General Certificate of Education
January 2005
Advanced Subsidiary Examination

MATHEMATICS (SPECIFICATION A) **MAM1/W**
Unit Mechanics 1

Wednesday 12 January 2005 Afternoon Session

In addition to this paper you will require:
- an 8-page answer book;
- the AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 20 minutes

Instructions
- Use blue or black ink or 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 MAM1/W.
- Answer **all** questions.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$ unless otherwise stated.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.
- Tie loosely any additional sheets you have used to the back of your answer book before handing it to the invigilator.

Information
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.

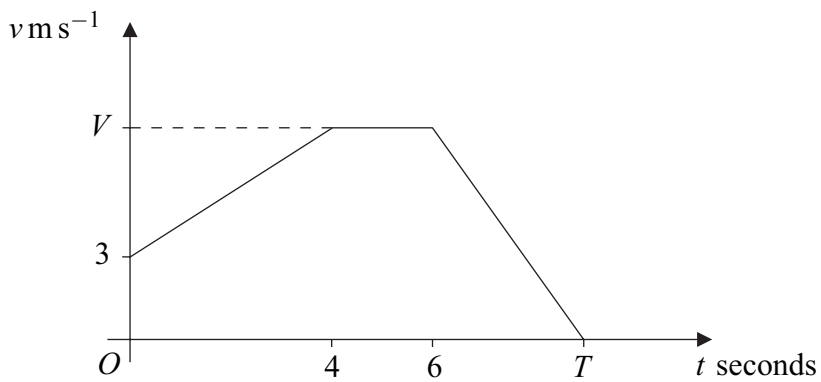
Advice
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

1 The velocity–time graph below models the motion of an athlete, Paula, during part of a training exercise.

When $t = 0$ she has velocity $3\,\text{m s}^{-1}$. She accelerates at a constant rate until $t = 4$ and her velocity is $V\,\text{m s}^{-1}$.

She runs with velocity $V\,\text{m s}^{-1}$ for 2 seconds and then decelerates at a constant rate of $f\,\text{m s}^{-2}$ until she comes to rest when $t = T$.



(a) Between $t = 0$ and $t = 4$, Paula runs a distance of 20 metres. Show that $V = 7$. *(2 marks)*

(b) The total distance Paula runs between $t = 4$ and $t = T$ is 35 metres.

(i) Find the value of T. *(4 marks)*

(ii) Find the value of f. *(2 marks)*

(c) Find Paula's average speed between $t = 0$ and $t = T$. *(2 marks)*

2 A particle P moves so that at time t seconds its position vector, $\mathbf{r}$ metres, is

$$\mathbf{r} = (t^3 - 9t)\mathbf{i} + 3t^2\mathbf{j}.$$

(a) Use differentiation to find the velocity of P at time t. *(2 marks)*

(b) The mass of P is $\frac{1}{3}$kg. Find the momentum of P at time t. *(1 mark)*

(c) Find the force acting on P when $t = 2$. *(3 marks)*

3 A particle A, of mass 0.1 kg, collides with a particle B, of mass 0.2 kg.

Immediately before the collision, the velocity of A is $\begin{bmatrix} 8 \\ 12 \end{bmatrix}$ m s^{-1} and the velocity of B is $\mathbf{V}$ m s^{-1}.

Immediately after the collision, the velocity of A is $\begin{bmatrix} -2 \\ 6 \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} 6 \\ 0 \end{bmatrix}$ m s^{-1}.

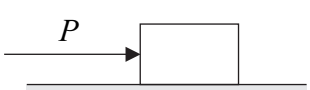
(a) Find $\mathbf{V}$. *(4 marks)*

(b) The collision occurs at the origin, O. After the collision, the particles continue to move with constant velocities.

(i) Find the position vectors of A and B two seconds after the collision occurs. *(2 marks)*

(ii) Find the distance between A and B two seconds after the collision occurs. *(3 marks)*

4 A small block, of mass 2 kg, is on a rough horizontal surface. The coefficient of friction between the block and the surface is $\frac{1}{7}$. A horizontal force of magnitude P newtons is applied to the block, as shown in the diagram.



(a) The magnitude of the frictional force that acts between the block and the surface is F newtons. Show that the maximum possible value of F is 2.8. *(2 marks)*

(b) The value of P increases gradually from 0 to 5.

(i) When $P = 1$, state the value of F. *(1 mark)*

(ii) When $P = 5$, the block moves with constant acceleration a m s^{-2}. Find the value of a. *(4 marks)*

5 A car moves in a straight line up a hill which is inclined at an angle of α to the horizontal, where $\sin\alpha = \frac{1}{14}$. The mass of the car is 1200 kg.

(a) During the first part of its motion, the car moves with constant speed and is subject to a propulsive force of 1500 newtons and a resistance force of R newtons.

(i) Draw a diagram showing the forces acting on the car. *(2 marks)*

(ii) Show that $R = 660$. *(4 marks)*

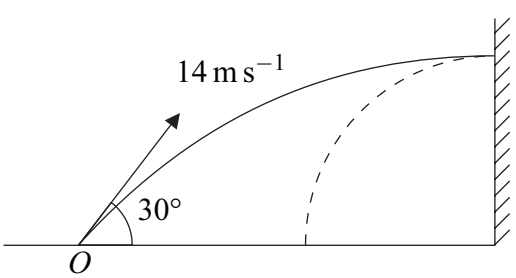
(iii) The car travels 60 metres in 4 seconds. Write down the speed of the car. *(1 mark)*

(b) During the second part of its motion, the propulsive force ceases to act and the resistance force is still 660 newtons. The car continues to move up the hill until it comes to rest.

(i) Find the magnitude of the retardation of the car in this stage. *(2 marks)*

(ii) Find the time between the propulsive force ceasing to act and the car coming to rest. *(2 marks)*

6 Adam kicks his ball from a point O on a horizontal surface towards a vertical wall. He kicks the ball with speed $14\,\text{m s}^{-1}$ at an angle of 30° to the horizontal, as shown in the diagram.



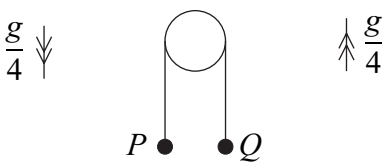
When the ball hits the wall, it is travelling **horizontally**.

(a) Find the vertical height above O at which the ball hits the wall. *(4 marks)*

(b) The ball rebounds horizontally from the wall. Find the time that the ball takes to reach the horizontal surface. *(3 marks)*

7 Two particles, P and Q, are attached to the ends of a light inextensible string which hangs over a smooth fixed peg, as shown in the diagram. The masses of P and Q are $5m$ and km respectively, where $k < 5$.

The particles are released from rest and move with acceleration of magnitude $\frac{g}{4}$.



(a) Find, in terms of m and g, the tension in the string. *(3 marks)*

(b) Find the value of k. *(3 marks)*

(c) Find the magnitude of the force on the peg due to the string. *(1 mark)*

(d) The particles are released from rest at the same horizontal level when $t = 0$. Find, in terms of g, the vertical distance between the particles when $t = \frac{2}{3}$. *(3 marks)*

END OF QUESTIONS

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