Cambridge International A Level

**Cambridge Assessment International Education**
Cambridge International Advanced Level

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*7004780907*

**MATHEMATICS** **9709/52**

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.

**1** A particle 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 horizontal surface. The particle is projected horizontally from $O$ with speed $4\ \text{m s}^{-1}$. Find the greatest distance of the particle from $O$. [3]

**2** A small ball is projected from a point $O$ on horizontal ground at an angle of 30° above the horizontal. At time $t$ s after projection the horizontal and vertically upwards displacements of the ball from $O$ are $x$ m and $y$ m respectively. It is given that $x = 40t$.

**(i)** Calculate the initial speed of the ball, and express $y$ in terms of $t$. [3]

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**(ii)** Hence find the equation of the trajectory of the ball. [2]

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**3** A particle $P$ of mass 0.5 kg is attached to one end of a light elastic string of natural length 0.6 m and modulus of elasticity 12 N. The other end of the string is attached to a fixed point $O$. The particle $P$ is projected vertically downwards with speed $2\,\text{m}\,\text{s}^{-1}$ from the point 0.5 m vertically below $O$. For an instant when the acceleration of $P$ is $4\,\text{m}\,\text{s}^{-2}$ downwards, find the extension of the string and the speed of $P$. [6]

**4** A particle is projected from a point $O$ on horizontal ground with speed $V\,\text{m}\,\text{s}^{-1}$ at an angle of 60° above the horizontal. At the instant 3 s after projection the direction of motion of the particle is 30° below the horizontal.

**(i)** Find $V$. [3]

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**(ii)** Calculate the distance of the particle from $O$ at the instant 3 s after projection. [3]

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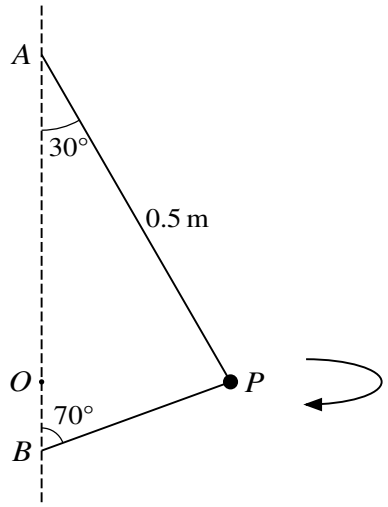
**5**




$A$ and $B$ are two fixed points on a vertical axis with $A$ above $B$. A particle $P$ of mass 0.4 kg is attached to $A$ by a light inextensible string of length 0.5 m. The particle $P$ is attached to $B$ by another light inextensible string. $P$ moves with constant speed in a horizontal circle with centre $O$ between $A$ and $B$. Angle $BAP = 30°$ and angle $ABP = 70°$ (see diagram).

**(i)** Given that the tensions in the two strings are equal, find the speed of $P$. [5]

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**(ii)** Given instead that the angular speed of $P$ is $12\,\text{rad}\,\text{s}^{-1}$, find the tensions in the strings. [5]

**6** A particle $P$ of mass 0.2 kg is projected horizontally from a fixed point $O$ on a smooth horizontal surface. When the displacement of $P$ from $O$ is $x$ m the velocity of $P$ is $v\,\text{m}\,\text{s}^{-1}$. A horizontal force of variable magnitude $0.09\sqrt{x}$ N directed away from $O$ acts on $P$. An additional force of constant magnitude 0.3 N directed towards $O$ acts on $P$.

**(i)** Show that $v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 0.45\sqrt{x} - 1.5$. [2]

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**(ii)** Find the value of $x$ for which the acceleration of $P$ is zero. [2]

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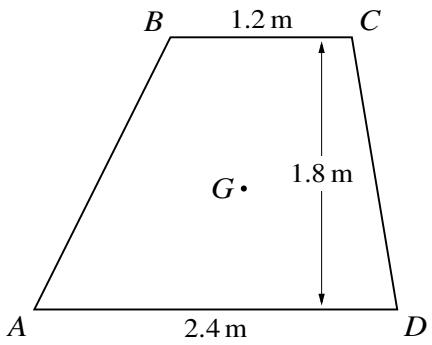
**(iii)** Given that the minimum value of $v$ is positive, find the set of possible values for the speed of projection. [5]

**7**




*ABCD* is a uniform lamina in the shape of a trapezium which has centre of mass *G*. The sides *AD* and *BC* are parallel and 1.8 m apart, with *AD* = 2.4 m and *BC* = 1.2 m (see diagram).

**(i)** Show that the distance of *G* from *AD* is 0.8 m. [4]

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The lamina is freely suspended at *A* and hangs in equilibrium with *AD* making an angle of 30° with the vertical.

**(ii)** Calculate the distance *AG*. [2]

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With the lamina still freely suspended at $A$ a horizontal force of magnitude 7 N acting in the plane of the lamina is applied at $D$. The lamina is in equilibrium with $AG$ making an angle of 10° with the downward vertical.

**(iii)** Find the two possible values for the weight of the lamina. [5]

## 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.

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