



# Cambridge International AS & A Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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## FURTHER MATHEMATICS

9231/32

Paper 3 Further Mechanics

May/June 2020

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  $10 \text{ ms}^{-2}$ .

### 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. Blank pages are indicated.



- 1 A particle  $P$  is projected with speed  $u$  at an angle of  $30^\circ$  above the horizontal from a point  $O$  on a horizontal plane and moves freely under gravity. The particle reaches its greatest height at time  $T$  after projection.

Find, in terms of  $u$ , the speed of  $P$  at time  $\frac{2}{3}T$  after projection. [5]

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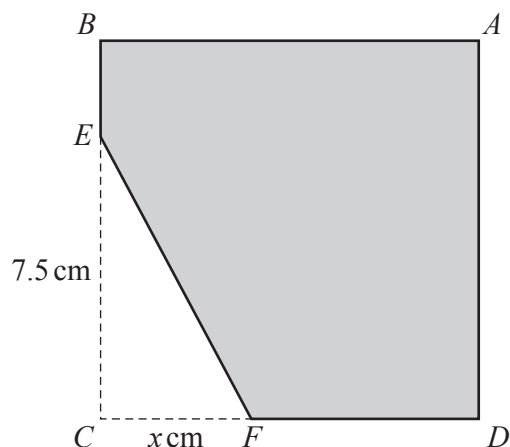
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A series of horizontal dotted lines for writing.







A uniform square lamina  $ABCD$  has sides of length 10 cm. The point  $E$  is on  $BC$  with  $EC = 7.5$  cm, and the point  $F$  is on  $DC$  with  $CF = x$  cm. The triangle  $EFC$  is removed from  $ABCD$  (see diagram). The centre of mass of the resulting shape  $ABEFD$  is a distance  $\bar{x}$  cm from  $CB$  and a distance  $\bar{y}$  cm from  $CD$ .

- (a) Show that  $\bar{x} = \frac{400 - x^2}{80 - 3x}$  and find a corresponding expression for  $\bar{y}$ . [4]

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The shape  $ABEFD$  is in equilibrium in a vertical plane with the edge  $DF$  resting on a smooth horizontal surface.

- (b) Find the greatest possible value of  $x$ , giving your answer in the form  $a + b\sqrt{2}$ , where  $a$  and  $b$  are constants to be determined. [3]

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(b) Find an expression for the displacement of  $P$  from its initial position when its velocity is  $2u$ . [5]

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The particle *P* loses two-thirds of its kinetic energy in the impact.

(b) Find the value of  $\alpha$  and the value of  $e$ . [5]

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- 7 A hollow cylinder of radius  $a$  is fixed with its axis horizontal. A particle  $P$ , of mass  $m$ , moves in part of a vertical circle of radius  $a$  and centre  $O$  on the smooth inner surface of the cylinder. The speed of  $P$  when it is at the lowest point  $A$  of its motion is  $\sqrt{\frac{7}{2}ga}$ .

The particle  $P$  loses contact with the surface of the cylinder when  $OP$  makes an angle  $\theta$  with the upward vertical through  $O$ .

- (a) Show that  $\theta = 60^\circ$ . [5]

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(b) Show that in its subsequent motion  $P$  strikes the cylinder at the point  $A$ . [5]

Dotted lines for writing the answer.

**Additional Page**

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

A series of horizontal dotted lines for writing answers.

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