

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS

9709/05

Paper 5 Mechanics 2 **(M2)**

October/November 2006

1 hour 15 minutes

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 on both sides of the paper.
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 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.

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.
At the end of the examination, fasten all your work securely together.

This document consists of 4 printed pages.



- 1 A stone is projected horizontally with speed 8 m s^{-1} from a point O at the top of a vertical cliff. The horizontal and vertically upward displacements of the stone from O are $x \text{ m}$ and $y \text{ m}$ respectively.

(i) Find the equation of the stone's trajectory. [2]

The stone enters the sea at a horizontal distance of 24 m from the base of the cliff.

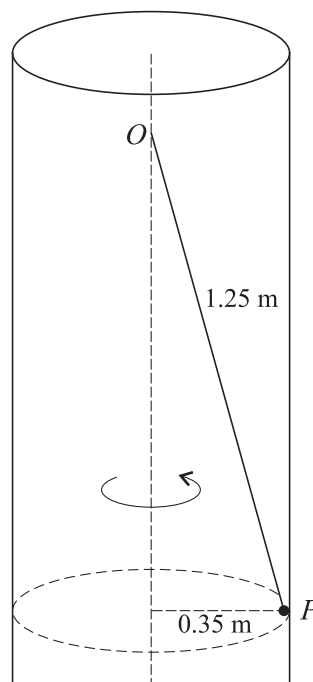
(ii) Find the height above sea level of the top of the cliff. [2]

- 2 A horizontal turntable rotates with constant angular speed 3 rad s^{-1} . A particle of mass 0.06 kg is placed on the turntable at a point 0.25 m from its centre. The coefficient of friction between the particle and the turntable is μ . As the turntable rotates, the particle moves with the turntable and no sliding takes place.

(i) Find the vertical and horizontal components of the contact force exerted on the particle by the turntable. [3]

(ii) Show that $\mu \geq 0.225$. [1]

3



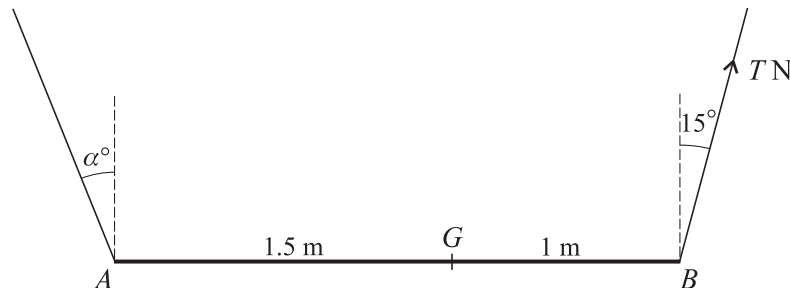
A hollow cylinder of radius 0.35 m has a smooth inner surface. The cylinder is fixed with its axis vertical. One end of a light inextensible string of length 1.25 m is attached to a fixed point O on the axis of the cylinder. A particle P of mass 0.24 kg is attached to the other end of the string. P moves with constant speed in a horizontal circle, in contact with the inner surface of the cylinder, and with the string taut (see diagram).

(i) Find the tension in the string. [2]

(ii) Given that the magnitude of the acceleration of P is 8 m s^{-2} , find the force exerted on P by the cylinder. [3]

- 4 A stone is projected from a point on horizontal ground with speed 25 m s^{-1} at an angle θ above the horizontal, where $\sin \theta = \frac{4}{5}$. At time 1.2 s after projection the stone passes through the point A. Subsequently the stone passes through the point B, which is at the same height above the ground as A. Find the horizontal distance AB. [5]

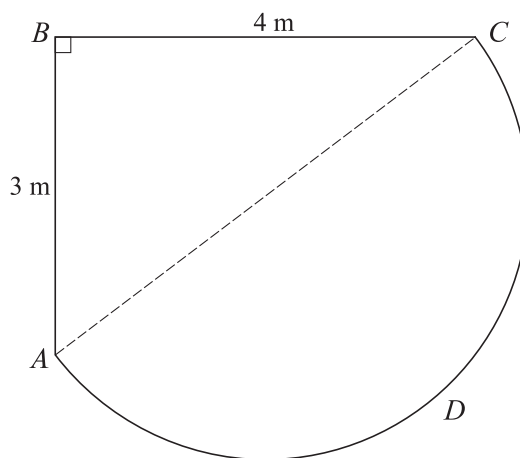
5



A non-uniform rod AB of length 2.5 m and mass 3 kg has its centre of mass at the point G of the rod, where $AG = 1.5 \text{ m}$. The rod hangs horizontally, in equilibrium, from strings attached at A and B . The strings at A and B make angles with the vertical of α° and 15° respectively. The tension in the string at B is $T \text{ N}$ (see diagram). Find

- (i) the value of T , [3]
 (ii) the value of α . [3]

6



A large uniform lamina is in the shape of a right-angled triangle ABC , with hypotenuse AC , joined to a semicircle ADC with diameter AC . The sides AB and BC have lengths 3 m and 4 m respectively, as shown in the diagram.

- (i) Show that the distance from AB of the centre of mass of the semicircular part ADC of the lamina is $\left(2 + \frac{2}{\pi}\right) \text{ m}$. [3]
 (ii) Show that the distance from AB of the centre of mass of the complete lamina is 2.14 m, correct to 3 significant figures. [5]

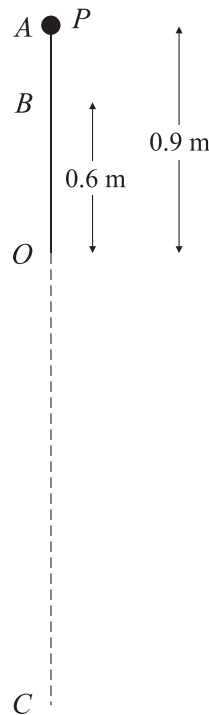
- 7 A cyclist starts from rest at a point O and travels along a straight path. At time t s after starting, the displacement of the cyclist from O is x m, and the acceleration of the cyclist is a m s⁻², where $a = 0.6x^{0.2}$.

(i) Find an expression for the velocity v m s⁻¹ of the cyclist in terms of x . [4]

(ii) Show that $t = 2.5x^{0.4}$. [3]

(iii) Find the distance travelled by the cyclist in the first 10 s of the journey. [2]

8



The diagram shows a light elastic string of natural length 0.6 m and modulus of elasticity 5 N with one end attached to a fixed point O . A particle P of mass 0.2 kg is attached to the other end of the string. P is held at the point A , which is 0.9 m vertically above O . The particle is released from rest and travels vertically downwards through O to the point C , where it starts to move upwards. B is the point of the line AC where the string first becomes slack.

(i) Find the speed of P at B . [4]

(ii) The extension of the string when P is at C is x m.

(a) Show that $x^2 - 0.48x - 0.81 = 0$. [3]

(b) Hence find the distance AC . [2]