

General Certificate of Education
June 2006
Advanced Level Examination



MATHEMATICS
Unit Mechanics 2A

MM2A/W

Tuesday 6 June 2006 1.30 pm to 2.45 pm

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.

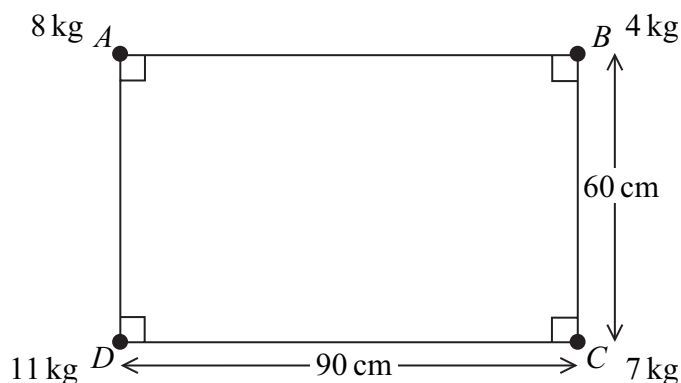
Answer **all** questions.

- 1 A particle moves in a horizontal plane, in which the unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. At time t seconds, its position vector, \mathbf{r} metres, is given by

$$\mathbf{r} = (2t^3 - t^2 + 6)\mathbf{i} + (8 - 4t^3 + t)\mathbf{j}$$

- (a) Find an expression for the velocity of the particle at time t . (3 marks)
- (b) (i) Find the velocity of the particle when $t = \frac{1}{3}$. (2 marks)
- (ii) State the direction in which the particle is travelling at this time. (1 mark)
- (c) Find the acceleration of the particle when $t = 4$. (3 marks)
- (d) The mass of the particle is 6 kg. Find the magnitude of the resultant force on the particle when $t = 4$. (3 marks)
- 2 Particles of masses 8 kg, 4 kg, 7 kg and 11 kg are attached to the vertices A , B , C and D respectively of a light, rigid, rectangular framework $ABCD$.

In the framework, $CD = 90$ cm and $BC = 60$ cm, as shown in the diagram.



- (a) Show that the centre of mass of the system of particles is 33 cm from AD . (3 marks)
- (b) Find the distance of the centre of mass of the system of particles from AB . (3 marks)
- (c) The framework is freely suspended from the corner A and hangs in equilibrium. Find the angle, in degrees, between the downward vertical and the side AB . (3 marks)

3 A block of mass 2 kg is placed on a horizontal surface. An elastic string has natural length 0.5 metres and modulus of elasticity 30 newtons. One end of the string is fixed to the surface at the point O and the other end is attached to the block. The block is pulled along the surface away from O until it is at the point P , where the length of OP is 1.8 metres. The block can be modelled as a particle.

(a) Calculate the elastic potential energy in the string when the block is at P . (2 marks)

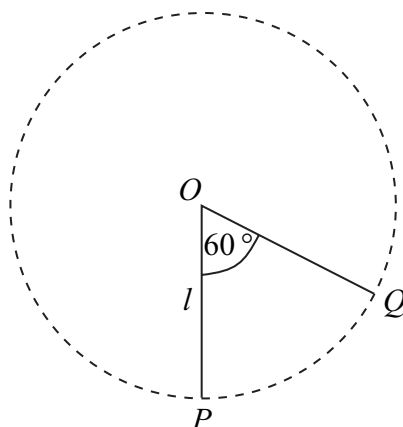
(b) Assume that the horizontal surface is smooth.

(i) The block is then released from P and moves towards O . Show that, when the block has moved 0.5 metres, its speed is 5.61 m s^{-1} , correct to three significant figures. (5 marks)

(ii) Find the speed of the block when it reaches O . (3 marks)

(c) Assume that the horizontal surface is rough and that the coefficient of friction between the surface and the block is 0.1. Find the speed of the block when it reaches O . (5 marks)

4 A particle of mass m is suspended from a fixed point O by a light inextensible string of length l . The particle hangs in equilibrium at the point P vertically below O . The particle is then set into motion with a horizontal velocity U so that it moves in a complete vertical circle with centre O . The point Q on the circle is such that $\angle POQ = 60^\circ$, as shown in the diagram.



(a) Find, in terms of g , l and U , the speed of the particle at Q . (4 marks)

(b) Find, in terms of g , l , m and U , the tension in the string when the particle is at Q . (5 marks)

Turn over for the next question

Turn over ►

- 5 A car of mass 1200 kg travels round a roundabout on a horizontal, circular path at a constant speed of 14 m s^{-1} . The radius of the circle is 50 metres. Assume that there is no resistance to the motion of the car and that the car can be modelled as a particle.
- (a) A friction force, directed towards the centre of the roundabout, acts on the car as it moves. Show that the magnitude of this friction force is 4704 N. *(4 marks)*
- (b) The coefficient of friction between the car and the road is μ . Show that $\mu \geq 0.4$. *(3 marks)*
- 6 A particle of mass 20 kg moves along a straight horizontal line. At time t seconds the velocity of the particle is $v \text{ m s}^{-1}$. A resistance force of magnitude $10\sqrt{v}$ newtons acts on the particle while it is moving. At time $t = 0$ the velocity of the particle is 25 m s^{-1} .
- (a) Show that, at time t
- $$v = \left(\frac{20-t}{4}\right)^2 \quad (7 \text{ marks})$$
- (b) State the value of t when the particle comes to rest. *(1 mark)*

END OF QUESTIONS