Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **October/November 2016**

1 hour 15 minutes

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

An answer booklet is provided inside this question paper. You should follow the instructions on the front cover of the answer booklet. If you need additional answer paper ask the invigilator for a continuation booklet.

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 **4** printed pages and **1** insert.

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1 A stone S is thrown horizontally from the top T of a high tower. At the instant 1.6 s after S is thrown, the line ST makes an angle of 30° below the horizontal. Find the speed with which S is thrown. [3]

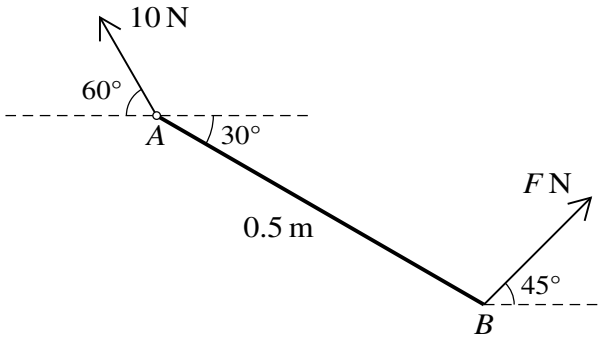
2 A particle P of mass 0.5 kg is attached to one end of a light elastic string with modulus of elasticity 24 N and natural length 0.6 m. The other end of the string is attached to a fixed point A. The particle P hangs in equilibrium vertically below A.

(i) Find the distance AP. [2]

The particle P is raised to A and released from rest.

(ii) Calculate the greatest speed of P in the subsequent motion. [3]

3



A non-uniform rod AB of length 0.5 m is freely hinged to a fixed point at A. The rod is in equilibrium at an angle of 30° with the horizontal with B below the level of A. Equilibrium is maintained by a force of magnitude F N applied at B acting at 45° above the horizontal in the vertical plane containing AB. The force exerted by the hinge on the rod has magnitude 10 N and acts at an angle of 60° above the horizontal (see diagram).

(i) By resolving horizontally and vertically, calculate F and the weight of the rod. [4]

(ii) Find the distance of the centre of mass of the rod from A. [3]

4 A particle P is projected with speed $20\,\text{m s}^{-1}$ at an angle of 30° above the horizontal from a point O on horizontal ground. P subsequently bounces when it first strikes the ground at the point A.

(i) Find the time after projection when P first strikes the ground, and the distance OA. [3]

When P bounces at A the horizontal component of the velocity of P is unchanged. The vertical component of velocity is $8\,\text{m s}^{-1}$ immediately after bouncing. P strikes the ground for the second time at B where it remains at rest.

(ii) Calculate the first and last times after projection at which the speed of P is $18\,\text{m s}^{-1}$. [5]

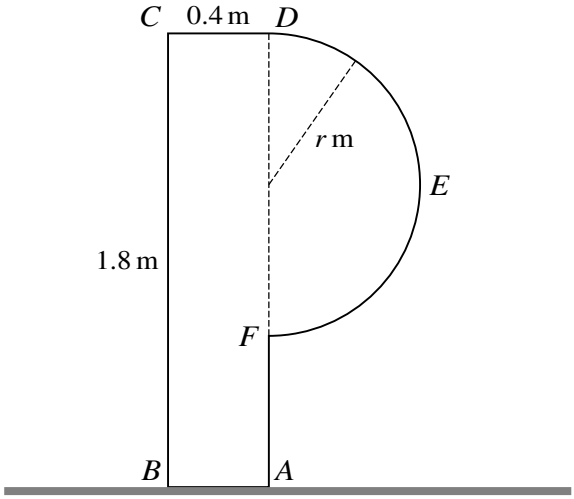
5 A particle P of mass 0.4 kg is released from rest at a point O on a smooth plane inclined at 30° to the horizontal. A force of magnitude $3e^{-t}$ N directed up a line of greatest slope acts on P, where t s is the time after release.

(i) Show that $\frac{dv}{dt} = 7.5e^{-t} - 5$, where v m s^{-1} is the velocity of P up the plane at time t s. [2]

(ii) Express v in terms of t. [3]

(iii) Find the distance of P from O when v has its maximum value. [3]

6



The diagram shows the cross-section $ABCDEF$ through the centre of mass of a uniform prism which rests with AB on rough horizontal ground. $ABCD$ is a rectangle with $AB = CD = 0.4$ m and $BC = AD = 1.8$ m. The other part of the cross-section is a semicircle with diameter DF and radius r m.

(i) Given that the prism is on the point of toppling, show that $r = 0.6$. [3]

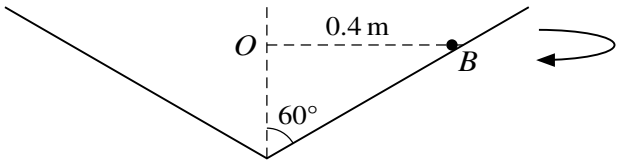
A force of magnitude P N is applied to the prism, acting at 60° to the upwards vertical along a tangent to the semicircle at a point between D and E. The prism has weight 15 N and is in equilibrium on the point of toppling about B.

(ii) Show that $P = 3.26$, correct to 3 significant figures. [4]

(iii) Find the smallest possible value of the coefficient of friction between the prism and the ground. [2]

[Question 7 is printed on the next page.]

7



A small ball B of mass 0.5 kg moves in a horizontal circle with centre O and radius 0.4 m on the smooth inner surface of a hollow cone fixed with its vertex down. The axis of the cone is vertical and the semi-vertical angle is 60° (see diagram).

(i) Show that the magnitude of the force exerted by the cone on B is 5.77 N, correct to 3 significant figures, and calculate the angular speed of B. [4]

One end of a light elastic string of natural length 0.45 m and modulus of elasticity 36 N is attached to B. The other end of the string is attached to the point on the axis 0.3 m above O. The ball B again moves on the surface of the cone in the same horizontal circle as before.

(ii) Calculate the speed of B. [6]