

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

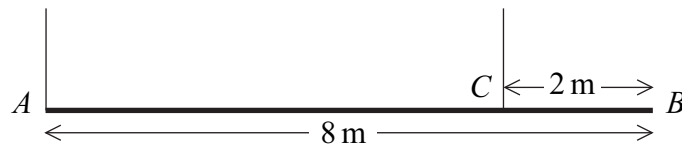
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 2A has a **written paper and coursework**.

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

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 $(2\mathbf{i} + 5\mathbf{j}) \text{ m}$.

Find the position vector, \mathbf{r} metres, of the particle at time t .

(5 marks)

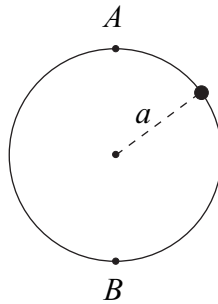
- 4 An elastic string of natural length 1.5 metres has one end attached to a fixed point O . A particle of mass 4 kg is attached to the other end of the string. The particle is released from rest at O .

- (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

Turn over ►

- 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

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

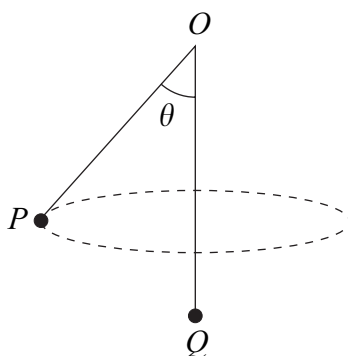
(b) The initial speed of the stone is U .

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