General Certificate of Education
Advanced Subsidiary Examination
June 2013

Mathematics MM1B

Unit Mechanics 1B

Friday 24 May 2013 9.00 am to 10.30 am

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 each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- 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.

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 A toy train of mass 300 grams is moving along a straight horizontal track at a speed of $2.8\,\text{m s}^{-1}$. This toy train collides with another toy train, of mass 200 grams, which is at rest on the same track. During the collision, the two trains lock together and then move together.

Find the speed of the trains immediately after the collision. *(3 marks)*

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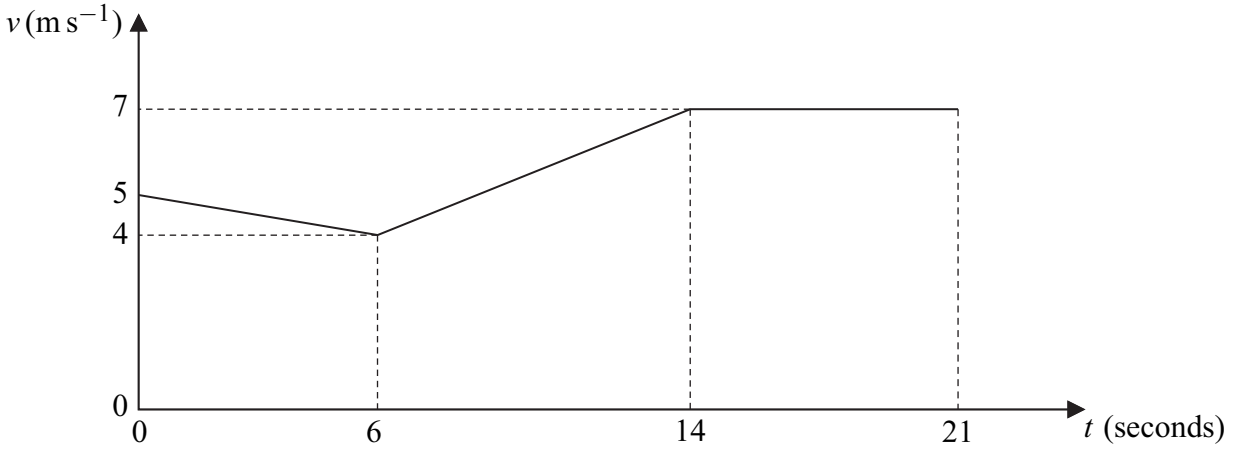
2 The graph shows how the speed of a cyclist, Hannah, varies as she travels for 21 seconds along a straight horizontal road.



(a) Find the distance travelled by Hannah in the 21 seconds. *(4 marks)*

(b) Find Hannah's average speed during the 21 seconds. *(2 marks)*

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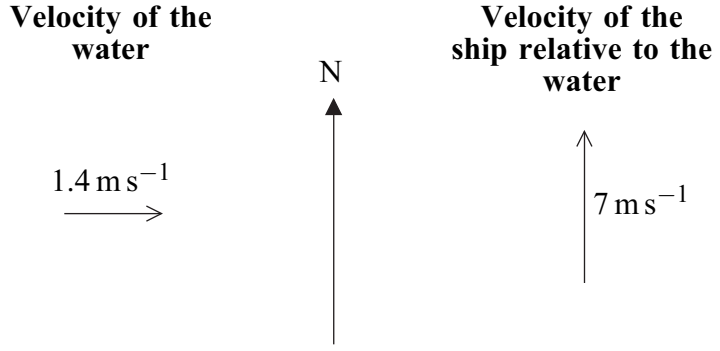
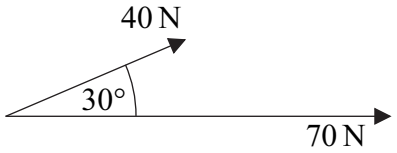
3 A ship travels through water that is moving due east at a speed of $1.4\,\text{m s}^{-1}$. The ship travels due north relative to the water at a speed of $7\,\text{m s}^{-1}$. The resultant velocity of the ship is $V\,\text{m s}^{-1}$ on a bearing α.



(a) Find V. *(2 marks)*

(b) Find α, giving your answer as a three-figure bearing, correct to the nearest degree. *(3 marks)*

4 Two forces, acting at a point, have magnitudes of 40 newtons and 70 newtons. The angle between the two forces is 30°, as shown in the diagram.



(a) Find the magnitude of the resultant of these two forces. *(4 marks)*

(b) Find the angle between the resultant force and the 70 newton force. *(3 marks)*

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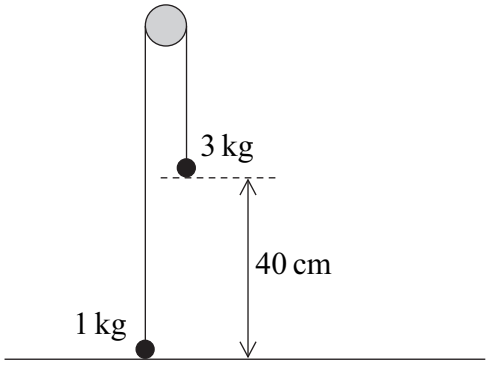
5 Two particles are connected by a light inextensible string that passes over a smooth peg. The particles have masses of 3 kg and 1 kg. The 1 kg particle is pulled down to ground level, where it is 40 cm below the level of the 3 kg particle, as shown in the diagram.



The particles are released from rest with the string vertical above each particle. Assume that no resistance forces act on the particles as they move.

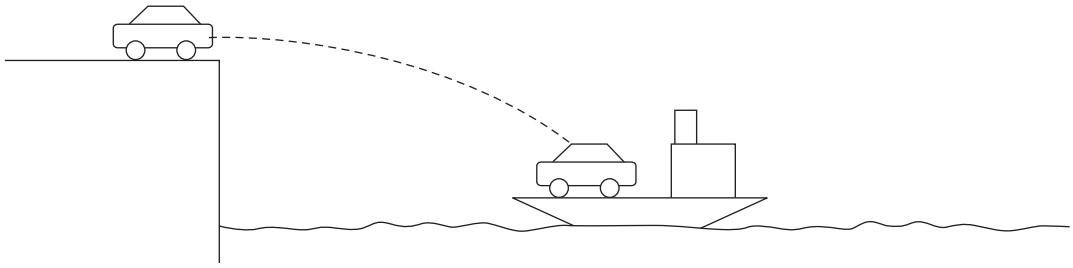
(a) By forming two equations of motion, one for each particle, find the magnitude of the acceleration of the particles after they have been released but before the 3 kg particle hits the ground. *(5 marks)*

(b) Find the speed of the 1 kg particle when the 3 kg particle hits the ground. *(2 marks)*

(c) After the 3 kg particle has hit the ground, the 1 kg particle continues to move and the string is now slack. Find the maximum height above ground level reached by the 1 kg particle. *(3 marks)*

(d) If a constant air resistance force also acts on the particles as they move, explain how this would change your answer for the acceleration in part **(a)**. Give a reason for your answer. *(2 marks)*

6 In a scene from an action movie, a car is driven off the edge of a cliff and lands on the deck of a boat in the sea, as shown in the diagram.



To land on the boat, the car must move 20 metres horizontally from the cliff. The level of the deck of the boat is 8 metres below the top of the cliff. Assume that the car is a particle which is travelling horizontally when it leaves the top of the cliff and that the car is not affected by air resistance as it moves.

(a) Find the time that it takes for the car to reach the deck of the boat. *(3 marks)*

(b) Find the speed at which the car is travelling when it leaves the top of the cliff. *(3 marks)*

(c) Find the speed of the car when it hits the deck of the boat. *(4 marks)*

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7 A block of mass 30 kg is dragged across a rough horizontal surface by a rope that is at an angle of 20° to the horizontal. The coefficient of friction between the block and the surface is 0.4 .

(a) The tension in the rope is 150 newtons.

(i) Draw a diagram to show the forces acting on the block as it moves. *(2 marks)*

(ii) Show that the magnitude of the normal reaction force on the block is 243 newtons, correct to three significant figures. *(3 marks)*

(iii) Find the magnitude of the friction force acting on the block. *(2 marks)*

(iv) Find the acceleration of the block. *(4 marks)*

(b) When the block is moving, the tension is reduced so that the block moves at a constant speed, with the angle between the rope and the horizontal unchanged. Find the tension in the rope when the block is moving at this constant speed. *(5 marks)*

(c) If the block were made to move at a greater **constant** speed, again with the angle between the rope and the horizontal unchanged, how would the tension in this case compare to the tension found in part **(b)**? *(1 mark)*

8 A helicopter travels at a constant height above the sea. It passes directly over a lighthouse with position vector $(500\mathbf{i} + 200\mathbf{j})$ metres relative to the origin, with a velocity of $(-17.5\mathbf{i} - 27\mathbf{j})\,\text{m s}^{-1}$. The helicopter moves with a constant acceleration of $(0.5\mathbf{i} + 0.6\mathbf{j})\,\text{m s}^{-2}$. The unit vectors **i** and **j** are directed east and north respectively.

(a) Find the position vector of the helicopter t seconds after it has passed over the lighthouse. *(3 marks)*

(b) The position vector of a rock is $(200\mathbf{i} - 400\mathbf{j})$ metres relative to the origin. Show that the helicopter passes directly over the rock, and state the time that it takes for the helicopter to move from the lighthouse to the rock. *(7 marks)*

(c) Find the average velocity of the helicopter as it moves from the lighthouse to the rock. *(3 marks)*

(d) Is the magnitude of the average velocity equal to the average speed of the helicopter? Give a reason for your answer. *(2 marks)*