

General Certificate of Education
June 2007
Advanced Level Examination



MATHEMATICS
Unit Mechanics 2A

MM2A/W

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 $g = 9.8 \text{ m s}^{-2}$, unless stated otherwise.

Information

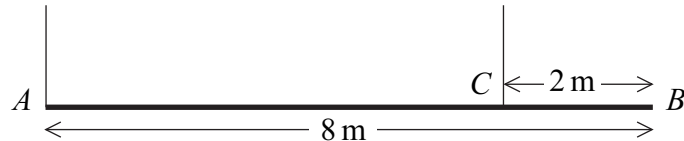
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 2A has a **written paper and coursework**.

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 m s⁻¹, it experiences a resistance force of magnitude $35v$ newtons.

- (a) On this road, the car has a maximum speed of 50 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 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 $(6\mathbf{i} + 30\mathbf{j})$ m s⁻¹. The velocity of the particle at time t is \mathbf{v} m s⁻¹.

Show that

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

- (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 .

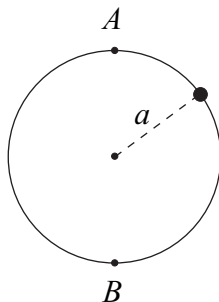
(a) Find the kinetic energy of the particle when the string becomes taut. (2 marks)

(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 $v = \sqrt{\frac{ag}{12}}$. (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

$$\frac{dv}{dt} = -\lambda v \quad (2 \text{ marks})$$

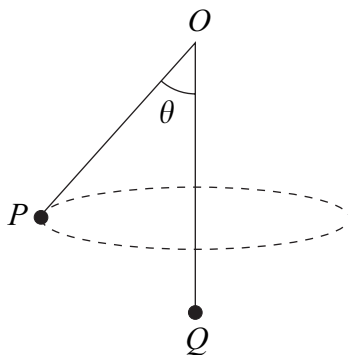
(b) The initial speed of the stone is U .

Show that

$$v = Ue^{-\lambda t} \quad (4 \text{ marks})$$

- 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 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