



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/32

Paper 3 Further Mechanics

October/November 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 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 [].

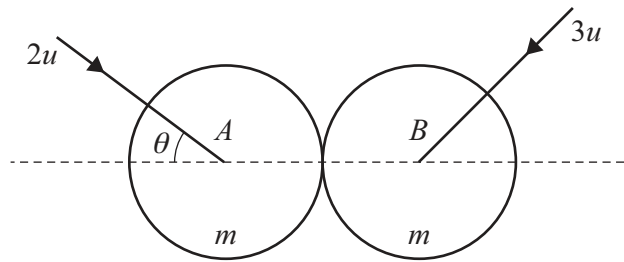
This document has **16** pages. Any blank pages are indicated.

- Find the distance of P below O when P first comes to instantaneous rest.

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, typical of notebook or legal stationery. There are no margins, text, or other markings on the page.



3



The diagram shows two identical smooth uniform spheres A and B of equal radii and each of mass m . The two spheres are moving on a smooth horizontal surface when they collide with speeds $2u$ and $3u$ respectively. Immediately before the collision, A 's direction of motion makes an angle θ with the line of centres and B 's direction of motion is perpendicular to that of A . After the collision, B moves perpendicular to the line of centres. The coefficient of restitution between the spheres is $\frac{1}{3}$.

- (a) Find the value of $\tan \theta$. [3]

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.



(b) Find the total loss of kinetic energy as a result of the collision.

[2]

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(c) Find, in degrees, the angle through which the direction of motion of A is deflected as a result of the collision.

[2]

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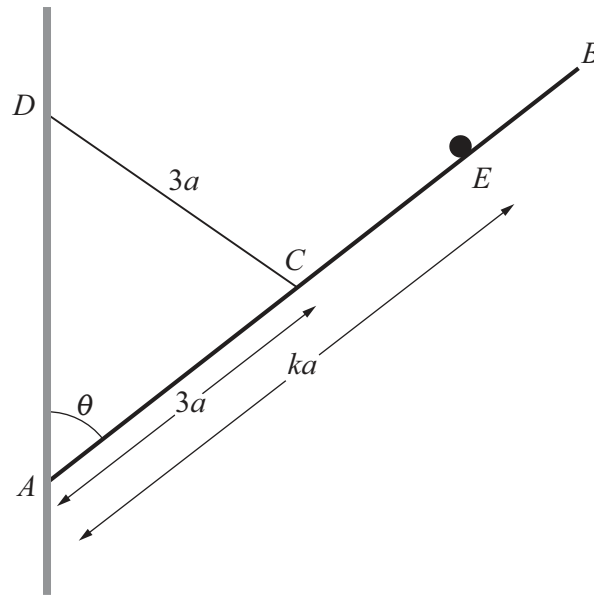
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The end A of a uniform rod AB of length $6a$ and weight W is in contact with a rough vertical wall. One end of a light inextensible string of length $3a$ is attached to the midpoint C of the rod. The other end of the string is attached to a point D on the wall, vertically above A . The rod is in equilibrium when the angle between the rod and the wall is θ , where $\tan \theta = \frac{3}{2}$. A particle of weight W is attached to the point E on the rod, where the distance AE is equal to ka ($3 < k < 6$) (see diagram). The rod and the string are in a vertical plane perpendicular to the wall. The coefficient of friction between the rod and the wall is $\frac{1}{3}$. The rod is about to slip down the wall.

- (a)** Find the value of k .

[5]

[illegible]

[illegible]



5 A particle P is projected from a point O on horizontal ground with speed u at an angle θ above the horizontal, where $\tan \theta = \frac{1}{3}$. The particle P moves freely under gravity and passes through the point with coordinates $(3a, \frac{4}{5}a)$ relative to horizontal and vertical axes through O in the plane of the motion.

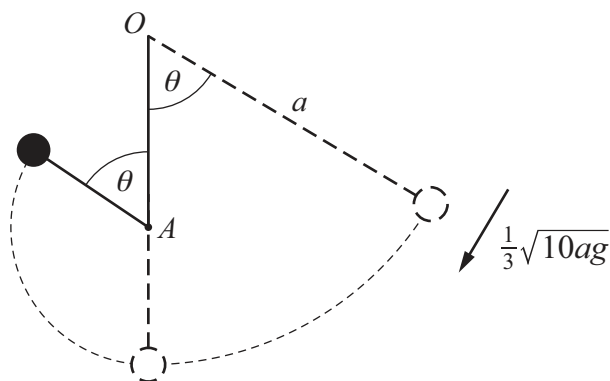
(a) Use the equation of the trajectory to show that $u^2 = 25ag$. [2]

[illegible]



[6]

[illegible]



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 . The particle P is held with the string taut and the string makes an angle θ with the downward vertical through O . The particle P is projected at right angles to the string with speed $\frac{1}{3}\sqrt{10ag}$ and begins to move downwards along a circular path. When the string is vertical, it strikes a small smooth peg at the point A which is vertically below O . The circular path and the point A are in the same vertical plane. After the string strikes the peg, the particle P begins to move in a vertical circle with centre A . When the string makes an angle θ with the upward vertical through A the string becomes slack (see diagram). The distance of A below O is $\frac{5}{9}a$.

- (a) Find the value of $\cos \theta$.

[6]

This image shows a full page of blank handwriting practice paper. It features multiple sets of horizontal lines, each consisting of a solid top line, a dashed midline, and a solid bottom line, providing a guide for letter formation and alignment. The lines are evenly spaced across the entire page.



- (b) Find the ratio of the tensions in the string immediately before and immediately after it strikes the peg. [4]



- (a) Find an expression for v in terms of t . [6]

[illegible]



- [5]

[illegible]

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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