Cambridge International A Level

Cambridge Assessment International Education
Cambridge International Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	CANDIDATE NUMBER

2272302195

MATHEMATICS **9709/51**

Paper 5 Mechanics 2 **(M2)** **October/November 2019**

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.

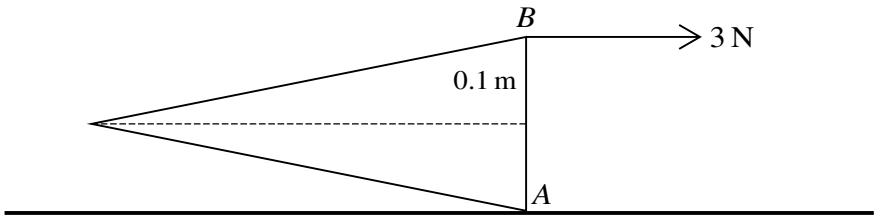
Answer **all** the questions in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\text{m}\,\text{s}^{-2}$.
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.

This document consists of **12** printed pages.

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1



A uniform solid cone has weight 5 N and base radius 0.1 m. AB is a diameter of the base of the cone. The cone is held in equilibrium, with A in contact with a rough horizontal surface and AB vertical, by a force applied at B. This force has magnitude 3 N and acts parallel to the axis of the cone (see diagram). Calculate the height of the cone. [3]

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2 A particle is projected from a point on horizontal ground with speed $15\,\text{m}\,\text{s}^{-1}$ at an angle of $\theta°$ above the horizontal. The particle strikes the ground 2 s after projection.

(i) Find θ. [2]

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(ii) Calculate the time after projection at which the direction of motion of the particle is 20° below the horizontal. [4]

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3 A smooth horizontal surface has two fixed points O and A which are 0.8 m apart. A particle P of mass 0.25 kg is projected with velocity 3 m s^{-1} horizontally from A in the direction away from O. The velocity of P is v m s^{-1} when the displacement of P from O is x m. A force of magnitude kv^2x^{-2} N opposes the motion of P.

(i) Show that $v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -4kv^2x^{-2}$. [1]

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(ii) Express v in terms of k and x. [5]

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4 A small ball B is projected with speed $30\,\text{m s}^{-1}$ at an angle of $60°$ above the horizontal from a point O. At time t s after projection the horizontal and vertically upwards displacements of B from O are x m and y m respectively.

(i) Express x and y in terms of t and hence find the equation of the trajectory of the ball. [4]

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(ii) Find the value of x for which OB makes an angle of $45°$ above the horizontal. [3]

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5 A particle P of mass 0.3 kg is attached to one end of a light elastic string of natural length 0.6 m and modulus of elasticity 9 N. The other end of the string is attached to a fixed point O on a smooth plane inclined at 30° to the horizontal. OA is a line of greatest slope of the plane with A below the level of O and $OA = 0.8$ m. The particle P is released from rest at A.

(i) Find the initial acceleration of P. [4]

(ii) Find the greatest speed of P. [5]

6 A and B are two fixed points on a vertical axis with A 0.6 m above B. A particle P of mass 0.3 kg is attached to A by a light inextensible string of length 0.5 m. The particle P is attached to B by a light elastic string with modulus of elasticity 46 N. The particle P moves with constant angular speed $8\,\text{rad}\,\text{s}^{-1}$ in a horizontal circle with centre at the mid-point of AB.

(i) Find the speed of P. [2]

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(ii) Calculate the tension in the string BP and hence find the natural length of this string. [7]

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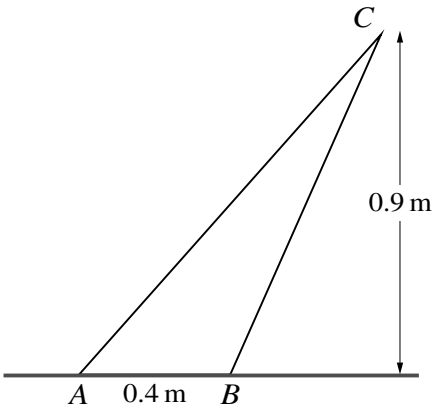
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ABC is the cross-section through the centre of mass of a uniform prism which rests with AB on a rough horizontal surface. $AB = 0.4$ m and C is 0.9 m above the surface (see diagram). The prism is on the point of toppling about its edge through B.

(i) Show that angle $BAC = 48.4°$, correct to 3 significant figures. [3]

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A force of magnitude 18 N acting in the plane of the cross-section and perpendicular to AC is now applied to the prism at C. The prism is on the point of rotating about its edge through A.

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

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(iii) Given also that the prism is on the point of slipping, calculate the coefficient of friction between the prism and the surface. [4]

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Additional Page

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