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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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 train travels along a straight horizontal track. It is travelling at a speed of $12\,\text{m s}^{-1}$ when it begins to accelerate uniformly. It reaches a speed of $40\,\text{m s}^{-1}$ after accelerating for 100 seconds.

(a) (i) Show that the acceleration of the train is $0.28\,\text{m s}^{-2}$. *(2 marks)*

(ii) Find the distance that the train travelled in the 100 seconds. *(2 marks)*

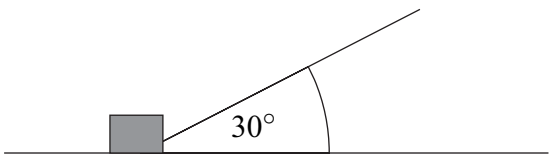
(b) The mass of the train is 200 tonnes and a resistance force of 40 000 N acts on the train. Find the magnitude of the driving force produced by the engine that acts on the train as it accelerates. *(3 marks)*

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 $0.1\,\text{m}\,\text{s}^{-2}$.



(a) Draw a diagram to show all of the forces acting on the box. *(1 mark)*

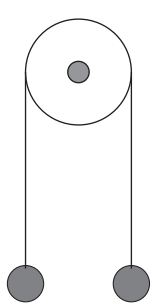
(b) Show that the magnitude of the friction force acting on the box is 32.1 N, correct to three significant figures. *(3 marks)*

(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.

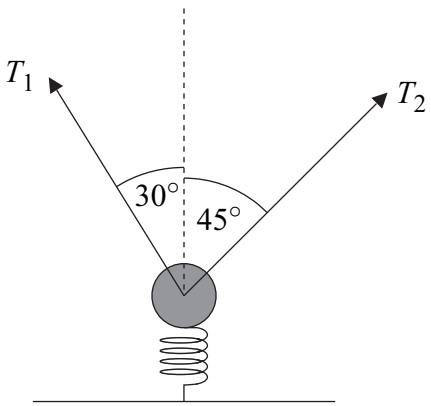


(a) State one modelling assumption that you should make about the pulley in order to determine the acceleration of the particles. *(1 mark)*

(b) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $4.2\,\text{m}\,\text{s}^{-2}$. *(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.

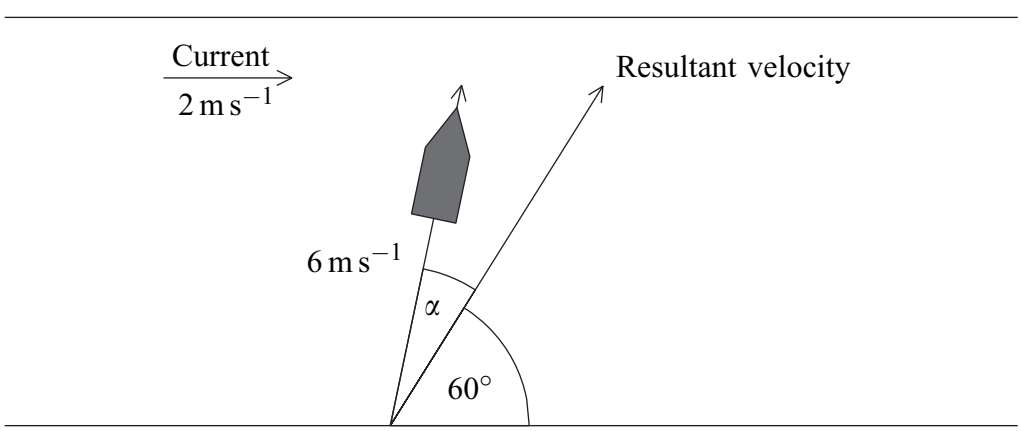


The system is in equilibrium and $T_1 = 200$.

(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 $6\,\text{m s}^{-1}$ relative to the water. It is used to cross a river in which the current flows at $2\,\text{m s}^{-1}$. 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 $\alpha = 16.8°$, correct to three significant figures. *(4 marks)*

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

7 The unit vectors **i** and **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 **r** metres. When $t = 0$ the velocity of the yacht is $(2\mathbf{i} - \mathbf{j})\,\mathrm{m\,s^{-1}}$, and when $t = 10$ the velocity of the yacht is $(-\mathbf{i} + \mathbf{j})\,\mathrm{m\,s^{-1}}$.

(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 **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 $12\,\mathrm{m\,s^{-1}}$ 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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