UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/51**

Paper 5 Mechanics 2 **(M2)** **May/June 2011**

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

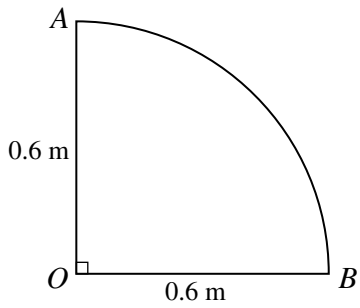
Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\text{m}\,\text{s}^{-2}$.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

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1 A particle is projected with speed $15\,\text{m s}^{-1}$ at an angle of 40° above the horizontal from a point on horizontal ground. Calculate the time taken for the particle to hit the ground. [2]

2



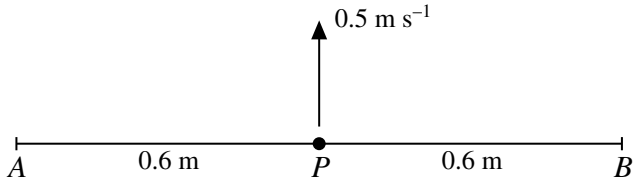
AOB is a uniform lamina in the shape of a quadrant of a circle with centre O and radius 0.6 m (see diagram).

(i) Calculate the distance of the centre of mass of the lamina from A. [3]

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

(ii) Find the angle between the vertical and the side AO of the lamina. [3]

3



A light elastic string of natural length 1.2 m and modulus of elasticity 24 N is attached to fixed points A and B on a smooth horizontal surface, where $AB = 1.2$ m. A particle P is attached to the mid-point of the string. P is projected with speed $0.5\,\text{m s}^{-1}$ along the surface in a direction perpendicular to AB (see diagram). P comes to instantaneous rest at a distance 0.25 m from AB.

(i) Show that the mass of P is 0.8 kg. [3]

(ii) Calculate the greatest deceleration of P. [3]

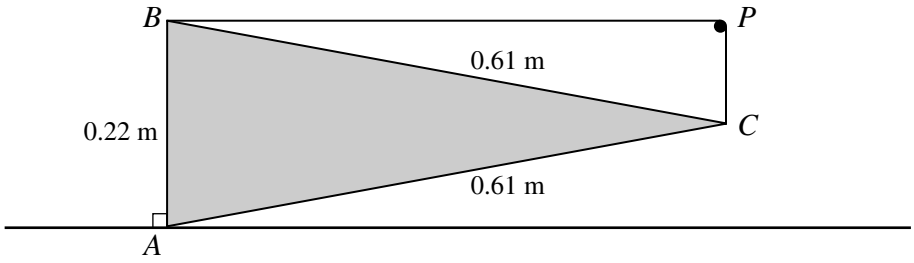
4 A particle P starts from rest at a point O and travels in a straight line. The acceleration of P is $(15 - 6x)\,\text{m s}^{-2}$, where x m is the displacement of P from O.

(i) Find the value of x for which P reaches its maximum velocity, and calculate this maximum velocity. [5]

(ii) Calculate the acceleration of P when it is at instantaneous rest and $x > 0$. [2]

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5



ABC is a uniform triangular lamina of weight 19 N, with $AB = 0.22$ m and $AC = BC = 0.61$ m. The plane of the lamina is vertical. A rests on a rough horizontal surface, and AB is vertical. The equilibrium of the lamina is maintained by a light elastic string of natural length 0.7 m which passes over a small smooth peg P and is attached to B and C. The portion of the string attached to B is horizontal, and the portion of the string attached to C is vertical (see diagram).

(i) Show that the tension in the string is 10 N. [3]

(ii) Calculate the modulus of elasticity of the string. [2]

(iii) Find the magnitude and direction of the force exerted by the surface on the lamina at A. [3]

6 A particle P is projected from a point O on horizontal ground. 0.4 s after the instant of projection, P is 5 m above the ground and a horizontal distance of 12 m from O.

(i) Calculate the initial speed and the angle of projection of P. [6]

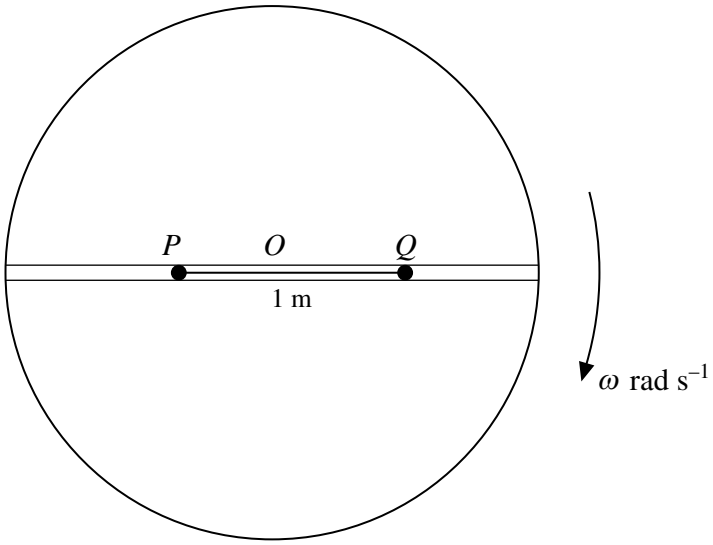
(ii) Find the direction of motion of the particle 0.4 s after the instant of projection. [3]

[Question 7 is printed on the next page.]

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[Turn over

7



A narrow groove is cut along a diameter in the surface of a horizontal disc with centre O. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, lie in the groove, and the coefficient of friction between each of the particles and the groove is μ. The particles are attached to opposite ends of a light inextensible string of length 1 m. The disc rotates with angular velocity ω rad s^{-1} about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

(i) Given that $\mu = 0.36$ and that both P and Q move in the same horizontal circle of radius 0.5 m, calculate the greatest possible value of ω and the corresponding tension in the string. [6]

(ii) Given instead that $\mu = 0$ and that the tension in the string is 0.48 N, calculate

(a) the radius of the circle in which P moves and the radius of the circle in which Q moves, [3]

(b) the speeds of the particles. [3]

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