General Certificate of Education
January 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 12 January 2007 9.00 am to 10.15 am

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

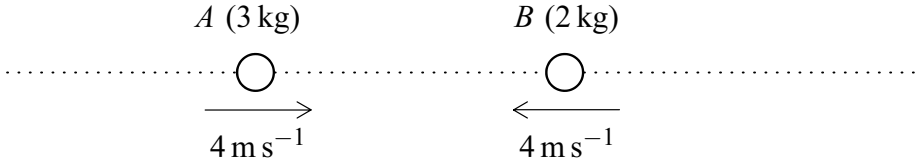
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1A/W.
- Answer **all** questions.
- Show all necessary working; otherwise 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 Two particles A and B have masses of 3 kg and 2 kg respectively. They are moving along a straight horizontal line towards each other. Each particle is moving with a speed of $4\,\mathrm{m\,s^{-1}}$ when they collide.



(a) If the particles coalesce during the collision to form a single particle, find the speed of the combined particle after the collision. *(3 marks)*

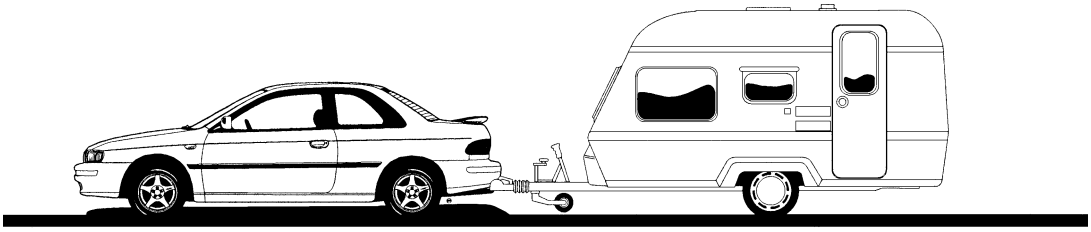
(b) If, after the collision, A moves in the same direction as before the collision with speed $0.4\,\mathrm{m\,s^{-1}}$, find the speed of B after the collision. *(3 marks)*

2 A motorcycle accelerates uniformly along a straight horizontal road so that, when it has travelled 20 metres, its velocity has increased from $12\,\mathrm{m\,s^{-1}}$ to $16\,\mathrm{m\,s^{-1}}$.

(a) Find the acceleration of the motorcycle. *(3 marks)*

(b) Find the time that it takes for the motorcycle to travel this distance. *(3 marks)*

3 A car, of mass 1500 kg, is towing a caravan, of mass 900 kg, along a straight horizontal road. The caravan is connected to the car by a horizontal tow bar. Resistance forces of magnitudes 400 N and 800 N act on the car and caravan respectively. The acceleration of the car and caravan is $0.8\,\mathrm{m\,s^{-2}}$.



(a) Show that the magnitude of the force that the car exerts on the caravan is 1520 N. *(3 marks)*

(b) Find the magnitude of the driving force produced by the car's engine. *(3 marks)*

4 A cricket ball is hit from the floor of a sports hall, which has a height of 6 metres. The initial velocity of the ball is $20\,\mathrm{m\,s^{-1}}$ at an angle of 60° above the horizontal.

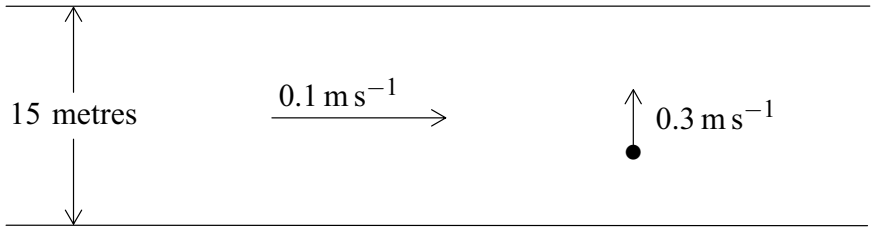
Assume that the cricket ball is a particle which moves only under the influence of gravity.

(a) Show that the ball hits the ceiling of the sports hall approximately 0.389 seconds after it was hit. *(5 marks)*

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

(c) Find the speed of the ball just before it hits the ceiling. *(5 marks)*

5 A girl in a boat is rowing across a river, in which the water is flowing at $0.1\,\mathrm{m\,s^{-1}}$. The velocity of the boat relative to the water is $0.3\,\mathrm{m\,s^{-1}}$ and is perpendicular to the bank, as shown in the diagram.



(a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

(b) Find the acute angle between the resultant velocity and the bank. *(3 marks)*

(c) The width of the river is 15 metres.

(i) Find the time that it takes the boat to cross the river. *(2 marks)*

(ii) Find the total distance travelled by the boat as it crosses the river. *(2 marks)*

Turn over for the next question

6 A trolley, of mass 100 kg, rolls at a constant speed along a straight line down a slope inclined at an angle of 4° to the horizontal.

Assume that a constant resistance force, of magnitude P newtons, acts on the trolley as it moves. Model the trolley as a particle.

(a) Draw a diagram to show the forces acting on the trolley. *(1 mark)*

(b) Show that $P = 68.4\,\text{N}$, correct to three significant figures. *(3 marks)*

(c) (i) Find the acceleration of the trolley if it rolls down a slope inclined at 5° to the horizontal and experiences the same constant force of magnitude P that you found in part (b). *(4 marks)*

(ii) Make one criticism of the assumption that the resistance force on the trolley is constant. *(1 mark)*

7 A particle is initially at the origin, where it has velocity $(5\mathbf{i} - 2\mathbf{j})\,\text{m s}^{-1}$. It moves with a constant acceleration $\mathbf{a}\,\text{m s}^{-2}$ for 10 seconds to the point with position vector $75\mathbf{i}$ metres.

(a) Show that $\mathbf{a} = 0.5\mathbf{i} + 0.4\mathbf{j}$. *(3 marks)*

(b) Find the position vector of the particle 8 seconds after it has left the origin. *(3 marks)*

(c) Find the position vector of the particle when it is travelling parallel to the unit vector $\mathbf{i}$. *(6 marks)*

END OF QUESTIONS