General Certificate of Education
January 2009
Advanced Subsidiary Examination

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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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**.

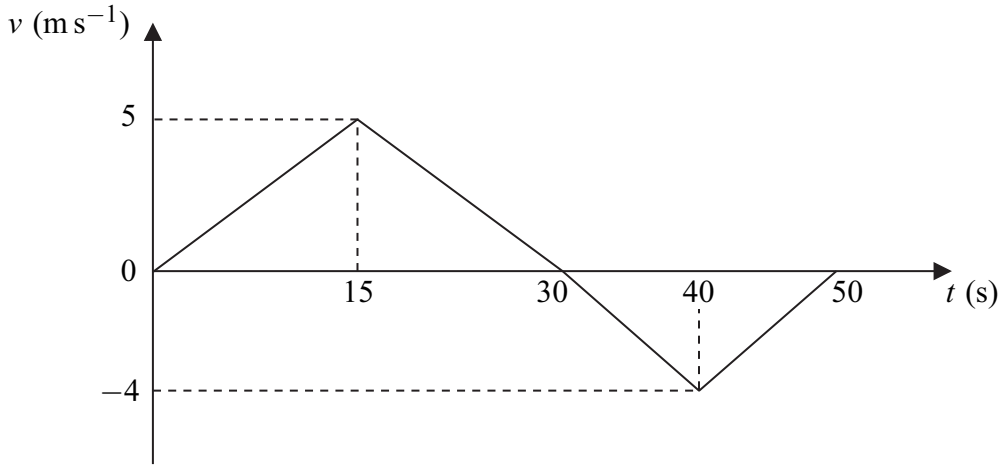
Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 A particle of mass 4 kg is travelling at $8\,\mathrm{m\,s^{-1}}$ 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.



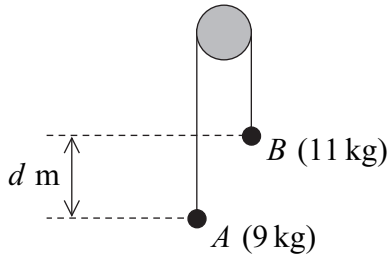
(a) State the times at which the velocity of the particle is zero. *(2 marks)*

(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.

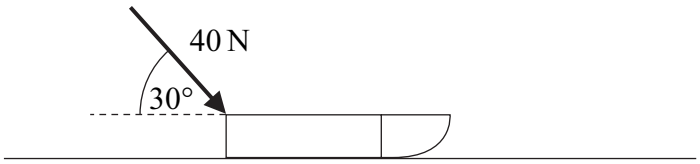
(a) By forming an equation of motion for each of the particles A and B, show that the acceleration of each particle has magnitude $0.98\,\text{m}\,\text{s}^{-2}$. *(5 marks)*

(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)*

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)*

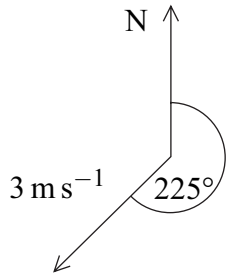
(c) When these two forces act on the particle, it has an acceleration of $(1.5\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-2}}$. Find the mass of the particle. *(2 marks)*

(d) The particle was initially at rest at the origin.

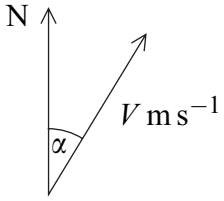
(i) Find an expression for the position vector of the particle when the forces have been applied to the particle for t seconds. *(2 marks)*

(ii) Find the distance of the particle from the origin when the forces have been applied to the particle for 2 seconds. *(2 marks)*

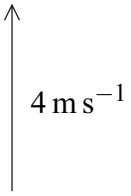
6 A boat is travelling in water that is moving south-west at a speed of $3\,\mathrm{m\,s^{-1}}$. The velocity of the boat relative to the water is $V\,\mathrm{m\,s^{-1}}$ on a bearing α. The resultant velocity of the boat is $4\,\mathrm{m\,s^{-1}}$ due north.



Velocity of the water



Velocity of the boat relative to the water



Resultant velocity of the boat

(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 $30\,\mathrm{m\,s^{-1}}$ 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 $28\,\mathrm{m\,s^{-1}}$, the magnitude of the vertical component of its velocity is $13.4\,\mathrm{m\,s^{-1}}$, 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 $28\,\mathrm{m\,s^{-1}}$. *(2 marks)*

END OF QUESTIONS

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