UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/53**

Paper 5 Mechanics 2 **(M2)** **October/November 2010**

1 hour 15 minutes

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

* 3 5 3 3 2 1 1 7 2 1 *

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 a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

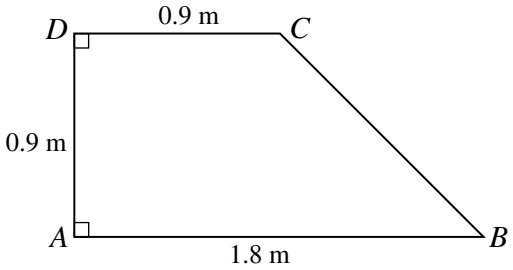
Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\text{m}\,\text{s}^{-2}$.
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



$ABCD$ is a uniform lamina with $AB = 1.8$ m, $AD = DC = 0.9$ m, and AD perpendicular to AB and DC (see diagram).

(i) Find the distance of the centre of mass of the lamina from AB and the distance from AD. [4]

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

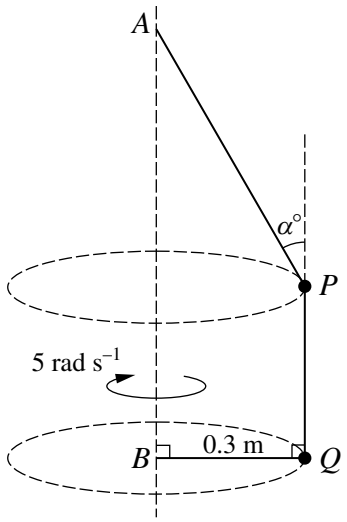
(ii) Calculate the angle between AB and the vertical. [2]

2 A particle P is projected with speed $26\,\text{m s}^{-1}$ at an angle of 30° above the horizontal from a point O on a horizontal plane.

(i) For the instant when the vertical component of the velocity of P is $5\,\text{m s}^{-1}$ downwards, find the direction of motion of P and the height of P above the plane. [4]

(ii) P strikes the plane at the point A. Calculate the time taken by P to travel from O to A and the distance OA. [3]

3



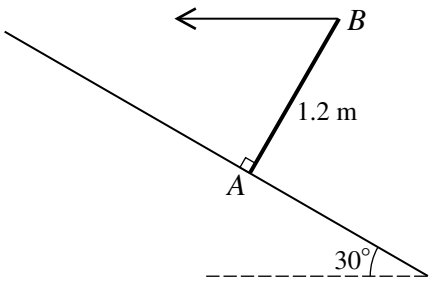
Particles P and Q have masses 0.8 kg and 0.4 kg respectively. P is attached to a fixed point A by a light inextensible string which is inclined at an angle α° to the vertical. Q is attached to a fixed point B, which is vertically below A, by a light inextensible string of length 0.3 m. The string BQ is horizontal. P and Q are joined to each other by a light inextensible string which is vertical. The particles rotate in horizontal circles of radius 0.3 m about the axis through A and B with constant angular speed $5\,\text{rad s}^{-1}$ (see diagram).

(i) By considering the motion of Q, find the tensions in the strings PQ and BQ. [3]

(ii) Find the tension in the string AP and the value of α. [5]

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4



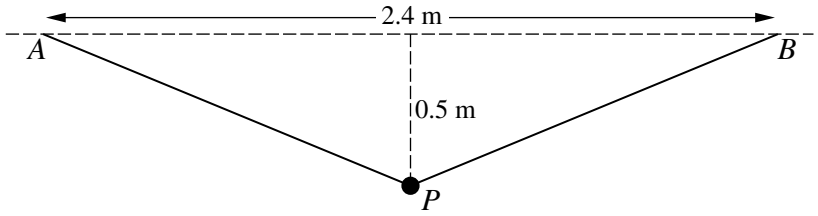
A uniform rod AB has weight 15 N and length 1.2 m. The end A of the rod is in contact with a rough plane inclined at 30° to the horizontal, and the rod is perpendicular to the plane. The rod is held in equilibrium in this position by means of a horizontal force applied at B, acting in the vertical plane containing the rod (see diagram).

(i) Show that the magnitude of the force applied at B is 4.33 N, correct to 3 significant figures. [3]

(ii) Find the magnitude of the frictional force exerted by the plane on the rod. [2]

(iii) Given that the rod is in limiting equilibrium, calculate the coefficient of friction between the rod and the plane. [3]

5



A light elastic string has natural length 2 m and modulus of elasticity λ N. The ends of the string are attached to fixed points A and B which are at the same horizontal level and 2.4 m apart. A particle P of mass 0.6 kg is attached to the mid-point of the string and hangs in equilibrium at a point 0.5 m below AB (see diagram).

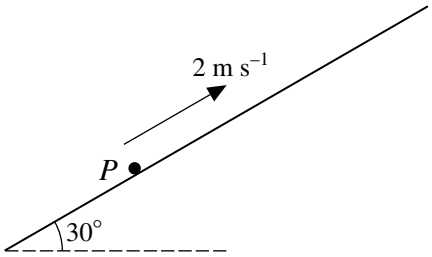
(i) Show that $\lambda = 26$. [4]

P is projected vertically downwards from the equilibrium position, and comes to instantaneous rest at a point 0.9 m below AB.

(ii) Calculate the speed of projection of P. [5]

[Question 6 is printed on the next page.]

6



A particle P of mass 0.2 kg is projected with velocity 2 m s^{-1} upwards along a line of greatest slope on a plane inclined at 30° to the horizontal (see diagram). Air resistance of magnitude $0.5v$ N opposes the motion of P, where v m s^{-1} is the velocity of P at time t s after projection. The coefficient of friction between P and the plane is $\frac{1}{2\sqrt{3}}$. The particle P reaches a position of instantaneous rest when $t = T$.

(i) Show that, while P is moving up the plane, $\frac{\mathrm{d}v}{\mathrm{d}t} = -2.5(3 + v)$. [3]

(ii) Calculate T. [4]

(iii) Calculate the speed of P when $t = 2T$. [5]

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