General Certificate of Education
Advanced Subsidiary Examination
January 2012

Mathematics MM1B

Unit Mechanics 1B

Friday 20 January 2012 1.30 pm to 3.00 pm

For this paper you must have:
- 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.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\ \mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

1 Two particles, A of mass 7 kg and B of mass 3 kg, are moving on a smooth horizontal plane when they collide. Just before the collision, the velocity of A is $(3\mathbf{i} + 8\mathbf{j})\,\text{m s}^{-1}$ and the velocity of B is $(6\mathbf{i} - 5\mathbf{j})\,\text{m s}^{-1}$. During the collision, the particles coalesce to form a single combined particle.

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

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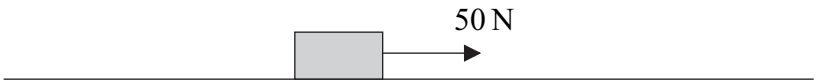
2 A block, of mass 4 kg, is made to move in a straight line on a rough horizontal surface by a horizontal force of 50 newtons, as shown in the diagram.



Assume that there is no air resistance acting on the block.

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

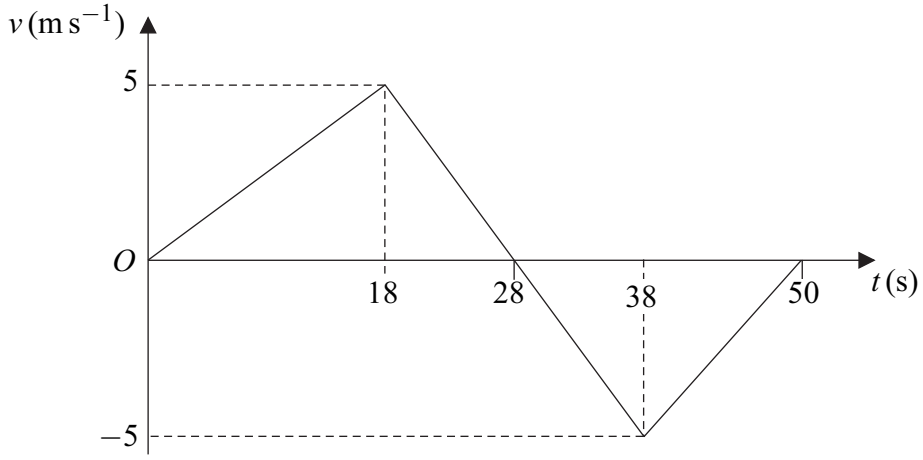
(b) Find the magnitude of the normal reaction force acting on the block. *(1 mark)*

(c) The acceleration of the block is $3\,\text{m s}^{-2}$. Find the magnitude of the friction force acting on the block. *(3 marks)*

(d) Find the coefficient of friction between the block and the surface. *(2 marks)*

(e) Explain how and why your answer to part **(d)** would change if you assumed that air resistance did act on the block. *(2 marks)*

3 The diagram shows a velocity–time graph for a train as it moves on a straight horizontal track for 50 seconds.



(a) Find the distance that the train moves in the first 28 seconds. *(2 marks)*

(b) Calculate the total distance moved by the train during the 50 seconds. *(3 marks)*

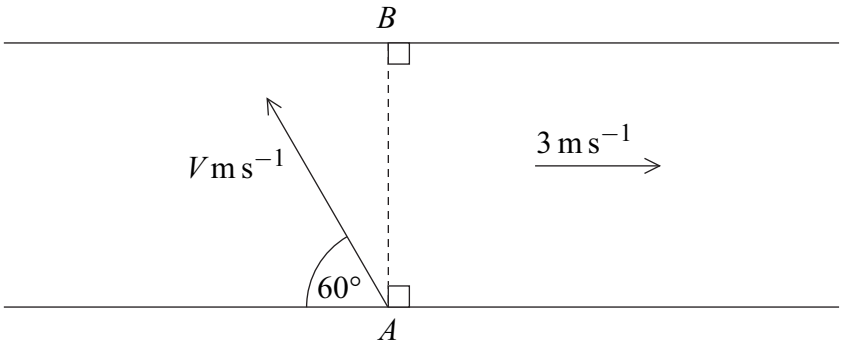
(c) Hence calculate the average speed of the train. *(2 marks)*

(d) Find the displacement of the train from its initial position when it has been moving for 50 seconds. *(1 mark)*

(e) Hence calculate the average velocity of the train. *(2 marks)*

(f) Find the acceleration of the train in the first 18 seconds of its motion. *(1 mark)*

4 A small ferry is used to cross a river which has straight parallel banks that are 200 metres apart. The water in the river moves at a constant speed of $3\,\text{m}\,\text{s}^{-1}$. The ferry travels from a point A on one bank to a point B directly opposite A on the other bank. The velocity of the ferry relative to the water is $V\,\text{m}\,\text{s}^{-1}$ at an angle of 60° to the upstream bank, as shown in the diagram.



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

(b) Find the time that it takes for the ferry to cross the river, giving your answer to the nearest second. *(3 marks)*

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5 A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal towbar. A resistance force of magnitude R newtons acts on the car and a resistance force of magnitude $2R$ newtons acts on the caravan. The car and caravan accelerate at a constant $1.6\,\text{m}\,\text{s}^{-2}$ when a driving force of magnitude 4720 newtons acts on the car.

(a) Find R. *(4 marks)*

(b) Find the tension in the towbar. *(3 marks)*

6 A cyclist freewheels, with a constant acceleration, in a straight line down a slope. As the cyclist moves 50 metres, his speed increases from $4\,\mathrm{m\,s^{-1}}$ to $10\,\mathrm{m\,s^{-1}}$.

(a) (i) Find the acceleration of the cyclist. *(3 marks)*

(ii) Find the time that it takes the cyclist to travel this distance. *(3 marks)*

(b) The cyclist has a mass of 70 kg. Calculate the magnitude of the resultant force acting on the cyclist. *(2 marks)*

(c) The slope is inclined at an angle α to the horizontal.

(i) Find α if it is assumed that there is no resistance force acting on the cyclist. *(3 marks)*

(ii) Find α if it is assumed that there is a constant resistance force of magnitude 30 newtons acting on the cyclist. *(3 marks)*

(d) Make a criticism of the assumption described in part **(c)(ii)**. *(1 mark)*

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7 A helicopter is initially at rest on the ground at the origin when it begins to accelerate in a vertical plane. Its acceleration is $(4.2\mathbf{i} + 2.5\mathbf{j})\,\mathrm{m\,s^{-2}}$ for the first 20 seconds of its motion. The unit vectors **i** and **j** are horizontal and vertical respectively.

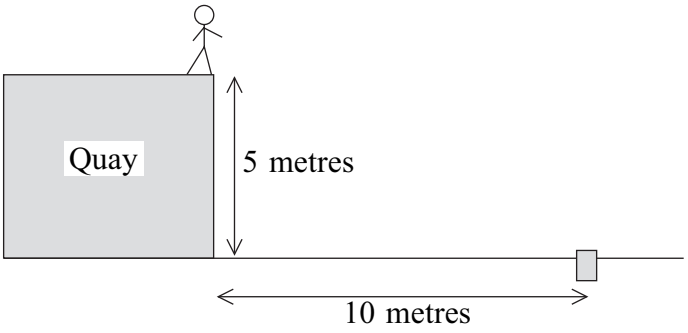
Assume that the helicopter moves over horizontal ground.

(a) Find the height of the helicopter above the ground at the end of the 20 seconds. *(3 marks)*

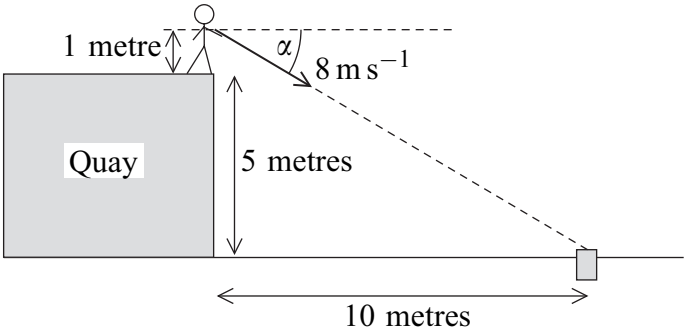
(b) Find the velocity of the helicopter at the end of the 20 seconds. *(2 marks)*

(c) Find the speed of the helicopter when it is at a height of 180 metres above the ground. *(7 marks)*

8 A girl stands at the edge of a quay and sees a tin can floating in the water. The water level is 5 metres below the top of the quay and the can is at a horizontal distance of 10 metres from the quay, as shown in the diagram.



The girl decides to throw a stone at the can. She throws the stone from a height of 1 metre above the top of the quay. The initial velocity of the stone is $8\,\mathrm{m\,s^{-1}}$ at an angle α below the horizontal, so that the initial velocity of the stone is directed at the can, as shown in the diagram.



Assume that the stone is a particle and that it experiences no air resistance as it moves.

(a) Find α. *(2 marks)*

(b) Find the time that it takes for the stone to reach the level of the water. *(6 marks)*

(c) Find the distance between the stone and the can when the stone hits the water. *(4 marks)*