

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

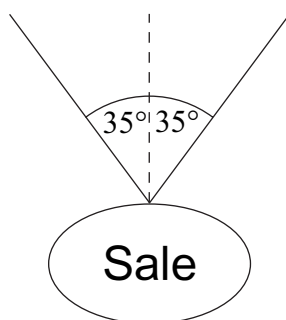
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice

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

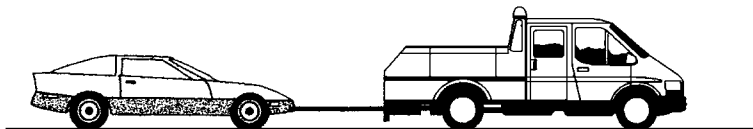
Answer **all** questions.

- 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 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 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° 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 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 m s^{-1} due north. The aeroplane actually travels on a bearing of 030° .

- (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° 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 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 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 m s^{-1} , at an angle of 40° 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 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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