OXFORDAQA

INTERNATIONAL QUALIFICATIONS

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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 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 Exam	iner's Use	
Question	Mark	
1		
2		
3		
4		
5		
6		
7		
8		
9		
TOTAL		



		Answer all questions in the spaces provided.		Do not v outside box
1		A particle of mass 0.5 kg moves on a straight line on a smooth horizontal surf	face.	
		The point O is on the line.		
		When the particle is at O its velocity is 50 m s ⁻¹		
		When the displacement of the particle from <i>O</i> 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]	
	-			
	-			
	-			
		Answer		
1	(b)	Answer Find the displacement of the particle from <i>O</i> when its velocity is 25 m s ⁻¹		
1				
1		Find the displacement of the particle from O when its velocity is 25 m s ⁻¹	[2 marks]	
1		Find the displacement of the particle from O when its velocity is 25 m s ⁻¹	[2 marks]	
1		Find the displacement of the particle from O when its velocity is 25 m s ^{-1} Give your answer in an exact form.	[2 marks]	
1		Find the displacement of the particle from O when its velocity is 25 m s ^{-1} Give your answer in an exact form.	[2 marks]	



2		Two particles A and B are moving on a smooth horizontal surface when they collide.	Do not write outside the box
		Particle <i>A</i> has mass 3 kg and before the collision has velocity $\begin{bmatrix} 3 \\ 2 \end{bmatrix}$ m s ⁻¹	
		Particle <i>B</i> has mass 5 kg and before the collision has velocity $\begin{bmatrix} 1.6 \\ -1 \end{bmatrix}$ m s ⁻¹	
		After the collision <i>B</i> has velocity $\begin{bmatrix} 1 \\ -0.4 \end{bmatrix}$ m s ⁻¹	
2	(a)	Find the velocity of <i>A</i> after the collision. [3 mark	s]
			_
			_
			_
			_
		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 mark	s]
			_
			_
			_
		Answer	6



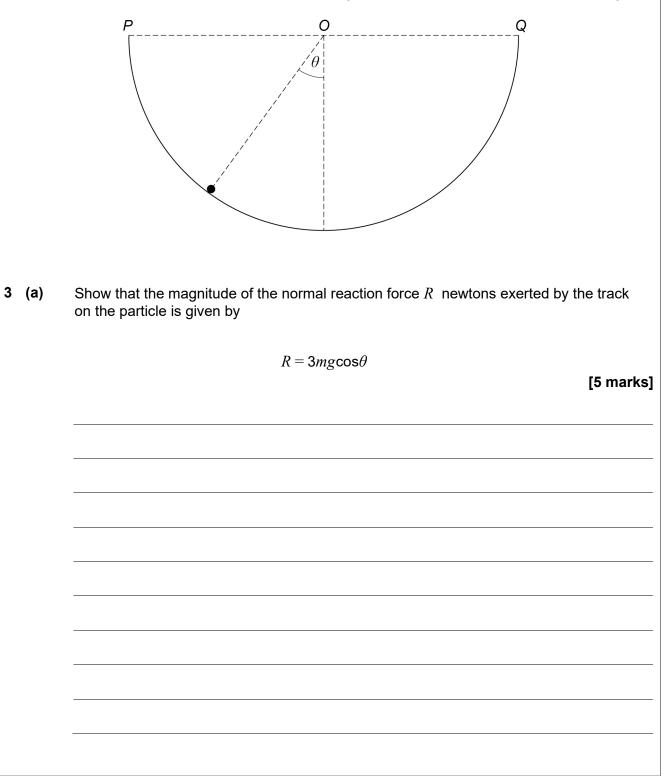
Turn over ►

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

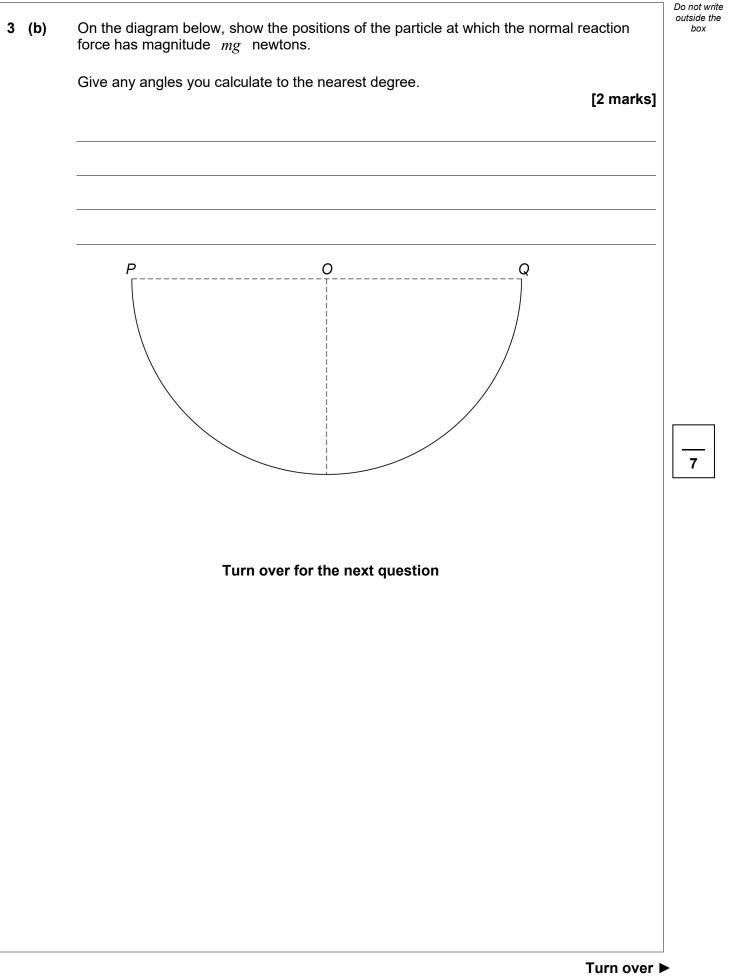
The points P and Q are at opposite ends of a horizontal diameter and O is the midpoint of this diameter.

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 θ to the vertical, as shown in the diagram.









		Do ou
4	A particle moves with simple harmonic motion on a straight line.	
	The particle has its maximum speed at the point O	
	The points <i>A</i> and <i>B</i> lie on the line.	
	At A the displacement of the particle from O is -4 metres and its speed is 3 m s ⁻¹	
	At <i>B</i> the displacement of the particle from <i>O</i> is 2 metres and its speed is 5 m s ^{-1}	
4 (a)	Find the amplitude of the motion.	
	Give your answer in an exact form. [5 marks]	
	Answer	



4 (b)	Find the period of the motion.		Do not write outside the box
	Give your answer in terms of π in an exact form.	[3 marks]	
	Answer		
4 (c)	Find the shortest time that it takes for the particle to move from A to B		
	Give your answer to three significant figures.	[4 marks]	
	Answer		12



A particle of mass 0.25 kg moves on a smooth straight horizontal line of infinite length.
The particle is initially at rest at the point O which lies on the line.
A force acts on the particle and is directed along the line.

A force acts on the particle and is directed along the line.	

When the displacement of the particle from O is x metres, the magnitude of the force is $2e^{-\frac{x}{10}}$ newtons.

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

Show that the work done by the force approaches a maximum value and state this 5 (a) maximum value.

Show the limiting process used.

5

[4 marks]

Do not write outside the

box

Maximum value



5	(b)	Find the range of values of the speed of the particle as it moves on the line.		Do not write outside the box
		Give your answer in an exact form.	[3 marks]	
		Answer		7
		Turn over for the next question		
			Turn over Þ	•



6		A light elastic string has natural length 0.5 metres and modulus of elasticity 14 newtons.
		One end of the elastic string is attached to a fixed point P
		The other end of the elastic string is attached to a sphere of mass 3.2 kg
		The elastic string is stretched and the sphere released from rest at the point Q , which is 3 metres vertically below P
6 (á	a)	Use an energy method to find the maximum speed of the sphere during the motion. [5 marks]
		Answer
6 (I	b) (i)	Show that the elastic string becomes slack during the motion. [2 marks]
		······



6	(b) (ii)	Find the minimum distance between the sphere and the point <i>P</i> [2 marks]	Do not wr outside th box
		Answer	
6	(c)	A student carries out an experiment to test the answer obtained in part (b)(ii)	
		From their experiment they find that the minimum distance of the sphere from P is 0.41 metres.	
		The student claims that the result from the experiment is different to the calculated answer because of air resistance.	
		The student assumes that the magnitude of the air resistance force acting on the sphere is constant as it is rising.	
		Find the magnitude of this constant air resistance force. [3 marks]	
		Answer	12



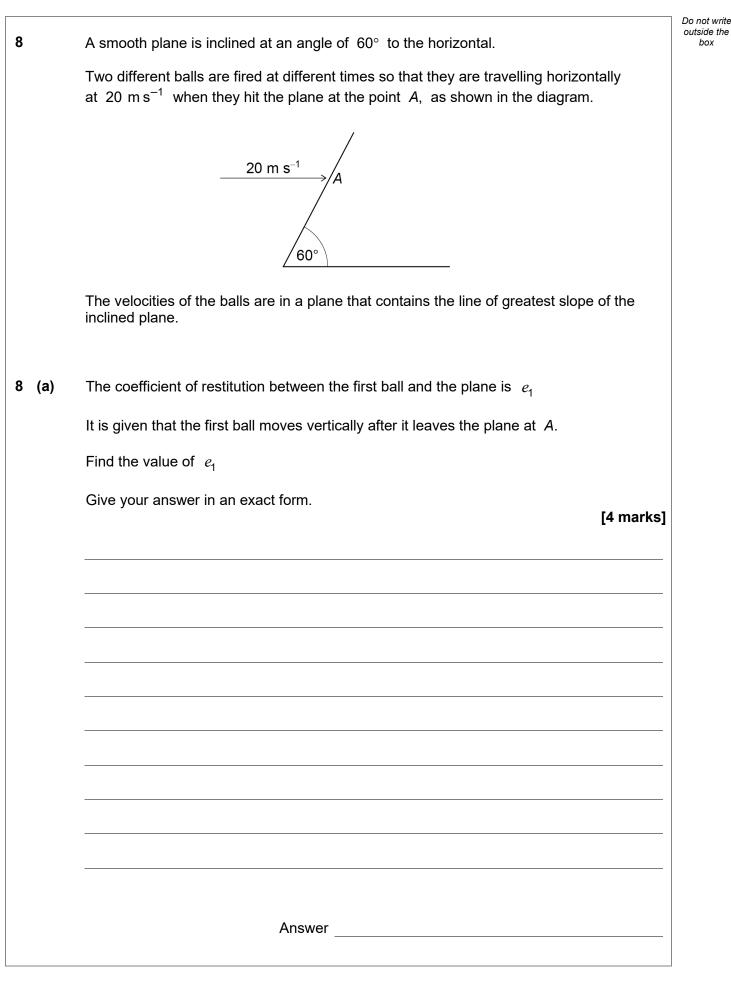
7	A simple pendulum consists of a light inextensible string of length d metres and a small sphere.
	The sphere is released from rest with the string taut and at a small angle to the vertical.
7 (a)	Show that the motion of the simple pendulum approximates to simple harmonic motion. [4 marks]



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7 (b)	In the case when $d = 0.8$ the sphere is released from rest with the string t	aut and at an
	angle of $\frac{\pi}{10}$ radians to the vertical.	
	Find the greatest distance that the sphere can move in an interval of time e quarter of the period.	qual to one
	Give your answer to three significant figures.	[2 marka]
		[3 marks]
	Answer	

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		Do not
8 (b)	The coefficient of restitution between the second ball and the plane is e_2	outsic
	The second ball leaves the inclined plane at A and returns to the plane for the first time at the point B	
	The point B is on the inclined plane further up than A	
	The distance between <i>A</i> and <i>B</i> is 2 metres.	
	Find the possible values of e_2	
	Give your answers to two decimal places. [6 marks]	
	Answer	10



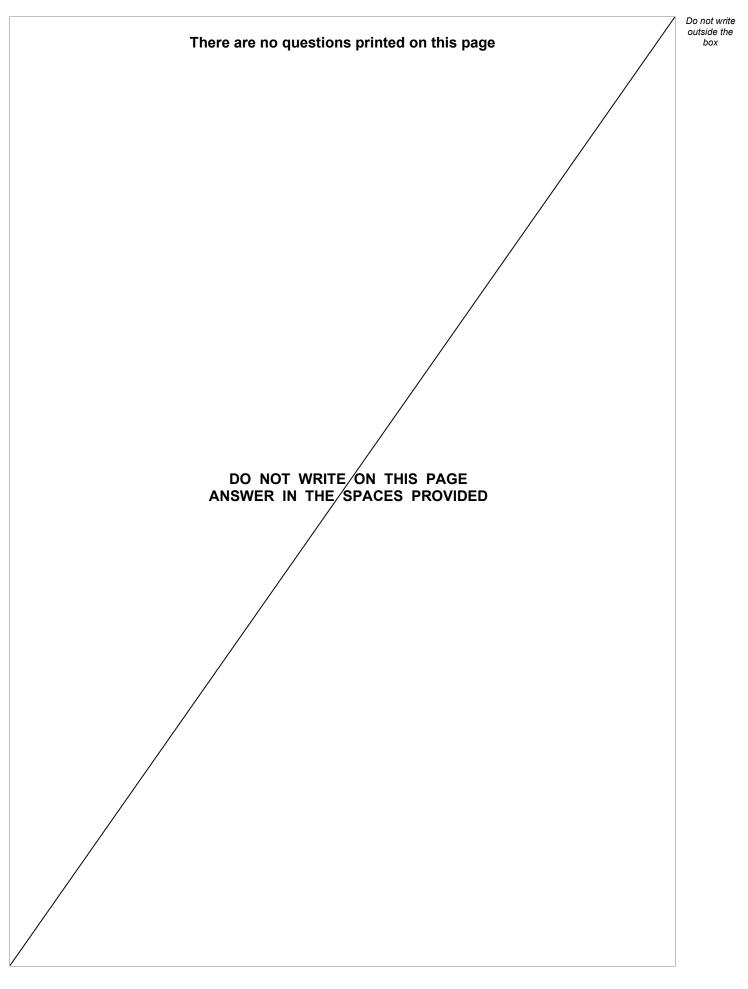
Do not write outside the 9 Two smooth spheres A and B of equal radii are moving on a horizontal surface when they collide. The mass of A is 3 kg and the mass of B is 2 kg Before the collision: • A has a velocity of 7 m s⁻¹ at an angle of 30° to the line of centres • *B* has a velocity of 6 m s⁻¹ at an angle of 45° to the line of centres The velocities are shown in the diagram below. 7 m s⁻¹ 6 m s⁻¹ 30° 45° Line of centres The coefficient of restitution between the two spheres is eIt is given that $e \ge \frac{2}{3}$ 9 (a) Find the range of possible speeds of *A* after the collision. Give your answers to two decimal places. [8 marks]



box

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9 (b)	On the diagram below show the range of possible directions of motion of <i>A</i> after the collision. Give any angles you calculate to the nearest degree. [4 marks]	
	Line of centres	12







Question number	Additional page, if required. Write the question numbers in the left-hand margin.	



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Question number	Additional page, if required. Write the question numbers in the left-hand margin.	
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