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# INTERNATIONAL A-LEVEL FURTHER MATHEMATICS

(9665/FM05) Unit FM2 Mechanics

Wednesday 18 January 2023 07:00 GMT 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 graphical calculator.

## Instructions

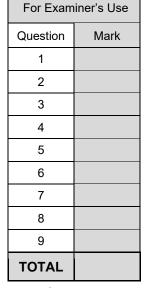
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer all questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for 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.





**FM05** 

1	A particle moves on a	straight horizontal line.
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At time  $\,t\,$  seconds the velocity of the particle is  $\,v\,$  m  $\,{\rm s}^{-1}$ 

The particle moves so that

$$\frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{v}{2}$$

When t = 0 it is given that v = 10

Find $v$ in terms of $t$	[4 marks]

-		

v =

4

A ball of mass 0.3 kg moves with velocity $\left(3\mathbf{i}+9\mathbf{j}\right)$ m s <sup>-1</sup>		
The ball is then hit by a bat and the ball's velocity becomes $\left(-2i-5j\right)$ m s <sup>-1</sup>		
Calculate the magnitude of the impulse exerted on the ball by the bat, giving your answer to three significant figures.		
[4 marks]		
Answer		

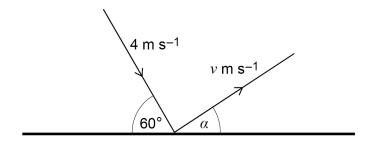


3 A disc is sliding on a smooth horizontal surface when it hits a smooth fixe	ed vertical wall.
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When the disc hits the wall, it has a speed of 4 m  $\rm s^{-1}$  and is moving at an angle of 60° to the wall.

When the disc leaves the wall, it has a speed of v m s<sup>-1</sup> and is moving at an angle of  $\alpha$  degrees to the wall.

The motion of the disc is shown in the diagram below.



The coefficient of restitution between the disc and the wall is e

3	(a)	Find $v$ in terms of $e$	[4 marks]
			v =



	<b>o</b>	
3 (b)	Determine the range of possible values of $v$ [2 marks]	Do not write outside the box
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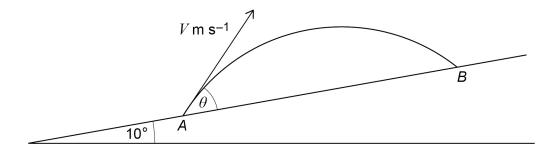


**4** A plane is inclined at an angle of 10° to the horizontal.

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 V m s<sup>-1</sup> at an angle  $\theta$  above the plane, as shown in the diagram below.



The time taken for the ball to move from A to B is 1.5 seconds.

The distance between the points A and B is 15 metres.



	Answer	
4 (b)	Calculate the value of $\ V$ giving your answer to <b>two</b> significant figures.	
	[2 marks]	
		١.
	$V = \underline{\hspace{1cm}}$	



5		A body moves with simple harmonic motion on a straight line between two points $A$ and $B$	
		The period of the motion is $5\pi$ seconds.	
		The point $C$ is 0.5 metres from $A$ , between $A$ and $B$	
		At $C$ the body has velocity 0.8 m s <sup>-1</sup> towards $A$	
5	(a)	Show that $AB = 8.5$ metres.	marks]



10

arks]
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6		An elastic string has natural length 0.8 metres and modulus of elasticity 2.8 newtons.	
		One end of the string is attached to a fixed point O and the other end is attached small sphere of mass 0.2 kg	ed to a
		The sphere is released from rest at O and falls vertically.	
6	(a)	Find the maximum length of the string in the subsequent motion.	4 marks]
		Answer	
6	(b)	Find the maximum tension in the string.	3 marks]



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	Answer	
6 (c)	Find the maximum speed of the sphere.	76
		[5 marks]
		_
	Answer	



7		A particle of mass $m$ kg is on a smooth horizontal surface.
		Two springs are attached to the particle, with the other ends of the springs attached to fixed points $A$ and $B$ , as shown in the diagram.
		$A \longrightarrow B$
		The spring attached to $A$ has stiffness $4k$ N m <sup>-1</sup> and natural length $2d$ metres.
		The spring attached to $B$ has stiffness $3k$ N $\mathrm{m}^{-1}$ and natural length $3d$ metres.
		The distance between $A$ and $B$ is $7d$ metres.
7	(a)	Find in terms of $d$ the distance of the particle from $A$ when it is in equilibrium. [3 marks]
		Answer



7	(b)	The particle is moved a distance $\frac{d}{2}$ metres towards $B$ from its equilibrium position and released from rest.
		In the subsequent motion the displacement of the particle to the right of its equilibrium position is $x$ metres at time $t$ seconds.
7	(b) (i)	Find in terms of $d$ , $k$ and $x$ the tension in the spring attached to $B$ [2 marks]
		Answer
7	(b) (ii)	Show that the motion of the particle is simple harmonic.  [5 marks]
		Question 7 continues on the next page



7	(b) (iii)	Find in terms of $k$ , $m$ and $\pi$ the period of the motion.	[2 marks]
		Answer	
7	(b) (iv)	Determine the maximum speed of the particle in terms of $d,k$ and $m$	[2 marks]
		Answer	



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**8** A block of mass 1.5 kg is placed on a rough horizontal surface.

The coefficient of friction between the block and the surface is 0.3

A light inextensible string is attached to the block and passes over a smooth peg.

The smooth peg is positioned on the edge of the horizontal surface.

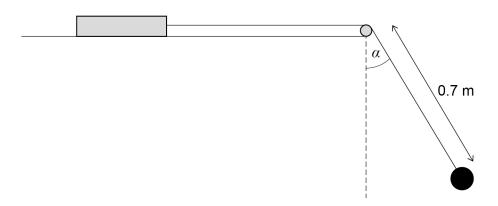
The string between the block and the peg is horizontal.

The other end of the string is attached to a particle of mass 0.4 kg

The particle is released from rest with the string at an angle  $\alpha$  degrees to the downward vertical.

The initial path of the particle is part of a vertical circle of radius 0.7 metres.

The diagram below shows the initial situation.



R	(a)	In a first case	$\alpha - 30$
O	lai	in a iiisi case	$\alpha = .50$

sliding for the first time, giving your answer to the nearest degree.	[7 marks]

Find the angle between the string and the vertical when the block is on the point of



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8 (b)	In a second case the block does not move.
	Find the maximum possible value of $\alpha$ giving your answer to the nearest degree.
	I find the maximum possible value of $\alpha$ giving your answer to the hearest degree.
	[5 marks]

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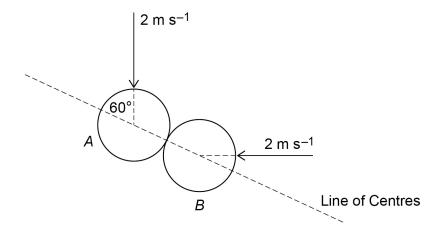
**9** Two smooth spheres, A and B, have the same radius of 1 cm and are moving on a horizontal surface when they collide.

The velocities of the spheres are perpendicular when they collide.

Before the collision, the speeds of both A and B are 2 m s<sup>-1</sup>

On impact, the velocity of A makes an angle of  $60^{\circ}$  to the line of centres.

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



The mass of A is 4 kg and the mass of B is 5 kg.

The coefficient of restitution between the spheres is  $\frac{3}{4}$ 

Find the distance between the centres of the spheres 2 seconds after the collision, giving your answer to three significant figures.

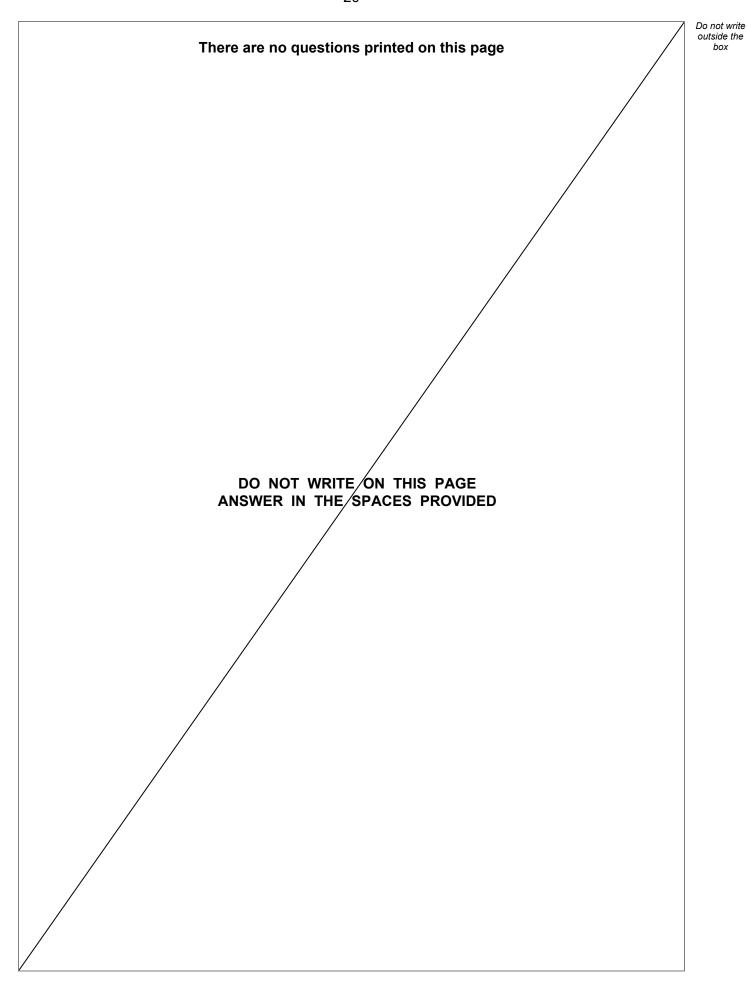
[11 marks]

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