

General Certificate of Education  
June 2007  
Advanced Subsidiary Examination



**MATHEMATICS**  
**Unit Mechanics 1B**

**MM1B**

Tuesday 5 June 2007 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**

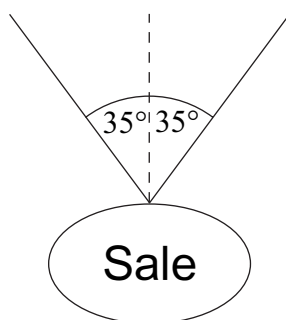
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

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Answer **all** questions.

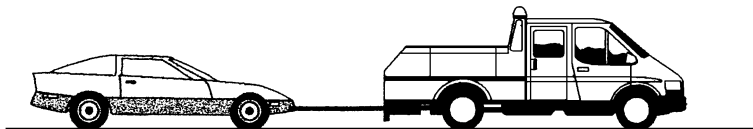
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- 1 A ball is released from rest at a height  $h$  metres above ground level. The ball hits the ground 1.5 seconds after it is released. Assume that the ball is a particle that does not experience any air resistance.
- (a) Show that the speed of the ball is  $14.7 \text{ m s}^{-1}$  when it hits the ground. (2 marks)
- (b) Find  $h$ . (2 marks)
- (c) Find the distance that the ball has fallen when its speed is  $5 \text{ m s}^{-1}$ . (3 marks)
- 2 Two particles,  $A$  and  $B$ , are moving on a smooth horizontal surface. Particle  $A$  has mass 2 kg and velocity  $\begin{bmatrix} 3 \\ -2 \end{bmatrix} \text{ m s}^{-1}$ . Particle  $B$  has mass 3 kg and velocity  $\begin{bmatrix} -4 \\ 1 \end{bmatrix} \text{ m s}^{-1}$ . The two particles collide, and they coalesce during the collision.
- (a) Find the velocity of the combined particles after the collision. (3 marks)
- (b) Find the speed of the combined particles after the collision. (2 marks)
- 3 A sign, of mass 2 kg, is suspended from the ceiling of a supermarket by two light strings. It hangs in equilibrium with each string making an angle of  $35^\circ$  to the vertical, as shown in the diagram. Model the sign as a particle.



- (a) By resolving forces horizontally, show that the tension is the same in each string. (2 marks)
- (b) Find the tension in each string. (5 marks)
- (c) If the tension in a string exceeds 40 N, the string will break. Find the mass of the heaviest sign that could be suspended as shown in the diagram. (3 marks)

- 4 A car, of mass 1200 kg, is connected by a tow rope to a truck, of mass 2800 kg. The truck tows the car in a straight line along a horizontal road. Assume that the tow rope is horizontal. A horizontal driving force of magnitude 3000 N acts on the truck. A horizontal resistance force of magnitude 800 N acts on the car. The car and truck accelerate at  $0.4 \text{ m s}^{-2}$ .



- (a) Find the tension in the tow rope. (3 marks)
- (b) Show that the magnitude of the horizontal resistance force acting on the truck is 600 N. (4 marks)
- (c) In fact, the tow rope is **not** horizontal. Assume that the resistance forces and the driving force are unchanged.

Is the tension in the tow rope greater or less than in part (a)?

Explain why.

(2 marks)

- 5 An aeroplane flies in air that is moving due east at a speed of  $V \text{ m s}^{-1}$ . The velocity of the aeroplane relative to the air is  $150 \text{ m s}^{-1}$  due north. The aeroplane actually travels on a bearing of  $030^\circ$ .

- (a) Show that  $V = 86.6 \text{ m s}^{-1}$ , correct to three significant figures. (2 marks)
- (b) Find the magnitude of the resultant velocity of the aeroplane. (3 marks)

**Turn over for the next question**

**Turn over ►**

6 A box, of mass 3 kg, is placed on a slope inclined at an angle of  $30^\circ$  to the horizontal. The box slides down the slope. Assume that air resistance can be ignored.

(a) A simple model assumes that the slope is smooth.

(i) Draw a diagram to show the forces acting on the box. (1 mark)

(ii) Show that the acceleration of the box is  $4.9 \text{ m s}^{-2}$ . (2 marks)

(b) A revised model assumes that the slope is rough. The box slides down the slope from rest, travelling 5 metres in 2 seconds.

(i) Show that the acceleration of the box is  $2.5 \text{ m s}^{-2}$ . (2 marks)

(ii) Find the magnitude of the friction force acting on the box. (3 marks)

(iii) Find the coefficient of friction between the box and the slope. (5 marks)

(iv) In reality, air resistance affects the motion of the box. Explain how its acceleration would change if you took this into account. (2 marks)

7 An arrow is fired from a point  $A$  with a velocity of  $25 \text{ m s}^{-1}$ , at an angle of  $40^\circ$  above the horizontal. The arrow hits a target at the point  $B$  which is at the same level as the point  $A$ , as shown in the diagram.



(a) State **two** assumptions that you should make in order to model the motion of the arrow. (2 marks)

(b) Show that the time that it takes for the arrow to travel from  $A$  to  $B$  is 3.28 seconds, correct to three significant figures. (4 marks)

(c) Find the distance between the points  $A$  and  $B$ . (2 marks)

(d) State the magnitude and direction of the velocity of the arrow when it hits the target. (2 marks)

(e) Find the minimum speed of the arrow during its flight. (2 marks)

**8** A boat is initially at the origin, heading due east at  $5 \text{ m s}^{-1}$ . It then experiences a constant acceleration of  $(-0.2\mathbf{i} + 0.25\mathbf{j}) \text{ m s}^{-2}$ . The unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  are directed east and north respectively.

- (a) State the initial velocity of the boat as a vector. *(1 mark)*
- (b) Find an expression for the velocity of the boat  $t$  seconds after it has started to accelerate. *(2 marks)*
- (c) Find the value of  $t$  when the boat is travelling due north. *(3 marks)*
- (d) Find the bearing of the boat from the origin when the boat is travelling due north. *(6 marks)*

**END OF QUESTIONS**

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