General Certificate of Education
Advanced Subsidiary Examination
June 2011

Mathematics MM1B

Unit Mechanics 1B

Thursday 26 May 2011 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 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.

1 A crane is used to lift a load, using a single vertical cable which is attached to the load. The load accelerates uniformly from rest. When it has risen 0.9 metres, its speed is $0.6\,\text{m}\,\text{s}^{-1}$.

(a) (i) Show that the acceleration of the load is $0.2\,\text{m}\,\text{s}^{-2}$. *(3 marks)*

(ii) Find the time taken for the load to rise 0.9 metres. *(2 marks)*

(b) Given that the mass of the load is 800 kg, find the tension in the cable while the load is accelerating. *(3 marks)*

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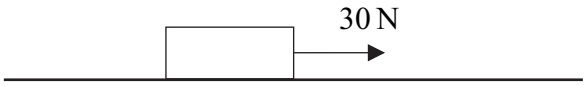
2 A wooden block, of mass 4 kg, is placed on a rough horizontal surface. The coefficient of friction between the block and the surface is 0.3 . A horizontal force, of magnitude 30 newtons, acts on the block and causes it to accelerate.



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

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

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

(d) Find the acceleration of the block. *(3 marks)*

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3 A pair of cameras records the time that it takes a car on a motorway to travel a distance of 2000 metres. A car passes the first camera whilst travelling at $32\,\text{m}\,\text{s}^{-1}$. The car continues at this speed for 12.5 seconds and then decelerates uniformly until it passes the second camera when its speed has decreased to $18\,\text{m}\,\text{s}^{-1}$.

(a) Calculate the distance travelled by the car in the first 12.5 seconds. *(1 mark)*

(b) Find the time for which the car is decelerating. *(3 marks)*

(c) Sketch a speed–time graph for the car on this 2000-metre stretch of motorway. *(3 marks)*

(d) Find the average speed of the car on this 2000-metre stretch of motorway. *(2 marks)*

4 Two particles, A and B, are moving on a smooth horizontal surface when they collide. The mass of A is 6 kg and the mass of B is m kg. Before the collision, the velocity of A is $(5\mathbf{i} + 18\mathbf{j})\,\mathrm{m\,s^{-1}}$ and the velocity of B is $(2\mathbf{i} - 5\mathbf{j})\,\mathrm{m\,s^{-1}}$. After the collision, the velocity of A is $8\mathbf{i}\,\mathrm{m\,s^{-1}}$ and the velocity of B is $V\mathbf{j}\,\mathrm{m\,s^{-1}}$.

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

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

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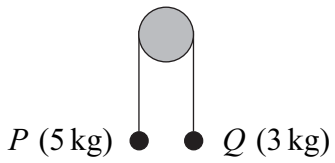
5 Two particles, P and Q, are connected by a string that passes over a fixed smooth peg, as shown in the diagram. The mass of P is 5 kg and the mass of Q is 3 kg.



The particles are released from rest in the position shown.

(a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $2.45\,\mathrm{m\,s^{-2}}$. *(5 marks)*

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

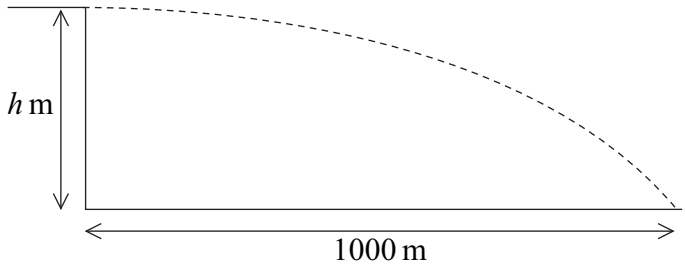
(c) State **two** modelling assumptions that you have made about the string. *(2 marks)*

(d) Particle P hits the floor when it has moved 0.196 metres and Q has not reached the peg.

(i) Find the time that it takes P to reach the floor. *(3 marks)*

(ii) Find the speed of P when it hits the floor. *(2 marks)*

6 A bullet is fired horizontally from the top of a vertical cliff, at a height of h metres above the sea. It hits the sea 4 seconds after being fired, at a distance of 1000 metres from the base of the cliff, as shown in the diagram.



(a) Find the initial speed of the bullet. *(2 marks)*

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

(c) Find the speed of the bullet when it hits the sea. *(4 marks)*

(d) Find the angle between the velocity of the bullet and the horizontal when it hits the sea. *(3 marks)*

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7 A helicopter is initially hovering above a lighthouse. It then sets off so that its acceleration is $(0.5\mathbf{i} + 0.375\mathbf{j})\,\mathrm{m\,s^{-2}}$. The helicopter does not change its height above sea level as it moves. The unit vectors **i** and **j** are directed east and north respectively.

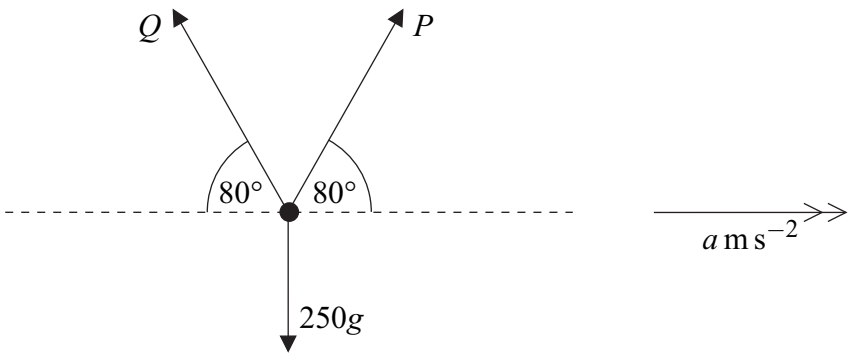
(a) Find the speed of the helicopter 20 seconds after it leaves its position above the lighthouse. *(4 marks)*

(b) Find the bearing on which the helicopter is travelling, giving your answer to the nearest degree. *(3 marks)*

(c) The helicopter stops accelerating when it is 500 metres from its initial position.

Find the time that it takes for the helicopter to travel from its initial position to the point where it stops accelerating. *(5 marks)*

8 Three forces act in a vertical plane on an object of mass 250 kg, as shown in the diagram.



The two forces P newtons and Q newtons each act at 80° to the horizontal. The object accelerates horizontally at $a\,\text{m s}^{-2}$ under the action of these forces.

(a) Show that

$$P = 125\left(\frac{a}{\cos 80°} + \frac{g}{\sin 80°}\right)$$ *(5 marks)*

(b) Find the value of a for which Q is zero. *(3 marks)*

END OF QUESTIONS