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
FURTHER MATHEMATICS

(9665/FM05) Unit FM2 Mechanics

Friday 16 January 2026 07:00 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	
10	
11	
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 IN THE SPACES PROVIDED

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

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1 A disc is moving on a smooth horizontal surface when it collides with a smooth fixed vertical wall.

When the disc collides with the wall, it has velocity 4 m s^{-1} at an angle of $60°$ to the wall.

When the disc leaves the wall, it has velocity v m s^{-1} at an angle of $\theta°$ to the wall.

The coefficient of restitution between the disc and the wall is $\frac{1}{3}$

Find the value of θ

[4 marks]

$\theta =$ _____

4

Turn over ►

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2 A particle of mass 3 kg is moving in a straight line on a smooth horizontal surface.

The displacement of the particle from the point O is x metres.

A force F newtons acts on the particle, where

$$F = \frac{x(5-x)}{4}$$

The force F acts along the line on which the particle is moving.

At O the particle has a speed of 4 m s^{-1}

The particle passes through the point A which has displacement 5 metres from O

2 (a) Find the work done by the force as the particle moves from O to A

Give your answer in an exact form.

[3 marks]

Answer _____

Do not write outside the box

2 (b) Find the speed of the particle at A

Give your answer in the form $\frac{\sqrt{a}}{b}$ where a and b are integers.

[2 marks]

Answer _____

5

Turn over for the next question

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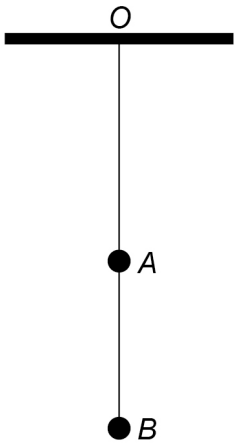
3 Two identical light elastic strings have natural length a metres and modulus of elasticity λ newtons.

One end of the first string is attached to a fixed point O and the other end is attached to a particle A of mass 2 kg

One end of the second string is also attached to A and the other end of this string is attached to a particle B of mass 3 kg

The system is initially in equilibrium, with A and B vertically below O, as shown in **Figure 1**

Figure 1



3 (a) Find the length OB

Give your answer in terms of a, g and λ

[4 marks]

Answer _____

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3 (b) The upper string connecting A and O is now cut.

3 (b) (i) Find the magnitude of the acceleration of A at the instant that this string is cut.

Give your answer in terms of g

[2 marks]

Answer _____

3 (b) (ii) State the acceleration of B at the instant that this string is cut.

[1 mark]

Answer _____

7

Turn over for the next question

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4 A particle of mass m kg is released from rest and falls vertically.

At time t seconds the particle has a speed v m s^{-1}

As the particle falls a resistance force of magnitude $\frac{v}{4}$ newtons acts on the particle.

4 (a) Find v

Give your answer in terms of m, g and t

[5 marks]

Answer _____

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4 (b) On the axes in **Figure 2** sketch a graph to show how v varies with t

[2 marks]

Figure 2

4 (c) Find the time that it takes for the particle to reach a speed of $2mg$ m s^{-1}

Give your answer in the form $m \ln a$ where a is an integer.

[2 marks]

Answer _____

9

Turn over for the next question

Do not write outside the box

5 A light elastic string has natural length 1.5 metres and modulus of elasticity 125 newtons.

One end of the string is attached to a fixed point A on a horizontal surface.

The other end of the string is attached to a particle of mass 4.2 kg

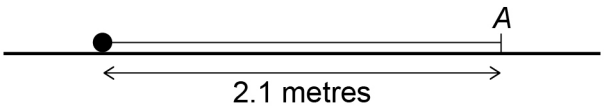
The coefficient of friction between the particle and the horizontal surface is μ

The particle is released from rest at a distance of 2.1 metres from A

The particle comes to rest with the string slack but before the particle reaches A

Figure 3 shows the initial position of the particle.

Figure 3



5 (a) Calculate the elastic potential energy of the string when its length is 2.1 metres.

[2 marks]

Answer _____

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5 (b) Find the range of possible values of μ

Give your values to three significant figures.

[5 marks]

Answer _____

5 (c) Find the maximum possible speed of the particle at the instant that the string becomes slack.

[3 marks]

Answer _____

10

Turn over ►

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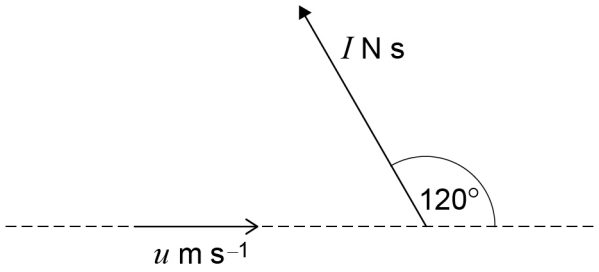
6 A particle of mass m kg is moving with a speed u m s^{-1} in a straight line on a smooth horizontal surface.

An impulse is exerted on the particle and causes it to change speed and direction.

The impulse of magnitude I N s acts at 120° to the original direction of motion of the particle as shown in **Figure 4**

Figure 4



After the impulse has been exerted the particle has speed v m s^{-1} and moves in a direction at an angle of 45° to the original motion of the particle.

6 (a) Express v in terms of u

Give your answer in an exact form.

[5 marks]

Answer _____

Do not write outside the box

6 (b) Find I

Give your answer in the form $mu\left(\sqrt{a}-b\right)$ where a and b are integers.

[2 marks]

Answer _____

7

Turn over for the next question

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7 A simple pendulum consists of a light inextensible string of length L metres attached to a small sphere.

The motion of a simple pendulum satisfies the differential equation

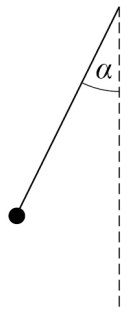
$$\frac{\mathrm{d}^2\theta}{\mathrm{d}t^2} = -\frac{g}{L}\theta$$

where θ radians is the angle between the string and the vertical at time t seconds.

It has been assumed that the angle θ is small.

The sphere is released from rest with the string taut and at an angle α to the downward vertical, as shown in **Figure 5**

Figure 5



For a particular simple pendulum $L = 0.7$ and the average speed of the sphere during each cycle is $\frac{7\sqrt{14}}{75}$ m s^{-1}

7 (a) Find the value of α

Give your answer in terms of π

[3 marks]

Answer _____

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7 (b) Find the time that it takes for the angle between the string and the vertical to decrease from α to $\frac{\alpha}{3}$

Give your answer to three decimal places.

[3 marks]

Answer _____

6

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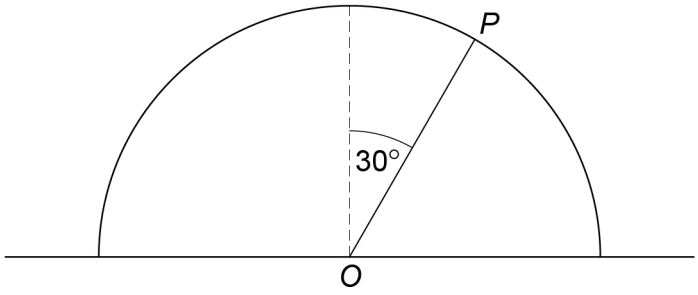
8 A smooth hemisphere of radius r metres and centre O is fixed to a horizontal surface.

A particle is set into motion on the hemisphere so that it has a speed U m s^{-1} at the top of the hemisphere.

The particle moves on the surface of the hemisphere until it reaches the point P where it leaves the hemisphere.

The radius OP makes an angle of 30° to the vertical as shown in **Figure 6**

Figure 6



Find U

Give your answer in terms of r and g

[5 marks]

Answer _____

5

Turn over ►

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9 A light spring has natural length 0.4 metres and stiffness 28 N m^{-1}

One end of the spring is attached to a fixed point.

The other end of the spring is attached to a particle of mass 0.2 kg

The particle initially hangs in equilibrium below the fixed point.

The particle is then pulled down and released from rest 0.03 metres below the equilibrium position.

9 (a) Find the extension of the spring when the particle is in equilibrium.

[2 marks]

Answer _____

9 (b) Show that the particle moves with simple harmonic motion.

[4 marks]

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9 (c) State the period of the motion.

Give your answer in terms of π

[1 mark]

Answer _____

9 (d) During the motion the particle moves through the points P and Q which are 0.02 metres apart.

The time taken for the particle to travel from P to Q without changing the direction of its velocity is T seconds.

Find the range of possible values of T

Give your answer in the form $a \leq T \leq b$ with the value of a and the value b correct to four decimal places.

[6 marks]

Answer _____

13

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10 Two spheres A and B of equal radius are moving on a smooth horizontal surface when they collide.

The mass of A is 2 kg and the mass of B is 3 kg

Before the collision A has velocity $\begin{bmatrix} 4 \\ -2 \end{bmatrix}$ m s^{-1} and B has velocity $\begin{bmatrix} 2 \\ 1 \end{bmatrix}$ m s^{-1}

After the collision A has velocity $\begin{bmatrix} 3 \\ 0 \end{bmatrix}$ m s^{-1}

Find the acute angle between the velocity of B after the collision and the line of centres at the time of the collision.

Give your answer to the nearest degree.

[7 marks]

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Answer _____

7

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11 A plane is inclined at an angle θ to the horizontal.

The points *A* and *B* are on the plane a distance of d metres apart.

A ball is projected from *A* up the plane with velocity $2V$ at an angle α to the plane, where $\alpha \leq 30°$

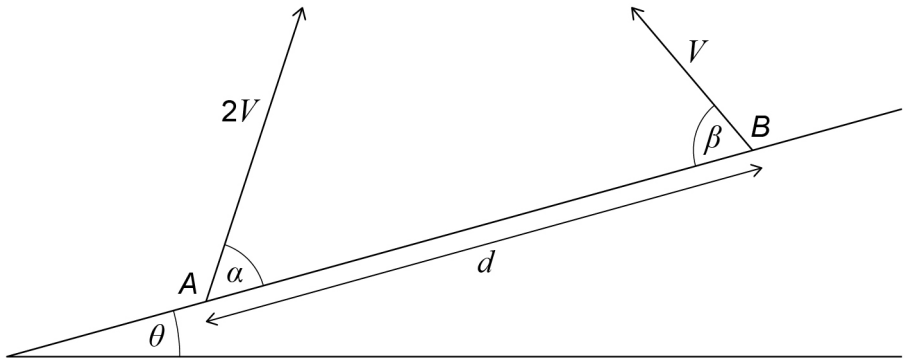
At the same instant in time a ball is projected from *B* down the plane with velocity V at an angle β to the plane.

The balls collide when they are each at their maximum distance from the plane.

The motion of the balls is in a plane that contains the line of greatest slope of the inclined plane.

Figure 7 shows the initial velocities of the balls.

Figure 7



Show that

$$d = \frac{V^2}{2g\cos\theta}\left(4\sin(2\alpha) + \sin(2\beta)\right)$$

[7 marks]

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END OF QUESTIONS

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