UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/51**

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

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.

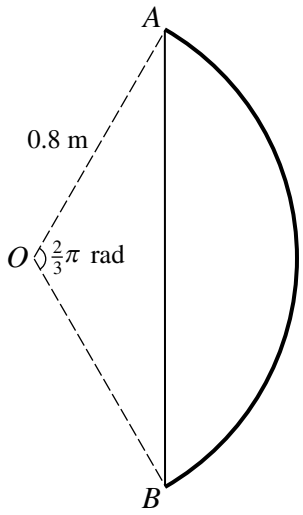
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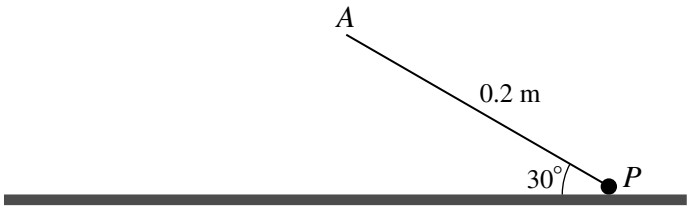
1 A horizontal circular disc rotates with constant angular speed $9\,\text{rad}\,\text{s}^{-1}$ about its centre O. A particle of mass 0.05 kg is placed on the disc at a distance 0.4 m from O. The particle moves with the disc and no sliding takes place. Calculate the magnitude of the resultant force exerted on the particle by the disc. [3]

2



A bow consists of a uniform curved portion AB of mass 1.4 kg, and a uniform taut string of mass m kg which joins A and B. The curved portion AB is an arc of a circle centre O and radius 0.8 m. Angle AOB is $\frac{2}{3}\pi$ radians (see diagram). The centre of mass of the bow (including the string) is 0.65 m from O. Calculate m. [6]

3



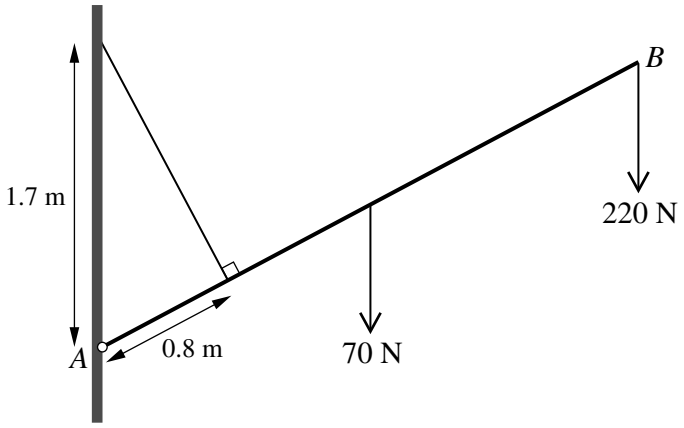
One end of a light inextensible string of length 0.2 m is attached to a fixed point A which is above a smooth horizontal surface. A particle P of mass 0.6 kg is attached to the other end of the string. P moves in a circle on the surface with constant speed $v\,\text{m}\,\text{s}^{-1}$, with the string taut and making an angle of 30° to the horizontal (see diagram).

(i) Given that $v = 1.5$, calculate the magnitude of the force that the surface exerts on P. [4]

(ii) Given instead that P moves with its greatest possible speed while remaining in contact with the surface, find v. [3]

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4



A uniform beam AB has length 2 m and weight 70 N. The beam is hinged at A to a fixed point on a vertical wall, and is held in equilibrium by a light inextensible rope. One end of the rope is attached to the wall at a point 1.7 m vertically above the hinge. The other end of the rope is attached to the beam at a point 0.8 m from A. The rope is at right angles to AB. The beam carries a load of weight 220 N at B (see diagram).

(i) Find the tension in the rope. [3]

(ii) Find the direction of the force exerted on the beam at A. [4]

5 A particle P of mass 0.28 kg is attached to the mid-point of a light elastic string of natural length 4 m. The ends of the string are attached to fixed points A and B which are at the same horizontal level and 4.8 m apart. P is released from rest at the mid-point of AB. In the subsequent motion, the acceleration of P is zero when P is at a distance 0.7 m below AB.

(i) Show that the modulus of elasticity of the string is 20 N. [4]

(ii) Calculate the maximum speed of P. [3]

6 A cyclist and his bicycle have a total mass of 81 kg. The cyclist starts from rest and rides in a straight line. The cyclist exerts a constant force of 135 N and the motion is opposed by a resistance of magnitude $9v$ N, where v m s^{-1} is the cyclist's speed at time t s after starting.

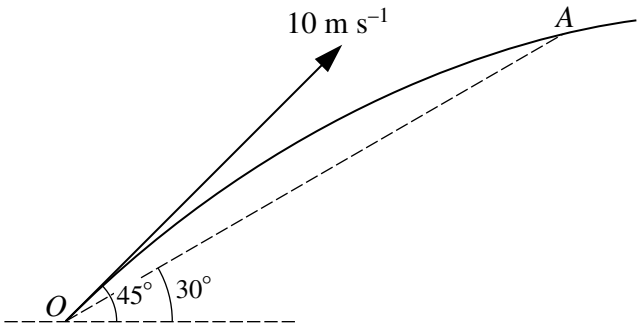
(i) Show that $\dfrac{9}{15 - v}\dfrac{\mathrm{d}v}{\mathrm{d}t} = 1$. [2]

(ii) Solve this differential equation to show that $v = 15\left(1 - \mathrm{e}^{-\frac{1}{9}t}\right)$. [4]

(iii) Find the distance travelled by the cyclist in the first 9 s of the motion. [4]

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7



A particle P is projected from a point O with initial speed $10\,\text{m}\,\text{s}^{-1}$ at an angle of 45° above the horizontal. P subsequently passes through the point A which is at an angle of elevation of 30° from O (see diagram). At time t s after projection the horizontal and vertically upward displacements of P from O are x m and y m respectively.

(i) Write down expressions for x and y in terms of t, and hence obtain the equation of the trajectory of P. [3]

(ii) Calculate the value of x when P is at A. [3]

(iii) Find the angle the trajectory makes with the horizontal when P is at A. [4]

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