

General Certificate of Education
June 2004
Advanced Subsidiary Examination



MATHEMATICS (SPECIFICATION A)
Unit Mechanics 1

MAM1/W

Friday 28 May 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 A child kicks a small toy brick in a straight line across a horizontal floor. The brick initially moves at 3.5 m s^{-1} and comes to rest in a distance of 2.5 metres.

(a) Show that the magnitude of the retardation of the brick is 2.45 m s^{-2} . (3 marks)

(b) The mass of the brick is 0.2 kg.

(i) Find the magnitude of the frictional force acting on the brick. (2 marks)

(ii) Find the coefficient of friction between the brick and the floor. (2 marks)

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

$$\mathbf{r} = 6t\mathbf{i} + t^2\mathbf{j}.$$

(a) Find the velocity of P at time t . (2 marks)

(b) Find an expression for the speed of P at time t . (2 marks)

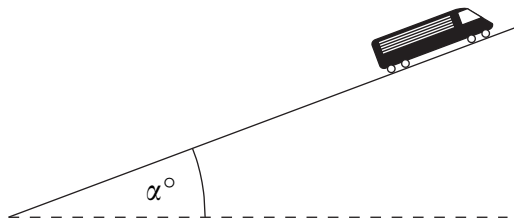
(c) Find the value of t when P moves with speed $6\sqrt{2} \text{ m s}^{-1}$. (2 marks)

3 A mountain railway train moves on a straight track. The mass of the train and its passengers is 1000 kg. During its motion the train moves under the action of a variable propulsive force, P newtons, and a constant resistance force of R newtons.

(a) During the first stage of its motion, the train moves horizontally with acceleration 0.25 m s^{-2} . In this stage, the value of P is 1200.

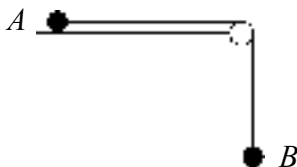
Show that $R = 950$. (3 marks)

(b) During the second stage of its motion, the train moves up a slope inclined at an angle α to the horizontal, where $\sin \alpha = 0.1$.



In this stage, the value of $P = 2100$, and the value of R remains at 950. Find the acceleration of the train. (4 marks)

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



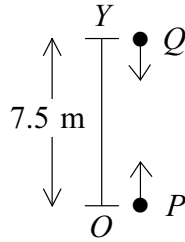
The particle A , of mass 0.6 kg , is in contact with a smooth horizontal surface, and the particle B , of mass 0.1 kg , hangs freely above the ground. The system is released from rest with the string taut and A moves towards the peg.

It can be assumed that, during the subsequent motion, A does **not** reach the peg.

- (a) While the particles move freely, the string is taut.
- (i) Show that the acceleration of the particles is 1.4 m s^{-2} . (5 marks)
 - (ii) Find the tension in the string. (1 mark)
 - (iii) Find the magnitude of the resultant force on the peg due to the tension in the string. (3 marks)
- (b) After q seconds of the motion, the particle B hits the ground and remains there. The string connecting A and B slackens and A continues to move towards the peg. Sketch a velocity–time graph to show the two stages of the motion of A after being released from rest. (3 marks)

TURN OVER FOR THE NEXT QUESTION

- 5 The point Y is 7.5 metres vertically above the point O . A particle P is projected vertically upwards from O and, at the same time, a particle Q is dropped from Y .

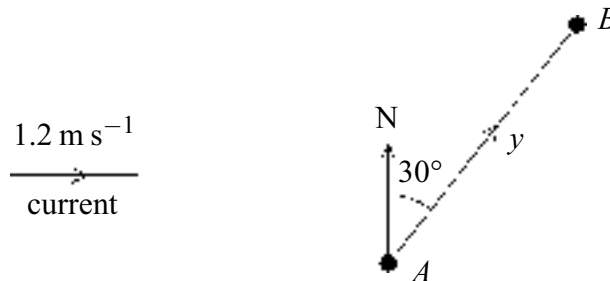


The time, t seconds, is measured from the start of the motion.

When $t = \frac{5}{7}$, P has risen 5 metres.

- (a) (i) Find the distance that Q has fallen when $t = \frac{5}{7}$. (2 marks)
- (ii) Verify that P and Q collide when $t = \frac{5}{7}$. (1 mark)
- (b) The masses of P and Q are 0.2 kg and 0.3 kg respectively. Immediately before the collision, P is moving vertically upwards with speed 3.5 m s^{-1} . The particles coalesce due to the collision. Use the conservation of momentum to find the magnitude and direction of the velocity of the combined particle immediately after the collision. (6 marks)
- 6 A boat sails on a bearing of α° with a constant speed of $x \text{ m s}^{-1}$ relative to the water. A tidal current acts at a constant speed of 1.2 m s^{-1} on a bearing of 090° .

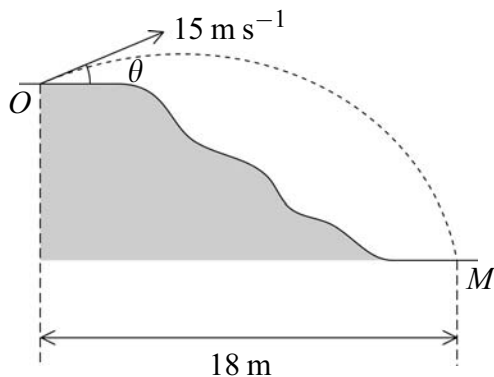
The resultant speed of the boat is $y \text{ m s}^{-1}$ on a bearing of 030° along the line AB , as shown in the diagram.



- (a) The distance AB is 120 metres and the boat takes 20 seconds to sail from A to B . Find the value of y . (1 mark)
- (b) Draw an appropriate triangle of velocities. (3 marks)
- (c) Find the northerly and easterly components of y . (2 marks)
- (d) Hence or otherwise:
- (i) show that the value of x is approximately 5.50 m s^{-1} ; (2 marks)
- (ii) find the value of α . (2 marks)

- 7 A golf ball is struck at a point O on a horizontal stretch of ground and moves with an initial velocity of 15 m s^{-1} at an angle of θ to the horizontal, where $\cos \theta = 0.8$. The ball subsequently lands at a point M which is at a lower horizontal level than O .

The horizontal distance between the points O and M is 18 metres, as shown in the diagram.



- (a) Find the time the ball takes to travel from O to M . (3 marks)
- (b) (i) Find the vertical component of the velocity of the ball when it reaches M . (4 marks)
- (ii) Find the angle the direction of motion of the ball makes with the horizontal when it reaches M . (2 marks)

END OF QUESTIONS

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