Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

6137780864

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **May/June 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 **14** printed pages and **2** blank pages.

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1 A particle P of mass 0.2 kg moves with speed 4 m s^{-1} and angular speed 5 rad s^{-1} in a horizontal circle on a smooth surface. P is attached to one end of a light elastic string of natural length 0.6 m. The other end of the string is attached to the point on the surface which is the centre of the circular motion of P.

(i) Find the radius of this circle. [1]

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(ii) Find the modulus of elasticity of the string. [4]

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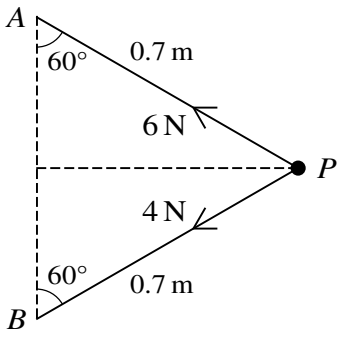

The ends of two light inextensible strings of length 0.7 m are attached to a particle P. The other ends of the strings are attached to two fixed points A and B which lie in the same vertical line with A above B. The particle P moves in a horizontal circle which has its centre at the mid-point of AB. Both strings are inclined at 60° to the vertical. The tension in the string attached to A is 6 N and the tension in the string attached to B is 4 N (see diagram).

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

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(ii) Calculate the speed of P. [3]

3 An open box in the shape of a cube with edges of length 0.2 m is placed with its base horizontal and its four sides vertical. The four sides and base are uniform laminas, each with weight 3 N.

(i) Calculate the height of the centre of mass of the box above its base. [3]

The box is now fitted with a thin uniform square lid of weight 3 N and with edges of length 0.2 m. The lid is attached to the box by a hinge of length 0.2 m and weight 2 N. The lid of the box is held partly open.

(ii) Find the angle which the lid makes with the horizontal when the centre of mass of the box (including the lid and hinge) is 0.12 m above the base of the box. [4]

4 A small object of mass 0.4 kg is released from rest at a point 8 m above the ground. The object descends vertically and when its downwards displacement from its initial position is x m the object has velocity v m s^{-1}. While the object is moving, a force of magnitude $0.2v^2$ N opposes the motion.

(i) Show that $v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 10 - 0.5v^2$. [2]

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(ii) Express v in terms of x. [4]

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(iii) Find the increase in the value of v during the final 4 m of the descent of the object. [2]

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5 A particle of mass 0.3 kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 6 N. The other end of the string is attached to a fixed point O. The particle is projected vertically downwards from O with initial speed $2\,\text{m}\,\text{s}^{-1}$.

(i) Calculate the greatest speed of the particle during its descent. [5]

(ii) Find the greatest distance of the particle below O. [3]

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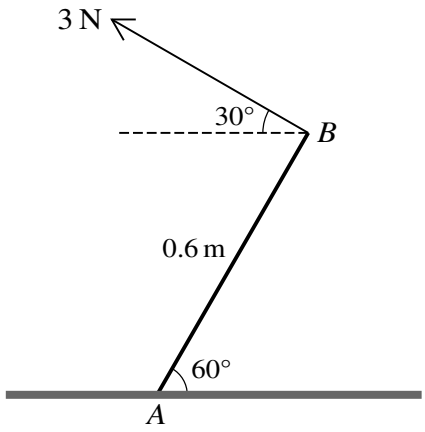

The end A of a non-uniform rod AB of length 0.6 m and weight 8 N rests on a rough horizontal plane, with AB inclined at 60° to the horizontal. Equilibrium is maintained by a force of magnitude 3 N applied to the rod at B. This force acts at 30° above the horizontal in the vertical plane containing the rod (see diagram).

(i) Find the distance of the centre of mass of the rod from A. [2]

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The 3 N force is removed, and the rod is held in equilibrium by a force of magnitude P N applied at B, acting in the vertical plane containing the rod, at an angle of 30° below the horizontal.

(ii) Calculate P. [2]

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In one of the two situations described, the rod AB is in limiting equilibrium.

(iii) Find the coefficient of friction at A. [4]

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7 A particle P is projected from a point O with speed V m s^{-1}. At time t s after projection the horizontal and vertically upwards displacements of P from O are x m and y m respectively. The equation of the trajectory of P is $y = 2x - \frac{25x^2}{V^2}$.

(i) Write down the value of $\tan\theta$, where θ is the angle of projection of P. [1]

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When $t = 4$, P passes through the point A where $x = y = a$.

(ii) Calculate V and a. [5]

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(iii) Find the direction of motion of P when it passes through A. [3]

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