



# Cambridge International AS & A Level

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## FURTHER MATHEMATICS

9231/34

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. Any blank pages are indicated.





- 1 One end of a light inextensible string of length  $a$  is attached to a fixed point  $O$ . The other end of the string is attached to a particle of mass  $m$ . The string is taut and makes an angle  $\theta$  with the downward vertical through  $O$ . The particle moves in a horizontal circle with speed  $2\sqrt{ag}$ .

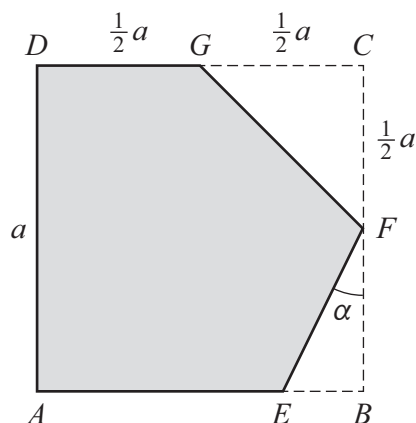
Find the value of  $\cos \theta$ .

[4]

[illegible]



2



A uniform lamina  $AEFGD$  is formed by removing two triangles from a square  $ABCD$  of side length  $a$ . Triangle  $FCG$  is isosceles and the two equal sides each have length  $\frac{1}{2}a$ . The angle between  $EF$  and  $BF$  is  $\alpha$ , where  $\tan \alpha = \frac{1}{2}$  (see diagram).

The centre of mass of the lamina is at a distance  $\bar{x}$  from  $AD$  and at a distance  $\bar{y}$  from  $AE$ .

- (a) Show that  $\bar{x} = \frac{5}{12}a$  and find a corresponding expression for  $\bar{y}$  in terms of  $a$ . [5]

[illegible]



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- (b) The lamina is freely suspended from the point  $G$  and hangs in equilibrium. The angle between  $DA$  and the downward vertical through  $G$  is  $\theta$ .
- Find the value of  $\theta$ . [2]

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- 3 A particle of mass  $m$  is attached to a fixed point  $O$  by a light inextensible string of length  $a$ . The particle moves in complete vertical circles about  $O$ . Points  $A$  and  $B$  are on the path of the particle.  $OA$  makes an angle of  $60^\circ$  with the upward vertical through  $O$ . The speed of the particle at  $A$  is  $u$  and the tension in the string at  $A$  is  $T_A$ . The point  $B$  is vertically below  $O$ . The speed of the particle at  $B$  is  $2u$  and the tension in the string at  $B$  is  $T_B$ .

(a) Show that  $T_B = kT_A$ , where  $k$  is a constant to be determined. [6]

[illegible]



- (b) Find the loss in kinetic energy of the particle between its lowest and highest points. Give your answer in terms of  $m$ ,  $g$  and  $a$ . [1]





- 4 Two particles  $A$  and  $B$  have masses  $km$  and  $m$  respectively. Particle  $A$  is at rest on a smooth horizontal surface and is exactly halfway between two fixed parallel smooth vertical walls. Particle  $B$  is moving on the surface with speed  $u$  in a direction perpendicular to the walls, and collides directly with  $A$ . The coefficient of restitution between the two particles is  $0.2$ . As a result of the collision, the direction of motion of  $B$  is reversed.

**(a)** Show that  $k > 5$ .

[3]

[illegible]



- (b) Particle  $B$  then collides with one of the vertical walls and rebounds. The coefficient of restitution between  $B$  and the wall is 0.8. It then collides again with particle  $A$  at the instant when  $A$  collides with the other vertical wall.

Find the value of  $k$ .

[3]

[illegible]



- 5 A particle  $P$  of mass  $m$  is moving in a straight horizontal line under a variable force  $m(v^2 - ku^2)$ , where  $v$  is the velocity of  $P$  at time  $t$ ,  $u$  is the initial velocity of  $P$ , and  $k$  is a positive constant. It is given that  $u > 0$  and  $k > 1$ .

**(a)** Explain why, initially, the acceleration and velocity of  $P$  have opposite directions. [1]

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**(b)** Find, in terms of  $k$ , the distance travelled by  $P$  until it first comes to instantaneous rest. [4]

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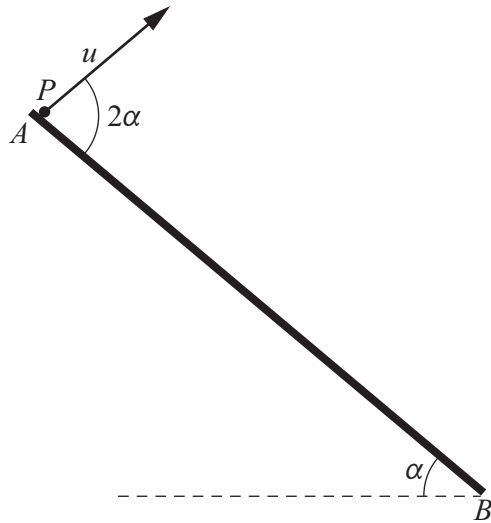




(c) Find, in terms of  $k$  and  $u$ , the time taken for  $P$  to first come to instantaneous rest.

[4]

[illegible]



The points  $A$  and  $B$  lie on the line of greatest slope of a smooth inclined plane, with  $A$  above  $B$ . The plane is inclined to the horizontal at an acute angle  $\alpha$ .

At time  $t = 0$ , a particle  $P$  is projected from  $A$  with speed  $u$  at an angle  $2\alpha$  to the plane and moves freely under gravity (see diagram). At the same time, a second particle  $Q$  is released from rest at  $A$ . Particle  $Q$  moves down the plane along the line of greatest slope. The two particles move in the same vertical plane. At time  $t = T$ , the two particles collide at point  $B$ . The length of  $AB$  is  $d$ .

- (a) By considering the motion of particle  $Q$ , show that  $T = \sqrt{\frac{2d}{g \sin \alpha}}$ . [2]

[illegible]





- 7 One end of a light elastic string of natural length  $8a$  and modulus of elasticity  $6mg$  is attached to a fixed point  $O$  on a rough plane. The plane is inclined at an angle  $\theta$  to the horizontal where  $\sin \theta = \frac{5}{13}$ . A particle  $P$  of mass  $m$  is attached to the other end of the string. The string lies along a line of greatest slope of the plane, with  $P$  below the level of  $O$ . The particle is held at a point such that the extension of the string is  $3a$ .

When  $P$  is released from rest, its acceleration is  $\frac{5}{4}g$  in the direction  $PO$ .

- (a)** Find the coefficient of friction between the particle and the plane. [4]

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**(b)** In its subsequent motion,  $P$  comes to rest at the point  $C$ .

Find, in terms of  $a$ , the distance  $OC$ .

[6]





Additional page

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