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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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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 $10\,\mathrm{m\,s^{-2}}$.

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.

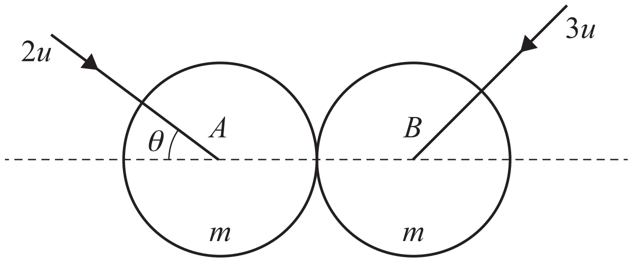
1 A particle of mass 2 kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 100 N. The other end of the string is attached to a fixed point O on a smooth horizontal surface. The particle is moving in a horizontal circle about O with the string taut and with constant angular speed 5 radians per second.

Find the extension of the string. [3]

2 A particle P of mass m is attached to one end of a light elastic spring of natural length a and modulus of elasticity $5mg$. The other end of the spring is attached to a fixed point O. The spring hangs vertically with P below O. The particle P is pulled down vertically and released from rest when the length of the spring is $\frac{3}{2}a$.

Find the distance of P below O when P first comes to instantaneous rest. [4]

3



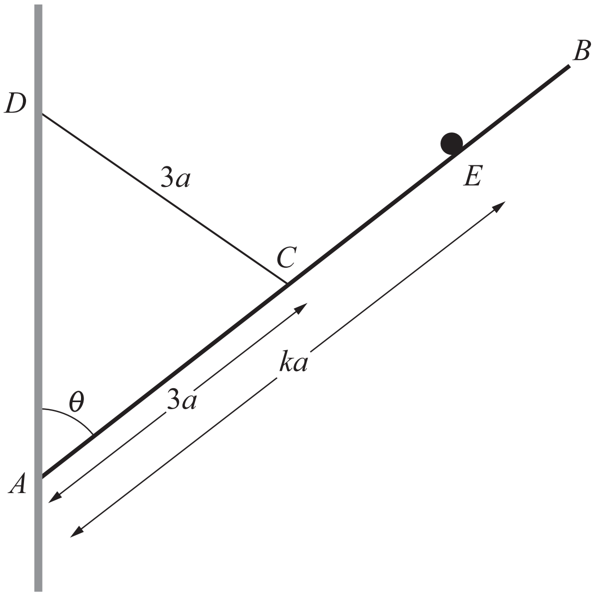
The diagram shows two identical smooth uniform spheres A and B of equal radii and each of mass m. The two spheres are moving on a smooth horizontal surface when they collide with speeds $2u$ and $3u$ respectively. Immediately before the collision, A's direction of motion makes an angle θ with the line 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]

(b) Find the total loss of kinetic energy as a result of the collision. [2]

(c) Find, in degrees, the angle through which the direction of motion of A is deflected as a result of the collision. [2]

4



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]

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(b) Find, in terms of W, the magnitude of the frictional force between the rod and the wall. [2]

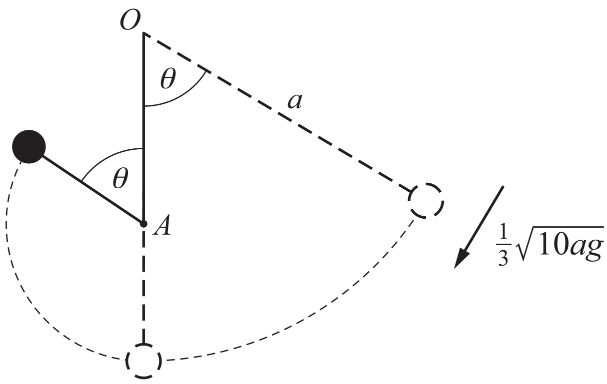
5 A particle P is projected from a point O on horizontal ground with speed u at an angle θ above the horizontal, where $\tan\theta = \frac{1}{3}$. The particle P moves freely under gravity and passes through the point with coordinates $(3a, \frac{4}{5}a)$ relative to horizontal and vertical axes through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

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

At the instant when P is moving horizontally, a particle Q is projected from O with speed V at an angle α above the horizontal. The particles P and Q reach the ground at the same point and at the same time.

(b) Express V^2 in the form kag, where k is a rational number. [6]

6



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]

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

7 A particle P of mass m kg is held at rest at a point O and released so that it moves vertically under gravity against a resistive force of magnitude $0.1mv^2$ N, where v m s^{-1} is the velocity of P at time t s.

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

The displacement of P from O at time t s is x m.

(b) Find an expression for v^2 in terms of x. [5]

Additional page

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