

General Certificate of Education
June 2005
Advanced Subsidiary Examination



**MATHEMATICS AND STATISTICS
(SPECIFICATION B)
Unit Mechanics 1**

MBM1

Wednesday 25 May 2005 Afternoon Session

In addition to this paper you will require:

- a 12-page answer book;
- the AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 45 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 MBM1.
- Answer **all** questions.
- Take $g = 9.8 \text{ m s}^{-2}$ unless stated otherwise.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.

Information

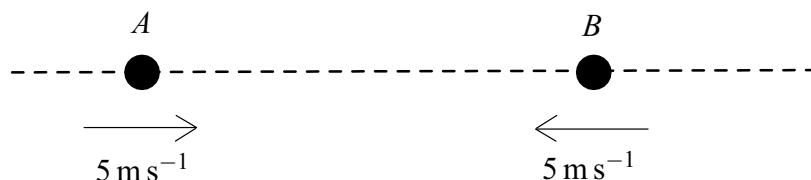
- The maximum mark for this paper is 80.
- Mark allocations are shown in brackets.

Advice

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

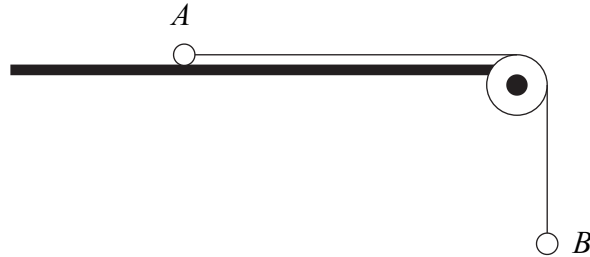
Answer **all** questions.

- 1 Two particles, A and B , are moving towards each other along a straight horizontal line. They are both moving at 5 m s^{-1} . The mass of A is 3 kg and the mass of B is 2 kg . The particles collide.



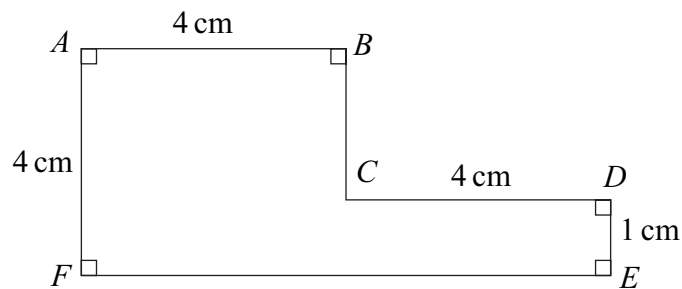
- (a) If the particles coalesce, find the speed of the combined particle after the collision. *(3 marks)*
- (b) If the particles do not coalesce during the collision, but the speed of particle A is reduced to 0.5 m s^{-1} and its direction of motion does not change, find the speed of particle B after the collision. *(4 marks)*
- 2 A ball is projected vertically upwards from a height of 5 metres above ground level. Its initial speed is 7 m s^{-1} . Assume that the ball is a particle and that no resistance forces act on it as it moves.
- (a) Show that the maximum height of the ball is 7.5 metres above ground level. *(3 marks)*
- (b) Show that the time that it takes the ball to reach its maximum height is 0.714 seconds , correct to three significant figures. *(2 marks)*
- (c) The ball is caught when it is at a height of 2 metres above ground level.
- (i) Find the total time for which the ball is moving. *(4 marks)*
- (ii) Find the speed of the ball when it is caught. *(3 marks)*
- 3 A lift has mass 800 kg . A vertical cable is attached to the lift. Model the lift as a particle.
- (a) Show that the tension in the cable is 8000 N , when the lift is accelerating upwards at 0.2 m s^{-2} . *(3 marks)*
- (b) Find the tension in the cable when the lift is accelerating downwards at 0.2 m s^{-2} . *(2 marks)*
- (c) Write down the tension in the cable when the lift is travelling at a constant speed. *(1 mark)*

- 4 The diagram shows two particles, A and B , which are connected by a light inextensible string. The string passes over a smooth light pulley. Particle A has mass 20 kg and rests on a rough horizontal surface. The coefficient of friction between the particle and the surface is 0.15 . Particle B has mass 5 kg and hangs with the string vertical, as shown in the diagram.



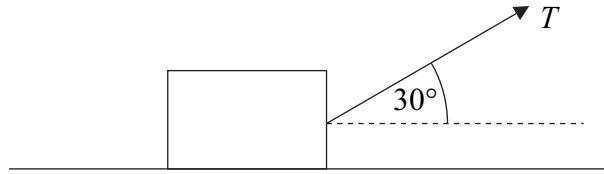
The particles are released from rest and begin to move.

- Find the magnitude of the friction force acting on A . (2 marks)
 - By forming an equation of motion for each particle, show that the acceleration of each particle has magnitude 0.784 m s^{-2} . (5 marks)
 - Find the tension in the string. (2 marks)
 - Find the distance that A moves in the first 3 seconds of its motion. Assume that the acceleration of A remains constant during this time. (3 marks)
- 5 The diagram shows a uniform lamina.



- Show that the centre of mass of the lamina is 2.8 cm from AF . (4 marks)
- Find the distance of the centre of mass from AB . (3 marks)
- The lamina is suspended in equilibrium from the corner A . Find the angle between AB and the vertical. (3 marks)

- 6 A heavy crate, of mass 200 kg, is pulled along a rough horizontal surface at a constant speed by a rope. The rope is at an angle of 30° to the horizontal. The tension in the rope is T newtons. The coefficient of friction between the crate and the surface is 0.6. Model the crate as a particle.



- (a) Draw a diagram to show the forces acting on the crate. (1 mark)
- (b) Show that the magnitude of the normal reaction force on the crate is $(1960 - 0.5T)$ newtons. (3 marks)
- (c) Find T . (5 marks)
- 7 A ball is kicked from ground level so that its initial velocity is 10 m s^{-1} , at an angle of 60° above the horizontal. It hits a wall, which is at a distance of 8 metres from the initial position of the ball.
- (a) Show that the ball hits the wall 1.6 seconds after it was kicked. (3 marks)
- (b) Find the height of the ball as it hits the wall. (3 marks)
- (c) Find the speed of the ball as it hits the wall. (5 marks)
- 8 A particle is initially at the origin and has velocity $(4\mathbf{i} + 3\mathbf{j}) \text{ m s}^{-1}$. It moves with constant acceleration, and 10 seconds later has velocity $(5\mathbf{i} - 2\mathbf{j}) \text{ m s}^{-1}$. The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively.
- (a) Show that the acceleration of the particle is $(0.1\mathbf{i} - 0.5\mathbf{j}) \text{ m s}^{-2}$. (3 marks)
- (b) Find an expression for the position vector of the particle at time t seconds. (2 marks)
- (c) Find the time when the particle is due east of the origin. (4 marks)
- (d) Find the time when the particle is moving due east. (4 marks)

END OF QUESTIONS