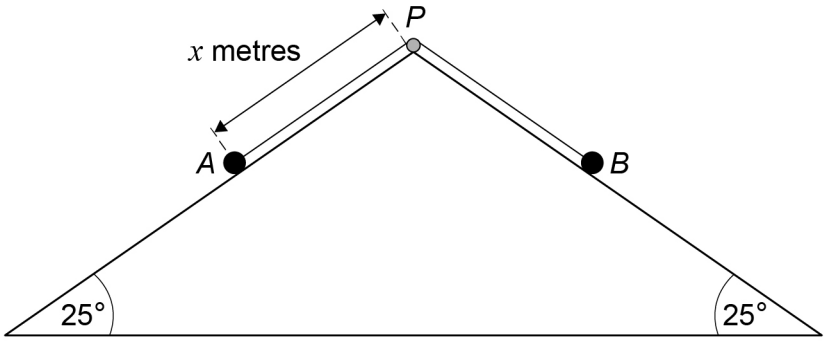
7 (c) Before being released, particle A is at a distance of x metres from P as shown in **Figure 6**

Figure 6



Exactly 4 seconds after both particles are released, the string breaks so that A and B are no longer connected.

It is given that in the subsequent motion, A does **not** collide with the peg at P

Find the minimum possible value of x

Give your answer to three significant figures.

[6 marks]

$x =$ _____

14

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Turn over for the next question

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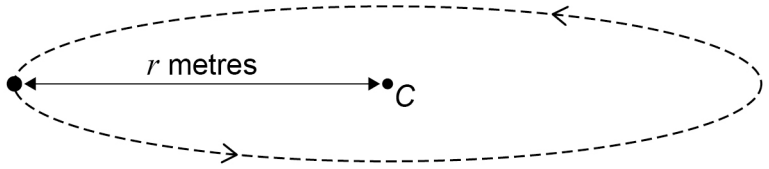
8 A particle of mass 6 kg is moving around the circumference of a horizontal circle.

The horizontal circle has radius r metres and centre C as shown in **Figure 7**

Figure 7



The particle experiences a force of magnitude F newtons directed towards C such that

$$F = \frac{k}{r^n}$$

where k and n are positive constants.

No other forces act on the particle.

In the case when $r = 2$, the speed of the particle around the circle is 0.5 m s^{-1}

In the case when $r = 10$, the speed of the particle around the circle is 0.02 m s^{-1}

Find the value of k and the value of n

[7 marks]

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$k =$ _____ $n =$ _____

7

Turn over for the next question

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9 A uniform rod of mass 20 kg has length 5 metres.

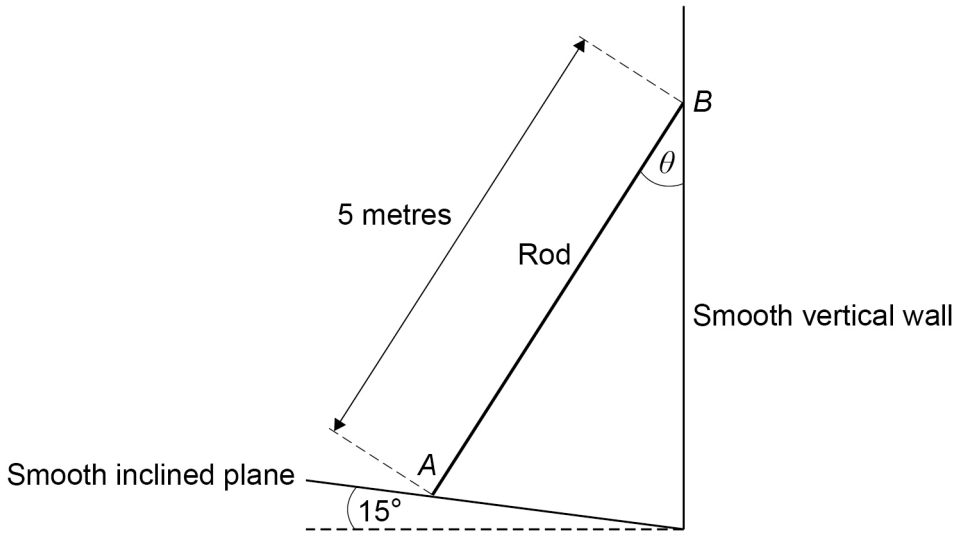
The rod rests with one end on a smooth inclined plane at the point *A*

The plane is inclined at an angle of 15° above the horizontal.

The other end of the rod rests against a smooth vertical wall at the point *B*

The rod is in equilibrium and makes an angle of θ with the smooth vertical wall, as shown in **Figure 8**

Figure 8



9 (a) The magnitude of the reaction force exerted on the rod at *A* due to its contact with the inclined plane is R newtons.

By considering the equilibrium of the forces acting on the rod, show that $R = 203$ correct to three significant figures.

[2 marks]

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9 (b) (i) Find the magnitude of the reaction force exerted on the rod due to its contact with the wall at B.

Give your value to three significant figures.

[2 marks]

Answer _____

9 (b) (ii) State with a reason the magnitude of the reaction force exerted on the wall at B due to its contact with the rod.

[2 marks]

Magnitude _____

Reason _____

9 (c) Find the angle θ

Give your answer to the nearest degree.

[4 marks]

$\theta =$ _____

10

END OF QUESTIONS

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