General Certificate of Education
June 2005
Advanced Level Examination

MATHEMATICS
Unit Mechanics 2A

MM2A/W

Thursday 16 June 2005 Afternoon Session

In addition to this paper you will require:
- an 8-page answer book;
- the **blue** AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 15 minutes

Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM2A/W.
- Answer **all** questions.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of tables or calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.
- Unit Mechanics 2A has a **written paper and coursework**.

Advice
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

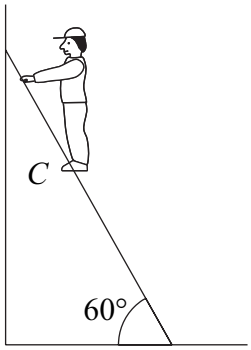
1 A light spring of natural length 0.4 metres and modulus of elasticity λ newtons lies on a smooth horizontal table. One end of the spring is attached to the table at a point O and the other end is attached to a particle. The particle is held in equilibrium on the table by a horizontal force of magnitude 12.5 newtons. In this position the length of the spring is 0.5 metres.

(a) Show that $\lambda = 50$. *(3 marks)*

(b) The horizontal force is removed and the particle, which is of mass 0.2 kg, is released from rest and moves towards O. Calculate its speed when the spring reaches its natural length. *(5 marks)*

2 A uniform ladder of length 3 metres and mass 35 kg rests in equilibrium with its foot on a rough horizontal floor and its top leaning against a smooth vertical wall. The vertical plane containing the ladder is perpendicular to the wall and the angle between the ladder and the floor is 60°.

A man of mass 90 kg is standing at a point C on the ladder. With the man in this position, the ladder is on the point of slipping. The coefficient of friction between the ladder and the floor is 0.3. The man may be modelled as a particle at C.

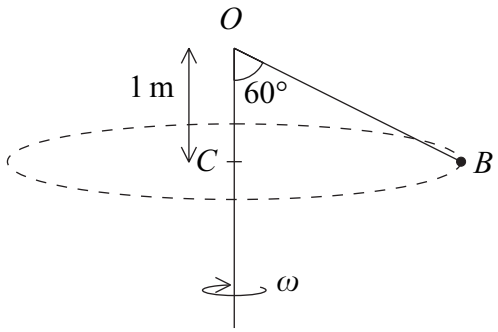


(a) Draw a diagram to show the forces acting on the ladder. *(1 mark)*

(b) Find the magnitude of the frictional force between the ladder and the ground. *(3 marks)*

(c) Show that the man is just over half way up the ladder. *(6 marks)*

3 The diagram shows a light inextensible cord that has one end O attached to the top of a fixed vertical pole.



A ball B of mass 0.4 kg is attached to the other end of the cord. The ball rotates around the pole with constant angular speed ω radians per second. It moves in a horizontal circle with centre C at a distance 1 metre vertically below O. The angle between OB and OC is 60°.

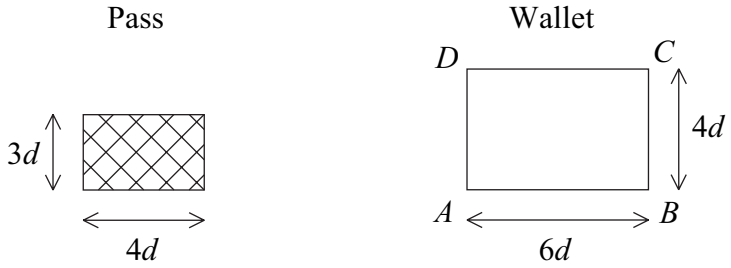
(a) Show that the tension in the cord is 7.84 newtons. *(3 marks)*

(b) Show that $\omega = 3.13$, correct to three significant figures. *(5 marks)*

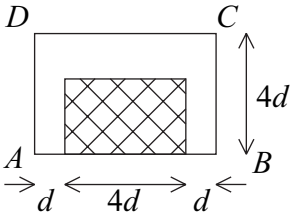
(c) Show that the ball takes approximately two seconds to travel once around the pole. *(1 mark)*

TURN OVER FOR THE NEXT QUESTION

4 A security pass, of length $4d$ and width $3d$, consists of a rectangular piece of plastic. The pass can be carried in a transparent plastic wallet, $ABCD$, where $AB = 6d$ and $BC = 4d$. The pass and the wallet, which may be modelled as uniform laminas, are shown in the diagrams.



The pass is placed inside the wallet with its longer edge along AB and its centre equidistant from BC and AD, as shown in the diagram below.



The mass of the pass is $4M$ and the mass of the wallet is M.

(a) Show that the distance of the centre of mass of the pass and wallet above AB is $1.6d$. *(4 marks)*

(b) The wallet, with the pass still inside and in the position shown in the diagram, is suspended freely from the point C. Find the angle, in degrees, that the edge CD makes with the vertical. *(4 marks)*

5 A particle travels along a straight line. At time t, the velocity of the particle is v. When $t = 0$, $v = u$. The acceleration of the particle throughout the motion is $\frac{k}{v}$, where k is a constant.

Show that

$$v^2 = u^2 + 2kt$$ *(6 marks)*

6 A particle P, of mass 0.25 kg, moves in a horizontal plane so that at time t seconds its velocity $\mathbf{v}\,\mathrm{m\,s^{-1}}$ is given by

$$\mathbf{v} = 8\sin t\,\mathbf{i} + 4\cos t\,\mathbf{j}$$

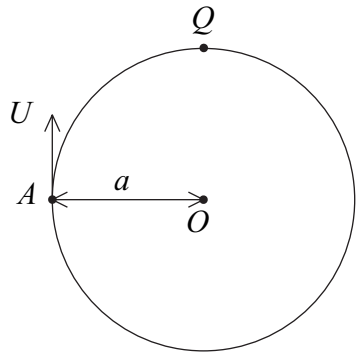
(a) Find the force, $\mathbf{F}$ newtons, acting on P at time t. *(3 marks)*

(b) (i) Show that the magnitude of $\mathbf{F}$ at time t is

$$\sqrt{(3\cos^2 t + 1)}$$ *(3 marks)*

(ii) Hence state the range of values of the magnitude of $\mathbf{F}$. *(2 marks)*

7 A smooth circular wire, of centre O and radius a, is fixed in a vertical plane. A small bead, of mass m, is free to move on the wire. The bead is projected upwards, with initial speed U, from a point A on the wire which is level with O, as shown in the diagram.



(a) Find, in terms of a and g, the least value of U required for the bead to reach the point Q, at the top of the circular wire, in the subsequent motion. *(3 marks)*

(b) If $U = \sqrt{\dfrac{5ag}{2}}$, find the vertical height, h, above the level of O at which the magnitude of the normal reaction between the bead and the wire is zero. *(8 marks)*

END OF QUESTIONS

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