



**Surname** \_\_\_\_\_

**Forename(s)** \_\_\_\_\_

**Centre Number** \_\_\_\_\_

**Candidate Number** \_\_\_\_\_

**Candidate Signature** \_\_\_\_\_

**I declare this is my own work.**

**A-level**

**FURTHER MATHEMATICS**

**Paper 3 Mechanics**

**7367/3M**

**Friday 7 June 2024 Afternoon**

**Time allowed: 2 hours**

**At the top of the page, write your surname and forename(s), your centre number, your candidate number and add your signature.**

**[Turn over]**



J U N 2 4 7 3 6 7 3 M 0 1

## **MATERIALS**

- **You must have the AQA Formulae and statistical tables booklet for A-level Mathematics and A-level Further Mathematics.**
- **You should have a graphical or scientific calculator that meets the requirements of the specification.**
- **You must ensure you have the other optional Question Paper/Answer Book for which you are entered (EITHER Discrete OR Statistics). You will have 2 hours to complete BOTH papers.**

## **INSTRUCTIONS**

- **Use black ink or black ball-point pen. Pencil should only be used for drawing.**
- **Answer ALL questions.**
- **You must answer each question in the space provided for that question.**
- **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 NOT write on blank pages.**
- **Show all necessary working; otherwise, marks for method may be lost.**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**

## **INFORMATION**

- **The marks for questions are shown in brackets.**
- **The maximum mark for this paper is 50.**

## **ADVICE**

- **Unless stated otherwise, you may quote formulae, without proof, from the booklet.**
- **You do not necessarily need to use all the space provided.**

**DO NOT TURN OVER UNTIL TOLD TO DO SO**



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

- 1** A particle moves in a circular path so that at time  $t$  seconds its position vector,  $r$  metres, is given by

$$r = 4 \sin(2t)\mathbf{i} + 4 \cos(2t)\mathbf{j}$$

**Find the velocity of the particle, in  $\text{m s}^{-1}$ , when  $t = 0$**

**Circle your answer. [1 mark]**

**8i**

**-8j**

**8j**

**8i - 8j**



2

As a particle moves along a straight horizontal line, it is subjected to a force  $F$  newtons that acts in the direction of motion of the particle.

At time  $t$  seconds,  $F = \frac{t}{5}$

Calculate the magnitude of the impulse on the particle between  $t = 0$  and  $t = 3$

Circle your answer. [1 mark]

0.3 N s

0.6 N s

0.9 N s

1.8 N s

[Turn over]



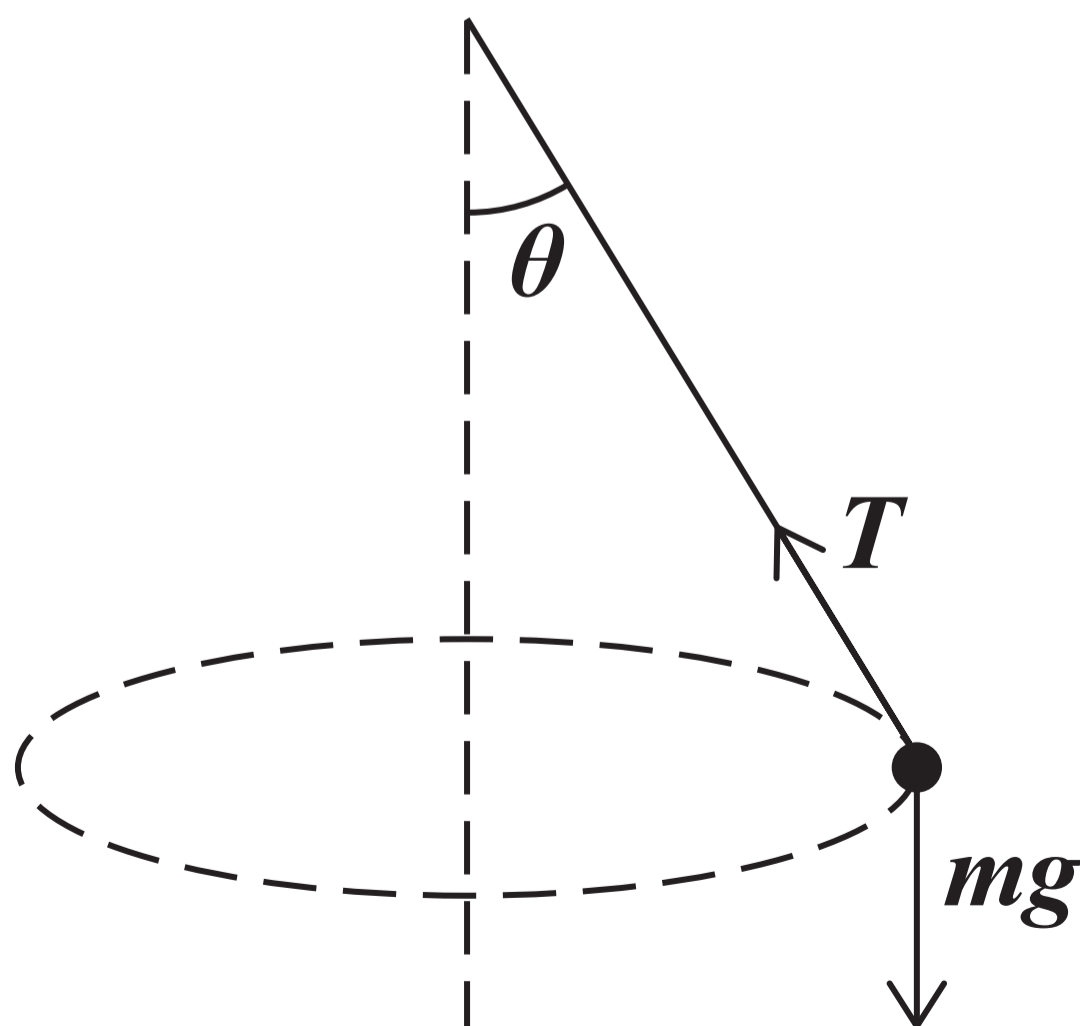
3

A conical pendulum consists of a light string and a particle of mass  $m$  kg

The conical pendulum completes horizontal circles with radius  $r$  metres and angular speed  $\omega$  radians per second. The string makes an angle  $\theta$  with the downward vertical.

The tension in the string is  $T$  newtons.

The conical pendulum and the forces acting on the particle are shown in the diagram.



Which **ONE** of the following statements is correct?

Tick (✓) **ONE** box. [1 mark]

$$T \cos \theta = mr\omega^2$$

$$T \sin \theta = mr\omega^2$$

$$T \cos \theta = \frac{m\omega^2}{r}$$

$$T \sin \theta = \frac{m\omega^2}{r}$$

[Turn over]



**4** A particle of mass 3 kg is attached to one end of a light inextensible string.

The other end of the string is attached to a fixed point on a smooth horizontal surface.

The particle is set into motion so that it moves with a constant speed  $4 \text{ m s}^{-1}$  in a circular path with radius 0.8 metres on the horizontal surface.

**4 (a)** Find the acceleration of the particle. [2 marks]

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**4 (b) Find the tension in the string.  
[1 mark]**

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- 5 When a sphere of radius  $r$  metres is falling at  $v$  m s<sup>-1</sup> it experiences an air resistance force  $F$  newtons.

The force is to be modelled as

$$F = kr^{\alpha}v^{\beta}$$

where  $k$  is a constant WITH UNITS kg m<sup>-2</sup>

- 5 (a) State the dimensions of  $F$   
[1 mark]

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6

**IN THIS QUESTION USE**

$$g = 9.8 \text{ m s}^{-2}$$

**A light elastic string has natural length 3 metres and modulus of elasticity 18 newtons.**

**One end of the elastic string is attached to a particle of mass 0.25 kg**

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

**The particle is released from rest at a point  $A$ , which is 4.5 metres vertically below  $O$**









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**6 (d) The point C is 3.6 metres vertically below O**

**Explain, showing any calculations that you make, why the speed of the particle is increasing the first time that the particle is at C [3 marks]**

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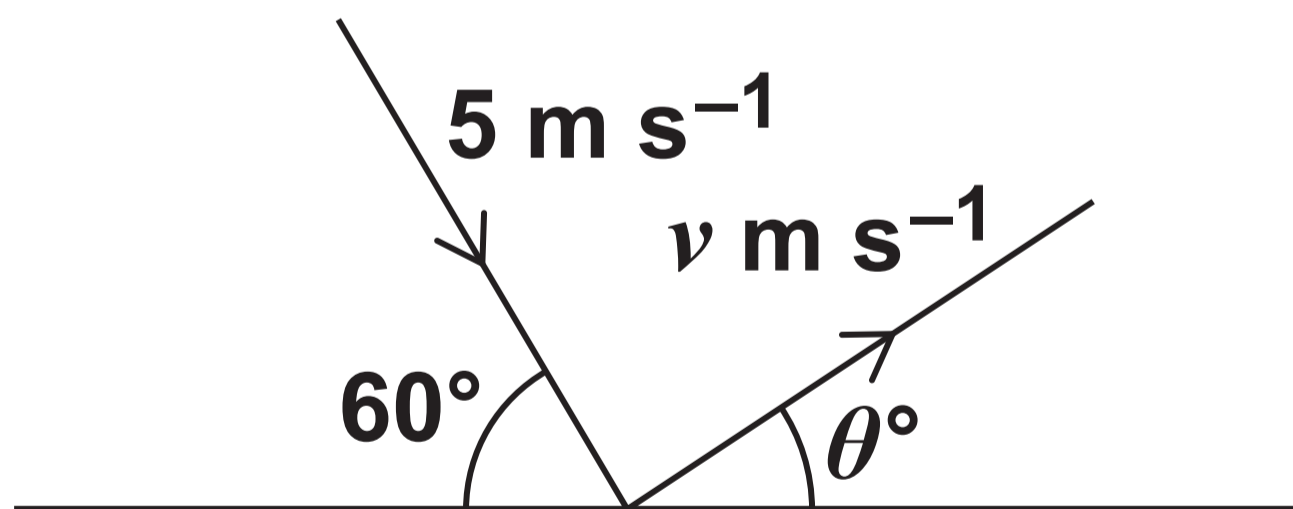
7

A sphere, of mass 0.2 kg, moving on a smooth horizontal surface, collides with a fixed wall.

Before the collision the sphere moves with speed  $5 \text{ m s}^{-1}$  at an angle of  $60^\circ$  to the wall.

After the collision the sphere moves with speed  $v \text{ m s}^{-1}$  at an angle of  $\theta^\circ$  to the wall.

The velocities are shown in the diagram below.



The coefficient of restitution between the wall and the sphere is 0.7









**7 (a) (iii) Find the magnitude of the impulse exerted on the sphere by the wall.**

**Give your answer to two significant figures. [2 marks]**

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**8** The finite region enclosed by the line  $y = kx$ , the  $x$ -axis and the line  $x = 5$  is rotated through  $360^\circ$  around the  $x$  axis to form a solid cone.

**8 (a) (i)** Use integration to show that the position of the centre of mass of the cone is independent of  $k$  [4 marks]

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**8 (a) (ii) State the distance between the base of the cone and its centre of mass. [1 mark]**

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**8 (b) State one assumption that you have made about the cone. [1 mark]**

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**8 (c) The plane face of the cone is placed on a rough inclined plane.**

**The coefficient of friction between the cone and the plane is 0.8**

**The angle between the plane and the horizontal is gradually increased from  $0^\circ$**

**Find the range of values of  $k$  for which the cone slides before it topples. [4 marks]**

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9

A small sphere, of mass  $m$ , is attached to one end of a light inextensible string of length  $a$

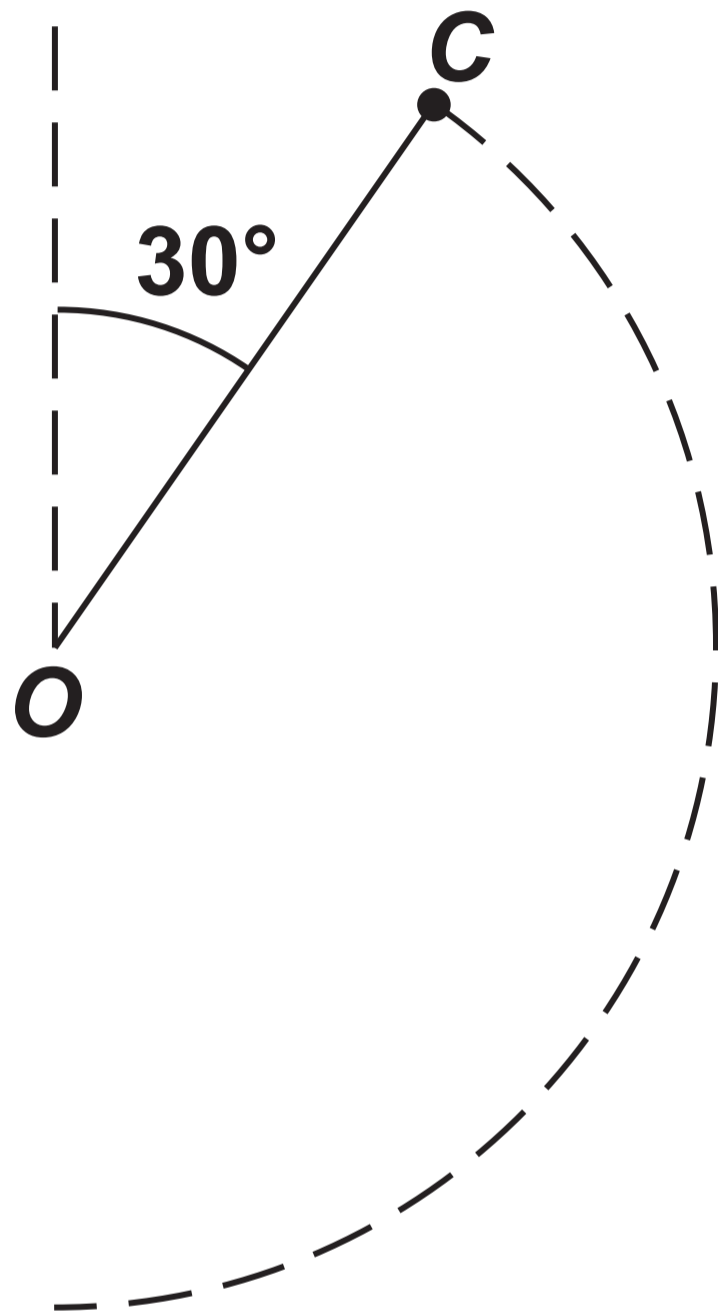
The other end of the string is attached to a fixed point  $O$

The sphere is at rest in equilibrium directly below  $O$  when it is struck, giving it a horizontal impulse of magnitude  $mU$

After the impulse, the sphere follows a circular path in a vertical plane containing the point  $O$  until the string becomes slack at the point  $C$



At  $C$  the string makes an angle of  $30^\circ$  with the upward vertical through  $O$ , as shown in the diagram below.



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- 9 (b) With reference to any modelling assumptions that you have made, explain why giving your answer as an inequality would be more appropriate, and state this inequality. [2 marks]**

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**END OF QUESTIONS**









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For Examiner's Use	
Question	Mark
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<b>TOTAL</b>	

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**G/LM/Jun24/7367/3M/G4006/V2**



4 6



2 4 6 A 7 3 6 7 / 3 M