

General Certificate of Education
January 2006
Advanced Level Examination



MATHEMATICS
Unit Mechanics 2A

MM2A/W

Monday 16 January 2006 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.
- All necessary working should be shown; 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

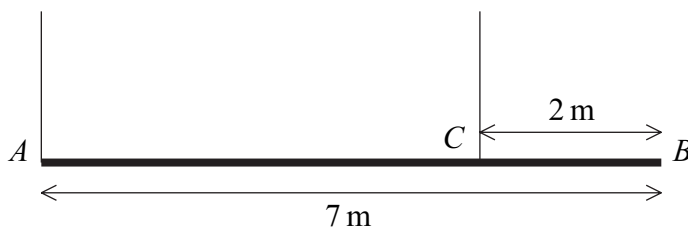
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 2A has a **written paper and coursework**.

Advice

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

Answer **all** questions.

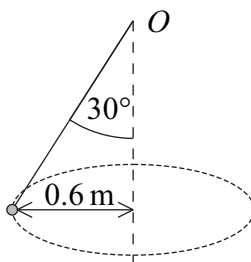
- 1 A uniform beam, AB , has mass 20 kg and length 7 metres. A rope is attached to the beam at A . A second rope is attached to the beam at the point C , which is 2 metres from B . Both of the ropes are vertical. The beam is in equilibrium in a horizontal position, as shown in the diagram.



Find the tensions in the two ropes.

(6 marks)

- 2 A particle, of mass 2 kg, is attached to one end of a light inextensible string. The other end is fixed to the point O . The particle is set into motion, so that it describes a horizontal circle of radius 0.6 metres, with the string at an angle of 30° to the vertical. The centre of the circle is vertically below O .



- (a) Show that the tension in the string is 22.6 N, correct to three significant figures.

(3 marks)

- (b) Find the speed of the particle.

(4 marks)

- 3 A particle moves in a straight line and at time t has velocity v , where

$$v = 2t - 12e^{-t}, \quad t \geq 0$$

- (a) (i) Find an expression for the acceleration of the particle at time t . (2 marks)
- (ii) State the range of values of the acceleration of the particle. (3 marks)
- (b) When $t = 0$, the particle is at the origin.

Find an expression for the displacement of the particle from the origin at time t . (4 marks)

- 4 A car has a maximum speed of 42 m s^{-1} when it is moving on a horizontal road. When the speed of the car is $v \text{ m s}^{-1}$, it experiences a resistance force of magnitude $30v$ newtons.

- (a) Show that the maximum power of the car is $52\,920 \text{ W}$. (2 marks)
- (b) The car has mass 1200 kg . It travels, from rest, up a slope inclined at 5° to the horizontal.

- (i) Show that, when the car is travelling at its maximum speed $V \text{ m s}^{-1}$ up the slope,

$$V^2 + 392 \sin 5^\circ V - 1764 = 0 \quad (4 \text{ marks})$$

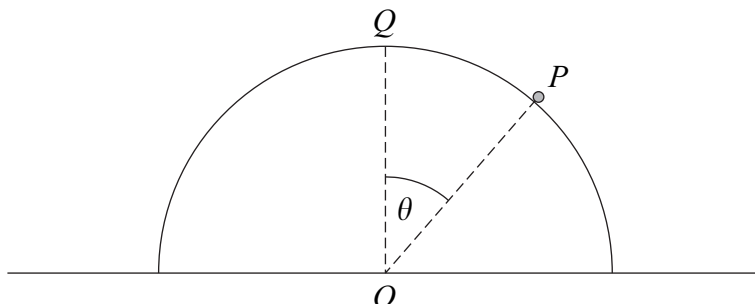
- (ii) Hence find V . (2 marks)

- 5 A car, of mass 1600 kg , is travelling along a straight horizontal road at a speed of 20 m s^{-1} when the driving force is removed. The car then freewheels and experiences a resistance force. The resistance force has magnitude $40v$ newtons, where $v \text{ m s}^{-1}$ is the speed of the car after it has been freewheeling for t seconds.

Find an expression for v in terms of t . (7 marks)

Turn over for the next question

- 6 A particle P , of mass m kg, is placed at the point Q on the top of a smooth upturned hemisphere of radius 3 metres and centre O . The plane face of the hemisphere is fixed to a horizontal table. The particle is set into motion with an initial horizontal velocity of 2 m s^{-1} . When the particle is on the surface of the hemisphere, the angle between OP and OQ is θ and the particle has speed $v \text{ m s}^{-1}$.



- (a) Show that $v^2 = 4 + 6g(1 - \cos \theta)$. (4 marks)
- (b) Find the value of θ when the particle leaves the hemisphere. (5 marks)

- 7 A particle, of mass 10 kg, is attached to one end of a light elastic string of natural length 0.4 metres and modulus of elasticity 100 N. The other end of the string is fixed to the point O .

- (a) Find the length of the elastic string when the particle hangs in equilibrium directly below O . (2 marks)
- (b) The particle is pulled down and held at a point P , which is 1 metre vertically below O .

Show that the elastic potential energy of the string when the particle is in this position is 45 J. (2 marks)

- (c) The particle is released from rest at the point P . In the subsequent motion, the particle has speed $v \text{ m s}^{-1}$ when it is x metres **below** O .

- (i) Show that, while the string is taut,

$$v^2 = 39.6x - 25x^2 - 14.6 \quad (7 \text{ marks})$$

- (ii) Find the value of x when the particle comes to rest for the first time after being released, given that the string is still taut. (3 marks)

END OF QUESTIONS