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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

FURTHER MATHEMATICS **9231/34**

Paper 3 Further Mechanics **May/June 2025**

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

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.

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1 A light spring of natural length a and modulus of elasticity $20mg$ is placed so that it stands vertically on a horizontal plane. The lower end of the spring is fixed to the plane. A particle of mass m is attached to the upper end of the spring.

The particle is pushed vertically downwards until the length of the spring is $\frac{3}{5}a$. The system is then released from rest.

Find the maximum extension of the spring in the subsequent motion. [5]

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2 A particle P of mass m kg moves along a horizontal straight line against a resistive force of magnitude $2mv^3$ N, where $v\,\text{m}\,\text{s}^{-1}$ is the velocity of P at time t s. When $t = 0$, $v = 1$.

(a) Find an expression for v in terms of t. [4]

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(b) Find the displacement of P from its initial position when $t = 6$. [3]

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3 A particle P is projected with speed u at an angle α above the horizontal from a point O on a horizontal plane and moves freely under gravity. The horizontal and vertical displacements of P from O at any subsequent time t are denoted by x and y respectively.

(a) Derive the equation of the trajectory of P in the form

$$y = x\tan\alpha - \frac{gx^2}{2u^2}\sec^2\alpha.$$ [4]

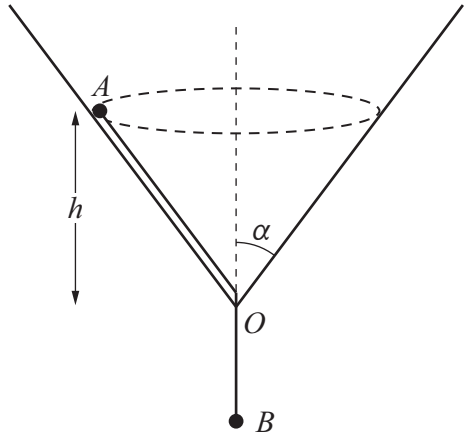
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It is given that $u = 20\sqrt{2}\,\text{m s}^{-1}$ and that the particle P passes through the point where $x = 64\,\text{m}$ and $y = 8\,\text{m}$.

(b) Find the possible values of $\tan\alpha$. [3]

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A hollow cone with a smooth inner surface is fixed with its vertex O downwards. The semi-vertical angle of the cone is α, where $\tan\alpha = \frac{3}{4}$. A light inextensible string has a particle A of mass m attached to one end and a particle B of mass m attached to the other end. The string passes through a small hole in the cone at O. Particle B hangs in equilibrium below O. Particle A is on the inner surface of the cone at a height h above the level of O and moves in horizontal circles with constant angular speed ω (see diagram).

Find ω in terms of g and h. [6]

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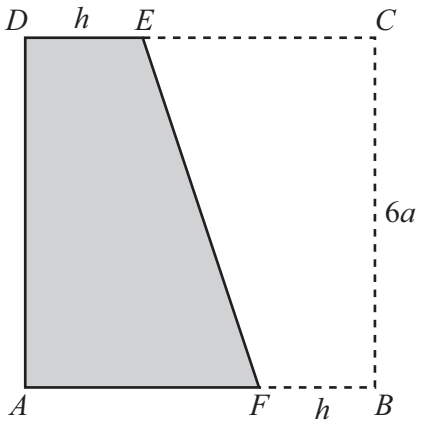
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ABCD is a uniform square lamina of side $6a$. Points E and F are on DC and AB respectively and are such that $DE = FB = h$. The quadrilateral $BCEF$ is removed from the square lamina (see diagram).

(a) Show that the distance of the centre of mass of the resulting lamina *AFED* from *AD* is $\frac{h^2 - 6ah + 36a^2}{18a}$ and find a corresponding expression for the distance of the centre of mass from *AB*. [5]

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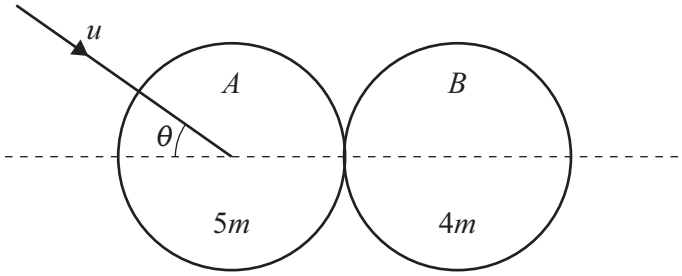
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When the lamina *AFED* is suspended from the point *D*, the edge *DA* makes an angle θ with the downward vertical, where $\tan\theta = \frac{7}{15}$.

(b) Find, in terms of a, the two possible values of h. [3]

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Two uniform smooth spheres A and B of equal radii have masses $5m$ and $4m$ respectively. Sphere A is moving with speed u on a horizontal surface when it collides with sphere B which is at rest. Immediately before the collision, A's direction of motion makes an angle θ with the line of centres (see diagram). The coefficient of restitution between the spheres is e.

(a) Show that the speed of B after the collision is $\frac{5}{9}u(1+e)\cos\theta$. [3]

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After the collision the kinetic energy of A is equal to the kinetic energy of B.

(b) Given that $\tan\theta = \frac{2}{3}$, find the value of e. [6]

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7 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 moves in complete vertical circles with centre O, with the string taut. When the string makes an angle θ with the downward vertical through O the speed of P is $\sqrt{4ag}$. The ratio of the greatest and least tensions in the string during the motion is 11 : 1.

Find the value of $\cos\theta$. [8]

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