

General Certificate of Education
January 2005
Advanced Subsidiary Examination



MATHEMATICS
Unit Mechanics 1B

MM1B

Monday 31 January 2005 Morning 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 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**.

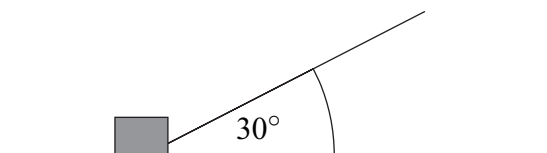
Advice

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

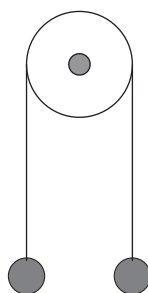
Answer **all** questions.

- 1 A train travels along a straight horizontal track. It is travelling at a speed of 12 m s^{-1} when it begins to accelerate uniformly. It reaches a speed of 40 m s^{-1} after accelerating for 100 seconds.
- (a) (i) Show that the acceleration of the train is 0.28 m s^{-2} . (2 marks)
- (ii) Find the distance that the train travelled in the 100 seconds. (2 marks)
- (b) The mass of the train is 200 tonnes and a resistance force of 40 000 N acts on the train. Find the magnitude of the driving force produced by the engine that acts on the train as it accelerates. (3 marks)
- 2 A particle, A , of mass 12 kg is moving on a smooth horizontal surface with velocity $\begin{bmatrix} 4 \\ 7 \end{bmatrix} \text{ m s}^{-1}$. It then collides and coalesces with a second particle, B , of mass 4 kg.
- (a) If before the collision the velocity of B was $\begin{bmatrix} 2 \\ 3 \end{bmatrix} \text{ m s}^{-1}$, find the velocity of the combined particle after the collision. (4 marks)
- (b) If after the collision the velocity of the combined particle is $\begin{bmatrix} 1 \\ 4 \end{bmatrix} \text{ m s}^{-1}$, find the velocity of B before the collision. (3 marks)

- 3 The diagram shows a rope that is attached to a box of mass 25 kg, which is being pulled along rough horizontal ground. The rope is at an angle of 30° to the ground. The tension in the rope is 40 N. The box accelerates at 0.1 m s^{-2} .

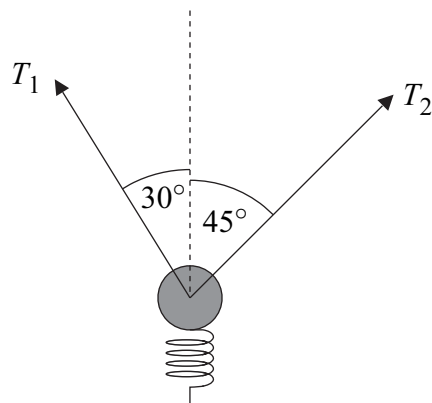


- (a) Draw a diagram to show all of the forces acting on the box. *(1 mark)*
- (b) Show that the magnitude of the friction force acting on the box is 32.1 N, correct to three significant figures. *(3 marks)*
- (c) Show that the magnitude of the normal reaction force that the ground exerts on the box is 225 N. *(3 marks)*
- (d) Find the coefficient of friction between the box and the ground. *(2 marks)*
- (e) State what would happen to the magnitude of the friction force if the angle between the rope and the horizontal were increased. Give a reason for your answer. *(2 marks)*
- 4 Two particles are connected by a string, which passes over a pulley. Model the string as light and inextensible. The particles have masses of 2 kg and 5 kg. The particles are released from rest.



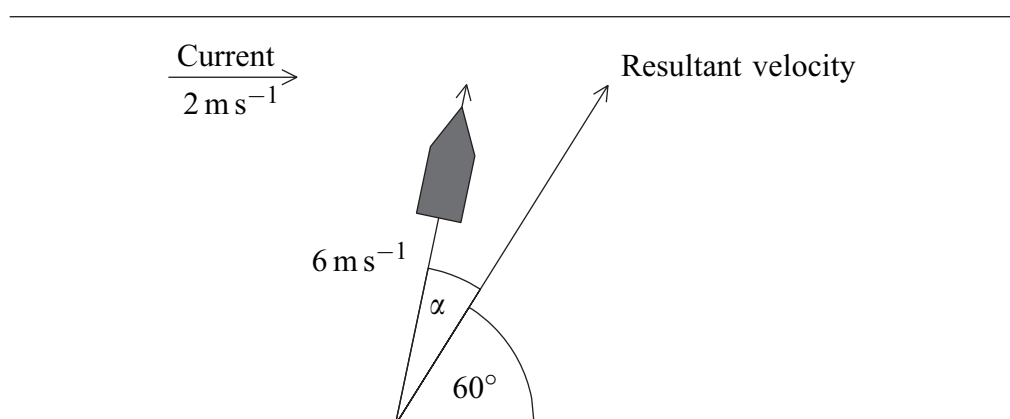
- (a) State one modelling assumption that you should make about the pulley in order to determine the acceleration of the particles. *(1 mark)*
- (b) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is 4.2 m s^{-2} . *(5 marks)*
- (c) Find the tension in the string. *(2 marks)*

- 5 Two ropes are attached to a load of mass 500 kg. The ropes make angles of 30° and 45° to the vertical, as shown in the diagram. The tensions in these ropes are T_1 and T_2 newtons. The load is also supported by a vertical spring.



The system is in equilibrium and $T_1 = 200$.

- (a) Show that $T_2 = 141$, correct to three significant figures. (3 marks)
- (b) Find the force that the spring exerts on the load. (4 marks)
- 6 A motor boat can travel at a speed of 6 m s^{-1} relative to the water. It is used to cross a river in which the current flows at 2 m s^{-1} . The resultant velocity of the boat makes an angle of 60° to the river bank, as shown in the diagram.



The angle between the direction in which the boat is travelling relative to the water and the resultant velocity is α .

- (a) Show that $\alpha = 16.8^\circ$, correct to three significant figures. (4 marks)
- (b) Find the magnitude of the resultant velocity. (3 marks)

- 7 The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. A yacht moves with a constant acceleration. At time t seconds the position vector of the yacht is \mathbf{r} metres. When $t = 0$ the velocity of the yacht is $(2\mathbf{i} - \mathbf{j})\text{ms}^{-1}$, and when $t = 10$ the velocity of the yacht is $(-\mathbf{i} + \mathbf{j})\text{ms}^{-1}$.
- (a) Find the acceleration of the yacht. *(3 marks)*
- (b) When $t = 0$ the yacht is 20 metres due east of the origin. Find an expression for \mathbf{r} in terms of t . *(3 marks)*
- (c) (i) Show that when $t = 20$ the yacht is due north of the origin. *(2 marks)*
- (ii) Find the speed of the yacht when $t = 20$. *(4 marks)*
- 8 A football is placed on a horizontal surface. It is then kicked, so that it has an initial velocity of 12ms^{-1} at an angle of 40° above the horizontal.
- (a) State two modelling assumptions that it would be appropriate to make when considering the motion of the football. *(2 marks)*
- (b) (i) Find the time that it takes for the ball to reach its maximum height. *(4 marks)*
- (ii) Hence show that the maximum height of the ball is 3.04 metres, correct to three significant figures. *(3 marks)*
- (c) After the ball has reached its maximum height, it hits the bar of a goal at a height of 2.44 metres. Find the horizontal distance of the goal from the point where the ball was kicked. *(7 marks)*

END OF QUESTIONS

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