General Certificate of Education
June 2006
Advanced Subsidiary Examination

MATHEMATICS   **MM1A/W**
Unit Mechanics 1A

Tuesday 6 June 2006   1.30 pm to 2.45 pm

For this paper you must have:
- an 8-page answer book
- the **blue** AQA booklet of formulae and statistical tables

You may use a graphics calculator.

Time allowed: 1 hour 15 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 MM1A/W.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 1A has a **written paper and coursework**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

                                                                                       MM1A/W

Answer **all** questions.

1   A small stone is dropped from a high bridge and falls vertically.

    (a)   Find the distance that the stone falls during the first 4 seconds of its motion.   *(3 marks)*

    (b)   Find the speed of the stone when it has been falling for 4 seconds.   *(2 marks)*

2   A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

    During the first stage, the car accelerates uniformly from rest to a velocity of $10\,\mathrm{m\,s^{-1}}$ in 6 seconds.

    During the second stage, the car travels with a constant velocity of $10\,\mathrm{m\,s^{-1}}$ for a further 4 seconds.

    During the third stage of the motion, the car travels with a uniform retardation of magnitude $0.8\,\mathrm{m\,s^{-2}}$ until it comes to rest.

    (a)   Show that the time taken for the **third** stage of the motion is 12.5 seconds.   *(2 marks)*

    (b)   Sketch a velocity–time graph for the car during the three stages of the motion.   *(4 marks)*

    (c)   Find the total distance travelled by the car during the motion.   *(3 marks)*

3   A stone rests in equilibrium on a rough plane inclined at an angle of 16° to the horizontal, as shown in the diagram. The mass of the stone is 0.5 kg.
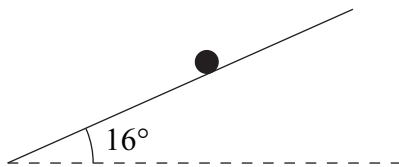
    (a)   Draw a diagram to show the forces acting on the stone.   *(1 mark)*

    (b)   Show that the magnitude of the frictional force acting on the stone is 1.35 newtons, correct to three significant figures.   *(3 marks)*

    (c)   Find the magnitude of the normal reaction force between the stone and the plane.   *(2 marks)*

    (d)   Hence find an inequality for the value of μ, the coefficient of friction between the stone and the plane.   *(2 marks)*

4 A block P is attached to a can Q by a light inextensible string. The string hangs over a smooth peg so that P and Q hang freely, as shown in the diagram.
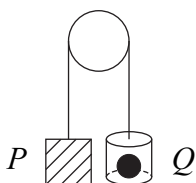

The block P and the can Q each has mass $0.2\,\text{kg}$. The can Q contains a small stone of mass $0.1\,\text{kg}$. The system is released from rest and the can Q and the stone move vertically downwards.

(a) By forming two equations of motion, show that the magnitude of the acceleration of P and Q is $1.96\,\text{m s}^{-2}$. *(5 marks)*

(b) Find the magnitude of the reaction force between the can and the stone. *(3 marks)*

5 The points A and B have position vectors $(3\mathbf{i} + 2\mathbf{j})$ metres and $(6\mathbf{i} - 4\mathbf{j})$ metres respectively. The vectors $\mathbf{i}$ and $\mathbf{j}$ are in a horizontal plane.

(a) A particle moves from A to B with constant velocity $(\mathbf{i} - 2\mathbf{j})\,\text{m s}^{-1}$. Calculate the time that the particle takes to move from A to B. *(3 marks)*

(b) The particle then moves from B to a point C with a constant acceleration of $2\mathbf{j}\,\text{m s}^{-2}$. It takes 4 seconds to move from B to C.

   (i) Find the position vector of C. *(4 marks)*

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

Turn over for the next question

Turn over ▶

6 A golf ball is struck from a point O with velocity $24\,\text{m s}^{-1}$ at an angle of $40°$ to the horizontal. The ball first hits the ground at a point P, which is at a height h metres above the level of O.
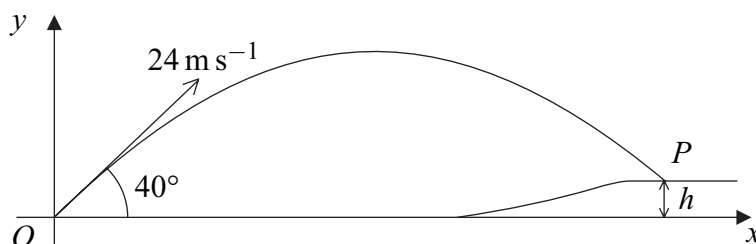
The horizontal distance between O and P is 57 metres.

(a) Show that the time that the ball takes to travel from O to P is 3.10 seconds, correct to three significant figures. *(3 marks)*

(b) Find the value of h. *(3 marks)*

(c) (i) Find the speed with which the ball hits the ground at P. *(5 marks)*

   (ii) Find the angle between the direction of motion and the horizontal as the ball hits the ground at P. *(2 marks)*

7 Two particles, A and B, are moving on a smooth horizontal surface.

The particle A has mass $m\,\text{kg}$ and is moving with velocity $\begin{bmatrix} 5 \\ -3 \end{bmatrix}\,\text{m s}^{-1}$.

The particle B has mass $0.2\,\text{kg}$ and is moving with velocity $\begin{bmatrix} 2 \\ 3 \end{bmatrix}\,\text{m s}^{-1}$.

(a) Find, in terms of m, an expression for the total momentum of the particles. *(2 marks)*

(b) The particles A and B collide and form a single particle C, which moves with velocity $\begin{bmatrix} k \\ 1 \end{bmatrix}\,\text{m s}^{-1}$, where k is a constant.

   (i) Show that $m = 0.1$. *(3 marks)*

   (ii) Find the value of k. *(3 marks)*

END OF QUESTIONS