

General Certificate of Education
June 2005
Advanced Subsidiary Examination



MATHEMATICS
Unit Mechanics 1B

MM1B

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 $g = 9.8 \text{ m s}^{-2}$, 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 $\begin{bmatrix} 4 \\ 2 \end{bmatrix} \text{ m s}^{-1}$. It then collides with a particle of mass 3 kg which has velocity $\begin{bmatrix} -1 \\ -1 \end{bmatrix} \text{ m s}^{-1}$. During the collision the particles coalesce and move with velocity $\begin{bmatrix} 1 \\ V \end{bmatrix} \text{ m s}^{-1}$.

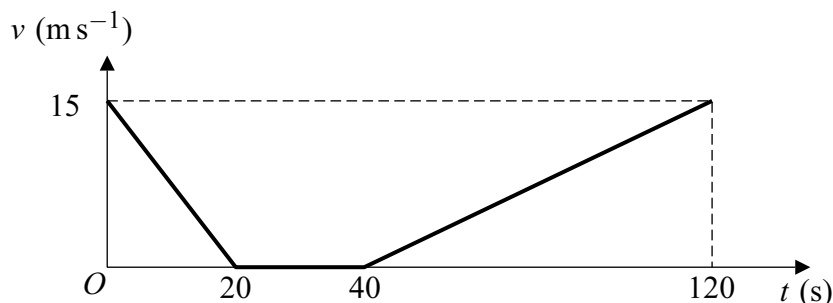
(a) Show that $m = 2$. (4 marks)

(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)

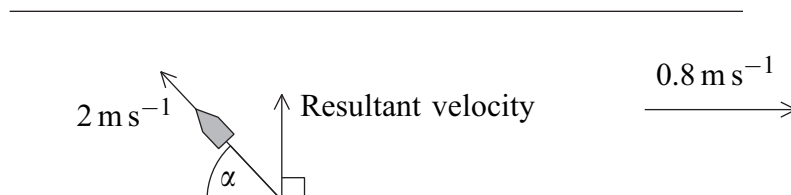
(b) The train should have travelled between A and B at a constant velocity of 15 m s^{-1} .

(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)

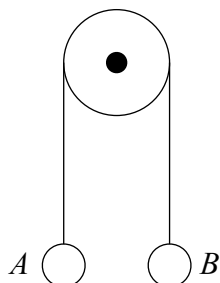
(ii) Calculate the time by which the train was delayed. (1 mark)

(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 m s^{-1} in still water. The boat is to cross a river in which a current flows at a speed of 0.8 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.

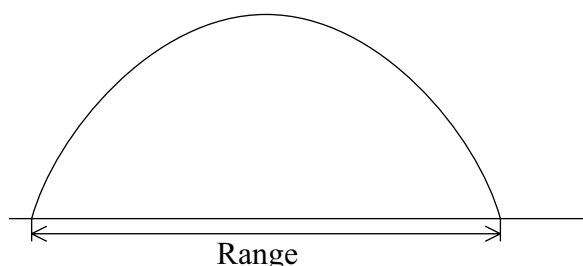


- (a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is 2.8 m s^{-2} . (5 marks)
- (b) Find the tension in the string. (2 marks)
- (c) When B has been moving for 0.5 seconds it hits the floor. Find the height of A , above the floor, at this time. Assume that A is still below the pulley when B hits the floor. (4 marks)

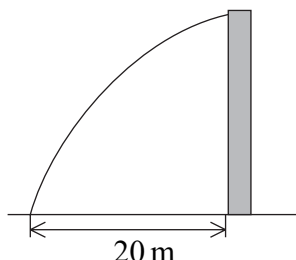
- 5 A sphere of mass 200 grams is released from rest and allowed to fall vertically.
- (a) A student states that the acceleration of the sphere is 9.8 m s^{-2} while it is falling. What modelling assumption is this student making? *(1 mark)*
- (b) The student conducts an experiment and finds that the acceleration of the ball is in fact 8 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 $(10\mathbf{i} + 24.5\mathbf{j})\text{ m s}^{-1}$ where the unit vectors \mathbf{i} and \mathbf{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)

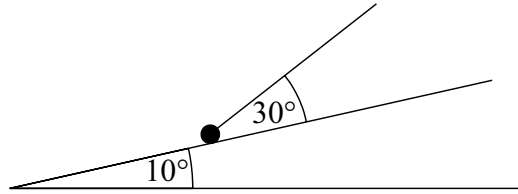
- (d) If a heavier ball were projected in the same way, would your answers to part (b) of this question change? Explain why. (2 marks)

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

- (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 \mathbf{i} direction. (2 marks)
- (c) Show that when $t = 4$ the speed of the particle is 20 m s^{-1} . (4 marks)

Turn over ►

- 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 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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