OXFORD

INTERNATIONAL AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

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INTERNATIONAL A-LEVEL
FURTHER MATHEMATICS

(9665/FM05) Unit FM2 − Mechanics

Thursday 27 June 2019 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.
- 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}

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

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.

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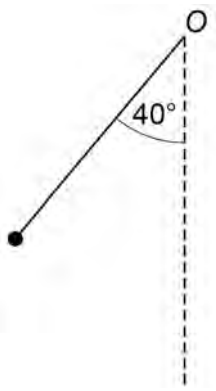
Answer **all** questions in the spaces provided.

1 A particle, of mass 0.1 kg, is attached to one end of a light inextensible string of length 0.8 metres.

The other end of the string is attached to a fixed point *O*.

The particle is released from rest with the string taut and at an angle of 40° to the vertical through *O*.



Assume that there are no resistance forces acting on the particle.

1 (a) Find the speed of the particle when it is directly below *O*.

[3 marks]

Answer _____ m s^{-1}

Do not write outside the box

1 (b) Find the tension in the string when the particle is directly below *O*.

[3 marks]

Answer _____ N

6

Turn over for the next question

Do not write outside the box

2 A bungee jumper, of mass 75 kg, is attached to one end of an elastic rope of natural length 20 metres.

The other end of the elastic rope is fixed to a bridge.

The bungee jumper steps off the bridge at the point where the rope is fixed and falls vertically downwards.

During the bungee jump the maximum length of the elastic rope is 50 metres.

2 (a) Find the modulus of elasticity of the elastic rope.

[3 marks]

Answer _____ N

Do not write outside the box

2 (b) Find the maximum speed of the bungee jumper during the motion.

[7 marks]

Answer _____ m s^{-1}

2 (c) State **two** key assumptions that you made to obtain the answers in parts **(a)** and **(b)**.

[1 mark]

11

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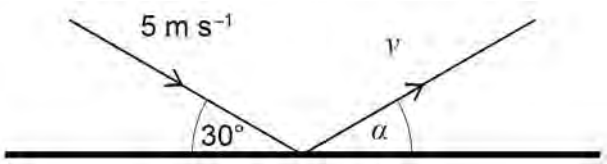
3 A disc, of mass 0.5 kg, is moving on a smooth horizontal surface, when it hits a smooth wall.

When it hits the wall, the disc is moving at 5 m s^{-1} and its velocity makes an angle of 30° with the wall.

The coefficient of restitution between the disc and the wall is 0.4

The disc rebounds with a speed of v m s^{-1} at an angle α to the wall, as shown in the diagram.



3 (a) Find the value of α.

[7 marks]

Answer _____

Do not write outside the box

3 (b) Find the value of v.

[3 marks]

Answer _____

3 (c) Find the magnitude of the impulse on the disc.

[3 marks]

Answer _____ N s

13

Turn over for the next question

4 A particle, of mass m, moves on a horizontal line subject to a resistance force of magnitude kv, where k is a constant and v is the speed of the particle at time t.

When $t = 0$, the particle is at the origin and has speed U.

4 (a) Show that

$$m\frac{\mathrm{d}v}{\mathrm{d}x} = -k$$

where x is the displacement of the particle at time t.

[2 marks]

4 (b) Show that the particle travels no further than $\frac{mU}{k}$ from the origin.

[4 marks]

Do not write outside the box

4 (c) Find, in terms of k and m, the time taken for the speed of the particle to decrease to $\frac{U}{2}$

[7 marks]

Answer _____

Turn over for the next question

13

Do not write outside the box

5 **In this question, give your final answer to each part to three significant figures.**

A sphere, of mass 0.5 kg, is attached to one end of a spring, of natural length 50 cm.

The other end of the spring is attached to a fixed point, *O*.

The sphere is pulled down and released from rest at a point directly below *O*.

The sphere performs simple harmonic motion moving between two points *A* and *B*, which are 10 cm apart, with *A* above *B*.

During this motion, the maximum speed of the sphere is 1.5 m s^{-1}

5 (a) Find the period of the motion.

[3 marks]

Answer _____ seconds

5 (b) Find the stiffness of the spring.

[3 marks]

Answer _____ N m^{-1}

Do not write outside the box

5 (c) Find the maximum length of the spring during the motion.

[4 marks]

Answer _____ m

5 (d) Find the speed of the sphere when the spring is at its natural length.

[3 marks]

Answer _____ m s^{-1}

13

6 A ball is thrown from a point O on a plane which is inclined at an angle of 30° to the horizontal.

The ball is thrown up the plane with velocity U m s^{-1} at an angle θ to the inclined plane.

The ball travels in a vertical plane containing a line of greatest slope of the inclined plane.

The velocity of the ball is perpendicular to the plane when it first hits the plane.

6 (a) Show that

$$\tan\theta = \frac{\sqrt{3}}{2}$$

[7 marks]

Do not write outside the box

6 (b) Find, in terms of U, the speed at which the ball first hits the plane.

[4 marks]

Answer _____

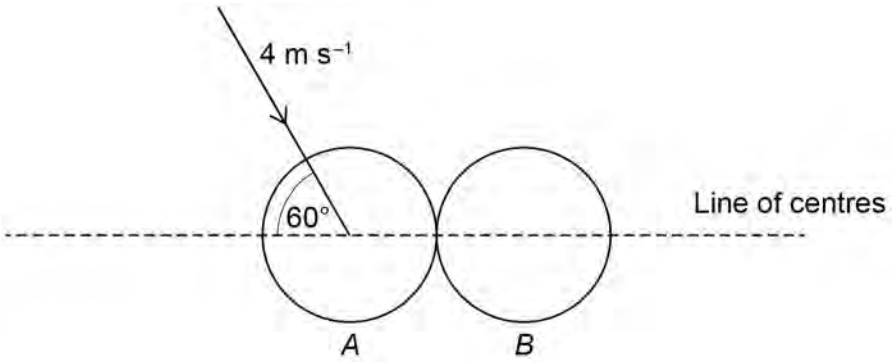
11

Turn over for the next question

7 Two smooth spheres, *A* and *B*, are the same size.

Sphere *B* is initially at rest on a smooth horizontal surface.

Sphere *A* is moving at 4 m s^{-1} at an angle of 60° to the line of centres when it collides with *B*, as shown in the diagram.



The mass of *A* is 3 kg and the mass of *B* is 2 kg.

The coefficient of restitution between the spheres is 0.6

7 (a) Describe the direction in which *B* moves after the collision.

[1 mark]

7 (b) Find the speed of *B* after the collision.

[6 marks]

Do not write outside the box

Answer _____ m s^{-1}

7 (c) Find the magnitude and direction of the velocity of *A* after the collision.

[4 marks]

Magnitude _____ m s^{-1}

Direction _____

7 (d) Find the magnitude of the impulse on *A* during the collision.

[2 marks]

Answer _____ N s

END OF QUESTIONS

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