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Centre number

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I declare this is my own work.

# INTERNATIONAL A-LEVEL FURTHER MATHEMATICS

(9665/FM05) Unit FM2 Mechanics

Monday 20 January 2025 07:00 GMT 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  $9.8 \text{ m s}^{-2}$

### 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.

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



J A N 2 5 F M 0 5 0 1

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

**1** A particle of mass  $0.5 \text{ kg}$  moves on a straight line on a smooth horizontal surface.

The point  $O$  is on the line.

When the particle is at  $O$  its velocity is  $50 \text{ m s}^{-1}$

When the displacement of the particle from  $O$  is  $x$  metres the velocity of the particle is  $v \text{ m s}^{-1}$

As the particle moves on the line it experiences a resistance force of magnitude  $5v^2$  newtons.

The particle does not experience any other forces in the horizontal direction.

**1 (a)** Find in terms of  $x$  an expression for  $v$

**[5 marks]**

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Answer \_\_\_\_\_

**1 (b)** Find the displacement of the particle from  $O$  when its velocity is  $25 \text{ m s}^{-1}$

Give your answer in an exact form.

**[2 marks]**

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Answer \_\_\_\_\_



- 2** Two particles  $A$  and  $B$  are moving on a smooth horizontal surface when they collide.

Particle  $A$  has mass  $3 \text{ kg}$  and before the collision has velocity  $\begin{bmatrix} 3 \\ 2 \end{bmatrix} \text{ m s}^{-1}$

Particle  $B$  has mass  $5 \text{ kg}$  and before the collision has velocity  $\begin{bmatrix} 1.6 \\ -1 \end{bmatrix} \text{ m s}^{-1}$

After the collision  $B$  has velocity  $\begin{bmatrix} 1 \\ -0.4 \end{bmatrix} \text{ m s}^{-1}$

- 2 (a)** Find the velocity of  $A$  after the collision.

**[3 marks]**

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Answer \_\_\_\_\_

- 2 (b)** Find the magnitude of the impulse exerted on  $B$  by  $A$  during the collision.

Give your answer in an exact form.

**[3 marks]**

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Answer \_\_\_\_\_



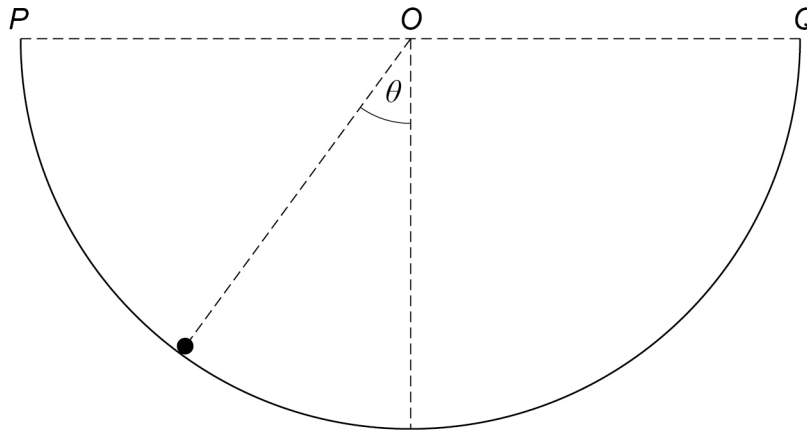
**3**

A smooth semi-circular track with radius  $a$  metres is fixed in a vertical plane.

The points  $P$  and  $Q$  are at opposite ends of a horizontal diameter and  $O$  is the midpoint of this diameter.

A particle of mass  $m$  kg is released from rest at the point  $P$  and slides on the inside of the track.

The radius from  $O$  to the particle is at angle  $\theta$  to the vertical, as shown in the diagram.

**3 (a)**

Show that the magnitude of the normal reaction force  $R$  newtons exerted by the track on the particle is given by

$$R = 3mg\cos\theta$$

**[5 marks]**


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- 3 (b)** On the diagram below, show the positions of the particle at which the normal reaction force has magnitude  $mg$  newtons.

Give any angles you calculate to the nearest degree.

**[2 marks]**

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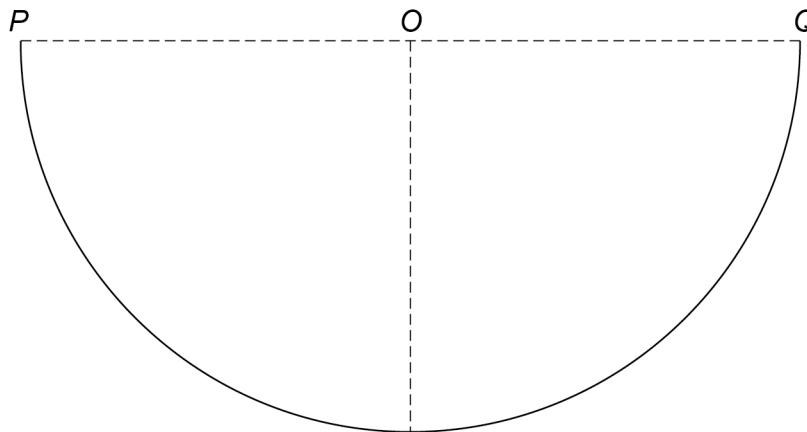
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**Turn over for the next question**

      
7

**Turn over ►**



Answer

Give your answer in terms of  $\pi$  in an exact form.

[illegible]

Give your answer to three significant figures.

[illegible]

12

The particle does not experience any other forces in the horizontal direction.

**[4 marks]**

[illegible]

Maximum value





- 5 (b)** Find the range of values of the speed of the particle as it moves on the line.

Give your answer in an exact form.

**[3 marks]**

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Answer \_\_\_\_\_

      
7

**Turn over for the next question**

**Turn over ►**



The elastic string is stretched and the sphere released from rest at the point  $Q$ , which is 3 metres vertically below  $P$

**[5 marks]**

[illegible]

Answer

**[2 marks]**

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**[2 marks]**

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**6 (c)** A student carries out an experiment to test the answer obtained in **part (b)(ii)**

Find the magnitude of this constant air resistance force.

**[3 marks]**

[illegible]

Answer

12

**Turn over ►**



The sphere is released from rest with the string taut and at a small angle to the vertical.

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Find the greatest distance that the sphere can move in an interval of time equal to one quarter of the period.

Give your answer to three significant figures.

**[3 marks]**

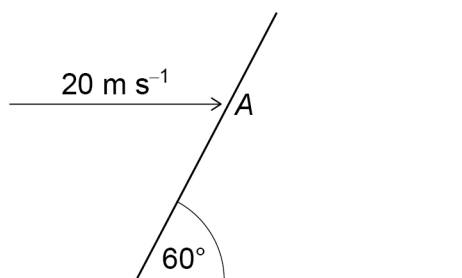
[illegible]

Answer

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- 8** A smooth plane is inclined at an angle of  $60^\circ$  to the horizontal.

Two different balls are fired at different times so that they are travelling horizontally at  $20 \text{ m s}^{-1}$  when they hit the plane at the point  $A$ , as shown in the diagram.



The velocities of the balls are in a plane that contains the line of greatest slope of the inclined plane.

- 8 (a)** The coefficient of restitution between the first ball and the plane is  $e_1$

It is given that the first ball moves vertically after it leaves the plane at  $A$ .

Find the value of  $e_1$

Give your answer in an exact form.

**[4 marks]**

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Answer \_\_\_\_\_



The second ball leaves the inclined plane at  $A$  and returns to the plane for the first time at the point  $B$

The distance between  $A$  and  $B$  is 2 metres.

Give your answers to two decimal places.

**[6 marks]**

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Answer

10







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Answer \_\_\_\_\_

- 9 (b)** On the diagram below show the range of possible directions of motion of *A* after the collision.

Give any angles you calculate to the nearest degree.

**[4 marks]**

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Line of centres

12

**END OF QUESTIONS**



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ANSWER IN THE SPACES PROVIDED**





