General Certificate of Education
January 2009
Advanced Subsidiary Examination

MATHEMATICS **MM1B**
Unit Mechanics 1B

Monday 19 January 2009 1.30 pm to 3.00 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 30 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 MM1B.
- 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 $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

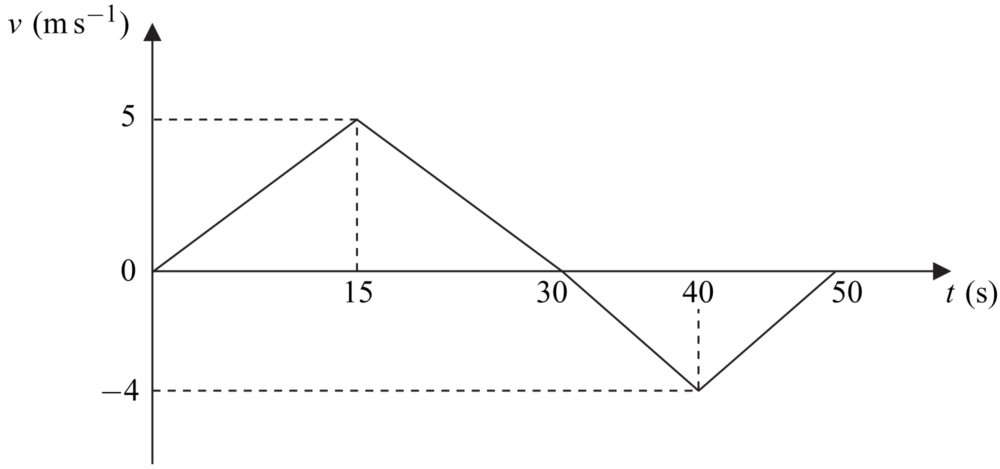
Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 Two particles, A and B, are travelling in the same direction with constant speeds along a straight line when they collide. Particle A has mass 2.5 kg and speed $12\,\text{m}\,\text{s}^{-1}$. Particle B has mass 1.5 kg and speed $4\,\text{m}\,\text{s}^{-1}$. 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)*

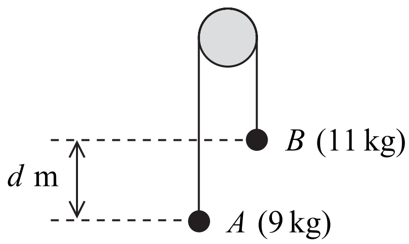
3 A box of mass 4 kg is held at rest on a plane inclined at an angle of 40° to the horizontal. The box is then released and slides down the plane.

(a) A simple model assumes that the only forces acting on the box are its weight and the normal reaction from the plane. Show that, according to this simple model, the acceleration of the box would be $6.30\,\mathrm{m\,s^{-2}}$, correct to three significant figures. *(3 marks)*

(b) In fact, the box moves down the plane with constant acceleration and travels 0.9 metres in 0.6 seconds. By using this information, find the acceleration of the box. *(3 marks)*

(c) Explain why the answer to part (b) is less than the answer to part (a). *(1 mark)*

4 Two particles, A and B, are connected by a string that passes over a 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. The motion of the particles is to be modelled using simple assumptions.

(a) State one assumption that should be made about the peg. *(1 mark)*

(b) State two assumptions that should be made about the string. *(2 marks)*

(c) By forming an equation of motion for each of the particles A and B, show that the acceleration of each particle has magnitude $0.98\,\mathrm{m\,s^{-2}}$. *(5 marks)*

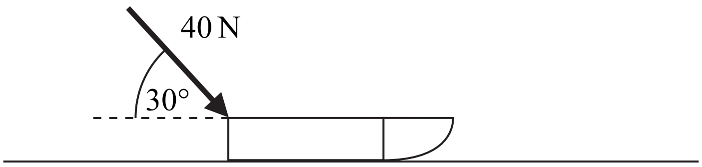
(d) When the particles have been moving for 0.5 seconds, they are at the same level.

(i) Find the speed of the particles at this time. *(2 marks)*

(ii) Find d. *(4 marks)*

Turn over ▶

5 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)*

6 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 **i** and **j** are perpendicular.

(a) Find the resultant of **P** and **Q**. *(2 marks)*

(b) Calculate the magnitude of the resultant of **P** and **Q**. *(2 marks)*

(c) When these two forces act on the particle, it has an acceleration of $(1.5\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-2}}$. 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)*

7 A boat is travelling in water that is moving north-east at a speed of $2\,\mathrm{m\,s^{-1}}$. The velocity of the boat relative to the water is $5\,\mathrm{m\,s^{-1}}$ due west.

Velocity of the water

Velocity of the boat relative to the water

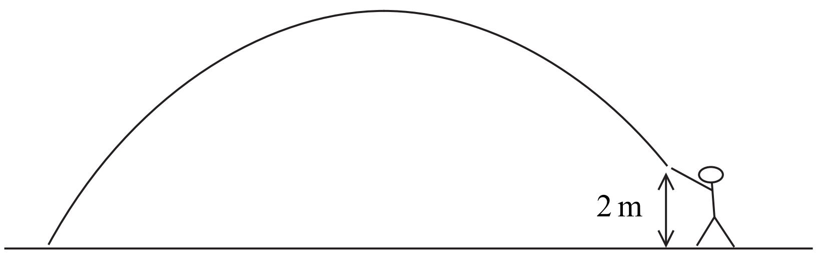
(a) Show that the magnitude of the resultant velocity of the boat is $3.85\,\mathrm{m\,s^{-1}}$, correct to three significant figures. *(4 marks)*

(b) Find the bearing on which the boat is travelling, giving your answer to the nearest degree. *(4 marks)*

8 A cricket ball is hit at ground level on a horizontal surface. It initially moves at $28\,\mathrm{m\,s^{-1}}$ at an angle of 50° above the horizontal.

(a) Find the maximum height of the ball during its flight. *(4 marks)*

(b) The ball is caught when it is at a height of 2 metres above ground level, as shown in the diagram.



Show that the time that it takes for the ball to travel from the point where it was hit to the point where it was caught is 4.28 seconds, correct to three significant figures. *(5 marks)*

(c) Find the speed of the ball when it is caught. *(5 marks)*

END OF QUESTIONS

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