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| Centre Number | | | | | | Candidate Number | | | | |
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| For Examiner's Use | |
| Examiner's Initials | |
| Question | Mark |
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| 2 | |
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| 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 $g = 9.8 \text{ m s}^{-2}$, 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.



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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 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 m s^{-1} .

Find m .

(3 marks)

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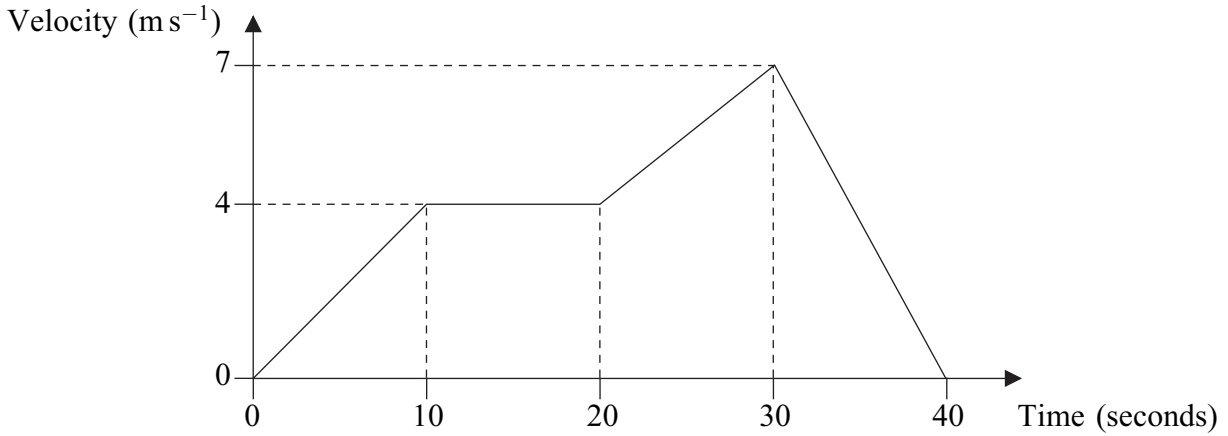
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2 The graph shows how the velocity of a train varies as it moves along a straight railway line.



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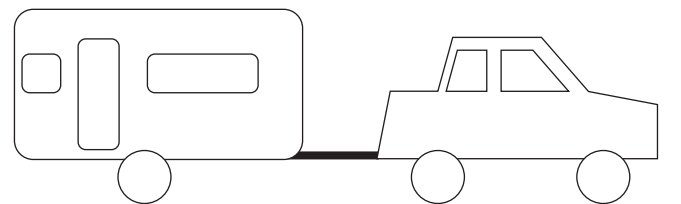
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- 3** A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal tow bar, as shown in the diagram.



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 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 m s^{-1} to 15 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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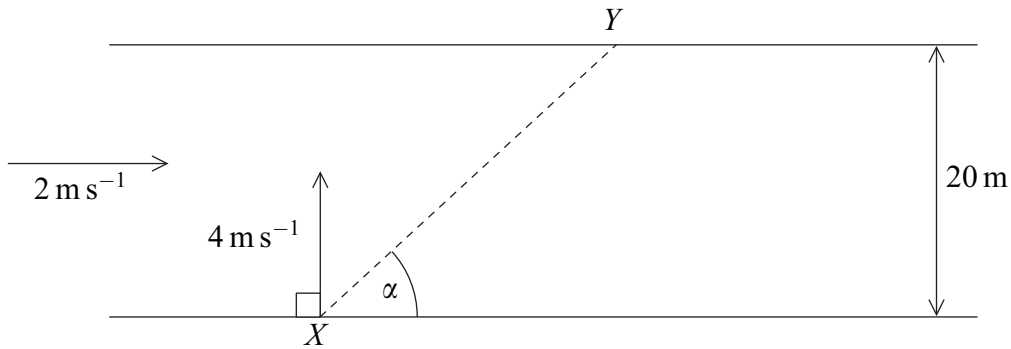
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- 4** A canoe is paddled across a river which has a width of 20 metres. The canoe moves from the point X on one bank of the river to the point Y on the other bank, so that its path is a straight line at an angle α to the banks. The velocity of the canoe relative to the water is 4 m s^{-1} perpendicular to the banks. The water flows at 2 m 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 $(-0.4\mathbf{i} + 0.2\mathbf{j}) \text{ m s}^{-2}$. Initially, it has velocity $(4\mathbf{i} + 0.5\mathbf{j}) \text{ m s}^{-1}$. The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively.

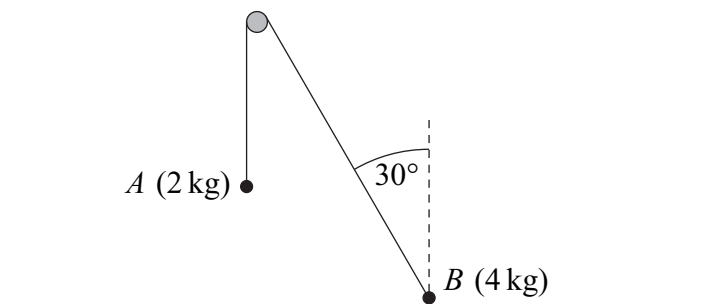
- (a)** Find an expression for the velocity of the particle at time t seconds. (2 marks)
- (b) (i)** Find the velocity of the particle when $t = 22.5$. (2 marks)
(ii) State the direction in which the particle is travelling at this time. (1 mark)
- (c)** Find the time when the speed of the particle is 5 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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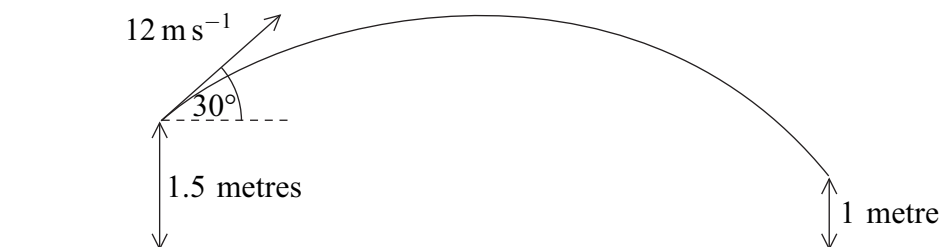
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- 7** An arrow is fired from a point at a height of 1.5 metres above horizontal ground. It has an initial velocity of 12 m s^{-1} at an angle of 30° above the horizontal. The arrow hits a target at a height of 1 metre above horizontal ground. The path 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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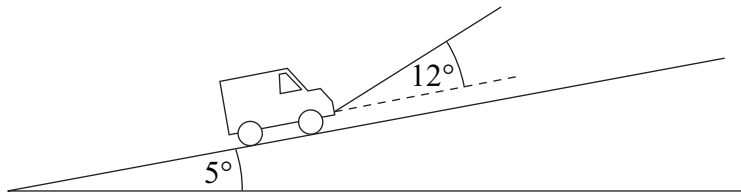


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- 8** A van, of mass 2000 kg, is towed up a slope inclined at 5° to the horizontal. The tow rope is at an angle of 12° to the slope. The motion of the van is opposed by a resistance force of magnitude 500 newtons. The van is accelerating up the slope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

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