CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

HIGHER MATHEMATICS   **8719/05**

MATHEMATICS   **9709/05**

Paper 5 Mechanics 2 **(M2)**

October/November 2003

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 $10 \, \mathrm{m\,s^{-2}}$.
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.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

This document consists of **4** printed pages.

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Local Examinations Syndicate   **[Turn over**

1 A railway engine of mass 50 000 kg travels at a constant speed of $25\,\mathrm{m\,s^{-1}}$ on a horizontal circular track of radius 1250 m. Find the magnitude of the horizontal force on the engine. [3]
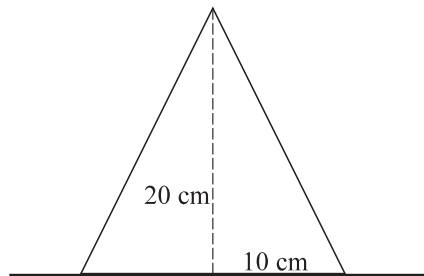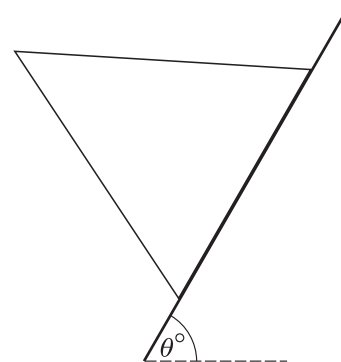
2

20 cm

10 cm

Fig. 1

$\theta°$

Fig. 2

A uniform solid cone has height 20 cm and base radius 10 cm. It is placed with its axis vertical on a rough horizontal plane (see Fig. 1). The plane is slowly tilted and the cone remains in equilibrium until the angle of inclination of the plane reaches $\theta°$, when the cone begins to topple without sliding (see Fig. 2).

  (i) Find the value of θ. [3]

  (ii) What can you say about the value of the coefficient of friction between the cone and the plane? [3]

3

P

0.3 m

O
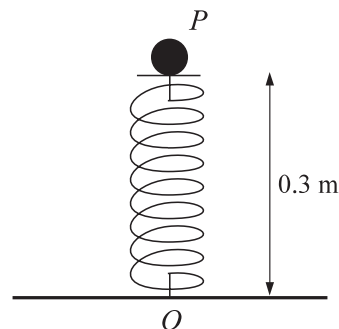
One end of a light elastic spring, of natural length 0.4 m and modulus of elasticity 88 N, is attached to a fixed point O. A particle P of mass 0.2 kg is attached to the other end of the spring and is held, with the spring compressed, at a point 0.3 m vertically above O, as shown in the diagram. P is now released from rest and moves vertically upwards.

  (i) Find the initial acceleration of P. [3]

  (ii) Find the initial elastic potential energy of the spring. [2]

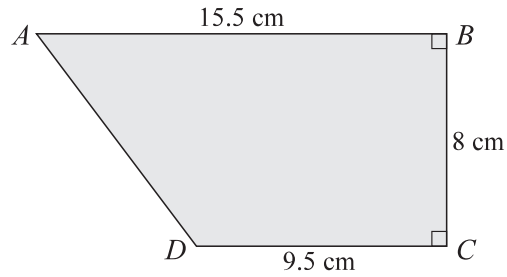 **(iii)** Find the speed of P when the distance OP is 0.4 m. [3]

3

4

Fig. 1

Fig. 1 shows a uniform lamina $ABCD$ with dimensions $AB = 15.5$ cm, $BC = 8$ cm and $CD = 9.5$ cm. Angles ABC and BCD are right angles.

(i) Show that the distance of the centre of mass of the lamina from the side BC is 6.37 cm. [4]
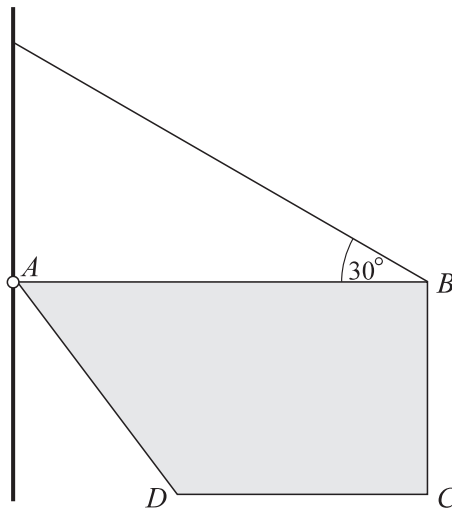

Fig. 2

The lamina is smoothly hinged to a wall at A and is supported, with AB horizontal, by a light wire attached at B. The other end of the wire is attached to a point on the wall, vertically above A, such that the wire makes an angle of 30° with AB (see Fig. 2). The mass of the lamina is 8 kg. Find

(ii) the tension in the wire, [4]

(iii) the magnitude of the vertical component of the force acting on the lamina at A. [2]

[Turn over

5 A stone is projected from a point on horizontal ground with a speed of $20\,\mathrm{m\,s^{-1}}$ at an angle of $\alpha°$ above the horizontal. The stone is moving horizontally when it hits a vertical wall at a point $7.2\,\mathrm{m}$ above the ground.

  (i) Find the value of α. [4]

After rebounding at right angles from the wall the speed of the stone is halved. Find

  (ii) the distance from the wall of the point at which the stone hits the ground, [4]

  (iii) the angle which the direction of motion of the stone makes with the horizontal, immediately before the stone hits the ground. [3]

6 A cyclist and his machine have a total mass of $80\,\mathrm{kg}$. The cyclist starts from rest and rides from the bottom to the top of a straight slope inclined at an angle θ to the horizontal, where $\sin\theta = 0.1$. The cyclist exerts a constant force of magnitude $120\,\mathrm{N}$. There is a resisting force of magnitude $8v\,\mathrm{N}$ acting on the cyclist, where $v\,\mathrm{m\,s^{-1}}$ is the cyclist's speed at time $t\,\mathrm{s}$ after the start.

  (i) Show that $\left(\dfrac{1}{5-v}\right)\dfrac{\mathrm{d}v}{\mathrm{d}t} = \dfrac{1}{10}$. [3]

  (ii) Solve this differential equation and hence show that $v = 5\big(1 - \mathrm{e}^{-\frac{1}{10}t}\big)$. [5]

  (iii) Given that the cyclist takes $20\,\mathrm{s}$ to reach the top of the slope, find the length of the slope. [4]