General Certificate of Education
November 2004
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Tuesday 2 November 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

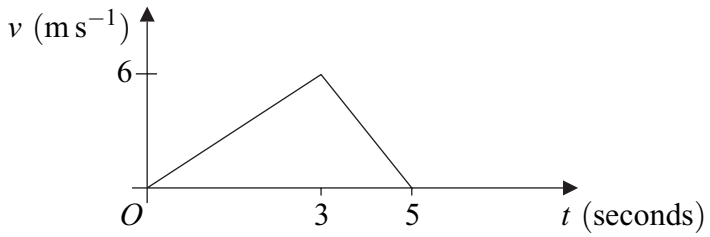
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MAM1/W.
- Answer **all** questions.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$ 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 Tom's motion as he runs across a playground.



(a) Find Tom's acceleration during the first 3 seconds of his motion. *(2 marks)*

(b) Find the total distance Tom runs during the 5 seconds of motion. *(3 marks)*

(c) State one criticism of this model of Tom's motion. *(1 mark)*

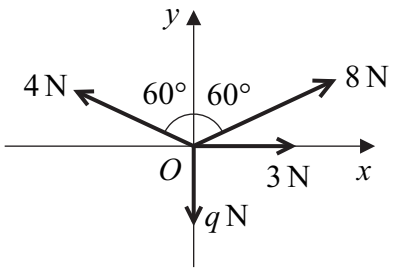
2 Two particles, A and B, of masses $3m$ kg and m kg respectively, are moving in the same straight line and in the same direction on a horizontal surface. The particles collide directly. As a result of the collision, the particles coalesce to form a single particle C.

Immediately before the collision, A is moving with speed $v\,\mathrm{m\,s^{-1}}$ and B is moving with speed $2\,\mathrm{m\,s^{-1}}$. Immediately after the collision, C is moving with speed $1.5\,\mathrm{m\,s^{-1}}$.

(a) Find the value of v. *(3 marks)*

(b) The surface on which the particles move is rough. After the collision, C moves with constant retardation and comes to rest at a distance of 3 metres from the point of collision. Find the magnitude of the retardation of C. *(3 marks)*

3 A particle is at a point O on a smooth horizontal surface. It is acted on by four horizontal forces of magnitudes 3 N, 8 N, 4 N and q N. The directions of these forces, relative to the horizontal axes Ox and Oy, are shown in the diagram below.



The resultant, **R** newtons, of these forces acts along the line Ox.

(a) Show that $q = 6$. *(4 marks)*

(b) Find the magnitude of **R**. *(3 marks)*

4 A particle P moves so that at time t it has velocity

$$\mathbf{v} = 4\mathbf{i} - 2t\mathbf{j}, \qquad t \geqslant 0.$$

When $t = 0$, the particle P has position vector $8\mathbf{j}$.

(a) Find the position vector of P at time t. *(4 marks)*

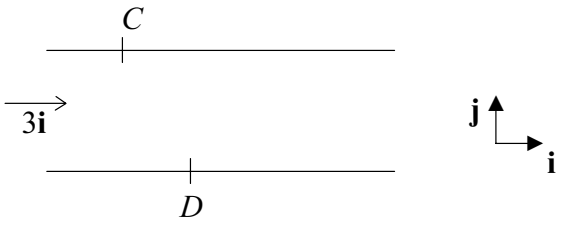
(b) Find the position vector of P when $t = 2$. *(1 mark)*

(c) Find the time when the position vector of P is in the direction of the vector $\mathbf{i}$. *(2 marks)*

5 Jane is playing with her toy motor boat. She releases the boat from the point C on one bank of a stream. The boat travels to the point D on the other bank of the stream.

Until it reaches D, the boat has constant velocity $2\mathbf{i} - 6\mathbf{j}\,\text{m s}^{-1}$ relative to the stream. The stream moves with constant velocity $3\mathbf{i}\,\text{m s}^{-1}$, affecting the motion of the boat.

The banks of the stream are parallel to $\mathbf{i}$, as shown in the diagram below.



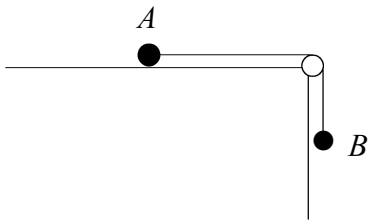
(a) Find the resultant velocity of the boat as it travels from C to D. *(1 mark)*

(b) Jane's sister turns the boat around and releases it from D so that it travels directly back to Jane at C. The boat travels along the straight line DC at the same speed as on the journey from C to D. The stream still moves with constant velocity $3\mathbf{i}\,\text{m s}^{-1}$.

(i) State the new resultant velocity of the boat as it travels back across the stream. *(1 mark)*

(ii) Find the magnitude of the constant velocity, relative to the stream, with which the boat travels from D to C. *(5 marks)*

6 Two particles, A and B, are connected by a light, inextensible string which passes over a smooth, fixed peg, as shown in the diagram.



The particle A is of mass 0.5 kg and the particle B is of mass 0.1 kg. The particle A is in contact with a rough horizontal surface.

(a) The system is at rest and the particle B hangs vertically.

(i) Show that the tension in the string is 0.98 newtons. *(1 mark)*

(ii) The particle A rests in limiting equilibrium. Show that the coefficient of friction between A and the surface is 0.2. *(3 marks)*

(iii) Draw a diagram to show the forces acting on the peg due to the string. *(1 mark)*

(iv) Find the magnitude of the resultant force on the peg due to the string. *(2 marks)*

(b) An additional mass of 0.1 kg is attached to the particle B and the system is released from rest. The particle A moves across the surface towards the peg and B moves vertically downwards. The particles move with acceleration $a\,\mathrm{m\,s^{-2}}$ and the tension in the string is T newtons.

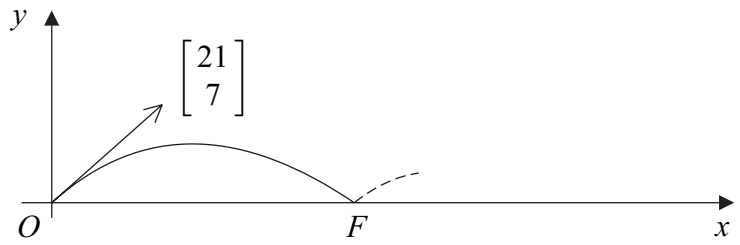
(i) Show that $a = 1.4$. *(5 marks)*

(ii) Find the value of T. *(1 mark)*

(iii) After falling a distance of 0.7 metres, B hits the ground. Find the time between the particles being released and B hitting the ground. *(2 marks)*

7 A ball is kicked from a point O on horizontal ground with velocity $\begin{bmatrix} 21 \\ 7 \end{bmatrix}$ m s^{-1}.

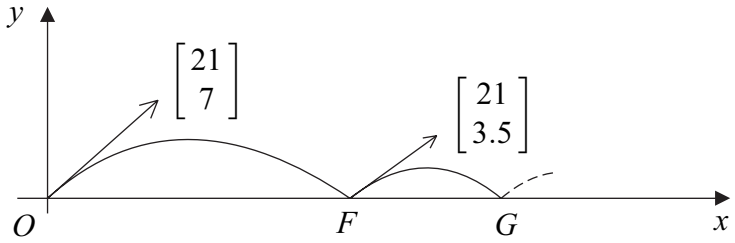
The ball subsequently hits the ground at a point F, as shown in the diagram.



(a) (i) Find the time between the ball being kicked and reaching F. *(3 marks)*

(ii) Find the distance OF. *(2 marks)*

(b) The ball rebounds from F with velocity $\begin{bmatrix} 21 \\ 3.5 \end{bmatrix}$ m s^{-1}. It subsequently hits the ground again at G and then rebounds, as shown in the diagram below.



Find the distance FG. *(4 marks)*

(c) After bouncing at G, the ball rebounds with velocity $\begin{bmatrix} 21 \\ 1.75 \end{bmatrix}$ m s^{-1}, so that the vertical component of the velocity is halved again, and then subsequently bounces next at H. Find the total distance OH. *(3 marks)*

END OF QUESTIONS