

Cambridge  
International  
**A Level**

**Cambridge International Examinations**  
Cambridge International Advanced Level

CANDIDATE  
NAME

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CENTRE  
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**MATHEMATICS**

**9709/53**

Paper 5 Mechanics 2 (M2)

**October/November 2018**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES.**

Answer **all** the questions in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

Where a numerical value for the acceleration due to gravity is needed, use  $10 \text{ m s}^{-2}$ .

The use of an electronic calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.

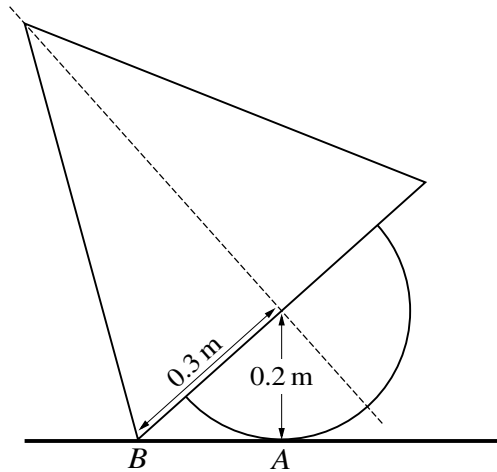
The number of marks is given in brackets [ ] at the end of each question or part question.

The total number of marks for this paper is 50.

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A uniform object is made by attaching the base of a solid hemisphere to the base of a solid cone so that the object has an axis of symmetry. The base of the cone has radius 0.3 m, and the hemisphere has radius 0.2 m. The object is placed on a horizontal plane with a point  $A$  on the curved surface of the hemisphere and a point  $B$  on the circumference of the cone in contact with the plane (see diagram).

- (i) Given that the object is on the point of toppling about  $B$ , find the distance of the centre of mass of the object from the base of the cone. [3]

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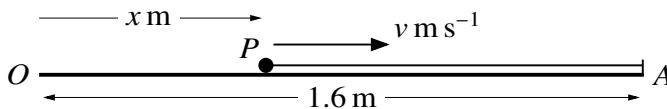
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A particle  $P$  of mass  $0.5 \text{ kg}$  is projected along a smooth horizontal surface towards a fixed point  $A$ . Initially  $P$  is at a point  $O$  on the surface, and after projection,  $P$  has a displacement from  $O$  of  $x \text{ m}$  and velocity  $v \text{ m s}^{-1}$ . The particle  $P$  is connected to  $A$  by a light elastic string of natural length  $0.8 \text{ m}$  and modulus of elasticity  $16 \text{ N}$ . The distance  $OA$  is  $1.6 \text{ m}$  (see diagram). The motion of  $P$  is resisted by a force of magnitude  $24x^2 \text{ N}$ .

- (i) Show that  $v \frac{dv}{dx} = 32 - 40x - 48x^2$  while  $P$  is in motion and the string is stretched. [3]

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The maximum value of  $v$  is  $4.5$ .

- (ii) Find the initial value of  $v$ . [5]

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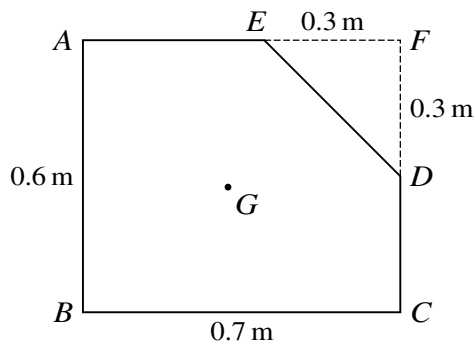
**Fig. 1**

Fig. 1 shows the cross-section  $ABCDE$  through the centre of mass  $G$  of a uniform prism. The cross-section consists of a rectangle  $ABCF$  from which a triangle  $DEF$  has been removed;  $AB = 0.6 \text{ m}$ ,  $BC = 0.7 \text{ m}$  and  $DF = EF = 0.3 \text{ m}$ .

- (i) Show that the distance of  $G$  from  $BC$  is  $0.276 \text{ m}$ , and find the distance of  $G$  from  $AB$ . [5]

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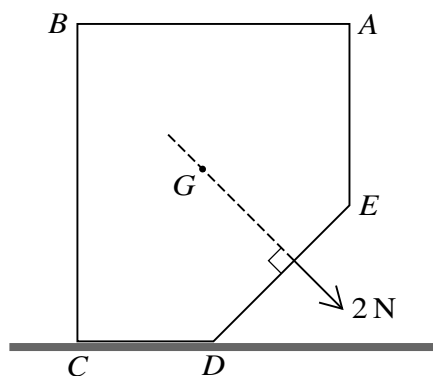
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**Fig. 2**

The prism is placed with  $CD$  on a rough horizontal surface. A force of magnitude  $2\text{ N}$  acting in the plane of the cross-section is applied to the prism. The line of action of the force passes through  $G$  and is perpendicular to  $DE$  (see Fig. 2). The prism is on the point of toppling about the edge through  $D$ .

**(ii)** Calculate the weight of the prism. [3]

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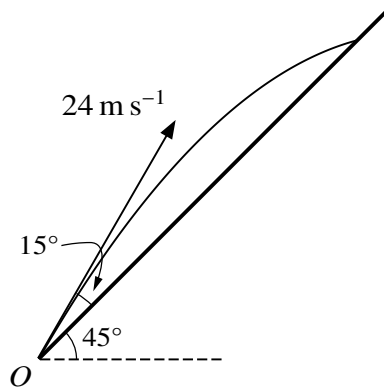
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A small object is projected with speed  $24 \text{ m s}^{-1}$  from a point  $O$  at the foot of a plane inclined at  $45^\circ$  to the horizontal. The angle of projection of the object is  $15^\circ$  above a line of greatest slope of the plane (see diagram). At time  $t$  s after projection, the horizontal and vertically upwards displacements of the object from  $O$  are  $x$  m and  $y$  m respectively.

- (i) Express  $x$  and  $y$  in terms of  $t$ , and hence find the value of  $t$  for the instant when the object strikes the plane. [4]

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