

General Certificate of Education
June 2006
Advanced Subsidiary Examination



MATHEMATICS
Unit Mechanics 1B

MM1B

Tuesday 6 June 2006 1.30 pm to 3.00 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 30 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 MM1B.
- 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

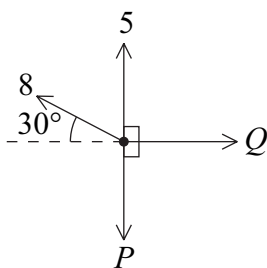
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

- 1 A stone is dropped from a high bridge and falls vertically.
- (a) Find the distance that the stone falls during the first 4 seconds of its motion. (3 marks)
- (b) Find the average speed of the stone during the first 4 seconds of its motion. (2 marks)
- (c) State one modelling assumption that you have made about the forces acting on the stone during the motion. (1 mark)
- 2 A particle is in equilibrium under the action of four horizontal forces of magnitudes 5 newtons, 8 newtons, P newtons and Q newtons, as shown in the diagram.



- (a) Show that $P = 9$. (3 marks)
- (b) Find the value of Q . (2 marks)

- 3 A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

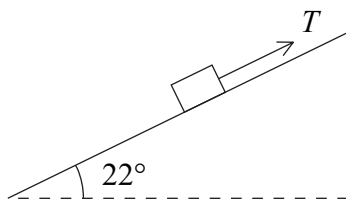
During the first stage, the car accelerates uniformly from rest to a velocity of 10 m s^{-1} in 6 seconds.

During the second stage, the car travels with a constant velocity of 10 m s^{-1} for a further 4 seconds.

During the third stage of the motion, the car travels with a uniform retardation of magnitude 0.8 m s^{-2} until it comes to rest.

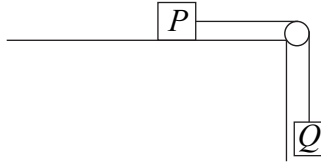
- (a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. (2 marks)
- (b) Sketch a velocity–time graph for the car during the three stages of the motion. (4 marks)
- (c) Find the total distance travelled by the car during the motion. (3 marks)
- (d) State one criticism of the model of the motion. (1 mark)
- 4 A block is being pulled up a rough plane inclined at an angle of 22° to the horizontal by a rope parallel to the plane, as shown in the diagram.

The mass of the block is 0.7 kg , and the tension in the rope is T newtons.



- (a) Draw a diagram to show the forces acting on the block. (1 mark)
- (b) Show that the normal reaction force between the block and the plane has magnitude 6.36 newtons, correct to three significant figures. (3 marks)
- (c) The coefficient of friction between the block and the plane is 0.25. Find the magnitude of the frictional force acting on the block during its motion. (2 marks)
- (d) The tension in the rope is 5.6 newtons. Find the acceleration of the block. (4 marks)

- 5 A small block P is attached to another small block Q by a light inextensible string. The block P rests on a rough horizontal surface and the string hangs over a smooth peg so that Q hangs freely, as shown in the diagram.



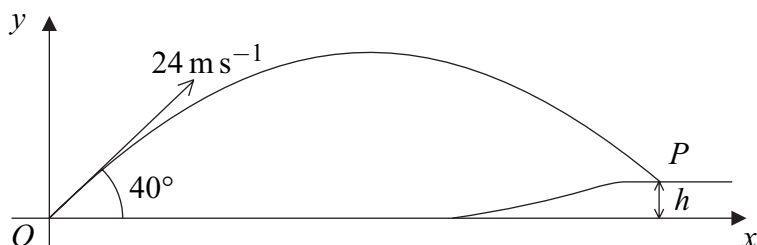
The block P has mass 0.4 kg and the coefficient of friction between P and the surface is 0.5 .

The block Q has mass 0.3 kg .

The system is released from rest and Q moves vertically downwards.

- (a) (i) Draw a diagram to show the forces acting on P . (1 mark)
- (ii) Show that the frictional force between P and the surface has magnitude 1.96 newtons . (2 marks)
- (b) By forming an equation of motion for each block, show that the magnitude of the acceleration of each block is 1.4 m s^{-2} . (5 marks)
- (c) Find the speed of the blocks after 3 seconds of motion. (2 marks)
- (d) After 3 seconds of motion, the string breaks. The blocks continue to move. Comment on how the speed of each block will change in the subsequent motion. For each block, give a reason for your answer. (4 marks)
- 6 The points A and B have position vectors $(3\mathbf{i} + 2\mathbf{j})$ metres and $(6\mathbf{i} - 4\mathbf{j})$ metres respectively. The vectors \mathbf{i} and \mathbf{j} are in a horizontal plane.
- (a) A particle moves from A to B with constant velocity $(\mathbf{i} - 2\mathbf{j})\text{ m s}^{-1}$. Calculate the time that the particle takes to move from A to B . (3 marks)
- (b) The particle then moves from B to a point C with a constant acceleration of $2\mathbf{j}\text{ m s}^{-2}$. It takes 4 seconds to move from B to C .
- (i) Find the position vector of C . (4 marks)
- (ii) Find the distance AC . (2 marks)

- 7 A golf ball is struck from a point O with velocity 24 m s^{-1} at an angle of 40° to the horizontal. The ball first hits the ground at a point P , which is at a height h metres above the level of O .



The horizontal distance between O and P is 57 metres.

- (a) Show that the time that the ball takes to travel from O to P is 3.10 seconds, correct to three significant figures. (3 marks)
- (b) Find the value of h . (3 marks)
- (c) (i) Find the speed with which the ball hits the ground at P . (5 marks)
- (ii) Find the angle between the direction of motion and the horizontal as the ball hits the ground at P . (2 marks)
- 8 Two particles, A and B , are moving on a smooth horizontal surface.

The particle A has mass m kg and is moving with velocity $\begin{bmatrix} 5 \\ -3 \end{bmatrix} \text{ m s}^{-1}$.

The particle B has mass 0.2 kg and is moving with velocity $\begin{bmatrix} 2 \\ 3 \end{bmatrix} \text{ m s}^{-1}$.

- (a) Find, in terms of m , an expression for the total momentum of the particles. (2 marks)
- (b) The particles A and B collide and form a single particle C , which moves with velocity $\begin{bmatrix} k \\ 1 \end{bmatrix} \text{ m s}^{-1}$, where k is a constant.
- (i) Show that $m = 0.1$. (3 marks)
- (ii) Find the value of k . (3 marks)

END OF QUESTIONS

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