

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL A-LEVEL FURTHER MATHEMATICS

(9665/FM05) Unit FM2 Mechanics

Friday 24 January 2020 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 graphics 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 Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	



J A N 2 0 F M 0 5 0 1

IB/G/Jan20/E9

FM05

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ANSWER IN THE SPACES PROVIDED**



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

- 1** A spring has stiffness 14.7 N m^{-1} and natural length 20 cm
One end of the spring is attached to a fixed point O.
A particle of mass 0.6 kg is attached to the other end of the spring.
Find the length of the spring when the particle is in equilibrium directly below O. **[3 marks]**

Answer _____

3

Turn over for the next question

Turn over ►



- 2** A particle moves with simple harmonic motion between two end points, A and B , that are 3 metres apart.

The particle takes 2 seconds to move directly from A to B .

- 2 (a)** Find the maximum speed of the particle.

[3 marks]

Answer _____

- 2 (b)** Find the speed of the particle when it is at the point C , which is 1 metre from A .

[3 marks]

Answer _____



2 (c) Find the time taken for the particle to move directly from *A* to *C*.

[3 marks]

Answer _____

9

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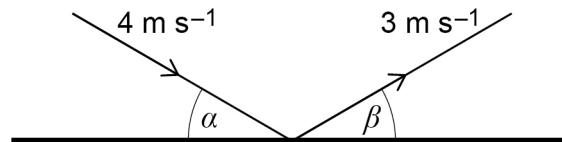
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3 A disc, of mass 0.2 kg, moving on a smooth horizontal surface hits a smooth vertical wall.

When it hits the wall, the disc is moving at 4 m s^{-1} at an angle α to the wall.

The disc rebounds with a speed of 3 m s^{-1} at an angle β to the wall.



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

3 (a) Show that

$$\tan \alpha = \frac{\tan \beta}{e}$$

[4 marks]

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are approximately 20 lines visible. The paper has a slight shadow on the right side, suggesting it's resting on a surface.

3 (b) It is given that $\alpha = 2\beta$, where $0^\circ < \beta < 45^\circ$

3 (b) (i) Find $\tan \beta$ in terms of e .

[3 marks]

Answer _____

3 (b) (ii) Find the set of possible values of e .

[1 mark]

Answer _____



The particle comes to rest at point B .

[6 marks]

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[6 marks]

[illegible]

12

Answer _____

- 5 (b)** Find the extension of the string when the speed of the sphere is a maximum.

[3 marks]

Answer _____

Question 5 continues on the next page

Turn over ►



[5 marks]

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[2 marks]

Answer

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The particle is then subject to a horizontal impulse so that it starts to move with speed $u \text{ m s}^{-1}$

Show that the minimum value of u is 6.3 , correct to two significant figures.

[4 marks]

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Find u .

[illegible]

10

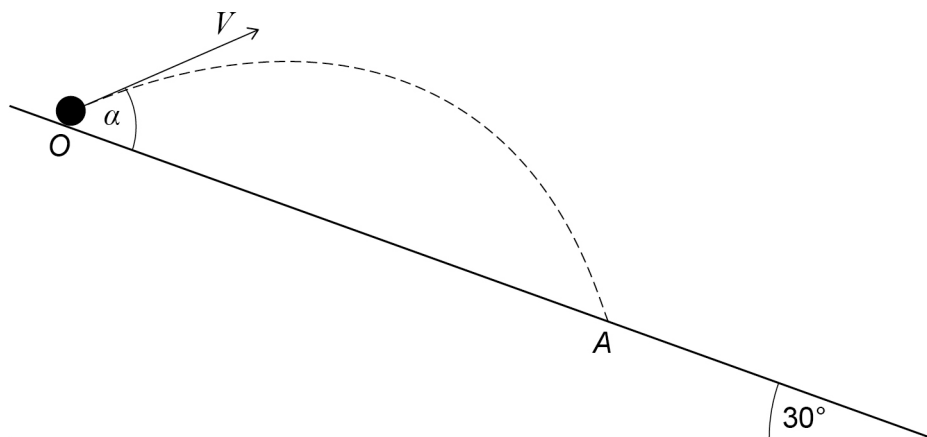
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7

A ball is projected from the point O on the plane and hits the plane again at the point A , which is further down the plane than O . OA is a line of greatest slope of the plane.

The initial velocity of the ball is $V \text{ m s}^{-1}$ at an angle α above the plane.



7

$$\frac{2V^2}{g \cos^2 30^\circ} \sin \alpha \cos(\alpha - 30^\circ)$$

[7 marks]

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7 (b) Find the value of α for which the distance OA is a maximum.

[3 marks]

Answer _____

10

Turn over ►



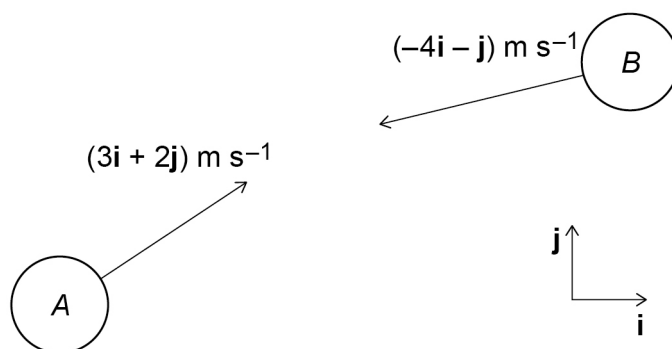
- 8** Two smooth spheres, A and B , are moving on a smooth horizontal surface when they collide.

The two spheres have the same radius.

The mass of A is 2 kg and the mass of B is 4 kg

Before the collision the velocity of A is $(3\mathbf{i} + 2\mathbf{j})\text{ m s}^{-1}$

Before the collision the velocity of B is $(-4\mathbf{i} - \mathbf{j})\text{ m s}^{-1}$



After the collision the velocity of A is $(-1.5\mathbf{i} - \mathbf{j})\text{ m s}^{-1}$

- 8 (a)** Find the velocity of B after the collision.

[3 marks]

Answer _____



[3 marks]

Answer _____

[7 marks]

[illegible]

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Answer _____

13

END OF QUESTIONS



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