General Certificate of Education
June 2009
Advanced Subsidiary Examination

MATHEMATICS
Unit Mechanics 1A

MM1A/W

Friday 5 June 2009 1.30 pm to 2.45 pm

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1A/W.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- 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 maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 1A has a **written paper and coursework**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 Two particles, A and B, are moving on a smooth horizontal surface when they collide. During the collision, the two particles coalesce to form a single combined particle. Particle A has mass 3 kg and particle B has mass 7 kg.

Before the collision, the velocity of A is $\begin{bmatrix} 6 \\ -2 \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} -1 \\ 4 \end{bmatrix}$ m s^{-1}.

(a) Find the velocity of the combined particle after the collision. *(3 marks)*

(b) Find the speed of the combined particle after the collision. *(2 marks)*

2 A motorcycle and rider, of total mass 300 kg, are accelerating in a straight line along a horizontal road at 2.2 m s^{-2}.

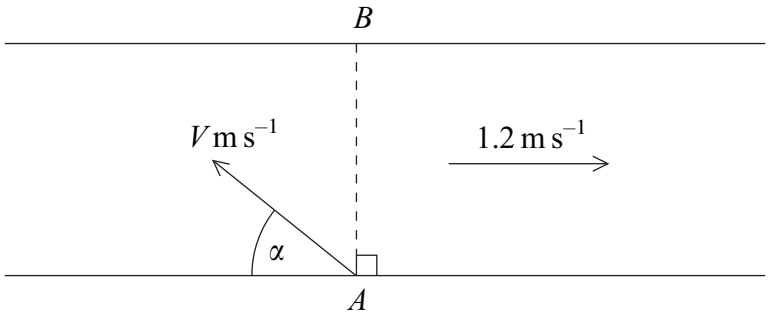
(a) Show that the magnitude of the resultant force acting on the motorcycle is 660 N. *(1 mark)*

(b) A forward driving force of P newtons together with a resistance force of magnitude 400 newtons act on the motorcycle. Find P. *(2 marks)*

(c) Find the time that it would take for the speed of the motorcycle to increase from 12 m s^{-1} to 23 m s^{-1}. *(3 marks)*

3 A river has parallel banks which are 16 metres apart. The water in the river flows at $1.2\,\text{m s}^{-1}$ parallel to the banks. A boat sets off from one bank at the point A and travels perpendicular to the bank so that it reaches the point B, which is directly opposite the point A. It takes the boat 10 seconds to cross the river.

The velocity of the boat relative to the water has magnitude $V\,\text{m s}^{-1}$ and is at an angle α to the bank, as shown in the diagram.

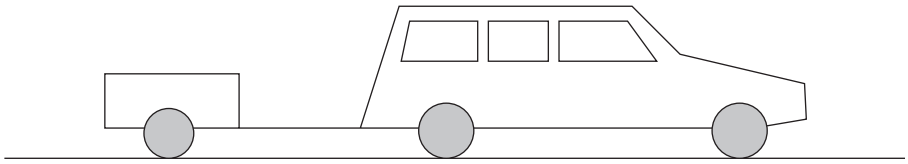


(a) Show that the magnitude of the resultant velocity of the boat is $1.6\,\text{m s}^{-1}$. *(1 mark)*

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

(c) Find α. *(2 marks)*

4 A car, of mass 1400 kg, is towing a trailer, of mass 600 kg. The two vehicles accelerate together at $1.3\,\text{m s}^{-2}$ along a straight horizontal road.



(a) Find the distance that the car and trailer would travel while accelerating from rest to $13\,\text{m s}^{-1}$. *(3 marks)*

(b) A forward driving force, of magnitude 3900 N, acts on the car. A resistance force, of magnitude 800 N, also acts on the car.

(i) A resistance force, of magnitude P newtons, acts on the trailer. Find P. *(3 marks)*

(ii) Find the magnitude of the force that the car exerts on the trailer. *(3 marks)*

5 A particle moves on a smooth horizontal plane. It is initially at the point A, with position vector $(9\mathbf{i} + 7\mathbf{j})$ m, and has velocity $(-2\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. The particle moves with a constant acceleration of $(0.25\mathbf{i} + 0.3\mathbf{j})\,\mathrm{m\,s^{-2}}$ for 20 seconds until it reaches the point B. The unit vectors **i** and **j** are directed east and north respectively.

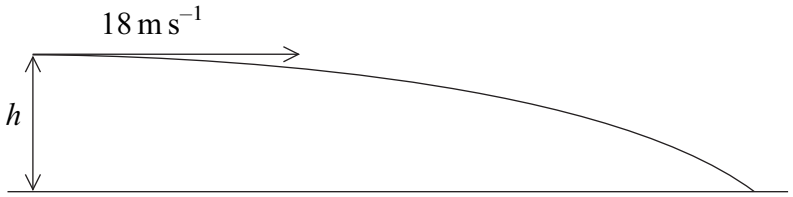
(a) Find the velocity of the particle at the point B. *(3 marks)*

(b) Find the velocity of the particle when it is travelling due north. *(4 marks)*

(c) Find the position vector of the point B. *(3 marks)*

(d) Find the average velocity of the particle as it moves from A to B. *(2 marks)*

6 An arrow is fired horizontally at a speed of $18\,\mathrm{m\,s^{-1}}$ from a point at a height of h metres above horizontal ground. The arrow hits the ground after it has been moving for 0.6 seconds. Model the arrow as a particle that moves only under the influence of gravity.

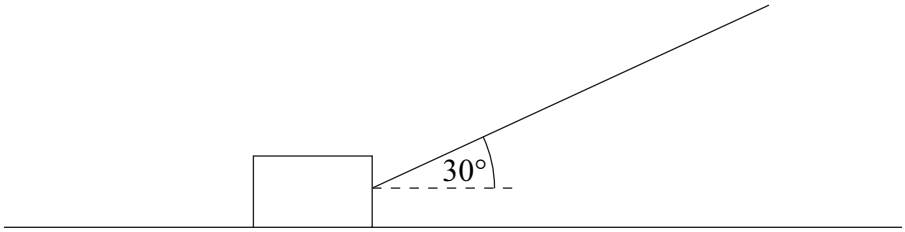


(a) Show that $h = 1.76$, correct to three significant figures. *(2 marks)*

(b) Find the horizontal distance travelled by the arrow during its flight. *(2 marks)*

(c) Find the speed of the arrow and the direction in which it is moving when it hits the ground. *(6 marks)*

7 The diagram shows a block, of mass 20 kg, being pulled along a rough horizontal surface by a rope inclined at an angle of 30° to the horizontal.



The coefficient of friction between the block and the surface is μ. Model the block as a particle which slides on the surface.

(a) If the tension in the rope is 60 newtons, the block moves at a constant speed.

(i) Show that the magnitude of the normal reaction force acting on the block is 166 N. *(3 marks)*

(ii) Find μ. *(4 marks)*

(b) If the rope remains at the same angle and the block accelerates at $0.8\,\text{m}\,\text{s}^{-2}$, find the tension in the rope. *(5 marks)*

END OF QUESTIONS

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