

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**

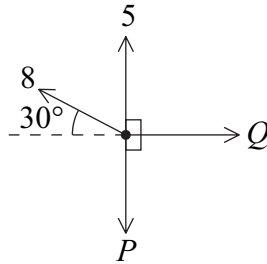
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

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Answer **all** questions.

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- 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.

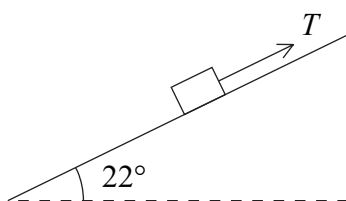
During the first stage, the car accelerates uniformly from rest to a velocity of  $10 \text{ m s}^{-1}$  in 6 seconds.

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

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

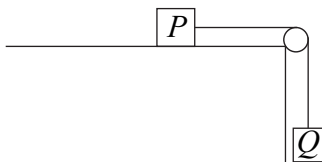
- (a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. (2 marks)
- (b) Sketch a velocity–time graph for the car during the three stages of the motion. (4 marks)
- (c) Find the total distance travelled by the car during the motion. (3 marks)
- (d) State one criticism of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

The mass of the block is  $0.7 \text{ kg}$ , 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.



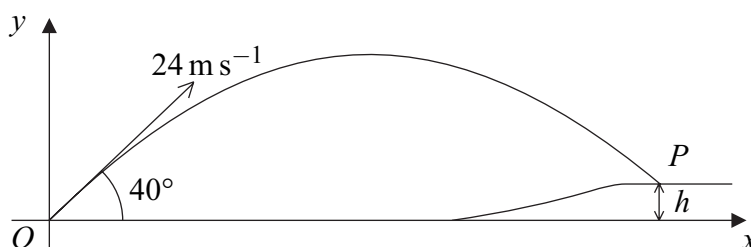
The block  $P$  has mass  $0.4 \text{ kg}$  and the coefficient of friction between  $P$  and the surface is  $0.5$ .

The block  $Q$  has mass  $0.3 \text{ kg}$ .

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  $1.96 \text{ newtons}$ . (2 marks)
- (b) By forming an equation of motion for each block, show that the magnitude of the acceleration of each block is  $1.4 \text{ m s}^{-2}$ . (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  $24 \text{ m s}^{-1}$  at an angle of  $40^\circ$  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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