General Certificate of Education
January 2006
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Monday 16 January 2006 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

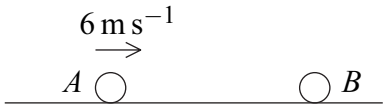
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1A/W.
- Answer **all** questions.
- All necessary working should be shown; 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, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

1 A particle A moves across a smooth horizontal surface in a straight line. The particle A has mass 2 kg and speed $6\,\mathrm{m\,s^{-1}}$. A particle B, which has mass 3 kg, is at rest on the surface. The particle A collides with the particle B.



(a) If, after the collision, A is at rest and B moves away from A, find the speed of B. *(3 marks)*

(b) If, after the collision, A and B move away from each other with speeds $v\,\mathrm{m\,s^{-1}}$ and $4v\,\mathrm{m\,s^{-1}}$ respectively, as shown in the diagram below, find the value of v.

(3 marks)

2 A girl throws a ball vertically upwards with a speed of $10.5\,\mathrm{m\,s^{-1}}$ and subsequently catches it at the same point from which it was thrown.

Find:

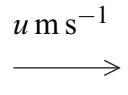
(a) the greatest height that the ball reaches above the point from which it is thrown; *(2 marks)*

(b) (i) the time that the ball takes to reach the greatest height; *(2 marks)*

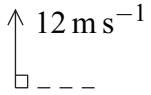
(ii) the time between the ball being thrown and being caught. *(1 mark)*

3 Water flows in a constant direction at a constant speed of $u\,\text{m s}^{-1}$. A boat travels in the water at a speed of $12\,\text{m s}^{-1}$ relative to the water.

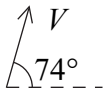
(a) The direction in which the boat travels relative to the water is perpendicular to the direction of motion of the water. The resultant velocity of the boat is $V\,\text{m s}^{-1}$ at an angle of 74° to the direction of motion of the water, as shown in the diagram.



Velocity of the water



Velocity of the boat relative to the water

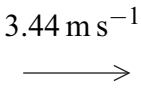


Resultant velocity of the boat

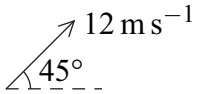
(i) Find V. *(2 marks)*

(ii) Show that $u = 3.44$, correct to three significant figures. *(3 marks)*

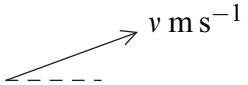
(b) The boat changes course so that it travels relative to the water at an angle of 45° to the direction of motion of the water. The resultant velocity of the boat is now of magnitude $v\,\text{m s}^{-1}$. The velocity of the water is unchanged, as shown in the diagram below.



Velocity of the water



Velocity of the boat relative to the water

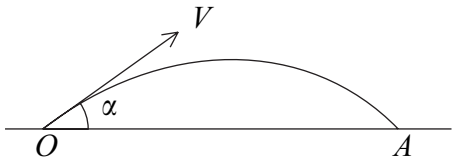


Resultant velocity of the boat

Find the value of v. *(4 marks)*

Turn over for the next question

4 A golf ball is projected from a point O with initial velocity V at an angle α to the horizontal. The ball first hits the ground at a point A which is at the same horizontal level as O, as shown in the diagram.



It is given that $V\cos\alpha = 6u$ and $V\sin\alpha = 2.5u$.

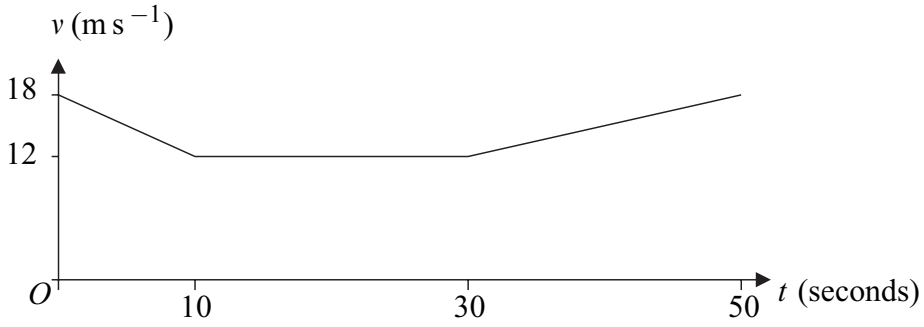
(a) Show that the time taken for the ball to travel from O to A is $\dfrac{5u}{g}$. *(4 marks)*

(b) Find, in terms of g and u, the distance OA. *(2 marks)*

(c) Find V in terms of u. *(2 marks)*

(d) State, in terms of u, the least speed of the ball during its flight from O to A. *(1 mark)*

5 The velocity–time graph below represents the three stages of the motion of a coach moving along a straight horizontal road. Initially the coach has velocity $18\,\text{m s}^{-1}$.



(a) During the first stage of the motion, the coach decelerates at a constant rate of $a\,\text{m s}^{-2}$ for 10 seconds until it reaches a velocity of $12\,\text{m s}^{-1}$.

(i) Find the value of a. *(2 marks)*

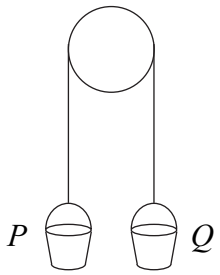
(ii) Find the distance that the coach travels during the 10 seconds. *(2 marks)*

(b) During the second stage of the motion, the coach travels for 20 seconds with constant velocity $12\,\text{m s}^{-1}$. Find the distance that the coach travels during these 20 seconds. *(1 mark)*

(c) During the third stage of the motion, the coach travels with constant acceleration, reaching a velocity of $18\,\text{m s}^{-1}$ after a further 20 seconds.

Find the average speed of the coach during the 50 seconds of the motion. *(4 marks)*

6 A builder ties two identical buckets, P and Q, to the ends of a light inextensible rope. He hangs the rope over a smooth beam so that the buckets hang in equilibrium, as shown in the diagram.



The buckets are each of mass 0.6 kg.

(a) (i) State the magnitude of the tension in the rope. *(1 mark)*

(ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*

(b) The bucket Q is held at rest while a stone, of mass 0.2 kg, is placed inside it. The system is then released from rest and, in the subsequent motion, bucket Q moves vertically downwards with the stone inside.

(i) By forming an equation of motion for each bucket, show that the magnitude of the tension in the rope during the motion is 6.72 newtons, correct to three significant figures. *(6 marks)*

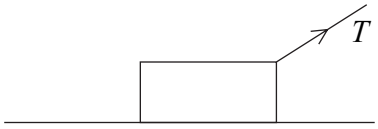
(ii) State the magnitude of the force exerted on the beam by the rope while the motion takes place. *(1 mark)*

Turn over for the next question

7 A crate is being pulled at constant speed across rough horizontal ground by a rope.

The crate is of weight 100 newtons and the frictional force between the crate and the ground is of magnitude 30 newtons.

The tension in the rope is of magnitude T newtons.



(a) Draw and label a diagram to show all the forces acting on the crate. *(1 mark)*

(b) The coefficient of friction between the crate and the ground is 0.5. Show that the normal reaction force between the crate and the ground is 60 newtons. *(2 marks)*

(c) Explain why the horizontal component of the tension in the rope is 30 newtons. *(2 marks)*

(d) Find the value of T. *(4 marks)*

(e) Find the angle that the rope makes with the horizontal. *(3 marks)*

END OF QUESTIONS

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