

## INTERNATIONAL QUALIFICATIONS

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# INTERNATIONAL A-LEVEL FURTHER MATHEMATICS

(9665/FM05) Unit FM2 Mechanics

Thursday 13 June 2024 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<sup>-2</sup>

# 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		
TOTAL		



		Answer <b>all</b> questions in the spaces provided.	
1		A ball of mass 0.3 kg falls vertically from rest.	
		It hits a horizontal surface and rebounds to a height of 0.4 metres above the s	urface.
1	(a)	Calculate the speed at which the ball leaves the horizontal surface.	[2 marks]
		Answer	
1	(b)	The impulse exerted on the ball by the surface has magnitude 3.24 N s	
		Find the coefficient of restitution between the ball and the surface.	[4 marks]
		Answer	



2	A light elastic string has modulus of elasticity 300 newtons and natural leng	th 2 metres.
	One end of the string is attached to a fixed point.	
	The other end of the string is attached to a particle of mass 6 kg	
	The particle is released from rest 2.5 metres vertically below the fixed point	
2 (a)	Find the magnitude and direction of the initial acceleration of the particle.	[3 marks]
	Magnitude	
	Direction	
2 (b)	Direction  Use an energy method to find the maximum speed of the particle in the subs motion.	
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3		A particle of mass 2 kg is initially at rest at the point O on a rough horizontal surface.		
		A horizontal force of magnitude $F$ newtons and constant direction starts to act particle.	on the	
		When the displacement of the particle from $\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$		
		$F = 10e^{-0.1x}$		
		The particle passes through the point A which is 5 metres from O		
3	(a)	Find the work done by the force $F$ as the particle moves from $$ O to the point $$ I	4 [ <b>3 marks]</b>	
		Answer		
3	(b)	The coefficient of friction between the particle and the surface is 0.2		
3	(b) (i)	Find the speed of the particle at A	[3 marks]	
		Answer		



3	(b) (ii)	ii) The particle comes to rest when the displacement from $O$ is $d$ metres.		
		Use a change of sign numerical method to verify that $d = 23$ correct to the nearest integer.		
			[4 marks]	

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Turn over for the next question



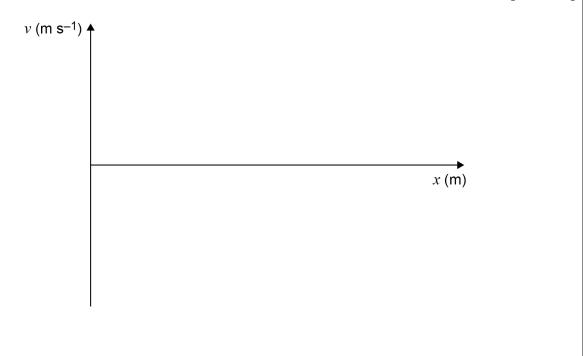


4		A particle of mass 2 kg moves on a straight horizontal line.	
		As the particle moves it experiences a resistance force of magnitude $(v^2 - 9)$ where $v$ m s <sup>-1</sup> is the velocity of the particle.	newtons,
		At the point O the particle has a velocity of 10 m s <sup>-1</sup>	
4	(a)	Find the velocity of the particle when its displacement from $\ensuremath{\mathcal{O}}$ is $x$ metres.	
		Give your answer in the form $v = \sqrt{a + be^{-x}}$ where $a$ and $b$ are integers.	[6 marks]
		Answer	



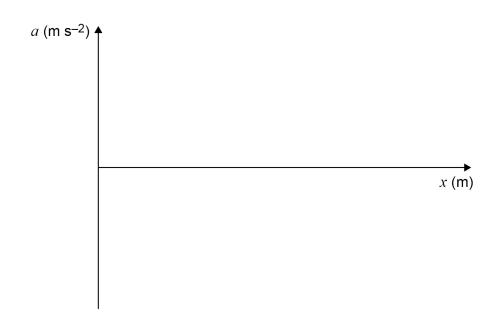
**4 (b)** On the axes below sketch a graph to show how the velocity of the particle varies with its displacement from *O* 

[2 marks]



**4 (c)** On the axes below sketch a graph to show how the acceleration of the particle varies with its displacement from *O* 

[3 marks]



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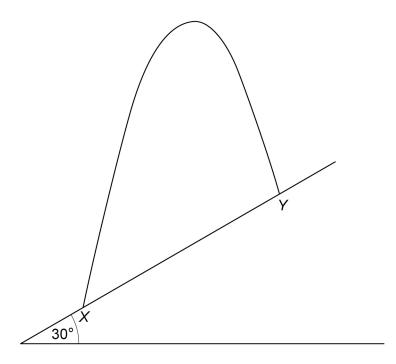
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**5** A plane is inclined at an angle of 30° to the horizontal.

A ball is projected up the plane from a point X on the plane.

The ball hits the plane for the first time at a point Y as shown in the diagram.



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

Give your values to the nearest integer.

The distance between the points X and Y is 4 metres.

The initial velocity of the ball is 10 m s<sup>-1</sup> at an angle  $\,\alpha^{\circ}\,$  above the plane, where  $\,\alpha$  < 60

By using the components of the ball's motion parallel and perpendicular to the plane, find the possible values of  $\ \alpha$ 

[8 marks]	•	·
		-



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8

6		I wo spheres A and B are moving on a smooth norizontal surface.	
		The two spheres collide.	
		Sphere A has mass 2 kg and velocity $\begin{bmatrix} 4 \\ 3 \end{bmatrix}$ m s <sup>-1</sup> before the collision.	
		Sphere <i>B</i> has mass 3 kg and velocity $\begin{bmatrix} -1 \\ 5 \end{bmatrix}$ m s <sup>-1</sup> before the collision.	
		After the collision sphere $A$ has velocity $\begin{bmatrix} 0.4 \\ 3 \end{bmatrix}$ m s <sup>-1</sup>	
6	(a)	Find the magnitude of the impulse exerted on <i>A</i> during the collision.	[3 marks]
		Answer	
6	(b)	Find the velocity of sphere <i>B</i> after the collision.	[3 marks]

		l I	
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		Answer	
6	(c)	Explain why the vector $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ is parallel to the line of centres during the collision. [2 marks]	
6	(d)	Find the coefficient of restitution between the two spheres.  [2 marks]	

Answer

Turn over ▶

10



Two springs are attached to a sphere of mass *m* kg which rests on a smooth horizontal surface.

The other end of one spring is attached to the fixed point *A* and the other end of the second string is attached to a fixed point *B*The points *A* and *B* are a distance 3*a* metres apart.

Both springs have natural length *a* metres.

The spring attached to *A* has stiffness *k* N m<sup>-1</sup> and the spring attached to *B* has stiffness 2*k* N m<sup>-1</sup>

The diagram shows the springs and the sphere.

A B

Show that the extension of the spring attached to *A* is  $\frac{2a}{3}$  metres when the system is in equilibrium.

[3 marks]

1	[3 marks]



7	(b)	The sphere is pulled a distance of $\frac{a}{10}$ metres from the equilibrium position to and released from rest.	wards <i>B</i>
7	(b) (i)	Show that the sphere moves with simple harmonic motion.	[5 marks]
7	(b) (ii)	The period of the motion is $\pi$ seconds.	
		Express $k$ in terms of $m$	[2 marks]
		Answer	
		Question 7 continues on the next page	





7	(b) (iii)	The point $C$ is $\frac{a}{20}$ metres from the equilibrium position.
		Hence, find the speed of the sphere at <i>C</i>
		Give your answer in an exact form in terms of $\it a$ [3 marks]
		Answer



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A smooth hemisphere with centre O has its base fixed to a horizontal surface.
A particle is released from rest at a point <i>A</i> on the curved surface of the hemisphere.
The particle passes through the point $B$ and leaves the hemisphere at the point $C$
At $\it B$ the angle between the radius $\it OB$ and the vertical is $\it  heta^\circ$
At $B$ the magnitude of the normal reaction force exerted on the particle is half of the maximum experienced by the particle as it moves from $A$ to $C$
At C the angle between the radius OC and the horizontal is 30°
The diagram shows the hemisphere and the points $A$ , $B$ and $C$
Find $\cos  heta^\circ$
Give your answer as a fraction.  [10 marks]



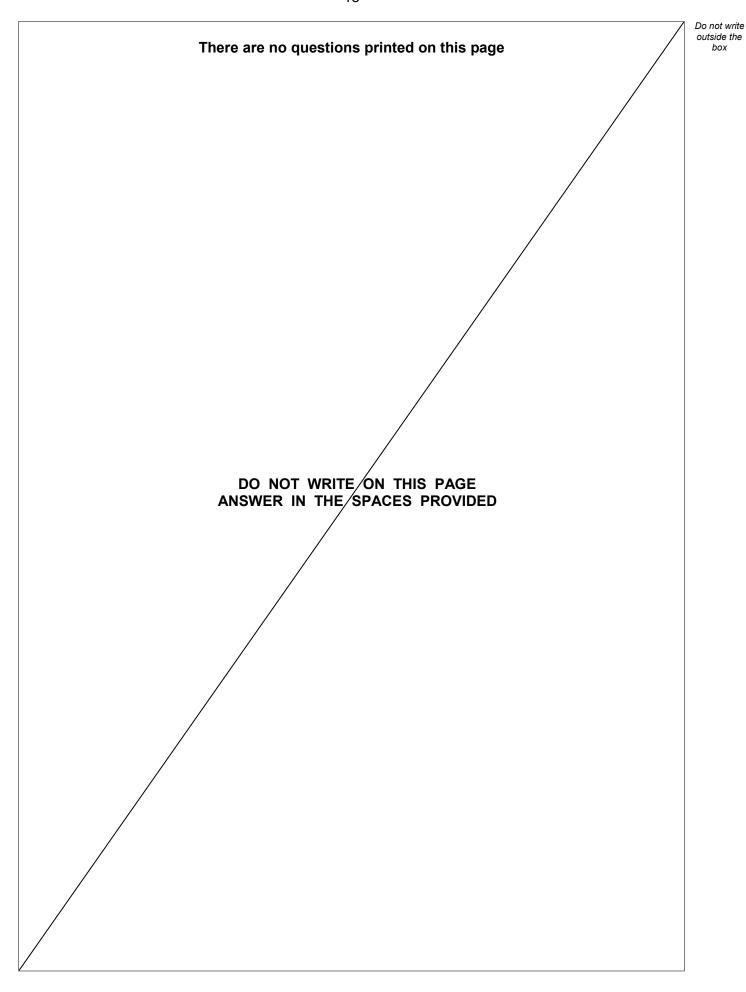


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