OXFORD

INTERNATIONAL
AQA EXAMINATIONS

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

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}

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.

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

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1 Two particles, *A* and *B*, are moving on a smooth horizontal surface when they collide and coalesce to form a single particle.

The mass of *A* is 2 kg and before the collision it has velocity $\mathbf{v}$ m s^{-1}

The mass of *B* is 3 kg and before the collision it has velocity $\mathbf{w}$ m s^{-1}

During the collision the impulse on *B* is $(-5\mathbf{i} - 4\mathbf{j})$ N s

After the collision the single particle moves with velocity $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1}

1 (a) Find $\mathbf{w}$

[3 marks]

Answer _____

1 (b) Find $\mathbf{v}$

[3 marks]

Answer _____

6

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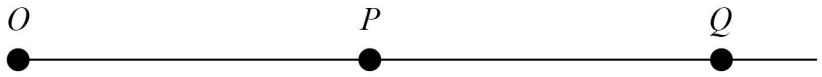
2 A force, F newtons, is the only force that acts on a body of mass 6 kg moving on a straight line.

The points O , P and Q lie on this line, as shown below.

Not to scale



The force acts in the direction OQ

When the displacement of the body is x metres from O , F is given by $F = 5\sqrt{x}$

At P , $x = 4$ and the body is moving towards Q with speed 4 m s^{-1}

At Q , $x = 9$

2 (a) Find the work done by the force on the body as it moves from P to Q

[3 marks]

Answer _____

2 (b) Find the speed of the body at Q giving your answer to three significant figures.

[3 marks]

Answer _____

6

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3 A particle moves with simple harmonic motion on a straight line.

When the particle is 0.2 metres from the equilibrium position, it has a speed of $\sqrt{21}$ m s^{-1}

When the particle is 0.4 metres from the equilibrium position, it has a speed of 3 m s^{-1}

3 (a) Find the amplitude of the motion.

[4 marks]

Answer _____

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3 (b) Find the period of the motion.

[3 marks]

Answer _____

3 (c) Calculate the maximum speed of the particle.

[1 mark]

Answer _____

8

Do not write outside the box

4 A bead, of mass m kg moves on a smooth horizontal wire.

At time t seconds the bead has velocity v m s^{-1}

When $t = 0$, $v = U$

The velocity of the bead is always positive.

A resistance force of magnitude kv^2 newtons acts on the bead as it moves.

4 (a) Show that

$$v = \frac{mU}{m + ktU}$$

[5 marks]

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4 (b) Find, in terms of m , k and U the time that it takes for the velocity of the bead to reduce to 90% of its initial value.

[3 marks]

Answer _____

8

Turn over for the next question

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5 A simple pendulum consists of a light inextensible string and a small sphere.

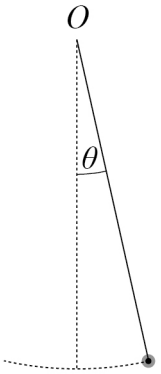
The length of the string is 2.45 metres.

The mass of the sphere is 40 grams.

One end of the string is attached to a fixed point O and the other end of the string is attached to the sphere.

The sphere is released from rest with the string taut and at an angle of $\frac{\pi}{12}$ radians to the vertical.

At time t seconds, the string makes an angle θ radians with the vertical through O as shown in the diagram.



5 (a) Show that, for small values of θ, the motion of the simple pendulum can be modelled as simple harmonic motion.

[4 marks]

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5 (b) Find the period of the motion.

[2 marks]

Answer _____

5 (c) Find the time that it takes for θ to decrease from $\frac{\pi}{24}$ to $\frac{\pi}{36}$

[4 marks]

Answer _____

10

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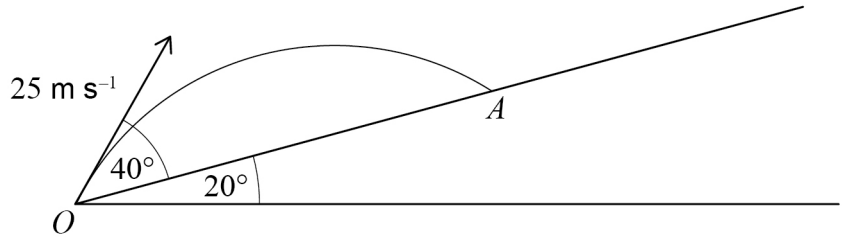
6 A plane is inclined at an angle of $20°$ to the horizontal.

A ball is projected from a point O on the plane and hits the plane again at a point A which is further up the plane.

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

The initial velocity of the ball is 25 m s^{-1} at an angle of $40°$ to the plane, as shown below.



6 (a) Find the maximum distance of the ball from the plane.

[4 marks]

Answer _____

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6 (b) Find the acute angle between the velocity of the ball and the plane when the ball hits the slope at A giving your answer to the nearest degree.

[7 marks]

Answer _____

11

Turn over ►

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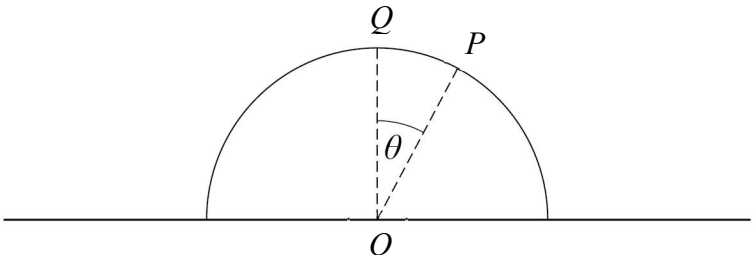
7 A particle P is initially at the highest point Q of a smooth upturned hemisphere of radius r metres and centre O

The plane face of the hemisphere is fixed to a horizontal table.

The particle is set into motion with an initial horizontal velocity of magnitude U m s^{-1}

As the particle moves on the hemisphere, the angle between OQ and OP is θ as shown in the diagram.



7 (a) Given that the particle leaves the hemisphere when $\theta = 30°$, find U in exact form in terms of g and r

[8 marks]

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Answer _____

7 (b) State, with a reason, whether or not your answer to **part (a)** would change if the mass of the particle was decreased.

[2 marks]

7 (c) State, with a reason, whether or not your answer to **part (a)** would change if the radius of the hemisphere was decreased.

[2 marks]

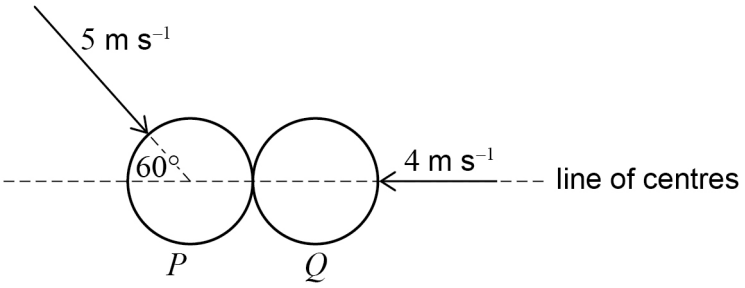
12

8 Two smooth spheres P and Q have the same radius and move on a horizontal surface and collide.

The mass of P is 3 kg and the mass of Q is 2 kg

Before the collision the speed of P is 5 m s^{-1} and the speed of Q is 4 m s^{-1}

The diagram shows the directions of the velocities of the spheres before the collision.



The coefficient of restitution between the spheres is $\frac{2}{5}$

Find the speeds of the spheres after the collision, giving your answer to three significant figures.

[10 marks]

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Speed of P = _____ Speed of Q = _____

10

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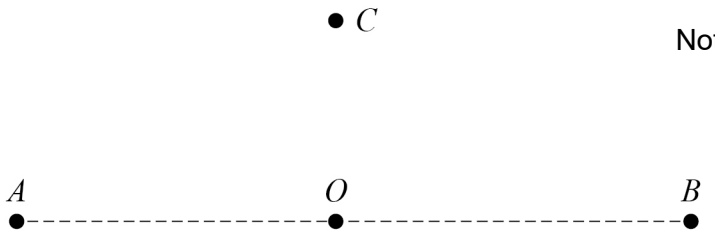
9 The points O , A and B are on a horizontal line with O at the mid-point of AB

The length of AB is 4 metres.

The point C is vertically above O

The diagram shows the positions of the points.



Three identical light elastic strings have natural length 3 metres.

One end of each string is attached to the fixed points A, B and C

The other end of each string is attached to a particle.

The particle is released from rest at the point O and moves downwards.

The particle reaches its maximum speed at a point below O . At this point the strings attached to A and B both make an angle of $30°$ to the vertical and the tensions in each of the **three** strings have the same magnitude.

Verify that subsequently the maximum distance between the point O and the particle is 5.9 metres, correct to two significant figures.

[9 marks]

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9

END OF QUESTIONS

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