General Certificate of Education
June 2005
Advanced Subsidiary Examination

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

Thursday 16 June 2005 Afternoon Session

In addition to this paper you will require:
- 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 tables or 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.
- Mark allocations are shown in brackets.
- Unit Mechanics 1A has a **written paper and coursework**.

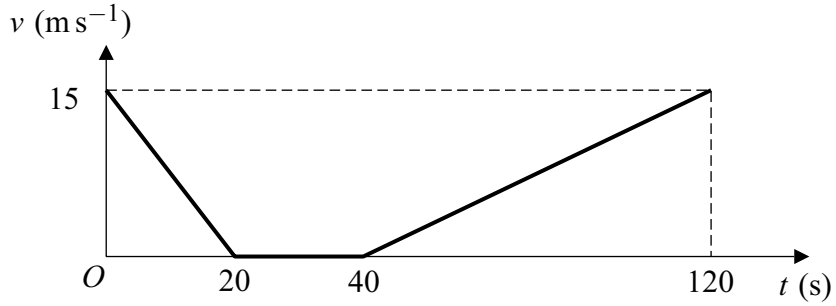
Advice
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

1 A train travels along a straight horizontal track between two points A and B.

Initially the train is at A and moving at $15\,\text{m s}^{-1}$. Due to a problem, the train has to slow down and stop. At time $t = 40$ seconds it begins to move again. At time $t = 120$ seconds the train is at B and moving at $15\,\text{m s}^{-1}$ again.

The graph below shows how the velocity of the train varies as it moves from A to B.



(a) Use the graph to find the total distance between the points A and B. *(4 marks)*

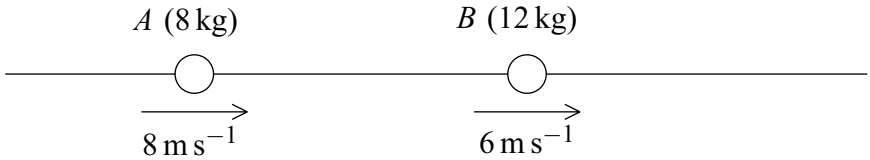
(b) The train should have travelled between A and B at a constant velocity of $15\,\text{m s}^{-1}$.

(i) Calculate the time that the train would take to travel between A and B at a speed of $15\,\text{m s}^{-1}$. *(1 mark)*

(ii) Calculate the time by which the train was delayed. *(1 mark)*

(c) The train has mass 500 tonnes. Find the resultant force acting on the train when $40 < t < 120$. *(4 marks)*

2 Two particles, A and B, are moving in the same direction along a straight line. Particle A has mass 8 kg and speed $8\,\text{m s}^{-1}$. Particle B has mass 12 kg and speed $6\,\text{m s}^{-1}$. The two particles collide.



(a) If, during the collision, the two particles coalesce, find the speed of the combined particle. *(3 marks)*

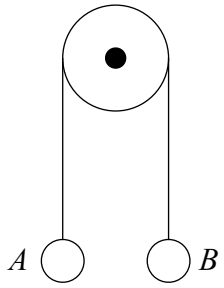
(b) If, after the collision, particle A continues to move in the same direction at $6.5\,\text{m s}^{-1}$, find the speed of B after the collision. *(3 marks)*

3 An aeroplane is heading due east at $200\,\text{m s}^{-1}$ relative to the air. A wind is blowing due north at $30\,\text{m s}^{-1}$.

(a) Find the magnitude of the resultant velocity of the aeroplane. *(3 marks)*

(b) Find the bearing on which the aeroplane actually travels. *(3 marks)*

4 Two particles, A of mass 5 kg and B of mass 9 kg, are attached to the ends of a light inextensible string. The string passes over a light smooth pulley as shown in the diagram. The particles are released from rest at the same height.



(a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $2.8\,\text{m s}^{-2}$. *(5 marks)*

(b) Find the tension in the string. *(2 marks)*

(c) When B has been moving for 0.5 seconds it hits the floor. Find the height of A, above the floor, at this time. Assume that A is still below the pulley when B hits the floor. *(4 marks)*

5 An arrow is fired horizontally with a speed of $30\,\text{m s}^{-1}$ from a height of 2 m above ground level. Model the arrow as a particle which does not experience air resistance.

(a) Show that the time taken for the arrow to hit the ground is 0.639 seconds, correct to three significant figures. *(4 marks)*

(b) Find the horizontal distance travelled by the arrow. *(2 marks)*

(c) Describe what happens, during the flight of the arrow, to the magnitude of:

(i) the horizontal component of the velocity;

(ii) the vertical component of the velocity. *(2 marks)*

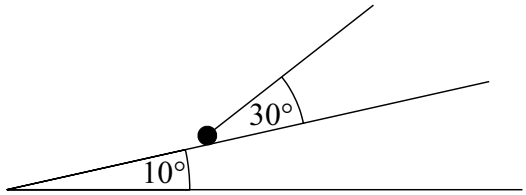
6 A particle moves on a smooth horizontal surface with acceleration $(3\mathbf{i} - 5\mathbf{j})\,\mathrm{m\,s^{-2}}$. Initially the velocity of the particle is $4\mathbf{j}\,\mathrm{m\,s^{-1}}$.

(a) Find an expression for the velocity of the particle at time t seconds. *(2 marks)*

(b) Find the time when the particle is travelling in the **i** direction. *(2 marks)*

(c) Show that when $t = 4$ the speed of the particle is $20\,\mathrm{m\,s^{-1}}$. *(4 marks)*

7 A rough slope is inclined at an angle of 10° to the horizontal. A particle of mass 6 kg is on the slope. A string is attached to the particle and is at an angle of 30° to the slope. The tension in the string is 20 N. The diagram shows the slope, the particle and the string.



The particle moves up the slope with an acceleration of $0.4\,\mathrm{m\,s^{-2}}$.

(a) Draw a diagram to show the forces acting on the particle. *(1 mark)*

(b) Show that the magnitude of the normal reaction force is 47.9 N, correct to three significant figures. *(4 marks)*

(c) Find the coefficient of friction between the particle and the slope. *(6 marks)*

END OF QUESTIONS

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