General Certificate of Education
June 2005
Advanced Subsidiary Examination

MATHEMATICS **MM1B**
Unit Mechanics 1B

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 30 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 MM1B.
- 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 75.
- Mark allocations are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

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

Answer **all** questions.

1 A particle of mass m has velocity $\begin{bmatrix} 4 \\ 2 \end{bmatrix}$ m s^{-1}. It then collides with a particle of mass 3 kg which has velocity $\begin{bmatrix} -1 \\ -1 \end{bmatrix}$ m s^{-1}. During the collision the particles coalesce and move with velocity $\begin{bmatrix} 1 \\ V \end{bmatrix}$ m s^{-1}.

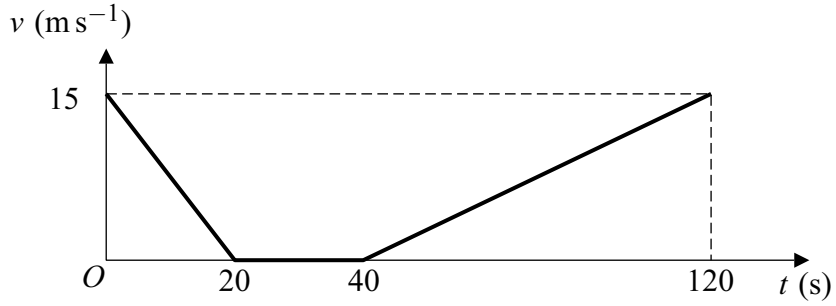
(a) Show that $m = 2$. *(4 marks)*

(b) Find V. *(3 marks)*

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

Initially the train is at A and moving at 15 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 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)*

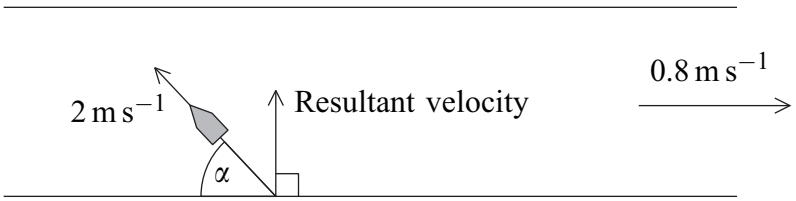
(b) The train should have travelled between A and B at a constant velocity of 15 m s^{-1}.

(i) Calculate the time that the train would take to travel between A and B at a speed of 15 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)*

3 A boat can travel at a speed of $2\,\mathrm{m\,s^{-1}}$ in still water. The boat is to cross a river in which a current flows at a speed of $0.8\,\mathrm{m\,s^{-1}}$. The angle between the direction in which the boat is pointing and the bank is α. The boat travels so that the resultant velocity of the boat is perpendicular to the bank.

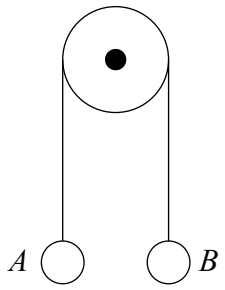


(a) Show that $\alpha = 66.4^\circ$ correct to three significant figures. *(3 marks)*

(b) (i) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

(ii) The width of the river is 14 metres. Find the time that it takes for the boat to cross the river. *(2 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 $2.8\,\mathrm{m\,s^{-2}}$. *(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 A sphere of mass 200 grams is released from rest and allowed to fall vertically.

(a) A student states that the acceleration of the sphere is $9.8\,\mathrm{m\,s^{-2}}$ while it is falling. What modelling assumption is this student making? *(1 mark)*

(b) The student conducts an experiment and finds that the acceleration of the ball is in fact $8\,\mathrm{m\,s^{-2}}$. He formulates a model for the motion that assumes a constant resistance force acts on the ball as it is falling.

(i) Calculate the magnitude of this resistance force based on this assumption. *(3 marks)*

(ii) Describe how the resistance force would vary in reality. *(1 mark)*

(c) In a revised model the resistance force is assumed to be proportional to the speed of the sphere.

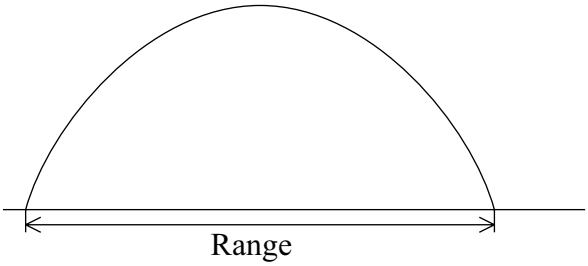
(i) State the initial acceleration of the sphere. *(1 mark)*

(ii) State what would happen to the acceleration of the sphere if it were able to fall for a long period of time. *(1 mark)*

6 A ball is hit from horizontal ground with velocity $(10\mathbf{i} + 24.5\mathbf{j})\,\mathrm{m\,s^{-1}}$ where the unit vectors **i** and **j** are horizontal and vertically upwards respectively.

(a) State two assumptions that you should make about the ball in order to make predictions about its motion. *(2 marks)*

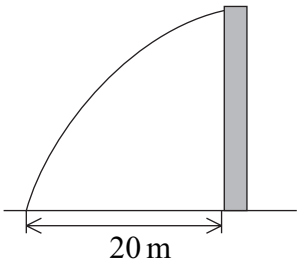
(b) The path of the ball is shown in the diagram.



(i) Show that the time of flight of the ball is 5 seconds. *(4 marks)*

(ii) Find the range of the ball. *(2 marks)*

(c) In fact the ball hits a vertical wall that is 20 metres from the initial position of the ball.



Find the height of the ball when it hits the wall. *(4 marks)*

(d) If a heavier ball were projected in the same way, would your answers to part (b) of this question change? Explain why. *(2 marks)*

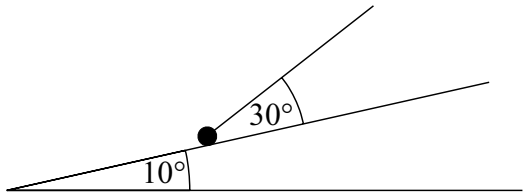
7 A particle moves on a smooth horizontal surface with acceleration $(3\mathbf{i} - 5\mathbf{j})\,\mathrm{m\,s^{-2}}$. Initially the velocity of the particle is $4\mathbf{j}\,\mathrm{m\,s^{-1}}$.

(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)*

8 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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