

MATHEMATICS
Unit Mechanics 1A

MM1A/W

Monday 19 January 2009 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 black ink or black 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 $g = 9.8 \text{ m s}^{-2}$, 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.

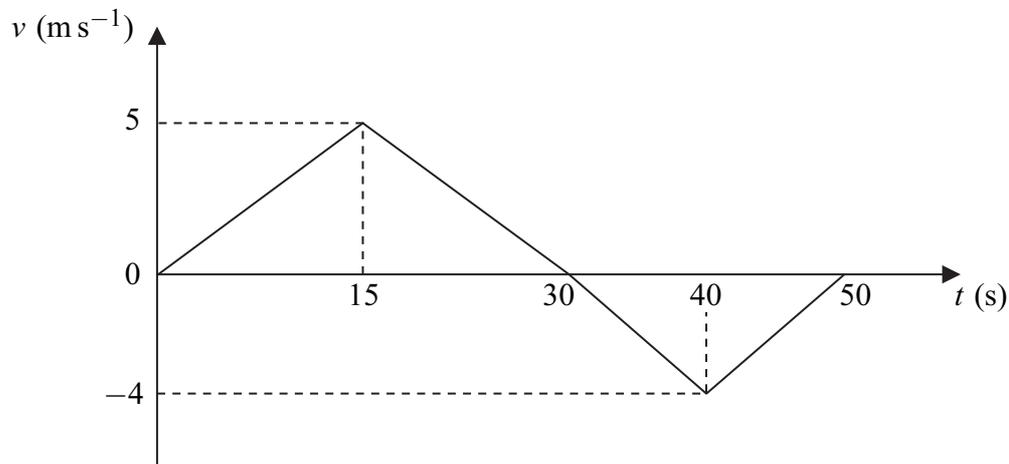
Answer **all** questions.

- 1 A particle of mass 4 kg is travelling at 8 m s^{-1} along a straight line when it collides with a stationary particle of mass 1 kg. After the collision, the two particles move together at the same speed.

Find the speed of the particles after the collision.

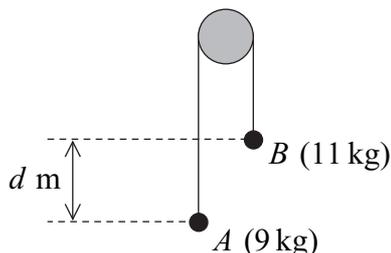
(3 marks)

- 2 The graph shows how the velocity of a particle varies during a 50-second period as it moves forwards and then backwards on a straight line.



- (a) State the times at which the velocity of the particle is zero. (2 marks)
- (b) Show that the particle travels a distance of 75 metres during the first 30 seconds of its motion. (2 marks)
- (c) Find the total distance travelled by the particle during the 50 seconds. (4 marks)
- (d) Find the distance of the particle from its initial position at the end of the 50-second period. (2 marks)

- 3 Two particles, A and B , are connected by a light inextensible string that passes over a smooth fixed peg, as shown in the diagram. The mass of A is 9 kg and the mass of B is 11 kg .



The particles are released from rest in the position shown, where B is d metres higher than A . Assume that no resistance forces act on the particles.

- (a) By forming an equation of motion for each of the particles A and B , show that the acceleration of each particle has magnitude 0.98 m s^{-2} . (5 marks)
- (b) When the particles have been moving for 0.5 seconds, they are at the same level.
- (i) Find the speed of the particles at this time. (2 marks)
- (ii) Find d . (4 marks)
- 4 A sledge of mass 8 kg is at rest on a rough horizontal surface. A child tries to move the sledge by pushing it with a pole, as shown in the diagram, but the sledge **does not move**. The pole is at an angle of 30° to the horizontal and exerts a force of 40 newtons on the sledge.



Model the sledge as a particle.

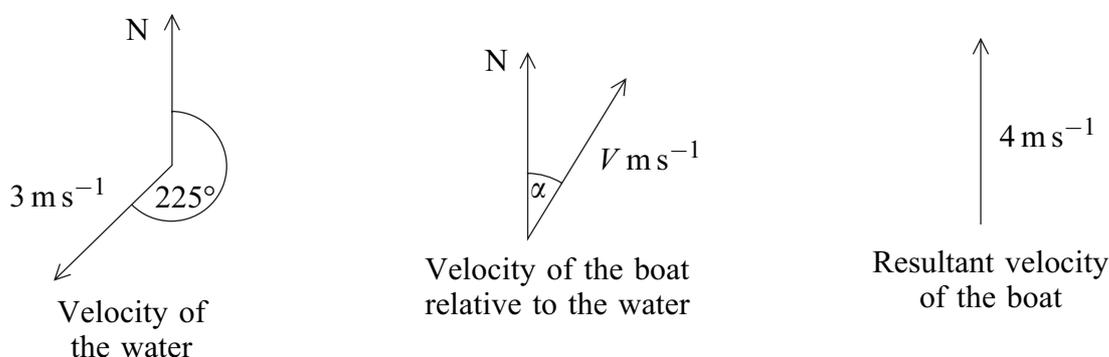
- (a) Draw a diagram to show the four forces acting on the sledge. (1 mark)
- (b) Show that the normal reaction force between the sledge and the surface has magnitude 98.4 N . (3 marks)
- (c) Find the magnitude of the friction force that acts on the sledge. (2 marks)
- (d) Find the least possible value of the coefficient of friction between the sledge and the surface. (3 marks)

Turn over ►

5 Two forces, $\mathbf{P} = (6\mathbf{i} - 3\mathbf{j})$ newtons and $\mathbf{Q} = (3\mathbf{i} + 15\mathbf{j})$ newtons, act on a particle. The unit vectors \mathbf{i} and \mathbf{j} are perpendicular.

- (a) Find the resultant of \mathbf{P} and \mathbf{Q} . (2 marks)
- (b) Calculate the magnitude of the resultant of \mathbf{P} and \mathbf{Q} . (2 marks)
- (c) When these two forces act on the particle, it has an acceleration of $(1.5\mathbf{i} + 2\mathbf{j}) \text{ m s}^{-2}$. Find the mass of the particle. (2 marks)
- (d) The particle was initially at rest at the origin.
- (i) Find an expression for the position vector of the particle when the forces have been applied to the particle for t seconds. (2 marks)
- (ii) Find the distance of the particle from the origin when the forces have been applied to the particle for 2 seconds. (2 marks)

6 A boat is travelling in water that is moving south-west at a speed of 3 m s^{-1} . The velocity of the boat relative to the water is $V \text{ m s}^{-1}$ on a bearing α . The resultant velocity of the boat is 4 m s^{-1} due north.



- (a) Show that $V = 6.48$, correct to three significant figures. (4 marks)
- (b) Find α , giving your answer to the nearest degree. (3 marks)

- 7 A football is kicked from ground level with an initial velocity of 30 m s^{-1} at an angle of 35° above the horizontal.
- (a) Find the maximum height of the ball above ground level. *(4 marks)*
- (b) Show that when the speed of the ball is 28 m s^{-1} , the magnitude of the vertical component of its velocity is 13.4 m s^{-1} , correct to three significant figures. *(4 marks)*
- (c) Find the angle between the velocity of the ball and the horizontal when the speed of the ball is 28 m s^{-1} . *(2 marks)*

END OF QUESTIONS

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