**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**General Certificate of Education Advanced Subsidiary Level**
**General Certificate of Education Advanced Level**

**HIGHER MATHEMATICS** **8719/5**

**MATHEMATICS** **9709/5**

PAPER 5 Mechanics 2 **(M2)**

**OCTOBER/NOVEMBER SESSION 2002**

1 hour 15 minutes

Additional materials:
Answer paper
Graph paper
List of Formulae (MF9)

**TIME** 1 hour 15 minutes

**INSTRUCTIONS TO CANDIDATES**

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

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 $10\,\text{m s}^{-2}$.

**INFORMATION FOR CANDIDATES**

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.

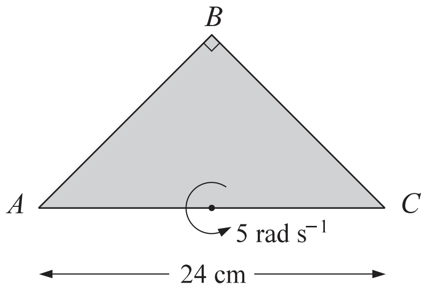
**This question paper consists of 4 printed pages.**



UNIVERSITY *of* CAMBRIDGE
Local Examinations Syndicate

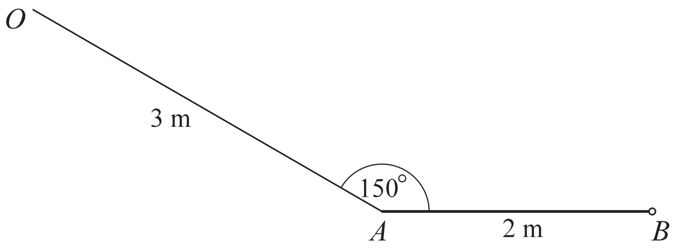
**[Turn over**

1




A uniform isosceles triangular lamina $ABC$ is right-angled at $B$. The length of $AC$ is 24 cm. The lamina rotates in a horizontal plane, about a vertical axis through the mid-point of $AC$, with angular speed $5\,\text{rad s}^{-1}$ (see diagram). Find the speed with which the centre of mass of the lamina is moving. [3]

2

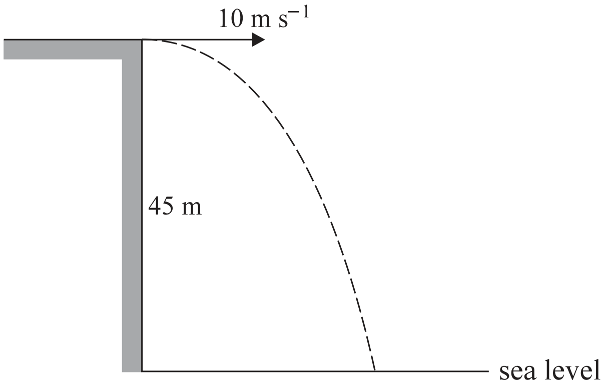



A uniform rod $AB$, of length 2 m and mass 10 kg, is freely hinged to a fixed point at the end $B$. A light elastic string, of modulus of elasticity 200 N, has one end attached to the end $A$ of the rod and the other end attached to a fixed point $O$, which is in the same vertical plane as the rod. The rod is horizontal and in equilibrium, with $OA = 3$ m and angle $OAB = 150°$ (see diagram). Find

**(i)** the tension in the string, [2]

**(ii)** the natural length of the string. [3]

3

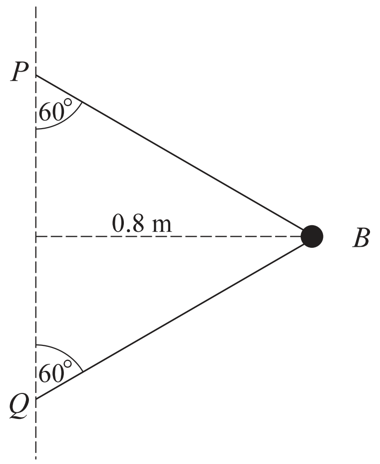



A stone is projected horizontally, with speed $10\,\text{m s}^{-1}$, from the top of a vertical cliff of height 45 m above sea level (see diagram). At time $t$ s after projection the horizontal and vertically upward displacements of the stone from the top of the cliff are $x$ m and $y$ m respectively.

**(i)** Write down expressions for $x$ and $y$ in terms of $t$, and hence obtain the equation of the stone's trajectory. [3]

**(ii)** Find the angle the trajectory makes with the horizontal at the point where the stone reaches sea level. [3]

**4**



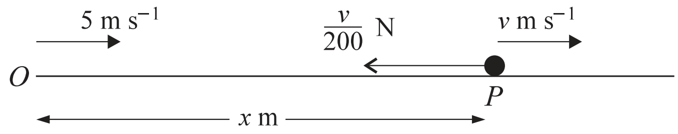

A small ball $B$ of mass 0.5 kg is attached to points $P$ and $Q$ on a fixed vertical axis by two light inextensible strings of equal length. Both of the strings are taut and each is inclined at $60^\circ$ to the vertical, as shown in the diagram. The ball moves with constant speed $4\,\text{m}\,\text{s}^{-1}$ in a horizontal circle of radius 0.8 m. Find the tension in the string $PB$. [6]

**5** A light elastic string has natural length 2 m and modulus of elasticity 1.5 N. One end of the string is attached to a fixed point $O$ of a smooth plane which is inclined at $30^\circ$ to the horizontal. The other end of the string is attached to a particle $P$ of mass 0.075 kg. $P$ is released from rest at $O$. Find

**(i)** the distance of $P$ from $O$ when $P$ is at its lowest point, [5]

**(ii)** the acceleration with which $P$ starts to move up the plane immediately after it has reached its lowest point. [4]

**6**




A particle $P$ of mass $\frac{1}{10}$ kg travels in a straight line on a smooth horizontal surface. It passes through the fixed point $O$ with velocity $5\,\text{m}\,\text{s}^{-1}$ at time $t = 0$. After $t$ seconds its displacement from $O$ is $x$ m and its velocity is $v\,\text{m}\,\text{s}^{-1}$. $P$ is subject to a single force of magnitude $\frac{v}{200}$ N which acts in a direction opposite to the motion (see diagram).

**(i)** Find an expression for $v$ in terms of $x$. [4]

**(ii)** Find an expression for $x$ in terms of $t$. [5]

**(iii)** Show that the value of $x$ is less than 100 for all values of $t$. [1]



**[Turn over**

**7** **(i)**

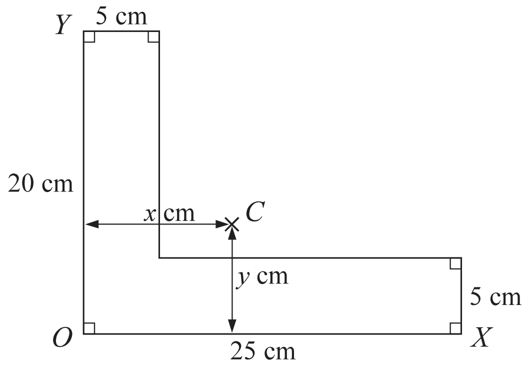



**Fig. 1**

Fig. 1 shows the cross section through the centre of mass $C$ of a uniform L-shaped prism. $C$ is $x$ cm from $OY$ and $y$ cm from $OX$. Find the values of $x$ and $y$. [4]

**(ii)**

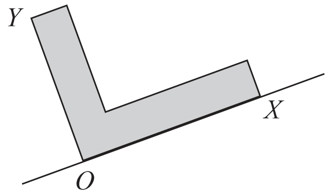



**Fig. 2**

The prism is placed on a rough plane with $OX$ in contact with the plane. The plane is tilted from the horizontal so that $OX$ lies along a line of greatest slope, as shown in Fig. 2. When the angle of inclination of the plane is sufficiently great the prism starts to slide (without toppling). Show that the coefficient of friction between the prism and the plane is less than $\frac{7}{5}$. [4]

**(iii)**

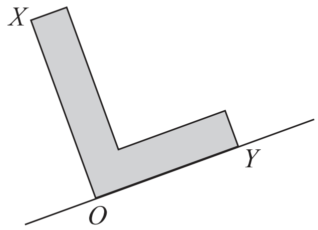



**Fig. 3**

The prism is now placed on a rough plane with $OY$ in contact with the plane. The plane is tilted from the horizontal so that $OY$ lies along a line of greatest slope, as shown in Fig. 3. When the angle of inclination of the plane is sufficiently great the prism starts to topple (without sliding). Find the least possible value of the coefficient of friction between the prism and the plane. [3]