General Certificate of Education
June 2004
Advanced Subsidiary Examination

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

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 $g = 9.8\,\text{m}\,\text{s}^{-2}$ 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** A child kicks a small toy brick in a straight line across a horizontal floor. The brick initially moves at $3.5\,\text{m s}^{-1}$ and comes to rest in a distance of 2.5 metres.

(a) Show that the magnitude of the retardation of the brick is $2.45\,\text{m s}^{-2}$. *(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)*

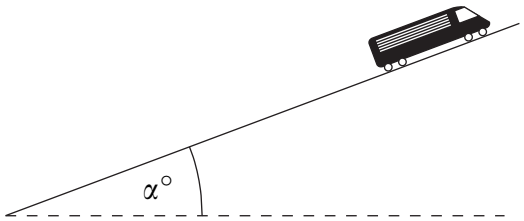
(c) Find the value of $t$ when $P$ moves with speed $6\sqrt{2}\,\text{m s}^{-1}$. *(2 marks)*

**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 $0.25\,\text{m s}^{-2}$. In this stage, the value of $P$ is 1200.

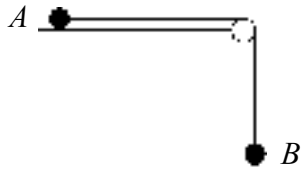
Show that $R = 950$. *(3 marks)*

(b) During the second stage of its motion, the train moves up a slope inclined at an angle $\alpha$ 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 $1.4\ \text{m s}^{-2}$. *(5 marks)*

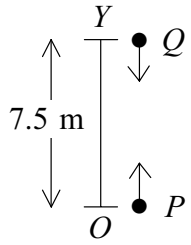
(ii) Find the tension in the string. *(1 mark)*

(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.

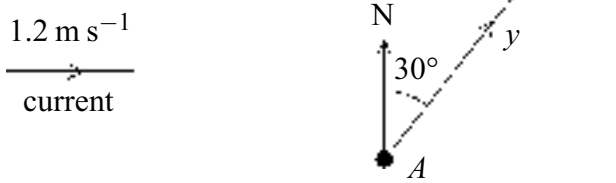
(a) (i) Find the distance that $Q$ has fallen when $t = \frac{5}{7}$. *(2 marks)*

(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 $3.5\,\text{m s}^{-1}$. 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 $\alpha°$ with a constant speed of $x\,\text{m s}^{-1}$ relative to the water. A tidal current acts at a constant speed of $1.2\,\text{m s}^{-1}$ 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)*

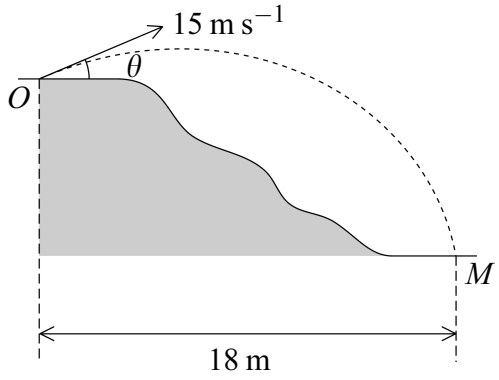
(d) Hence or otherwise:

(i) show that the value of $x$ is approximately $5.50\,\text{m s}^{-1}$; *(2 marks)*

(ii) find the value of $\alpha$. *(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 $15\,\text{m s}^{-1}$ at an angle of $\theta$ 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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