Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	CANDIDATE NUMBER

* 1 6 9 4 4 6 9 8 2 2 *

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **February/March 2017**

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.
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.

This document consists of **13** printed pages and **3** blank pages.

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1 A small ball is projected with speed $15\ \text{m s}^{-1}$ at an angle of 60° above the horizontal. Find the distance from the point of projection of the ball at the instant when it is travelling horizontally. [5]

2 A cylindrical container is open at the top. The curved surface and the circular base of the container are both made from the same thin uniform material. The container has radius 0.2 m and height 0.9 m.

(i) Show that the centre of mass of the container is 0.405 m from the base. [3]

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The container is placed with its base on a rough inclined plane. The container is in equilibrium on the point of slipping down the plane and also on the point of toppling.

(ii) Find the coefficient of friction between the container and the plane. [3]

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3 A particle P is projected with speed $20\,\text{m}\,\text{s}^{-1}$ at an angle of $60°$ below the horizontal, from a point O which is 30 m above horizontal ground.

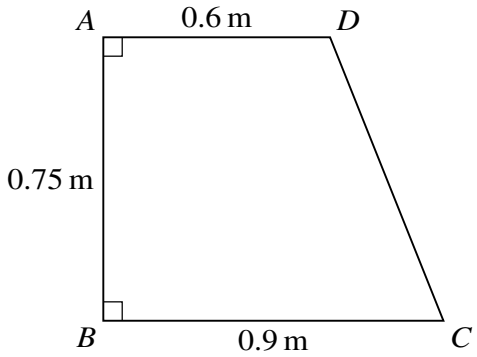
(i) Calculate the time taken by P to reach the ground. [3]

(ii) Calculate the speed and direction of motion of P immediately before it reaches the ground. [4]

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4



The diagram shows a uniform lamina $ABCD$ with $AB = 0.75$ m, $AD = 0.6$ m and $BC = 0.9$ m. Angle BAD = angle $ABC = 90°$.

(i) Show that the distance of the centre of mass of the lamina from AB is 0.38 m, and find the distance of the centre of mass from BC. [5]

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The lamina is freely suspended at B and hangs in equilibrium.

(ii) Find the angle between BC and the vertical. [2]

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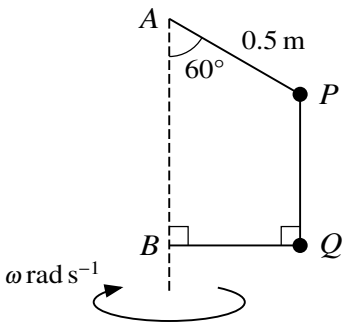
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Two particles P and Q have masses 0.4 kg and m kg respectively. P is attached to a fixed point A by a light inextensible string of length 0.5 m which is inclined at an angle of 60° to the vertical. P and Q are joined to each other by a light inextensible vertical string. Q is attached to a fixed point B, which is vertically below A, by a light inextensible string. The string BQ is taut and horizontal. The particles rotate in horizontal circles about an axis through A and B with constant angular speed ω rad s^{-1} (see diagram). The tension in the string joining P and Q is 1.5 N.

(i) Find the tension in the string AP and the value of ω. [4]

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(ii) Find m and the tension in the string BQ. [3]

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6 O and A are fixed points on a rough horizontal surface, with $OA = 1$ m. A particle P of mass 0.4 kg is projected horizontally with speed $U\,\text{m s}^{-1}$ from A in the direction OA and moves in a straight line. After projection, when the displacement of P from O is x m, the velocity of P is $v\,\text{m s}^{-1}$. The coefficient of friction between the surface and P is 0.4. A force of magnitude $\frac{0.8}{x}$ N acts on P in the direction PO.

(i) Show that, while the particle is in motion, $v\frac{\mathrm{d}v}{\mathrm{d}x} = -4 - \frac{2}{x}$. [3]

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It is given that P comes to instantaneous rest between $x = 2.0$ and $x = 2.1$.

(ii) Find the set of possible values of U. [5]

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7 One end of a light elastic string of natural length 0.6 m and modulus of elasticity 24 N is attached to a fixed point O. The other end of the string is attached to a particle P of mass 0.4 kg which hangs in equilibrium vertically below O.

(i) Calculate the extension of the string. [2]

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P is projected vertically downwards from the equilibrium position with speed $5\,\text{m}\,\text{s}^{-1}$.

(ii) Calculate the distance P travels before it is first at instantaneous rest. [4]

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When P is first at instantaneous rest a stationary particle of mass 0.4 kg becomes attached to P.

(iii) Find the greatest speed of the combined particle in the subsequent motion. [4]

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