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

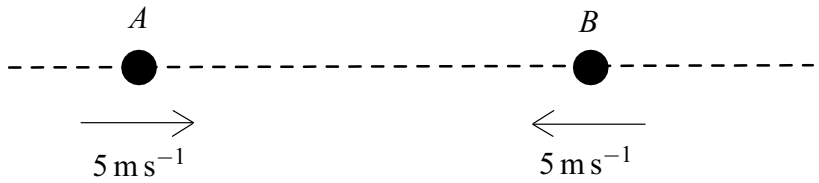
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MBM1.
- Answer **all** questions.
- Take $g = 9.8 \text{ m s}^{-2}$ unless 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 $5\,\text{m s}^{-1}$. 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 $0.5\,\text{m s}^{-1}$ 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 $7\,\text{m s}^{-1}$. 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)*

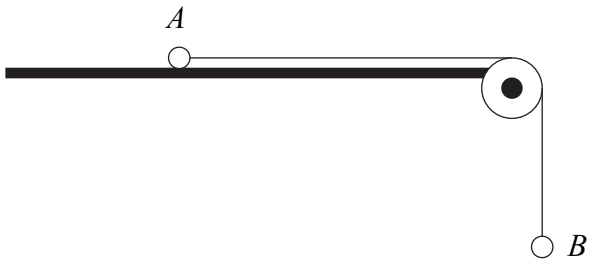
3 A lift has mass 800 kg. A vertical cable is attached to the lift. Model the lift as a particle.

(a) Show that the tension in the cable is 8000 N, when the lift is accelerating upwards at $0.2\,\text{m s}^{-2}$. *(3 marks)*

(b) Find the tension in the cable when the lift is accelerating downwards at $0.2\,\text{m s}^{-2}$. *(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.

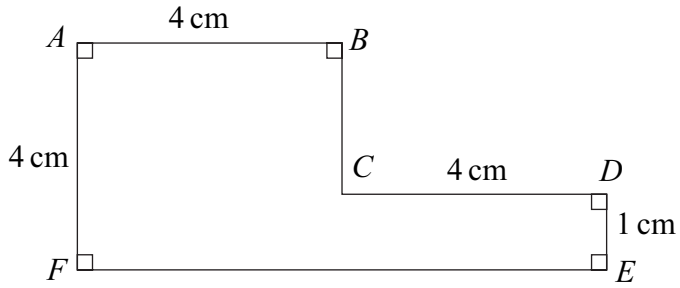
(a) Find the magnitude of the friction force acting on A. *(2 marks)*

(b) By forming an equation of motion for each particle, show that the acceleration of each particle has magnitude $0.784\,\text{m}\,\text{s}^{-2}$. *(5 marks)*

(c) Find the tension in the string. *(2 marks)*

(d) 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.

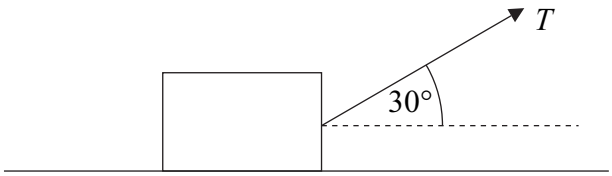


(a) Show that the centre of mass of the lamina is 2.8 cm from AF. *(4 marks)*

(b) Find the distance of the centre of mass from AB. *(3 marks)*

(c) 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 $10\,\mathrm{m\,s^{-1}}$, 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 $(4\mathbf{i} + 3\mathbf{j})\,\mathrm{m\,s^{-1}}$. It moves with constant acceleration, and 10 seconds later has velocity $(5\mathbf{i} - 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

(a) Show that the acceleration of the particle is $(0.1\mathbf{i} - 0.5\mathbf{j})\,\mathrm{m\,s^{-2}}$. *(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