



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/33

Paper 3 Further Mechanics

May/June 2022

1 hour 30 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

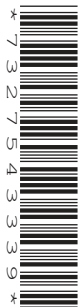
INSTRUCTIONS

- 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.



[4]

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

2 A particle P of mass m is attached to one end of a light elastic string of natural length a and modulus of elasticity $\frac{4}{3}mg$. The other end of the string is attached to a fixed point O on a rough horizontal surface. The particle is at rest on the surface with the string at its natural length. The coefficient of friction between P and the surface is $\frac{1}{3}$. The particle is projected along the surface in the direction OP with a speed of $\frac{1}{2}\sqrt{ga}$.

Find the greatest extension of the string during the subsequent motion. [5]

[illegible]

[5]

[illegible]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of three horizontal dashed lines, providing a guide for letter height and placement. The lines are evenly spaced and extend across the entire width of the page, leaving no margins or additional text.

- 4 One end of a light inextensible string of length a is attached to a fixed point O . A particle of mass m is attached to the other end of the string and is held with the string taut at the point A . At A the string makes an angle θ with the upward vertical through O . The particle is projected perpendicular to the string in a downward direction from A with a speed u . It moves along a circular path in the vertical plane.

When the string makes an angle α with the downward vertical through O , the speed of the particle is $2u$ and the magnitude of the tension in the string is 10 times its magnitude at A .

It is given that $u = \sqrt{\frac{2}{3}ga}$.

- (a) Find, in terms of m and g , the magnitude of the tension in the string at A . [6]

[illegible]

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(b) Find the value of $\cos \alpha$. [2]

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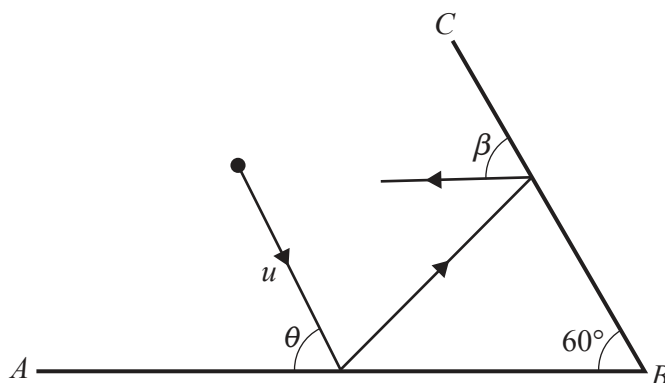
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[illegible]

[illegible]

6



AB and BC are two fixed smooth vertical barriers on a smooth horizontal surface, with angle $ABC = 60^\circ$. A particle of mass m is moving with speed u on the surface. The particle strikes AB at an angle θ with AB . It then strikes BC and rebounds at an angle β with BC (see diagram). The coefficient of restitution between the particle and each barrier is e and $\tan \theta = 2$.

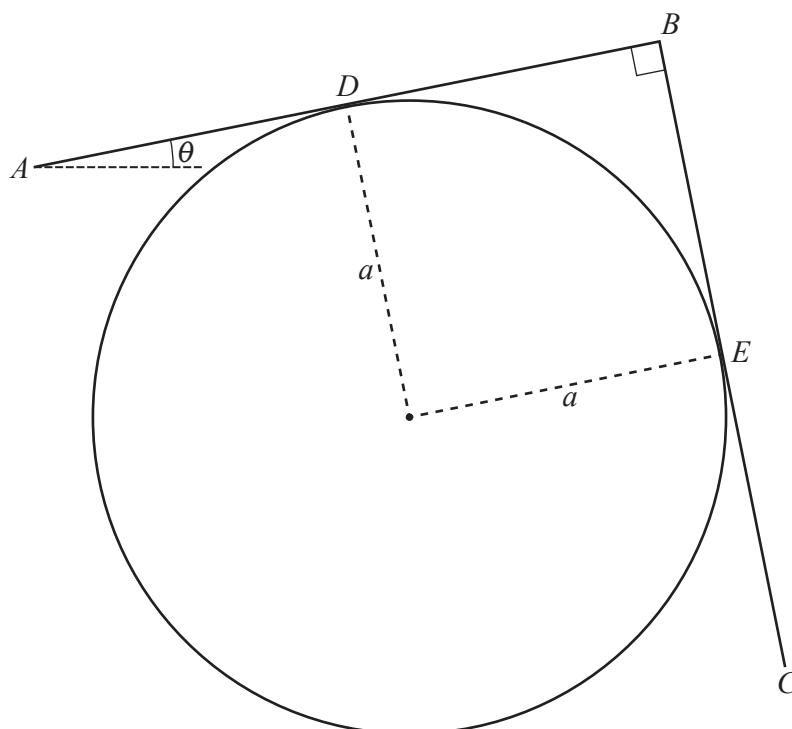
The kinetic energy of the particle after the first collision is 40% of its kinetic energy before the first collision.

- (a) Find the value of e . [4]

[illegible]

[4]

[illegible]



A uniform cylinder with a rough surface and of radius a is fixed with its axis horizontal. Two identical uniform rods AB and BC , each of weight W and length $2a$, are rigidly joined at B with AB perpendicular to BC . The rods rest on the cylinder in a vertical plane perpendicular to the axis of the cylinder with AB at an angle θ to the horizontal. D and E are the midpoints of AB and BC respectively and also the points of contact of the rods with the cylinder (see diagram). The rods are about to slip in a clockwise direction. The coefficient of friction between each rod and the cylinder is μ .

The normal reaction between AB and the cylinder is R and the normal reaction between BC and the cylinder is N .

- (a) Find the ratio $R : N$ in terms of μ . [6]

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(b) Given that $\mu = \frac{1}{3}$, find the value of $\tan \theta$. [3]

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