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General Certificate of Education
Advanced Subsidiary Examination
June 2012

Mathematics MM1B

Unit Mechanics 1B

Thursday 24 May 2012 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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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.

Condensed

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1 As a boat moves, it travels at $5\,\text{m s}^{-1}$ due north, relative to the water. The water is moving due west at $2\,\text{m s}^{-1}$.

(a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

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

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2 Two toy trains, A and B, are moving in the same direction on a straight horizontal track when they collide. As they collide, the speed of A is $4\,\text{m s}^{-1}$ and the speed of B is $3\,\text{m s}^{-1}$. Immediately after the collision, they move together with a speed of $3.8\,\text{m s}^{-1}$.

The mass of A is 2 kg. Find the mass of B. *(3 marks)*

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3 A car is travelling at a speed of $20\,\text{m s}^{-1}$ along a straight horizontal road. The driver applies the brakes and a constant braking force acts on the car until it comes to rest.

(a) Assume that no other horizontal forces act on the car.

(i) After the car has travelled 75 metres, its speed has reduced to $10\,\text{m s}^{-1}$. Find the acceleration of the car. *(3 marks)*

(ii) Find the time taken for the speed of the car to reduce from $20\,\text{m s}^{-1}$ to zero. *(2 marks)*

(iii) Given that the mass of the car is 1400 kg, find the magnitude of the constant braking force. *(2 marks)*

(b) Given that a constant air resistance force of magnitude 200 N acts on the car during the motion, find the magnitude of the constant braking force. *(1 mark)*

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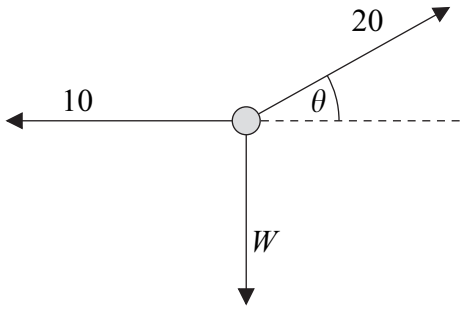
4 A particle, of weight W newtons, is held in equilibrium by two forces of magnitudes 10 newtons and 20 newtons. The 10-newton force is horizontal and the 20-newton force acts at an angle θ above the horizontal, as shown in the diagram. All three forces act in the same vertical plane.



(a) Find θ. *(3 marks)*

(b) Find W. *(2 marks)*

(c) Calculate the mass of the particle. *(2 marks)*

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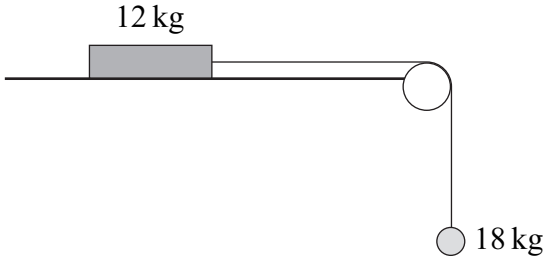
5 A block, of mass 12 kg, lies on a horizontal surface. The block is attached to a particle, of mass 18 kg, by a light inextensible string which passes over a smooth fixed peg. Initially, the block is held at rest so that the string supports the particle, as shown in the diagram.



The block is then released.

(a) Assuming that the surface is smooth, use two equations of motion to find the magnitude of the acceleration of the block and particle. *(4 marks)*

(b) In reality, the surface is rough and the acceleration of the block is $3\,\mathrm{m\,s^{-2}}$.

(i) Find the tension in the string. *(3 marks)*

(ii) Calculate the magnitude of the normal reaction force acting on the block. *(1 mark)*

(iii) Find the coefficient of friction between the block and the surface. *(5 marks)*

(c) State two modelling assumptions, other than those given, that you have made in answering this question. *(2 marks)*

Turn over ▶

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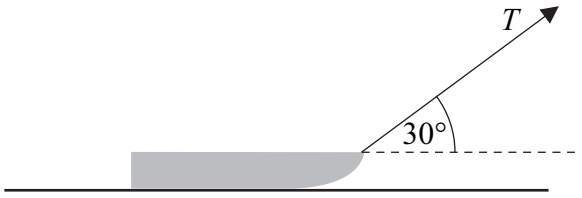
6 A child pulls a sledge, of mass 8 kg, along a rough horizontal surface, using a light rope. The coefficient of friction between the sledge and the surface is 0.3 . The tension in the rope is T newtons. The rope is kept at an angle of 30° to the horizontal, as shown in the diagram.



Model the sledge as a particle.

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

(b) Find the magnitude of the normal reaction force acting on the sledge, in terms of T. *(3 marks)*

(c) Given that the sledge accelerates at $0.05\,\text{m}\,\text{s}^{-2}$, find T. *(6 marks)*

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7 A particle moves with a constant acceleration of $(0.1\mathbf{i} - 0.2\mathbf{j})\,\text{m}\,\text{s}^{-2}$. It is initially at the origin where it has velocity $(-\mathbf{i} + 3\mathbf{j})\,\text{m}\,\text{s}^{-1}$. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

(a) Find an expression for the position vector of the particle t seconds after it has left the origin. *(2 marks)*

(b) Find the time that it takes for the particle to reach the point where it is due east of the origin. *(3 marks)*

(c) Find the speed of the particle when it is travelling south-east. *(6 marks)*

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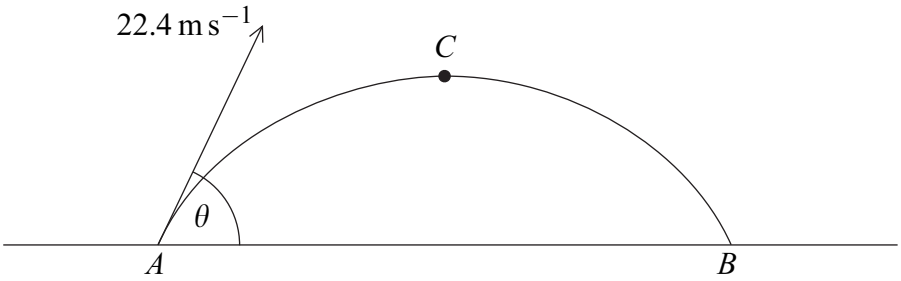
8 A particle is launched from the point A on a horizontal surface, with a velocity of $22.4\,\text{m}\,\text{s}^{-1}$ at an angle θ above the horizontal, as shown in the diagram.



After 2 seconds, the particle reaches the point C, where it is at its maximum height above the surface.

(a) Show that $\sin\theta = 0.875$. *(3 marks)*

(b) Find the height of the point C above the horizontal surface. *(3 marks)*

(c) The particle returns to the surface at the point B. Find the distance between A and B. *(3 marks)*

(d) Find the length of time during which the height of the particle above the surface is greater than 5 metres. *(5 marks)*

(e) Find the minimum speed of the particle. *(2 marks)*

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