



# Cambridge International AS & A Level

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## FURTHER MATHEMATICS

9231/33

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

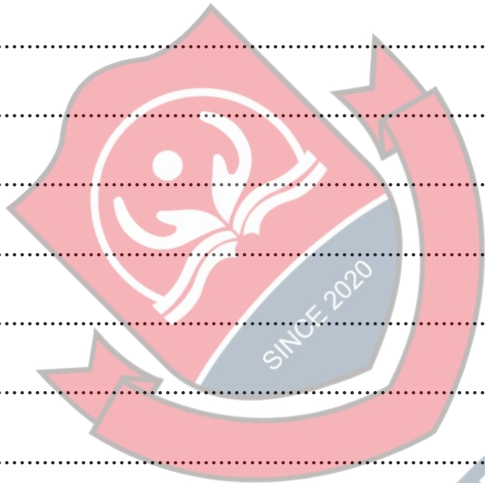
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction 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  $10 \text{ m s}^{-2}$ .

### 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, in either order, the value of  $u$  and the value of  $H$ .

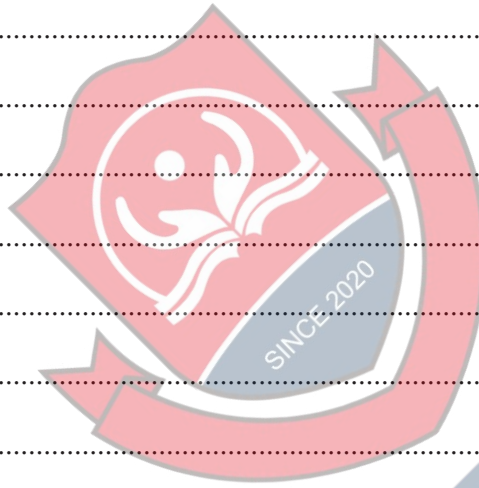


4Uadmission

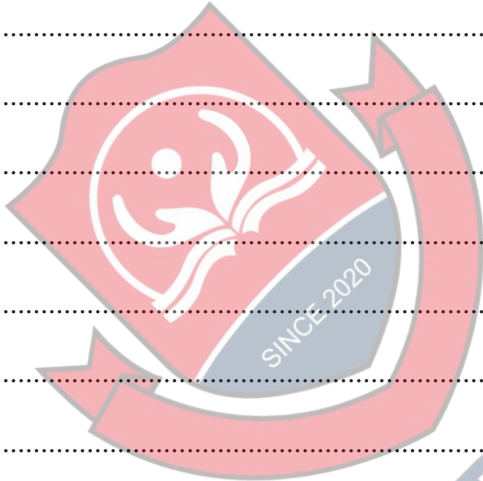
- 2 A particle  $P$  of mass  $m$  is attached to one end of a light inextensible string of length  $a$ . The other end of the string is attached to a fixed point  $O$ . The particle  $P$  is held at the point  $A$  with the string taut. It is given that  $OA$  makes an angle  $\theta$  with the downward vertical through  $O$ , where  $\tan \theta = \frac{3}{4}$ . The particle  $P$  is projected perpendicular to  $OA$  in an upwards direction with speed  $\sqrt{5ag}$ , and it starts to move along a circular path in a vertical plane. When  $P$  is at the point  $B$ , where angle  $AOB$  is a right angle, the tension in the string is  $T$ .

Find  $T$  in terms of  $m$  and  $g$ .

[5]



- (a)** Given that the particle just reaches  $O$  in the subsequent motion, find the value of  $d$ . [6]

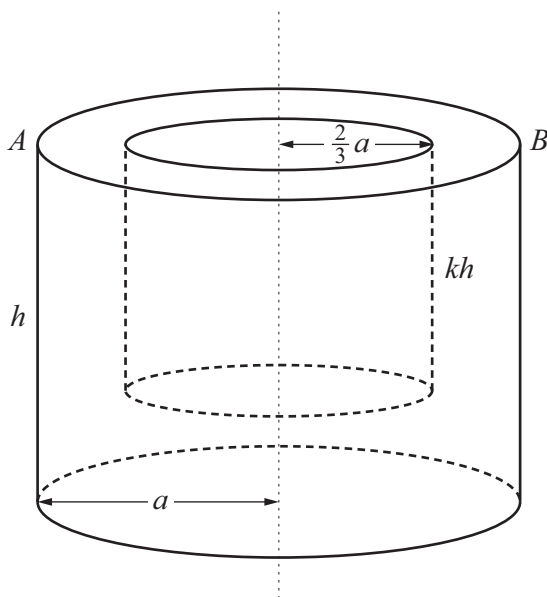




[2]



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An object is formed by removing a cylinder of radius  $\frac{2}{3}a$  and height  $kh$  ( $k < 1$ ) from a uniform solid cylinder of radius  $a$  and height  $h$ . The vertical axes of symmetry of the two cylinders coincide. The upper faces of the two cylinders are in the same plane as each other. The points  $A$  and  $B$  are the opposite ends of a diameter of the upper face of the object (see diagram).

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





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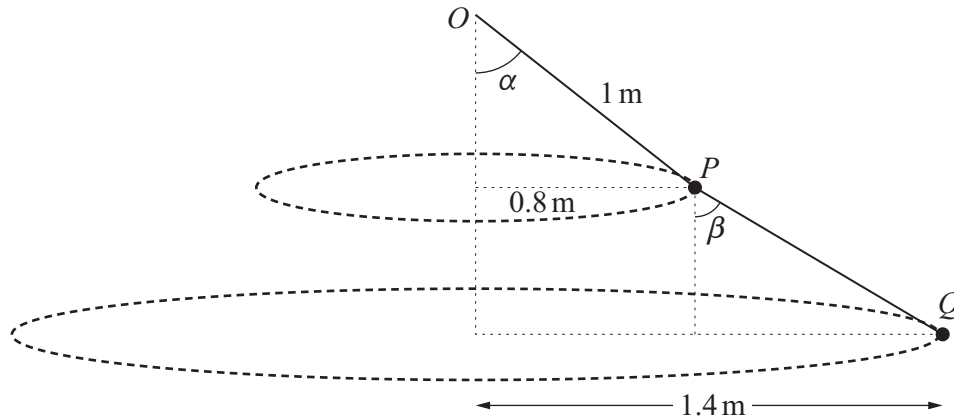
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[3]





A particle  $P$  of mass  $0.05\text{ kg}$  is attached to one end of a light inextensible string of length  $1\text{ m}$ . The other end of the string is attached to a fixed point  $O$ . A particle  $Q$  of mass  $0.04\text{ kg}$  is attached to one end of a second light inextensible string. The other end of this string is attached to  $P$ .

The particle  $P$  moves in a horizontal circle of radius  $0.8\text{ m}$  with angular speed  $\omega\text{ rad s}^{-1}$ . The particle  $Q$  moves in a horizontal circle of radius  $1.4\text{ m}$  also with angular speed  $\omega\text{ rad s}^{-1}$ . The centres of the circles are vertically below  $O$ , and  $O$ ,  $P$  and  $Q$  are always in the same vertical plane. The strings  $OP$  and  $PQ$  remain at constant angles  $\alpha$  and  $\beta$  respectively to the vertical (see diagram).

- (a) Find the tension in the string  $OP$ .

[3]





[3]

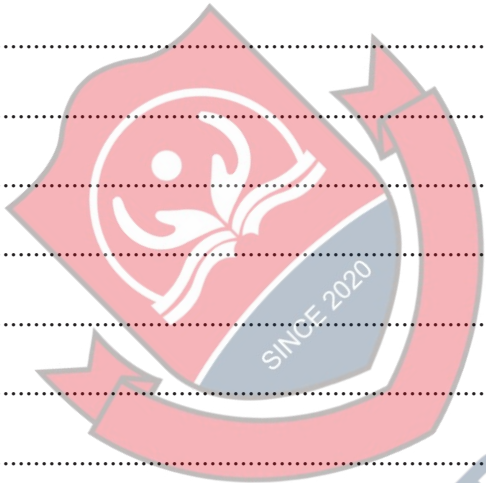
[2]

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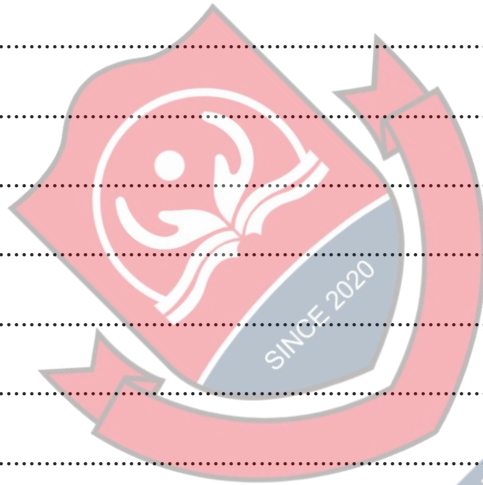




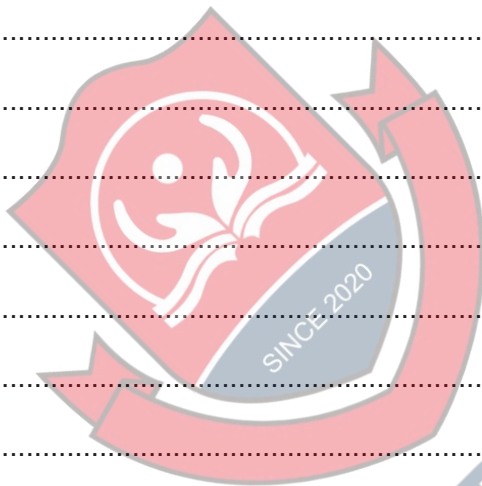
(b) Find the value of  $e$ . [6]



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



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