OXFORD AQA
INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

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

Surname _____

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I declare this is my own work.

INTERNATIONAL A-LEVEL
FURTHER MATHEMATICS

(9665/FM05) Unit FM2 Mechanics

Friday 19 January 2024 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 Two particles A and B are moving on a smooth horizontal surface.

The two particles collide.

Particle A has mass 2 kg and has velocity $\begin{bmatrix} 4 \\ 7 \end{bmatrix}$ m s^{-1} before the collision.

Particle B has mass 6 kg and has velocity $\begin{bmatrix} 6 \\ -4 \end{bmatrix}$ m s^{-1} before the collision.

After the collision particle A has velocity $\begin{bmatrix} 7 \\ 1 \end{bmatrix}$ m s^{-1}

1 (a) Find the velocity of B after the collision.

[4 marks]

Answer _____

Do not write outside the box

1 (b) Find the magnitude of the impulse exerted on A during the collision.

Give your answer in exact form.

[4 marks]

Answer _____

8

Turn over for the next question

Do not write outside the box

2 A particle moves with simple harmonic motion between two points A and B which are 1.5 metres apart on a straight line.

The period of the motion is 4 seconds.

2 (a) Calculate the maximum speed of the particle.

Give your answer in terms of π

[2 marks]

Answer _____

2 (b) The point C is between A and B and the distance between A and C is 0.3 metres.

Find the speed of the particle at C

Give your answer in terms of π

[2 marks]

Answer _____

Do not write outside the box

2 (c) Find the time that it takes for the particle to move directly from A to C

Give your answer to four significant figures.

[3 marks]

Answer _____

7

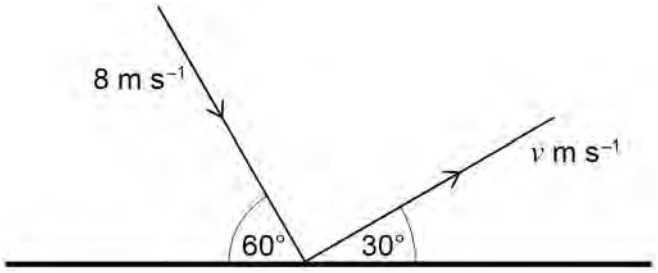
Turn over for the next question

Do not write outside the box

3 A disc of mass 0.2 kg is moving on a smooth horizontal surface, when it hits a smooth vertical wall which is fixed to the surface.

When it hits the wall, the disc is moving at $8\ \text{m s}^{-1}$ and its velocity makes an angle of $60°$ to the wall.

When the disc leaves the wall it has a velocity of $v\ \text{m s}^{-1}$ at an angle $30°$ to the wall, as shown in the diagram.



3 (a) Find the value of v

Give your answer in an exact form.

[3 marks]

Answer _____

Do not write outside the box

3 (b) Find the coefficient of restitution between the wall and the disc.

[3 marks]

Answer _____

3 (c) Find the magnitude of the impulse exerted on the disc.

Give your answer in an exact form.

[3 marks]

Answer _____

9

Turn over ►

Do not write outside the box

4 A light inextensible string has length 80 cm

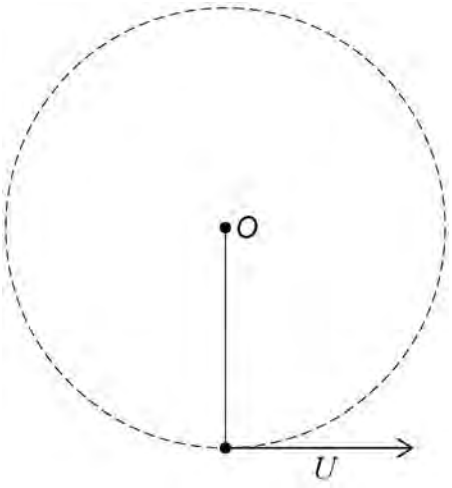
One end of the string is attached to a fixed point *O*

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

The particle is set into motion so that it completes vertical circles with centre *O*

At its lowest point, the particle has speed U m s^{-1}

The path the particle follows is shown in the diagram below.



Find the minimum value of U

[5 marks]

Do not write outside the box

Answer _____

5

Turn over for the next question

Do not write outside the box

5 A particle of mass m kg is released from rest at time $t = 0$ on a rough plane inclined at 30° to the horizontal.

The particle slides down the plane.

The coefficient of friction between the particle and the plane is μ

The speed of the particle is v m s^{-1} at time t seconds.

The particle experiences an air resistance force of magnitude mkv newtons where k is a constant.

Find an expression for v in terms of g, k, μ and t

[8 marks]

Do not write outside the box

Answer _____

8

Do not write outside the box

6 A simple pendulum consists of a light inextensible string of length 1.4 metres and a small sphere.

At time $t = 0$ the sphere is released from rest with the string taut and at an angle of $\frac{\pi}{20}$ radians to the vertical.

6 (a) Show that the motion of the simple pendulum approximates to simple harmonic motion.

[5 marks]

6 (b) At time $t = T$ the sphere has moved a total distance of 1.8 metres.

Find the value of T

[8 marks]

Do not write outside the box

Answer _____

13

Do not write outside the box

7 Two identical light elastic strings have modulus of elasticity 800 newtons and natural length 5 metres.

One end of each string is attached to a particle of mass 7 kg

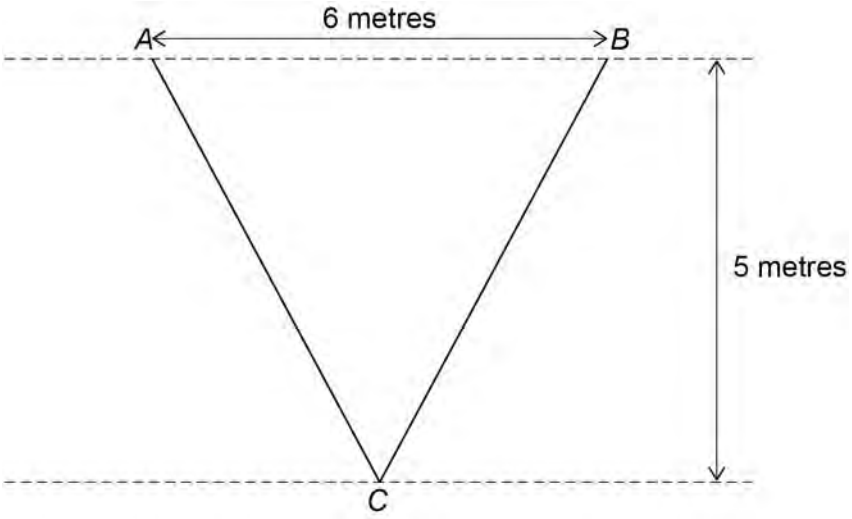
The other end of one string is attached to the point *A* and the other end of the second string is attached to the point *B*

The points *A* and *B* are 6 metres apart and at the same level.

The particle is released from rest at the point *C* which is 5 metres vertically below the level of the points *A* and *B*

When the particle is released, the magnitude of the tension is the same in each string.

The elastic strings are shown in the diagram below.



7 (a) Find the total elastic potential energy of the system when the particle is released.

Give your answer to three significant figures.

[4 marks]

Answer _____

Do not write outside the box

7 (b) Find the speed of the particle when the strings are at their natural lengths.

[5 marks]

Answer _____

7 (c) Find the maximum height of the particle above C

[2 marks]

Answer _____

11

Turn over ►

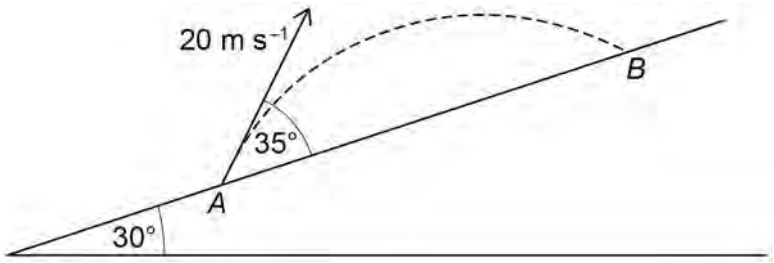
Do not write outside the box

8 A smooth plane is inclined at an angle of $30°$ to the horizontal.

A ball is projected from a point A on the plane and hits the plane for the first time at a point B

The line AB is a line of greatest slope of the plane.

The initial velocity of the ball is $20\,\text{m s}^{-1}$ at an angle $35°$ above the plane.



8 (a) Find the speed of the ball when it hits the plane at B

[7 marks]

Do not write outside the box

Answer _____

8 (b) At B the ball bounces and hits the plane again at the point C which is between A and B

Find the range of possible values for the coefficient of restitution between the ball and the plane.

[4 marks]

Answer _____

11

Do not write outside the box

9 Two smooth spheres A and B have the same diameter and are on a smooth horizontal surface.

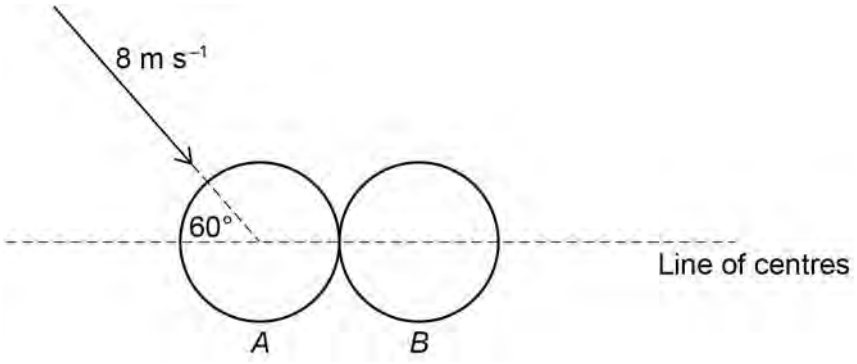
The mass of A is 12 kg and the mass of B is 3 kg

Sphere A is set into motion and hits sphere B which is at rest.

Before the collision the velocity of A is $8\,\text{m}\,\text{s}^{-1}$ at an angle of $60°$ to the line of centres.

The coefficient of restitution between the spheres is e

The diagram shows the velocity of sphere A before the collision.



9 (a) Find, in terms of e, the speed of A after the collision.

[6 marks]

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Answer _____

9 (b) Find the maximum possible change in the speed of A due to the collision.

Give your answer in the form $\frac{p-q\sqrt{21}}{r}$ where p, q and r are positive integers.

[2 marks]

Answer _____

8

END OF QUESTIONS

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