General Certificate of Education
June 2007
Advanced Subsidiary Examination

MATHEMATICS **MM1A/W**
Unit Mechanics 1A

Tuesday 5 June 2007 1.30 pm to 2.45 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 15 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 MM1A/W.
- 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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 1A has a **written paper and coursework**.

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

Answer **all** questions.

1 A hot air balloon is at rest on the ground. When the balloon is released, it rises to a height of 320 metres in 80 seconds. The balloon moves under the action of its weight and a vertical lift force. Assume that the balloon has a constant acceleration during this motion.

(a) Show that the acceleration of the balloon is $0.1\,\mathrm{m\,s^{-2}}$. *(3 marks)*

(b) Find the speed of the balloon when it reaches a height of 320 metres. *(2 marks)*

(c) The mass of the balloon is 450 kg. Show that the magnitude of the vertical lift force is 4500 N, correct to two significant figures. *(3 marks)*

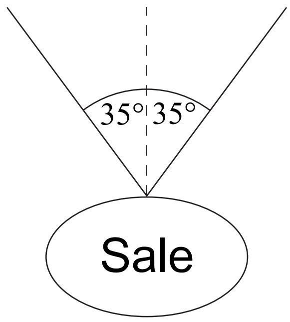
(d) After a while, the vertical lift force is reduced so that the balloon rises at a constant speed. State the magnitude of the vertical lift force when this is the case. *(1 mark)*

2 Two particles, A and B, are moving on a smooth horizontal surface. Particle A has mass 2 kg and velocity $\begin{bmatrix} 3 \\ -2 \end{bmatrix}\,\mathrm{m\,s^{-1}}$. Particle B has mass 3 kg and velocity $\begin{bmatrix} -4 \\ 1 \end{bmatrix}\,\mathrm{m\,s^{-1}}$. 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.



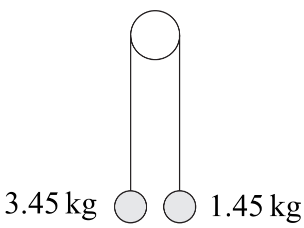
(a) By resolving forces horizontally, show that the tension is the same in each string. *(2 marks)*

(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 Two particles, of masses 3.45 kg and 1.45 kg, are connected by a light string that passes over a smooth peg. The particles are released from rest with the strings vertical, as shown in the diagram.



(a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $4\,\text{m s}^{-2}$. *(5 marks)*

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

(c) Initially the particles are at the same level.

Find the speed of the heavier particle when it is 1 metre lower than the lighter particle. Assume that neither particle hits the floor or the peg. *(3 marks)*

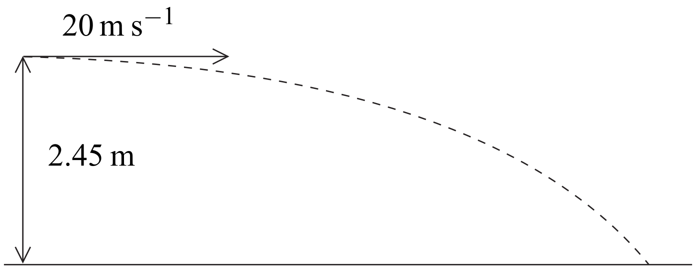
Turn over for the next question

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

(a) Show that $V = 86.6\,\mathrm{m\,s^{-1}}$, correct to three significant figures. *(2 marks)*

(b) Find the magnitude of the resultant velocity of the aeroplane. *(3 marks)*

6 A tennis ball is hit from a height of 2.45 metres above horizontal ground. Initially it travels horizontally at a speed of $20\,\mathrm{m\,s^{-1}}$, as shown in the diagram.



(a) Show that the time taken for the tennis ball to reach the ground is 0.707 seconds, correct to three significant figures. *(3 marks)*

(b) Find the horizontal distance travelled by the ball when it hits the ground. *(2 marks)*

(c) Find the angle between the velocity of the ball and the horizontal when the ball hits the ground. *(4 marks)*

7 A boat is initially at the origin, heading due east at $5\,\mathrm{m\,s^{-1}}$. It then experiences a constant acceleration of $(-0.2\mathbf{i} + 0.25\mathbf{j})\,\mathrm{m\,s^{-2}}$. 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