



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/32

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} .

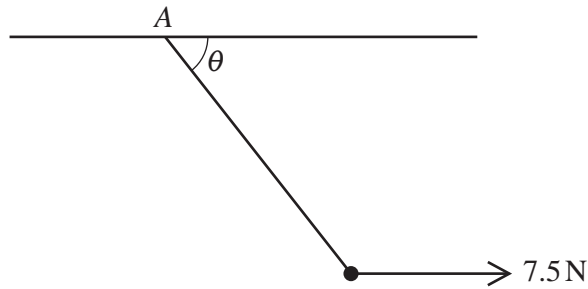
INFORMATION

- 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.

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1



A particle of weight 10N is attached to one end of a light elastic string. The other end of the string is attached to a fixed point A on a horizontal ceiling. A horizontal force of 7.5 N acts on the particle. In the equilibrium position, the string makes an angle θ with the ceiling (see diagram). The string has natural length 0.8 m and modulus of elasticity 50 N.

(a) Find the tension in the string. [2]

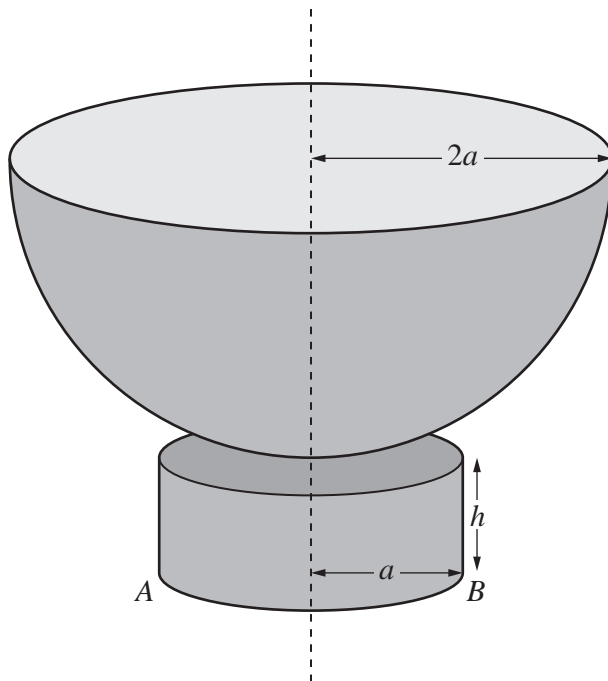
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(b) Find the vertical distance between the particle and the ceiling. [3]

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An object is composed of a hemispherical shell of radius $2a$ attached to a closed hollow circular cylinder of height h and base radius a . The hemispherical shell and the hollow cylinder are made of the same uniform material. The axes of symmetry of the shell and the cylinder coincide. AB is a diameter of the lower end of the cylinder (see diagram).

- (a) Find, in terms of a and h , an expression for the distance of the centre of mass of the object from AB . [4]

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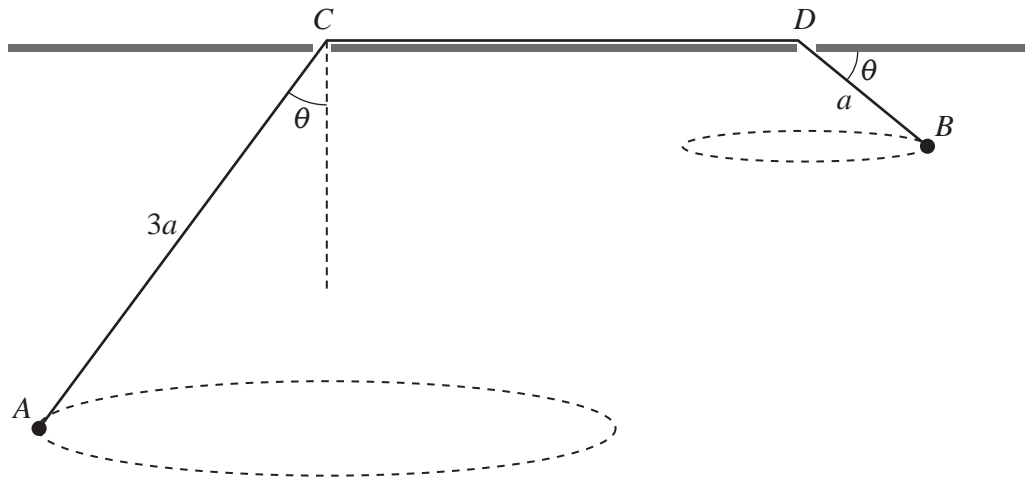
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A light inextensible string AB passes through two small holes C and D in a smooth horizontal table where $AC = 3a$ and $DB = a$. A particle of mass m is attached at the end A and moves in a horizontal circle with angular velocity ω . A particle of mass $\frac{3}{4}m$ is attached to the end B and moves in a horizontal circle with angular velocity $k\omega$. AC makes an angle θ with the downward vertical and DB makes an angle θ with the horizontal (see diagram).

Find the value of k .

[7]

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6 Two uniform smooth spheres A and B of equal radii have masses m and km respectively. The two spheres are on a horizontal surface. Sphere A is travelling with speed u towards sphere B which is at rest. The spheres collide. Immediately before the collision, the direction of motion of A makes an angle α with the line of centres. The coefficient of restitution between the spheres is $\frac{1}{2}$.

(a) Show that the speed of B after the collision is $\frac{3u \cos \alpha}{2(1+k)}$ and find also an expression for the speed of A along the line of centres after the collision, in terms of k , u and α . [4]

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7 Particles *P* and *Q* are projected in the same vertical plane from a point *O* at the top of a cliff. The height of the cliff exceeds 50 m. Both particles move freely under gravity. Particle *P* is projected with speed $\frac{35}{2} \text{ m s}^{-1}$ at an angle α above the horizontal, where $\tan \alpha = \frac{4}{3}$. Particle *Q* is projected with speed $u \text{ m s}^{-1}$ at an angle β above the horizontal, where $\tan \beta = \frac{1}{2}$. Particle *Q* is projected one second after the projection of particle *P*. The particles collide T s after the projection of particle *Q*.

(a) Write down expressions, in terms of T , for the horizontal displacements of *P* and *Q* from *O* when they collide and hence show that $4uT = 21\sqrt{5}(T + 1)$. [4]

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(b) Find the value of T . [4]

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(c) Find the horizontal and vertical displacements of the particles from O when they collide. [3]

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