Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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8	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2011

Mathematics MM1B

Unit Mechanics 1B

Wednesday 19 January 2011 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.

Answer **all** questions in the spaces provided.

1 A trolley, of mass 5 kg, is moving in a straight line on a smooth horizontal surface. It has a velocity of $6\,\mathrm{m\,s^{-1}}$ when it collides with a stationary trolley, of mass m kg. Immediately after the collision, the trolleys move together with velocity $2.4\,\mathrm{m\,s^{-1}}$.

Find m. *(3 marks)*

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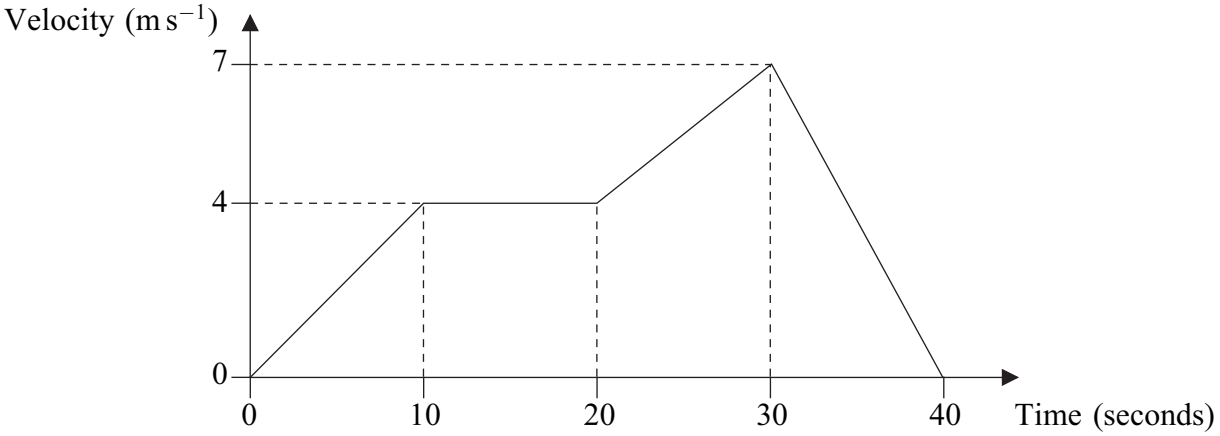
2 The graph shows how the velocity of a train varies as it moves along a straight railway line.



(a) Find the total distance travelled by the train. *(4 marks)*

(b) Find the average speed of the train. *(2 marks)*

(c) Find the acceleration of the train during the first 10 seconds of its motion. *(2 marks)*

(d) The mass of the train is 200 tonnes. Find the magnitude of the resultant force acting on the train during the first 10 seconds of its motion. *(2 marks)*

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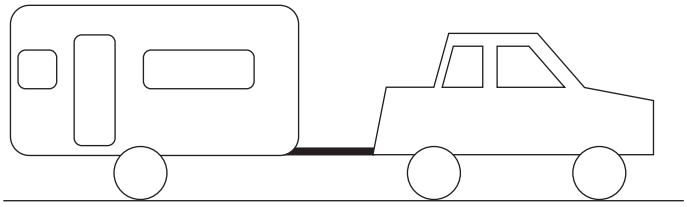
3 A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal tow bar, as shown in the diagram.



Assume that a constant resistance force of magnitude 200 newtons acts on the car and a constant resistance force of magnitude 300 newtons acts on the caravan. A constant driving force of magnitude P newtons acts on the car in the direction of motion. The car and caravan accelerate at $0.8\,\text{m s}^{-2}$.

(a) (i) Find P. *(3 marks)*

(ii) Find the magnitude of the force in the tow bar that connects the car to the caravan. *(3 marks)*

(b) (i) Find the time that it takes for the speed of the car and caravan to increase from $7\,\text{m s}^{-1}$ to $15\,\text{m s}^{-1}$. *(3 marks)*

(ii) Find the distance that they travel in this time. *(3 marks)*

(c) Explain why the assumption that the resistance forces are constant is unrealistic. *(1 mark)*

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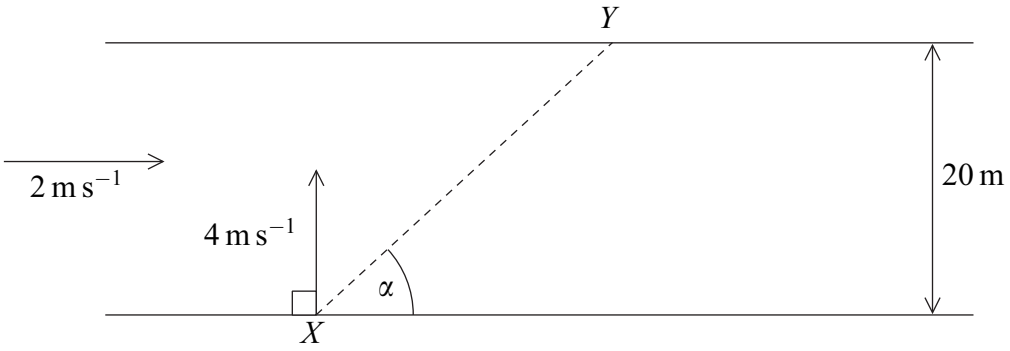
4 A canoe is paddled across a river which has a width of 20 metres. The canoe moves from the point X on one bank of the river to the point Y on the other bank, so that its path is a straight line at an angle α to the banks. The velocity of the canoe relative to the water is $4\,\text{m}\,\text{s}^{-1}$ perpendicular to the banks. The water flows at $2\,\text{m}\,\text{s}^{-1}$ parallel to the banks.



Model the canoe as a particle.

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

(b) Find the angle α. *(2 marks)*

(c) Find the time that it takes for the canoe to travel from X to Y. *(2 marks)*

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5 A particle moves with constant acceleration $(-0.4\mathbf{i} + 0.2\mathbf{j})\,\mathrm{m\,s^{-2}}$. Initially, it has velocity $(4\mathbf{i} + 0.5\mathbf{j})\,\mathrm{m\,s^{-1}}$. The unit vectors **i** and **j** are directed east and north respectively.

(a) Find an expression for the velocity of the particle at time t seconds. *(2 marks)*

(b) (i) Find the velocity of the particle when $t = 22.5$. *(2 marks)*

(ii) State the direction in which the particle is travelling at this time. *(1 mark)*

(c) Find the time when the speed of the particle is $5\,\mathrm{m\,s^{-1}}$. *(6 marks)*

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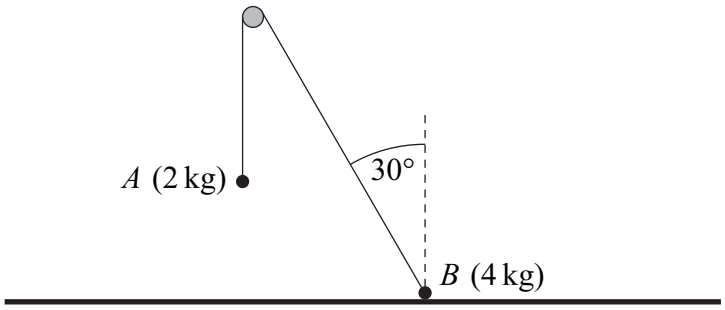
6 Two particles, A and B, are connected by a light inextensible string which passes over a smooth peg. Particle A has mass 2 kg and particle B has mass 4 kg. Particle A hangs freely with the string vertical. Particle B is at rest in equilibrium on a rough horizontal surface with the string at an angle of 30° to the vertical. The particles, peg and string are shown in the diagram.



(a) By considering particle A, find the tension in the string. *(2 marks)*

(b) Draw a diagram to show the forces acting on particle B. *(2 marks)*

(c) Show that the magnitude of the normal reaction force acting on particle B is 22.2 newtons, correct to three significant figures. *(3 marks)*

(d) Find the least possible value of the coefficient of friction between particle B and the surface. *(4 marks)*

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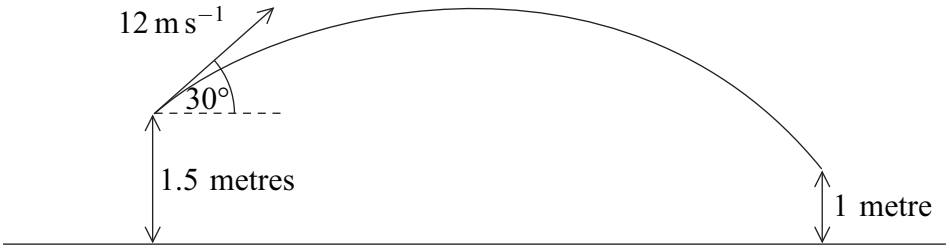
7 An arrow is fired from a point at a height of 1.5 metres above horizontal ground. It has an initial velocity of $12\,\text{m}\,\text{s}^{-1}$ at an angle of 30° above the horizontal. The arrow hits a target at a height of 1 metre above horizontal ground. The path of the arrow is shown in the diagram.



Model the arrow as a particle.

(a) Show that the time taken for the arrow to travel to the target is 1.30 seconds, correct to three significant figures. *(5 marks)*

(b) Find the horizontal distance between the point where the arrow is fired and the target. *(2 marks)*

(c) Find the speed of the arrow when it hits the target. *(4 marks)*

(d) Find the angle between the velocity of the arrow and the horizontal when the arrow hits the target. *(2 marks)*

(e) State one assumption that you have made about the forces acting on the arrow. *(1 mark)*

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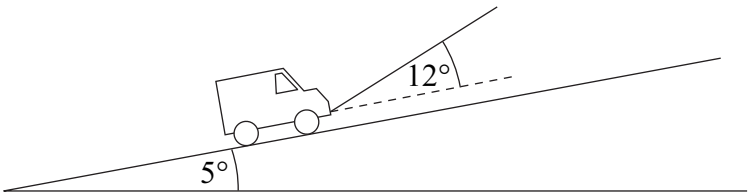
8 A van, of mass 2000 kg, is towed up a slope inclined at 5° to the horizontal. The tow rope is at an angle of 12° to the slope. The motion of the van is opposed by a resistance force of magnitude 500 newtons. The van is accelerating up the slope at $0.6\,\text{m}\,\text{s}^{-2}$.



Model the van as a particle.

(a) Draw a diagram to show the forces acting on the van. *(2 marks)*

(b) Show that the tension in the tow rope is 3480 newtons, correct to three significant figures. *(5 marks)*

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END OF QUESTIONS