Cambridge International A Level

**Cambridge International Examinations**
Cambridge International Advanced Level

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| CANDIDATE NAME | |
| CENTRE NUMBER | CANDIDATE NUMBER |

*2450536727*

**MATHEMATICS** **9709/53**

Paper 5 Mechanics 2 **(M2)** **May/June 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 $10\,\text{m}\,\text{s}^{-2}$.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

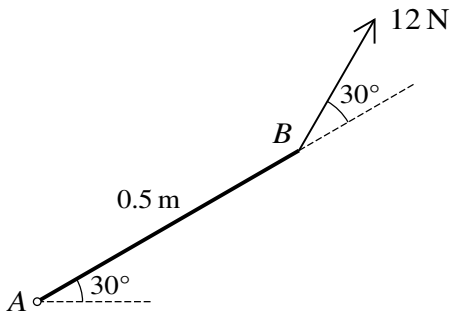
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.

This document consists of **14** printed pages and **2** blank pages.


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**1** A small ball $B$ is projected from a point $O$ on horizontal ground. The initial velocity of $B$ has horizontal and vertically upwards components of $18\,\text{m s}^{-1}$ and $25\,\text{m s}^{-1}$ respectively. For the instant 4 s after projection, find the speed and direction of motion of $B$. [4]

**2**




A non-uniform rod $AB$ of length 0.5 m and weight 8 N is freely hinged to a fixed point at $A$. The rod makes an angle of 30° with the horizontal with $B$ above the level of $A$. The rod is held in equilibrium by a force of magnitude 12 N acting in the vertical plane containing the rod at an angle of 30° to $AB$ applied at $B$ (see diagram). Find the distance of the centre of mass of the rod from $A$. [3]

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**[Turn over**

**3** A particle $P$ of mass 0.4 kg is projected horizontally along a smooth horizontal plane from a point $O$. At time $t$ s after projection the velocity of $P$ is $v$ m s$^{-1}$. A force of magnitude $0.8t$ N directed away from $O$ acts on $P$ and a force of magnitude $2e^{-t}$ N opposes the motion of $P$.

**(i)** Show that $\frac{dv}{dt} = 2t - 5e^{-t}$. [2]

**(ii)** Given that $v = 8$ when $t = 1$, express $v$ in terms of $t$. [3]

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**(iii)** Find the speed of projection of $P$. [2]

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**4** A small object is projected from a point $O$ with speed $V$ m s$^{-1}$ at an angle of 45° above the horizontal. 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 equation of the path. [4]

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The object passes through the point with coordinates (24, 18).

**(ii)** Find $V$. [2]

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**(iii)** The object passes through two points which are 22.5 m above the level of $O$. Find the values of $x$ for these points. [3]

**5** A particle $P$ of mass 0.7 kg is attached by a light elastic string to a fixed point $O$ on a smooth plane inclined at an angle of 30° to the horizontal. The natural length of the string is 0.5 m and the modulus of elasticity is 20 N. The particle $P$ is projected up the line of greatest slope through $O$ from a point $A$ below the level of $O$. The initial kinetic energy of $P$ is 1.8 J and the initial elastic potential energy in the string is also 1.8 J.

**(i)** Find the distance $OA$. [2]

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**(ii)** Find the greatest speed of $P$ in the motion. [6]

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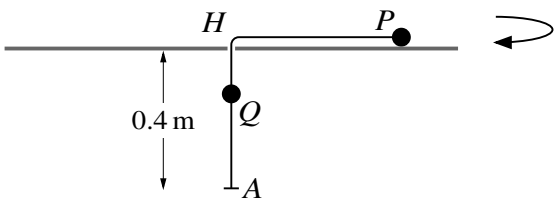
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**6**




A particle $P$ of mass 0.2 kg is attached to one end of a light inextensible string of length 0.6 m. The other end of the string is attached to a particle $Q$ of mass 0.3 kg. The string passes through a small hole $H$ in a smooth horizontal surface. A light elastic string of natural length 0.3 m and modulus of elasticity 15 N joins $Q$ to a fixed point $A$ which is 0.4 m vertically below $H$. The particle $P$ moves on the surface in a horizontal circle with centre $H$ (see diagram).

**(i)** Calculate the greatest possible speed of $P$ for which the elastic string is not extended. [4]

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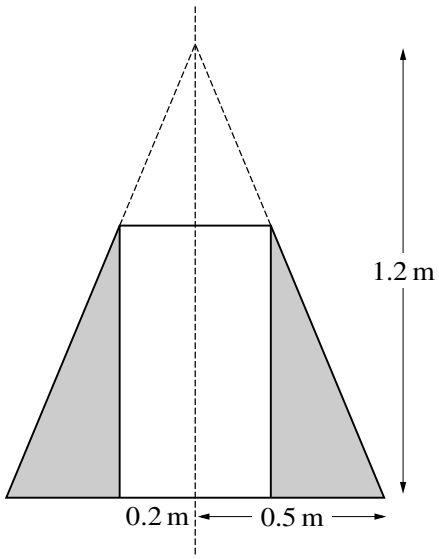
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**(ii)** Find the distance $HP$ given that the angular speed of $P$ is $8\,\text{rad}\,\text{s}^{-1}$. [5]

**7**




A uniform solid cone has height 1.2 m and base radius 0.5 m. A uniform object is made by drilling a cylindrical hole of radius 0.2 m through the cone along the axis of symmetry (see diagram).

**(i)** Show that the height of the object is 0.72 m and that the volume of the cone removed by the drilling is $0.0352\pi\,\text{m}^3$. [4]

[The volume of a cone is $\frac{1}{3}\pi r^2 h$.]

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**(ii)** Find the distance of the centre of mass of the object from its base. [6]

## Additional Page

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