

General Certificate of Education
January 2008
Advanced Level Examination



MATHEMATICS
Unit Mechanics 2A

MM2A/W

Tuesday 15 January 2008 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.

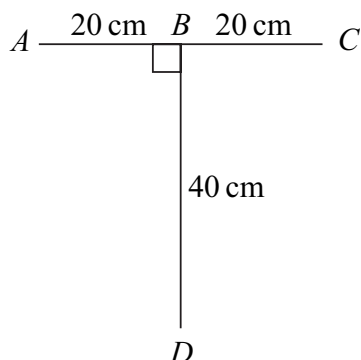
- 1 A ball is thrown vertically upwards from ground level with an initial speed of 15 m s^{-1} . The ball has a mass of 0.6 kg . Assume that the only force acting on the ball after it is thrown is its weight.
- (a) Calculate the initial kinetic energy of the ball. *(2 marks)*
- (b) By using conservation of energy, find the maximum height above ground level reached by the ball. *(3 marks)*
- (c) By using conservation of energy, find the kinetic energy and the speed of the ball when it is at a height of 3 m above ground level. *(4 marks)*

- 2 A particle moves in a horizontal plane under the action of a single force, \mathbf{F} newtons. The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. At time t seconds, the position vector, \mathbf{r} metres, of the particle is given by

$$\mathbf{r} = (t^3 - 3t^2 + 4)\mathbf{i} + (4t + t^2)\mathbf{j}$$

- (a) Find an expression for the velocity of the particle at time t . *(2 marks)*
- (b) The mass of the particle is 3 kg .
- (i) Find an expression for \mathbf{F} at time t . *(3 marks)*
- (ii) Find the magnitude of \mathbf{F} when $t = 3$. *(2 marks)*
- (c) Find the value of t when \mathbf{F} acts due north. *(2 marks)*

- 3 Two identical uniform rods, AC and BD , are rigidly joined together to form a letter T, as shown in the diagram. The two rods are perpendicular.



- (a) Explain why the centre of mass of the letter T lies on BD . (1 mark)
- (b) Find the distance of the centre of mass of the letter T from AC . (3 marks)
- (c) The letter T is freely suspended from A .

Find, to the nearest degree, the angle between AC and the horizontal when the letter T hangs in equilibrium. (3 marks)

- 4 A light elastic string has natural length 6 metres and modulus of elasticity 300 newtons. It has one end attached to a fixed point, A , on a rough horizontal plane. The other end of the string is attached to a particle of mass 4 kilograms. The particle is pulled along the plane until it is 8 metres from the point A . The particle is then released from rest.

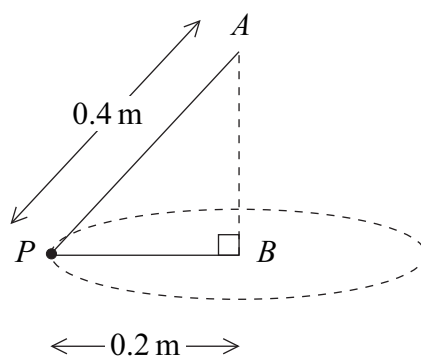
- (a) Calculate the elastic potential energy of the string when the particle is 8 metres from the point A . (2 marks)
- (b) The coefficient of friction between the particle and the plane is 0.3.

Show that the speed of the particle when the string becomes slack is 6.18 m s^{-1} , correct to three significant figures. (6 marks)

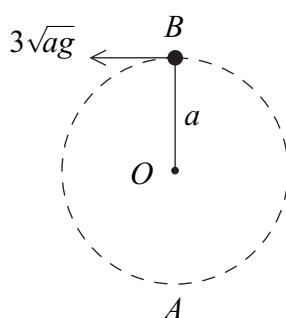
Turn over for the next question

Turn over ►

- 5 Two light inextensible strings, of lengths 0.4 m and 0.2 m, each have one end attached to a particle, P , of mass 4 kg. The other ends of the strings are attached to the points A and B respectively. The point A is vertically above the point B . The particle moves in a horizontal circle, centre B and radius 0.2 m, at a speed of 2 m s^{-1} . The particle and strings are shown in the diagram.



- (a) Calculate the magnitude of the acceleration of the particle. (2 marks)
- (b) Show that the tension in string PA is 45.3 N, correct to three significant figures. (4 marks)
- (c) Find the tension in string PB . (3 marks)
- 6 A light inextensible string, of length a , has one end attached to a fixed point O . A particle, of mass m , is attached to the other end. The particle is moving in a vertical circle, centre O . When the particle is at B , vertically above O , the string is taut and the particle is moving with speed $3\sqrt{ag}$.



- (a) Find, in terms of g and a , the speed of the particle at the lowest point, A , of its path. (4 marks)
- (b) Find, in terms of g and m , the tension in the string when the particle is at A . (4 marks)

7 A car of mass 600 kg is driven along a straight horizontal road. The resistance to motion of the car is kv^2 newtons, where $v \text{ m s}^{-1}$ is the velocity of the car at time t seconds and k is a constant.

- (a) When the engine of the car has power 8 kW, show that the equation of motion of the car is

$$600 \frac{dv}{dt} - \frac{8000}{v} + kv^2 = 0 \quad (4 \text{ marks})$$

- (b) When the velocity of the car is 20 m s^{-1} , the engine is turned off.

- (i) Show that the equation of motion of the car now becomes

$$600 \frac{dv}{dt} = -kv^2 \quad (1 \text{ mark})$$

- (ii) Find, in terms of k , the time taken for the velocity of the car to drop to 10 m s^{-1} .
(5 marks)

END OF QUESTIONS

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