Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **May/June 2015**

1 hour 15 minutes

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

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 $10\,\mathrm{m\,s^{-2}}$.
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.
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 P of mass 0.6 kg is on the rough surface of a horizontal disc with centre O. The distance OP is 0.4 m. The disc and P rotate with angular speed $3\,\text{rad}\,\text{s}^{-1}$ about a vertical axis which passes through O. Find the magnitude of the frictional force which the disc exerts on the particle, and state the direction of this force. [3]

2 One end of a light elastic string of natural length 0.5 m and modulus of elasticity 30 N is attached to a fixed point O. The other end of the string is attached to a particle P which hangs in equilibrium vertically below O, with $OP = 0.8$ m.

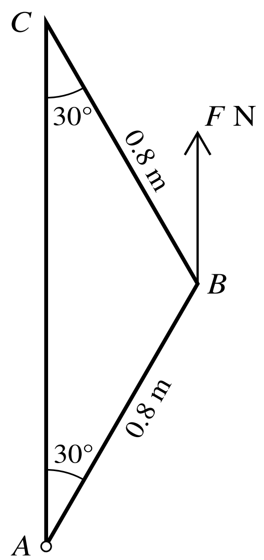
(i) Show that the mass of P is 1.8 kg. [2]

The particle is pulled vertically downwards and released from rest from the point where $OP = 1.2$ m.

(ii) Find the speed of P at the instant when the string first becomes slack. [3]

3 A triangular frame ABC consists of two uniform rigid rods each of length 0.8 m and weight 3 N, and a longer uniform rod of weight 4 N. The triangular frame has $AB = BC$, and angle BAC = angle $BCA = 30°$.

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



The vertex A of the frame is attached to a smooth hinge at a fixed point. The frame is held in equilibrium with AC vertical by a vertical force of magnitude F N applied to the frame at B (see diagram).

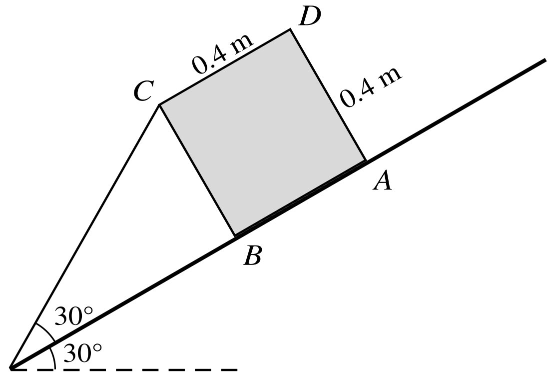
(ii) Calculate F, and state the magnitude and direction of the force acting on the frame at the hinge. [3]

4 One end of a light inextensible string of length 0.5 m is attached to a fixed point A. The other end of the string is attached to a particle P of weight 6 N. Another light inextensible string of length 0.5 m connects P to a fixed point B which is 0.8 m vertically below A. The particle P moves with constant speed in a horizontal circle with centre at the mid-point of AB. Both strings are taut.

(i) Calculate the speed of P when the tension in the string BP is 2 N. [5]

(ii) Show that the angular speed of P must exceed 5 rad s^{-1}. [3]

5



A uniform solid cube with edges of length 0.4 m rests in equilibrium on a rough plane inclined at an angle of 30° to the horizontal. $ABCD$ is a cross-section through the centre of mass of the cube, with AB along a line of greatest slope. B lies below the level of A. One end of a light elastic string with modulus of elasticity 12 N and natural length 0.4 m is attached to C. The other end of the string is attached to a point below the level of B on the same line of greatest slope, such that the string makes an angle of 30° with the plane (see diagram). The cube is on the point of toppling. Find

(i) the tension in the string, [3]

(ii) the weight of the cube. [4]

[Questions 6 and 7 are printed on the next page.]

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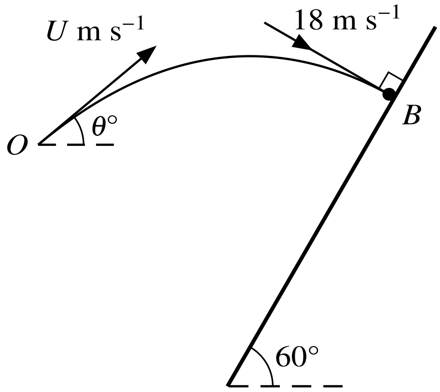

Fig. 1

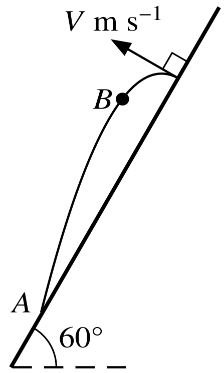

Fig. 2

A small ball B is projected with speed $U\,\mathrm{m\,s^{-1}}$ at an angle of $\theta°$ above the horizontal from a point O. At time 2 s after the instant of projection, B strikes a smooth wall which slopes at 60° to the horizontal. The speed of B is $18\,\mathrm{m\,s^{-1}}$ and its direction of motion is perpendicular to the wall at the instant of impact (see Fig. 1). B bounces off the wall with speed $V\,\mathrm{m\,s^{-1}}$ in a direction perpendicular to the wall. At time 0.8 s after B bounces off the wall, B strikes the wall again at a lower point A (see Fig. 2).

(i) Find U and θ. [5]

(ii) By considering the motion of B after it bounces off the wall, calculate V. [4]

7 A force of magnitude $0.4t$ N, applied at an angle of 30° above the horizontal, acts on a particle P, where t s is the time since the force starts to act. P is at rest on rough horizontal ground when $t = 0$. The mass of P is 0.2 kg and the coefficient of friction between P and the ground is μ.

(i) Given that P is about to slip when $t = 2$, find μ and the value of t for the instant when P loses contact with the ground. [5]

(ii) While P is moving on the ground, it has velocity $v\,\mathrm{m\,s^{-1}}$ at time t s. Show that

$$\frac{\mathrm{d}v}{\mathrm{d}t} = 2.165t - 4.330,$$

where the coefficients are correct to 4 significant figures. [3]

(iii) Calculate the speed of P when it loses contact with the ground. [4]