Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/51**

Paper 5 Mechanics 2 **(M2)** **May/June 2014**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

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READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name on all the work you hand in.
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 $10\,\text{m}\,\text{s}^{-2}$.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

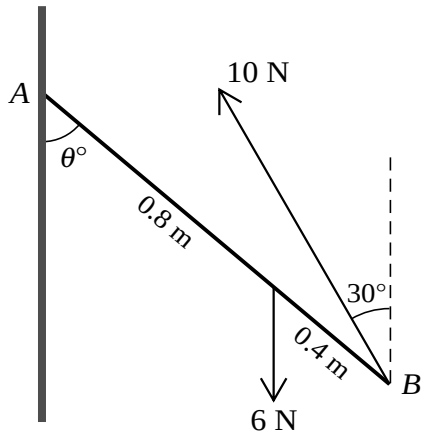
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **4** printed pages.

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1 A particle is projected with speed $12\,\text{m s}^{-1}$ from a point on horizontal ground. The particle strikes the ground 1.6 s after the instant of projection. Calculate the angle of projection. [2]

2



A non-uniform rod AB of weight 6 N rests in limiting equilibrium with the end A in contact with a rough vertical wall. $AB = 1.2$ m, the centre of mass of the rod is 0.8 m from A, and the angle between AB and the downward vertical is $\theta°$. A force of magnitude 10 N acting at an angle of 30° to the upwards vertical is applied to the rod at B (see diagram). The rod and the line of action of the 10 N force lie in a vertical plane perpendicular to the wall. Calculate

(i) the value of θ, [4]

(ii) the coefficient of friction between the rod and the wall. [2]

3 A light elastic string has natural length 0.8 m and modulus of elasticity 16 N. One end of the string is attached to a fixed point O, and a particle P of mass 0.4 kg is attached to the other end of the string. The particle P hangs in equilibrium vertically below O.

(i) Show that the extension of the string is 0.2 m. [2]

P is projected vertically downwards from the equilibrium position. P first comes to instantaneous rest at the point where $OP = 1.4$ m.

(ii) Calculate the speed at which P is projected. [3]

(iii) Find the speed of P at the first instant when the string subsequently becomes slack. [2]

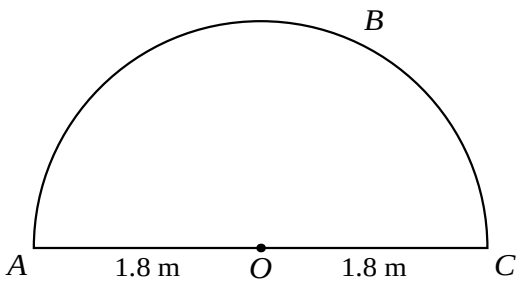
4 A particle P is projected with speed $20\,\text{m s}^{-1}$ at an angle of 40° above the horizontal from a point O on horizontal ground.

(i) Find the height of P above the ground when P has speed $18\,\text{m s}^{-1}$. [2]

(ii) Calculate the length of time for which the speed of P is less than $18\,\text{m s}^{-1}$, and find the horizontal distance travelled by P during this time. [6]

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5



A uniform metal frame $OABC$ is made from a semicircular arc ABC of radius 1.8 m, and a straight rod AOC with $AO = OC = 1.8$ m (see diagram).

(i) Calculate the distance of the centre of mass of the frame from O. [3]

A uniform semicircular lamina of radius 1.8 m has weight 27.5 N. A non-uniform object is formed by attaching the frame $OABC$ around the perimeter of the lamina. The object is freely suspended from a fixed point at A and hangs in equilibrium. The diameter AOC of the object makes an angle of 22° with the vertical.

(ii) Calculate the weight of the frame. [5]

6 A particle P of mass 0.6 kg is released from rest at a point above ground level and falls vertically. The motion of P is opposed by a force of magnitude $3v$ N, where v m s^{-1} is the speed of P. Immediately before P reaches the ground, $v = 1.95$.

(i) Calculate the time after its release when P reaches the ground. [5]

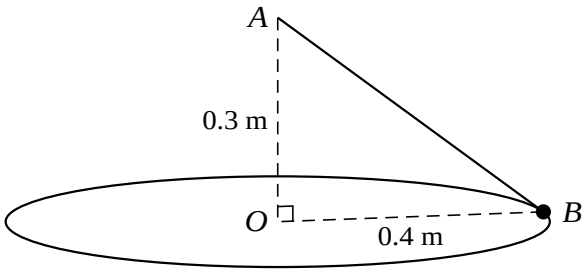
P is now projected horizontally with speed 1.95 m s^{-1} across a smooth horizontal surface. The motion of P is again opposed by a force of magnitude $3v$ N, where v m s^{-1} is the speed of P.

(ii) Calculate the distance P travels after projection before coming to rest. [3]

[Question 7 is printed on the next page.]

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7



A small bead B of mass m kg moves with constant speed in a horizontal circle on a fixed smooth wire. The wire is in the form of a circle with centre O and radius 0.4 m. One end of a light elastic string of natural length 0.4 m and modulus of elasticity $42m$ N is attached to B. The other end of the string is attached to a fixed point A which is 0.3 m vertically above O (see diagram).

(i) Show that the vertical component of the contact force exerted by the wire on the bead is $3.7m$ N upwards. [3]

(ii) Given that the contact force has zero horizontal component, find the angular speed of B. [2]

(iii) Given instead that the horizontal component of the contact force has magnitude $2m$ N, find the two possible speeds of B. [3]

The string is now removed. B again moves on the wire in a horizontal circle with constant speed. It is given that the vertical and horizontal components of the contact force exerted by the wire on the bead have equal magnitudes.

(iv) Find the speed of B. [3]

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