

General Certificate of Education
January 2006
Advanced Subsidiary Examination



MATHEMATICS
Unit Mechanics 1A

MM1A/W

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 $g = 9.8 \text{ m s}^{-2}$, unless stated otherwise.

Information

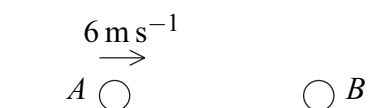
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 1A has a **written paper and coursework**.

Advice

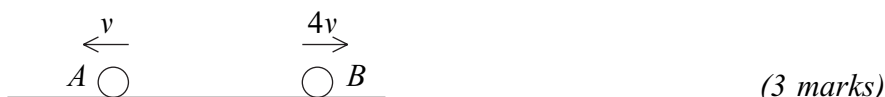
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

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 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 $v\text{ m s}^{-1}$ and $4v\text{ m s}^{-1}$ respectively, as shown in the diagram below, find the value of v .



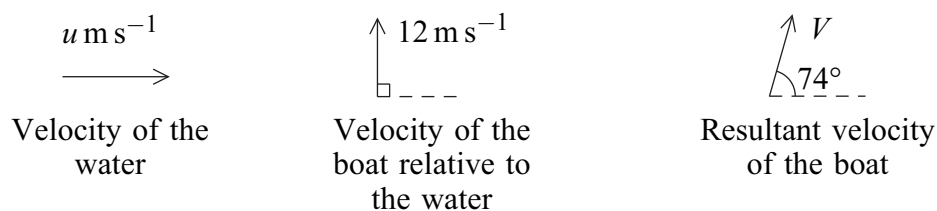
- 2 A girl throws a ball vertically upwards with a speed of 10.5 m s^{-1} and subsequently catches it at the same point from which it was thrown.

Find:

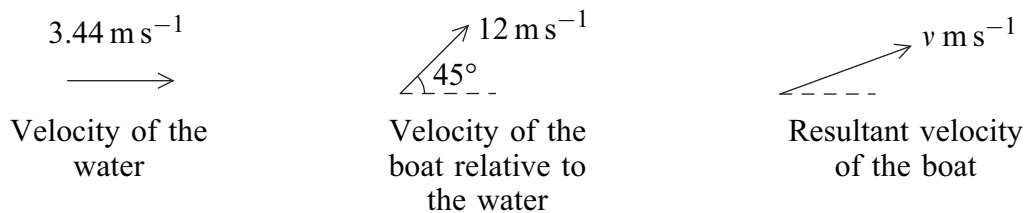
- (a) the greatest height that the ball reaches above the point from which it is thrown;
(2 marks)
- (b) (i) the time that the ball takes to reach the greatest height;
(2 marks)
- (ii) the time between the ball being thrown and being caught.
(1 mark)

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 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.



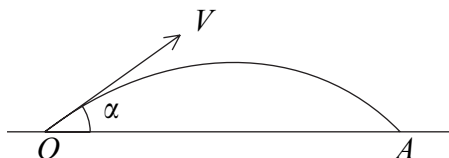
- (i) Find V . (2 marks)
- (ii) Show that $u = 3.44$, correct to three significant figures. (3 marks)
- (b) The boat changes course so that it travels relative to the water at an angle of 45° to the direction of motion of the water. The resultant velocity of the boat is now of magnitude $v \text{ m s}^{-1}$. The velocity of the water is unchanged, as shown in the diagram below.



Find the value of v . (4 marks)

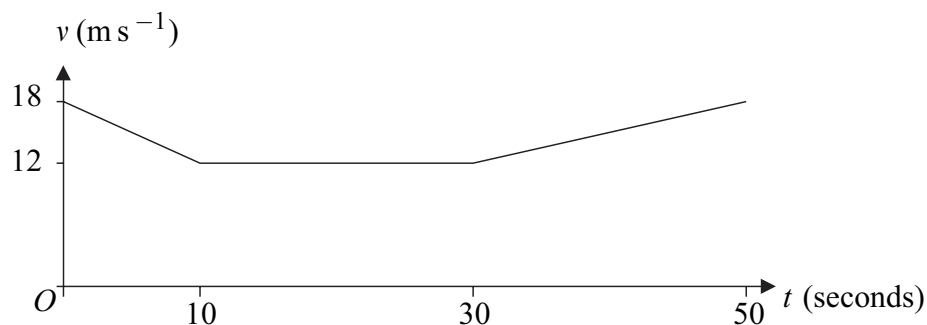
Turn over for the next question

- 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 $V \sin \alpha = 2.5u$.

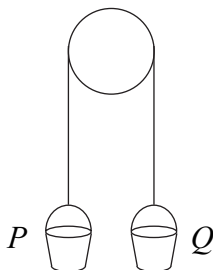
- (a) Show that the time taken for the ball to travel from O to A is $\frac{5u}{g}$. (4 marks)
- (b) Find, in terms of g and u , the distance OA . (2 marks)
- (c) Find V in terms of u . (2 marks)
- (d) State, in terms of u , the least speed of the ball during its flight from O to A . (1 mark)
- 5 The 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 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 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 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 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 .

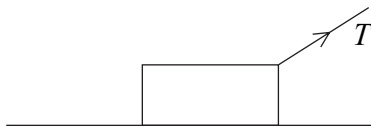
- (a) (i) State the magnitude of the tension in the rope. *(1 mark)*
- (ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*
- (b) The bucket Q is held at rest while a stone, of mass 0.2 kg , is placed inside it. The system is then released from rest and, in 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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