



# Cambridge International AS & A Level

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## FURTHER MATHEMATICS

9231/32

Paper 3 Further Mechanics

May/June 2026

1 hour 30 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

### INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- Where a numerical value for the acceleration due to gravity ( $g$ ) is needed, use  $10 \text{ m s}^{-2}$ .

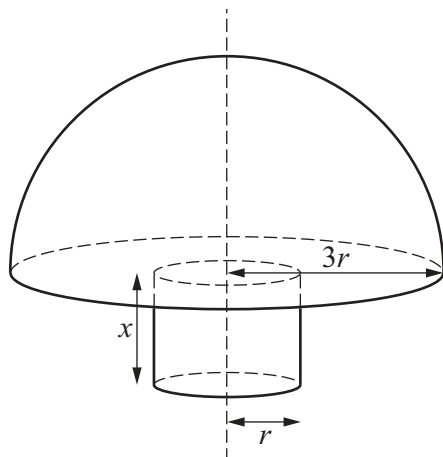
### INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages.



1



An object consists of a uniform solid hemisphere of radius  $3r$  attached to a uniform solid cylinder of radius  $r$  and height  $x$ . The hemisphere and the cylinder are made of the same material. The axes of symmetry of the hemisphere and the cylinder coincide (see diagram).

- (a) Find, in terms of  $r$  and  $x$ , the distance of the centre of mass of the object from the base of the cylinder.

[4]

[illegible]



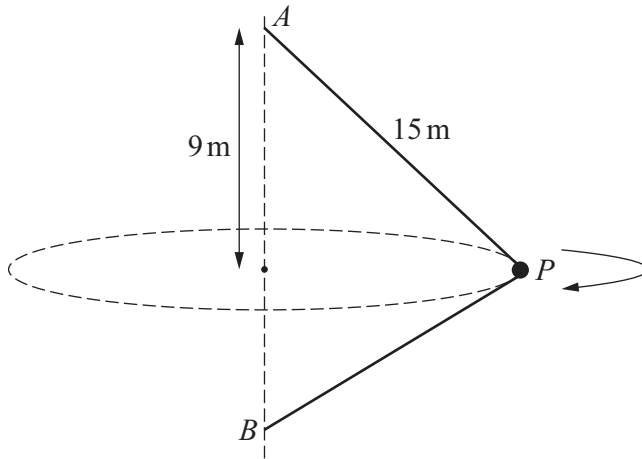
- (b) The point  $A$  lies on the circumference of the base of the hemisphere. When the object is freely suspended from point  $A$ , the base of the hemisphere makes an angle  $\theta$  with the downward vertical through  $A$ .

It is given that  $x = r$ .

Find the value of  $\theta$ .

[3]

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for handwriting practice or general writing. There are no margins, text, or other markings on the page.



The point  $B$  is vertically below the point  $A$ . One end of a light inextensible string is attached to  $A$ , and the other end is attached to  $B$ . A particle  $P$  of mass  $7\text{ kg}$  is attached to the string so that the length  $AP$  is  $15\text{ m}$ . The particle  $P$  moves at a constant angular speed of  $4$  radians per second in a horizontal circle with centre between  $A$  and  $B$  at a distance  $9\text{ m}$  vertically below  $A$  (see diagram). The string has length  $28\text{ m}$ , and both sections of the string are taut.

The tensions in the sections of the string  $AP$  and  $BP$  are  $T_A$  and  $T_B$  respectively.

Find the value of  $T_A$  and the value of  $T_B$ .

[5]

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**[Turn over**



- 3** A particle  $P$  of mass  $6.4\text{ kg}$  moves along a straight horizontal line. At time  $t\text{ s}$ , the speed of  $P$  is  $v\text{ m s}^{-1}$  and the distance of  $P$  from its starting position is  $x\text{ m}$ . The forces acting on  $P$  are a constant driving force of magnitude  $8\text{ N}$  and a resistive force of magnitude  $0.5v^2\text{ N}$ . Initially,  $P$  is at rest.

(a) Find the speed of  $P$  when it has travelled 0.8 m. [5]

[illegible]



(b) Find an expression for  $t$  in terms of  $v$ .

[4]

[illegible]



- 4 A particle  $P$  is moving on a fixed smooth horizontal surface with speed  $u$ . The particle collides with a fixed smooth vertical barrier. Immediately before the collision, the direction of motion of  $P$  makes an angle  $\alpha$  with the barrier, where  $\tan \alpha = \frac{12}{5}$ .

The kinetic energy of  $P$  after the collision is  $\frac{4}{13}$  times its kinetic energy before the collision.

- (a) Find the coefficient of restitution between  $P$  and the barrier. [4]

[illegible]



- (b) A second smooth vertical barrier is fixed to the surface and to the first barrier. The angle between the two barriers is  $120^\circ$ . Particle  $P$  subsequently collides with the second barrier and rebounds immediately after with speed  $w$  at an angle  $\theta$  with the second barrier. The coefficient of restitution is the same as in the first collision.

Find the value of  $\theta$  correct to 3 significant figures.

[4]

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- 5** A particle of mass  $m$  is attached to a fixed point  $O$  by a light inextensible string of length  $a$ . The particle initially hangs directly below  $O$  at the point  $A$ . The particle is then projected horizontally with speed  $2\sqrt{ag}$ , and begins to move in a vertical circle.
- (a)** Find an expression for the tension in the string when it has turned through an angle  $\theta$ . Give your answer in terms of  $m$ ,  $g$  and  $\theta$ . [4]

[illegible]



- (b)** Find, in terms of  $a$ , the maximum height above the horizontal through  $A$  that is reached by the particle.

[5]

[illegible]



- 6** A light elastic string has natural length 2.5 m and modulus of elasticity 15 N. One end of the string is attached to the fixed point  $O$ , and the other end is attached to a particle  $P$  of mass 1.5 kg. The particle  $P$  is held at  $O$  and then released from rest so that it begins to fall vertically. In its subsequent motion,  $P$  moves with velocity  $v \text{ m s}^{-1}$  when the extension of the string is  $x \text{ m}$ . The maximum extension of the string during this motion is  $E \text{ m}$ .

(a) Show that, for  $0 < x < E$ ,

$$v^2 = -4(x^2 - 5x - 12.5). \quad [3]$$

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(b) Find the value of  $E$ .

[1]

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(c) Find the maximum speed of  $P$ .

[2]

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- 7 The points  $O$  and  $A$  lie on a horizontal plane 10 m apart. The point  $A$  lies at the foot of another plane which is inclined at an angle of  $\alpha$  above the horizontal such that  $\tan \alpha = \frac{4}{3}$ . The point  $B$  is on the inclined plane at a distance of 5 m from  $A$  measured along a line of greatest slope. The points  $O$ ,  $A$  and  $B$  are in the same vertical plane and angle  $OAB$  is obtuse.

A particle is projected from  $O$  at an angle  $\theta$  to the horizontal with initial speed  $u \text{ m s}^{-1}$  towards the inclined plane. The particle moves freely under gravity. The particle strikes the inclined plane at the point  $B$  when its direction of motion is perpendicular to the inclined plane.

Find, in either order, the value of  $u$  and the value of  $\theta$ .

[6]

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