



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/33

Paper 3 Further Mechanics

May/June 2024

1 hour 30 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

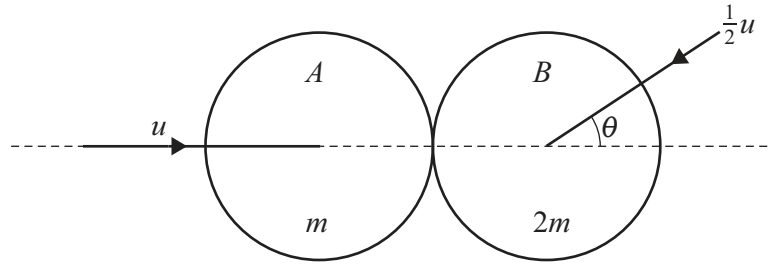
INSTRUCTIONS

- 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 or correction fluid.
- 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 ms^{-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.



Two smooth uniform spheres A and B of equal radii have masses m and $2m$ respectively. The two spheres are moving on a smooth horizontal surface when they collide with speeds u and $\frac{1}{2}u$ respectively. Immediately before the collision, A 's direction of motion is along the line of centres, and B 's direction of motion makes an angle θ with the line of centres (see diagram).

As a result of the collision, the direction of motion of A is reversed and its speed is reduced to $\frac{1}{4}u$. The direction of motion of B again makes an angle θ with the line of centres, but on the opposite side of the line of centres. The speed of B is unchanged.

Find the value of the coefficient of restitution between the spheres.

[4]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



- Particle P moves in a horizontal circle on the surface of the table with constant speed $\sqrt{\frac{1}{2}ga}$. Particle Q hangs in equilibrium vertically below the hole with $HQ = \frac{1}{4}a$.

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- This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, typical of notebook or legal stationery. There are no margins, text, or other markings on the page.

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3 A particle P 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 . When the particle is hanging vertically below O , it is projected horizontally with speed u so that it begins to move along a circular path. When P is at the lowest point of its motion, the tension in the string is T . When OP makes an angle θ with the upward vertical, the tension in the string is S .

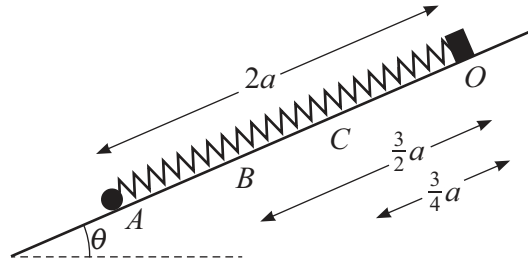
(a) Show that $S = T - 3mg(1 + \cos \theta)$. [5]

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



[2]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



A light spring of natural length a and modulus of elasticity kmg is attached to a fixed point O on a smooth plane inclined to the horizontal at an angle θ , where $\sin \theta = \frac{3}{4}$. A particle of mass m is attached to the lower end of the spring and is held at the point A on the plane, where $OA = 2a$ and OA is along a line of greatest slope of the plane (see diagram).

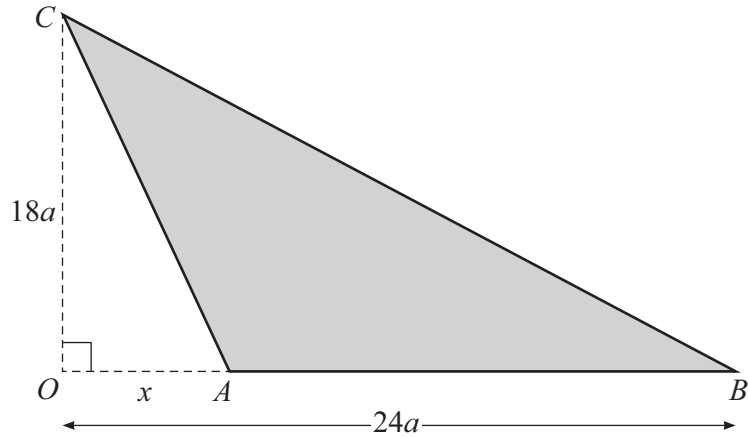
The particle is released from rest and is moving with speed V when it passes through the point B on the plane, where $OB = \frac{3}{2}a$. The speed of the particle is $\frac{1}{2}V$ when it passes through the point C on the plane, where $OC = \frac{3}{4}a$.

Find the value of k .

[7]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

[illegible]



A uniform lamina is in the form of a triangle OBC , with $OC = 18a$, $OB = 24a$ and angle $COB = 90^\circ$. The point A on OB is such that $OA = x$ (see diagram). The triangle OAC is removed from the lamina.

- (a) Find, in terms of a and x , the distance of the centre of mass of the remaining object ABC from OC . [3]

[illegible]



(b) Find x in terms of a .

This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.



6 A particle P is projected with speed $u \text{ ms}^{-1}$ at an angle θ above the horizontal from a point O and moves freely under gravity. After 5 seconds the speed of P is $\frac{3}{4}u$.

(a) Show that $\frac{7}{16}u^2 - 100u \sin \theta + 2500 = 0$. [3]

[illegible]



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[5]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of horizontal dotted lines spaced evenly down the page, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text present.

- (a) Find an expression for v in terms of t .

[6]

This image shows a full page of a worksheet designed for handwriting practice. It features 20 evenly spaced, horizontal dashed lines across the entire width of the page. The background is plain white, providing a clear guide for letter height and placement. There are no margins, text, or other markings present.



[3]

[illegible]

[2]

This image shows a blank sheet of white paper with ten horizontal dotted lines spaced evenly apart, resembling notebook paper. The lines are light gray and extend across the full width of the page. There is no handwriting or other markings on the paper.

If you use the following page to complete the answer to any question, the question number must be clearly shown.

[illegible]

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