General Certificate of Education
June 2009
Advanced Subsidiary Examination

MATHEMATICS MM1B
Unit Mechanics 1B

Friday 5 June 2009 1.30 pm to 3.00 pm

For this paper you must have:
- 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 black ink or black 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.
- Show all necessary working; 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.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 Two particles, A and B, are moving on a smooth horizontal surface when they collide. During the collision, the two particles coalesce to form a single combined particle. Particle A has mass 3 kg and particle B has mass 7 kg.

Before the collision, the velocity of A is $\begin{bmatrix} 6 \\ -2 \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} -1 \\ 4 \end{bmatrix}$ m s^{-1}.

(a) Find the velocity of the combined particle after the collision. *(3 marks)*

(b) Find the speed of the combined particle after the collision. *(2 marks)*

2 A lift is travelling upwards and accelerating uniformly. During a 5 second period, it travels 16 metres and the speed of the lift increases from u m s^{-1} to 4.2 m s^{-1}.

(a) Find u. *(3 marks)*

(b) Find the acceleration of the lift. *(3 marks)*

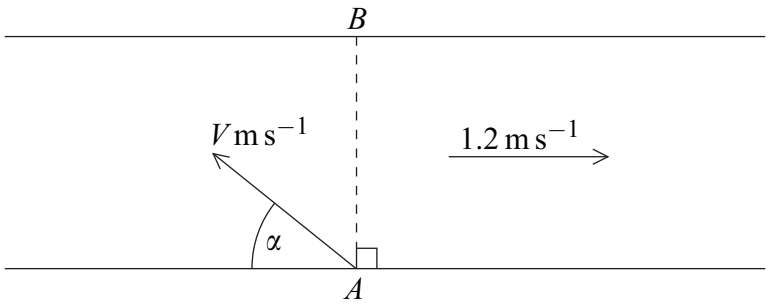
3 A car is travelling in a straight line on a horizontal road. A driving force, of magnitude 3000 N, acts in the direction of motion and a resistance force, of magnitude 600 N, opposes the motion of the car. Assume that no other horizontal forces act on the car.

(a) Find the magnitude of the resultant force on the car. *(2 marks)*

(b) The mass of the car is 1200 kg. Find the acceleration of the car. *(2 marks)*

4 A river has parallel banks which are 16 metres apart. The water in the river flows at $1.2\,\text{m s}^{-1}$ parallel to the banks. A boat sets off from one bank at the point A and travels perpendicular to the bank so that it reaches the point B, which is directly opposite the point A. It takes the boat 10 seconds to cross the river.

The velocity of the boat relative to the water has magnitude $V\,\text{m s}^{-1}$ and is at an angle α to the bank, as shown in the diagram.



(a) Show that the magnitude of the resultant velocity of the boat is $1.6\,\text{m s}^{-1}$. *(1 mark)*

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

(c) Find α. *(2 marks)*

(d) State one modelling assumption that you needed to make about the boat. *(1 mark)*

Turn over for the next question

5 A block, of mass 14 kg, is held at rest on a rough horizontal surface. The coefficient of friction between the block and the surface is 0.25. A light inextensible string, which passes over a fixed smooth peg, is attached to the block. The other end of the string is attached to a particle, of mass 6 kg, which is hanging at rest.

The block is released and begins to accelerate.

(a) Find the magnitude of the friction force acting on the block. *(3 marks)*

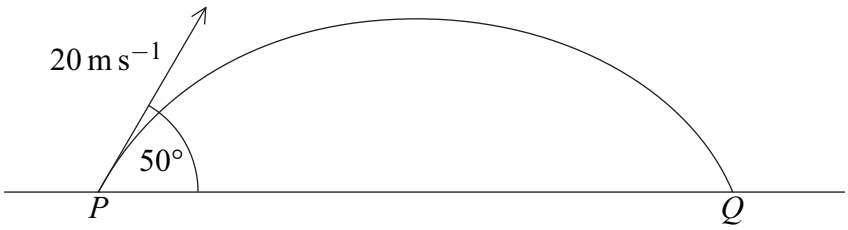
(b) By forming two equations of motion, one for the block and one for the particle, show that the magnitude of the acceleration of the block and the particle is $1.225\,\text{m}\,\text{s}^{-2}$. *(5 marks)*

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

(d) When the block is released, it is 0.8 metres from the peg. Find the speed of the block when it hits the peg. *(3 marks)*

(e) When the block reaches the peg, the string breaks and the particle falls a further 0.5 metres to the ground. Find the speed of the particle when it hits the ground. *(3 marks)*

6 A ball is kicked from the point P on a horizontal surface. It leaves the surface with a velocity of $20\,\mathrm{m\,s^{-1}}$ at an angle of $50°$ above the horizontal and hits the surface for the first time at the point Q. Assume that the ball is a particle that moves only under the influence of gravity.



(a) Show that the time that it takes the ball to travel from P to Q is 3.13 s, correct to three significant figures. *(4 marks)*

(b) Find the distance between the points P and Q. *(2 marks)*

(c) If a heavier ball were projected from P with the same velocity, how would the distance between P and Q, calculated using the same modelling assumptions, compare with your answer to part (b)? Give a reason for your answer. *(2 marks)*

(d) Find the maximum height of the ball above the horizontal surface. *(3 marks)*

(e) State the magnitude and direction of the velocity of the ball as it hits the surface. *(2 marks)*

7 A particle moves on a smooth horizontal plane. It is initially at the point A, with position vector $(9\mathbf{i} + 7\mathbf{j})\,\mathrm{m}$, and has velocity $(-2\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. The particle moves with a constant acceleration of $(0.25\mathbf{i} + 0.3\mathbf{j})\,\mathrm{m\,s^{-2}}$ for 20 seconds until it reaches the point B. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

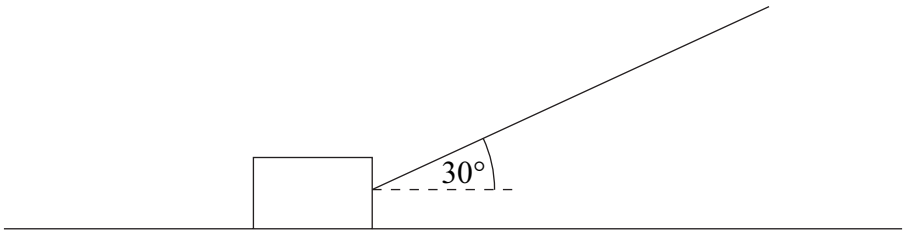
(a) Find the velocity of the particle at the point B. *(3 marks)*

(b) Find the velocity of the particle when it is travelling due north. *(4 marks)*

(c) Find the position vector of the point B. *(3 marks)*

(d) Find the average velocity of the particle as it moves from A to B. *(2 marks)*

8 The diagram shows a block, of mass 20 kg, being pulled along a rough horizontal surface by a rope inclined at an angle of 30° to the horizontal.



The coefficient of friction between the block and the surface is μ. Model the block as a particle which slides on the surface.

(a) If the tension in the rope is 60 newtons, the block moves at a constant speed.

(i) Show that the magnitude of the normal reaction force acting on the block is 166 N. *(3 marks)*

(ii) Find μ. *(4 marks)*

(b) If the rope remains at the same angle and the block accelerates at $0.8\,\text{m}\,\text{s}^{-2}$, find the tension in the rope. *(5 marks)*

END OF QUESTIONS

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