General Certificate of Education
June 2007
Advanced Level Examination

MATHEMATICS **MM2A/W**
Unit Mechanics 2A

Thursday 7 June 2007 9.00 am to 10.15 am

For this paper you must have:
- 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

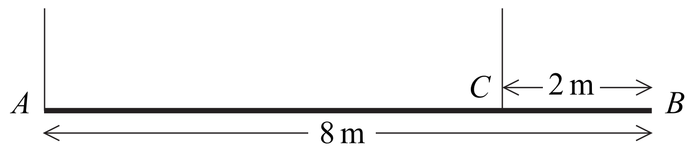
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM2A/W.
- Answer **all** questions.
- Show all necessary working; otherwise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

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

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 A uniform plank, AB, is 8 m long and has mass 30 kg. It is supported in equilibrium in a horizontal position by two vertical inextensible ropes. One of the ropes is attached to the plank at A and the other rope to the point C, where $BC = 2$ m, as shown in the diagram.



Find the tension in each rope. *(5 marks)*

2 A car of mass 1500 kg is travelling along a straight horizontal road. When the car is travelling at a speed of $v\,\mathrm{m\,s^{-1}}$, it experiences a resistance force of magnitude $35v$ newtons.

(a) On this road, the car has a maximum speed of 50 $\mathrm{m\,s^{-1}}$.

Show that the maximum power of the car is 87 500 watts. *(4 marks)*

(b) Find the maximum possible acceleration of the car when its speed on the road is $30\,\mathrm{m\,s^{-1}}$. *(5 marks)*

3 A particle has mass 800 kg. A single force of $(2400\,\mathbf{i} - 4800t\,\mathbf{j})$ newtons acts on the particle at time t seconds. No other forces act on the particle.

(a) Find the acceleration of the particle at time t. *(2 marks)*

(b) At time $t = 0$, the velocity of the particle is $(6\mathbf{i} + 30\mathbf{j})\,\mathrm{m\,s^{-1}}$. The velocity of the particle at time t is $\mathbf{v}\,\mathrm{m\,s^{-1}}$.

Show that

$$\mathbf{v} = (6 + 3t)\,\mathbf{i} + (30 - 3t^2)\,\mathbf{j}$$ *(4 marks)*

(c) Initially, the particle is at the point with position vector $(2\mathbf{i} + 5\mathbf{j})$ m.

Find the position vector, $\mathbf{r}$ metres, of the particle at time t. *(5 marks)*

4 An elastic string of natural length 1.5 metres has one end attached to a fixed point O. A particle of mass 4 kg is attached to the other end of the string. The particle is released from rest at O.

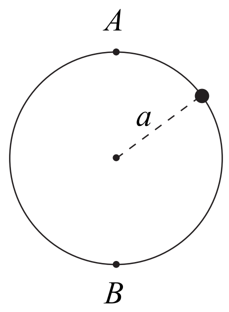
(a) Find the kinetic energy of the particle when the string becomes taut. *(2 marks)*

(b) The particle first comes to rest when it is 3.5 metres below O.

Show that the modulus of elasticity of the string is 103 N, correct to three significant figures. *(4 marks)*

(c) Find the speed of the particle when it is 2.7 metres below O. *(5 marks)*

5 A bead of mass m moves on a smooth circular ring of radius a which is fixed in a vertical plane, as shown in the diagram. Its speed at A, the highest point of its path, is v and its speed at B, the lowest point of its path, is $7v$.



(a) Show that $v = \sqrt{\dfrac{ag}{12}}$. *(5 marks)*

(b) Find the reaction of the ring on the bead, in terms of m and g, when the bead is at A. *(4 marks)*

Turn over for the next question

6 A stone of mass m is moving along the smooth horizontal floor of a tank which is filled with a viscous liquid. At time t, the stone has speed v. As the stone moves, it experiences a resistance force of magnitude λmv, where λ is a constant.

(a) Show that

$$\frac{\mathrm{d}v}{\mathrm{d}t} = -\lambda v$$ *(2 marks)*

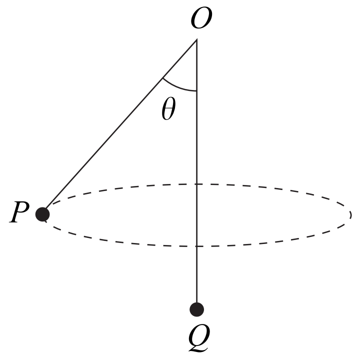
(b) The initial speed of the stone is U.

Show that

$$v = U\mathrm{e}^{-\lambda t}$$ *(4 marks)*

7 A particle, P, of mass 3 kg is attached to one end of a light inextensible string. The string passes through a smooth fixed ring, O, and a second particle, Q, of mass 5 kg is attached to the other end of the string. The particle Q hangs at rest vertically below the ring and the particle P moves with speed $4\,\mathrm{m\,s^{-1}}$ in a horizontal circle, as shown in the diagram.

The angle between OP and the vertical is θ.



(a) Explain why the tension in the string is 49 N. *(2 marks)*

(b) Find θ. *(3 marks)*

(c) Find the radius of the horizontal circle. *(4 marks)*

END OF QUESTIONS