General Certificate of Education
January 2004
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Monday 12 January 2004 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 the 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.

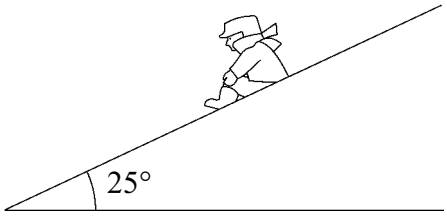
Answer **all** questions.

1 Four forces, $\begin{bmatrix}6\\0\end{bmatrix}$ newtons, $\begin{bmatrix}0\\4\end{bmatrix}$ newtons, $\begin{bmatrix}-3\\-4.5\end{bmatrix}$ newtons and $\begin{bmatrix}3\\-2\end{bmatrix}$ newtons, act on a particle.

(a) Express the resultant, **F** newtons, of these four forces as a column vector. *(2 marks)*

(b) Find the magnitude of **F**. *(2 marks)*

2 A children's slide is straight and inclined at 25° to the horizontal, as shown in the diagram.



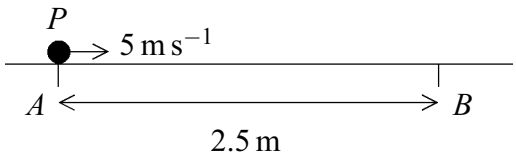
Matthew, of mass 35 kg, goes down the slide at constant speed.

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

(b) Find the magnitude of the normal reaction force between Matthew and the slide. *(3 marks)*

(c) Find the coefficient of friction between Matthew and the slide. *(4 marks)*

3 A particle P moves in a straight line across a horizontal surface with retardation of magnitude $1.8\,\text{m}\,\text{s}^{-2}$. The particle P passes through a point A with velocity $5\,\text{m}\,\text{s}^{-1}$, as shown in the diagram. It subsequently passes **twice** through the point B, where $AB = 2.5$ metres.



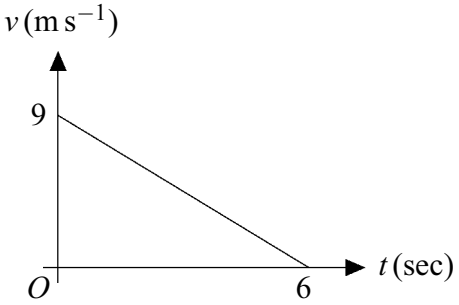
(a) Find the velocities of P on the two occasions when it passes through B. *(3 marks)*

(b) Hence, or otherwise, find the length of time between the two occasions when P passes through B. *(3 marks)*

4 Lisa is riding her bicycle in a straight horizontal line. When she is moving with velocity $9\,\mathrm{m\,s^{-1}}$, she applies the brakes and comes to rest 6 seconds later.

During the 6 seconds of the braking period, Lisa's motion could be modelled in two ways.

(a) In the **first model**, Lisa's velocity decreases at a constant rate, as shown in the diagram below.



(i) Find the magnitude of Lisa's retardation during the motion. *(2 marks)*

(ii) Find the distance that Lisa travels during the motion. *(2 marks)*

(b) In the **second model**, Lisa's velocity, $v\,\mathrm{m\,s^{-1}}$, at time t seconds is given by

$$v = 9 - \frac{t^2}{4}, \qquad 0 \leqslant t \leqslant 6.$$

Find the distance that Lisa travels during the motion. *(4 marks)*

(c) State, giving a reason, in which model Lisa has the greater average speed. *(1 mark)*

5 A particle P moves so that at time t seconds it has position vector $\mathbf{r}$ metres, where

$$\mathbf{r} = (t^4 - 2t^2)\mathbf{i} + (4t^3 - t^4)\mathbf{j}.$$

(a) Find an expression for the velocity of P at time t. *(3 marks)*

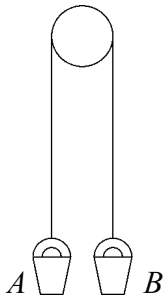
The mass of P is 0.25 kg.

(b) Find an expression for the momentum of P at time t. *(1 mark)*

(c) Find an expression for the force, $\mathbf{F}$, acting on P at time t. *(3 marks)*

(d) Find the exact value of t when $\mathbf{F}$ acts in the direction of the vector $\mathbf{j}$. *(2 marks)*

6 Two identical buckets, A and B, are attached to the ends of a light, inextensible cord. The cord hangs over a smooth beam and the system is at rest, as shown in the diagram.



The buckets are each of mass 0.4 kg.

(a) State the magnitude of the tension in the cord. *(1 mark)*

(b) A lump of clay, of mass 0.2 kg, is pressed against the underside of bucket A, and sticks there. The system is then released from rest and, in the subsequent motion, bucket A moves vertically downwards with the clay attached.

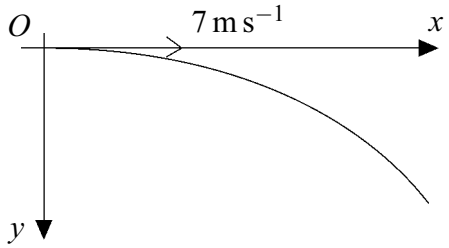
(i) Show that the magnitude of the acceleration of the buckets during the subsequent motion is $1.96\,\text{m}\,\text{s}^{-2}$. *(5 marks)*

(ii) Find the speed of the buckets after 1.5 seconds of motion. *(2 marks)*

(c) After 1.5 seconds of motion, the clay drops off the underside of bucket A. The clay subsequently falls freely under gravity.

Find an expression, in terms of t, for the vertical distance between the underside of bucket A and the lump of clay t seconds after the clay has dropped off the bucket. You may assume B has not reached the beam. *(4 marks)*

7 Elaine kicks a ball off a cliff top. She kicks the ball from a point O and it subsequently moves in a vertical plane with respect to axes which are horizontal and vertically downwards, as shown in the diagram.



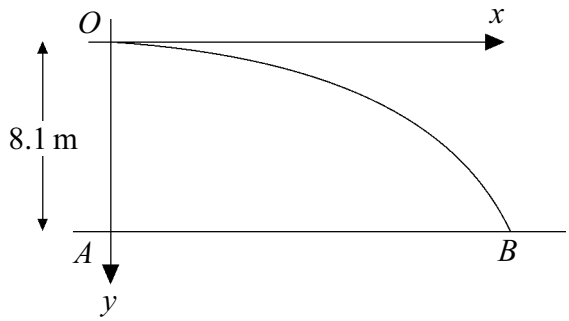
The initial velocity of the ball is horizontal and of magnitude $7\,\text{m}\,\text{s}^{-1}$.

(a) Find the coordinates of the ball t seconds after it has been kicked. *(3 marks)*

(b) Show that the equation of the path of the ball is

$$y = \frac{x^2}{10}.$$ *(2 marks)*

The ball subsequently lands on a horizontal beach. The point A on the beach is vertically below O and the ball lands at the point B on the beach, as shown in the diagram.



(c) The distance OA is 8.1 metres.

Find the distance AB. *(2 marks)*

(d) Find the speed of the ball as it reaches B. *(5 marks)*

END OF QUESTIONS