



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/31

Paper 3 Further Mechanics

May/June 2021

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.

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3 One end of a light elastic string, of natural length a and modulus of elasticity kmg , is attached to a fixed point A . The other end of the string is attached to a particle P of mass $4m$. The particle P hangs in equilibrium a distance x vertically below A .

(a) Show that $k = \frac{4a}{x-a}$. [1]

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An additional particle, of mass $2m$, is now attached to P and the combined particle is released from rest at the original equilibrium position of P . When the combined particle has descended a distance $\frac{1}{3}a$, its speed is $\frac{1}{3}\sqrt{ga}$.

(b) Find x in terms of a . [6]

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The solid is placed on a plane that is inclined to the horizontal at an angle θ . The base of the cylinder is in contact with the plane. The plane is sufficiently rough to prevent sliding. It is given that $3h = 2r$ and that the solid is on the point of toppling when $\tan \theta = \frac{4}{3}$.

(b) Find the value of k .

[3]

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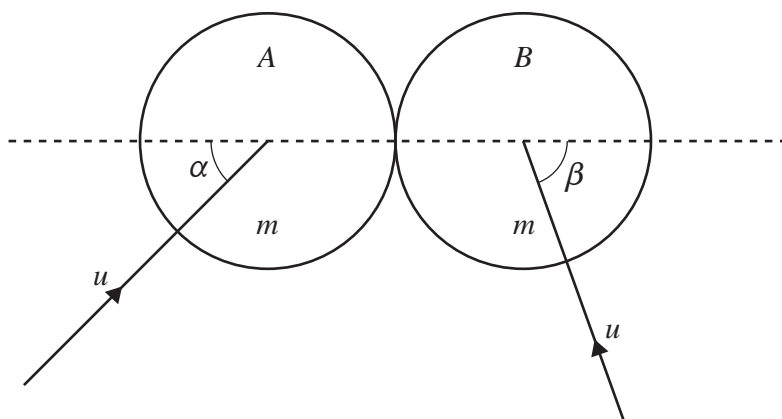
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Two uniform smooth spheres A and B of equal radii each have mass m . The two spheres are each moving with speed u on a horizontal surface when they collide. Immediately before the collision, A 's direction of motion makes an angle α with the line of centres, and B 's direction of motion makes an angle β with the line of centres (see diagram). The coefficient of restitution between the spheres is $\frac{1}{3}$ and $2 \cos \beta = \cos \alpha$.

- (a) Show that the direction of motion of A after the collision is perpendicular to the line of centres. [4]

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The total kinetic energy of the spheres after the collision is $\frac{3}{4}mu^2$.

(b) Find the value of α . [4]

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Additional Page

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

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