

General Certificate of Education  
November 2004  
Advanced Subsidiary Examination



**MATHEMATICS (SPECIFICATION A)**  
**Unit Mechanics 1**

**MAM1/W**

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  $g = 9.8 \text{ m s}^{-2}$  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**

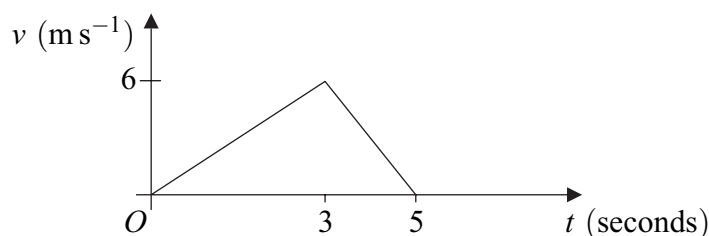
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.

**Advice**

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

Answer **all** questions.

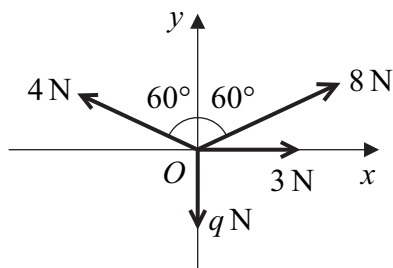
- 1 The velocity–time graph below models Tom’s motion as he runs across a playground.



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

- (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,  $\mathbf{R}$  newtons, of these forces acts along the line  $Ox$ .

- (a) Show that  $q = 6$ . (4 marks)
- (b) Find the magnitude of  $\mathbf{R}$ . (3 marks)

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

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

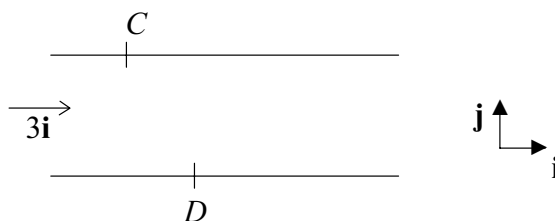
When  $t = 0$ , the particle  $P$  has position vector  $8\mathbf{j}$ .

- (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.

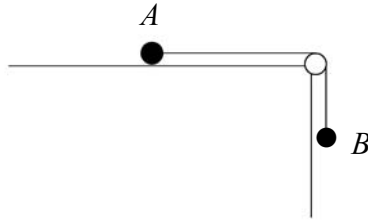
Until it reaches  $D$ , the boat has constant velocity  $2\mathbf{i} - 6\mathbf{j} \text{ m s}^{-1}$  relative to the stream. The stream moves with constant velocity  $3\mathbf{i} \text{ m s}^{-1}$ , affecting the motion of the boat.

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.

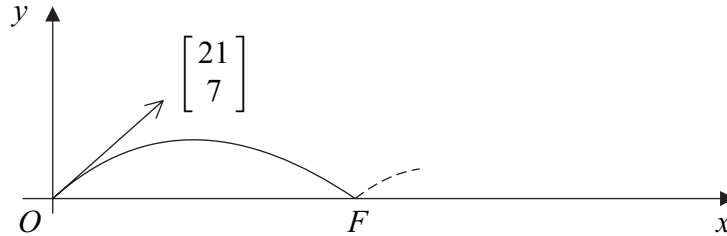


The particle  $A$  is of mass  $0.5$  kg and the particle  $B$  is of mass  $0.1$  kg. The particle  $A$  is in contact with a rough horizontal surface.

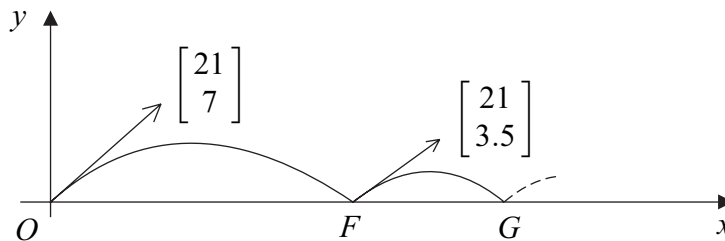
- (a) The system is at rest and the particle  $B$  hangs vertically.
- (i) Show that the tension in the string is  $0.98$  newtons. *(1 mark)*
  - (ii) The particle  $A$  rests in limiting equilibrium. Show that the coefficient of friction between  $A$  and the surface is  $0.2$ . *(3 marks)*
  - (iii) 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  $a$   $\text{m s}^{-2}$  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  $\begin{bmatrix} 21 \\ 7 \end{bmatrix} \text{ m s}^{-1}$ .

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  $\begin{bmatrix} 21 \\ 3.5 \end{bmatrix} \text{ m s}^{-1}$ . 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  $\begin{bmatrix} 21 \\ 1.75 \end{bmatrix} \text{ m s}^{-1}$ , 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**