General Certificate of Education
June 2006
Advanced Subsidiary Examination

# MATHEMATICS
# Unit Mechanics 1B

**MM1B**

Tuesday 6 June 2006 1.30 pm to 3.00 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 30 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 MM1B.
- 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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

**Information**
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

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

Answer **all** questions.

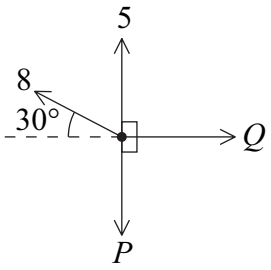
**1** A stone is dropped from a high bridge and falls vertically.

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

(b) Find the average speed of the stone during the first 4 seconds of its motion. *(2 marks)*

(c) State one modelling assumption that you have made about the forces acting on the stone during the motion. *(1 mark)*

**2** A particle is in equilibrium under the action of four horizontal forces of magnitudes 5 newtons, 8 newtons, $P$ newtons and $Q$ newtons, as shown in the diagram.




(a) Show that $P = 9$. *(3 marks)*

(b) Find the value of $Q$. *(2 marks)*

**3** 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)*

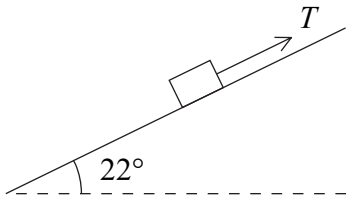
(b) Sketch a velocity–time graph for the car during the three stages of the motion. *(4 marks)*

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

(d) State one criticism of the model of the motion. *(1 mark)*

**4** A block is being pulled up a rough plane inclined at an angle of 22° to the horizontal by a rope parallel to the plane, as shown in the diagram.

The mass of the block is 0.7 kg, and the tension in the rope is $T$ newtons.



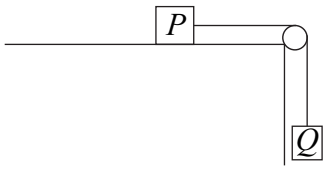

(a) Draw a diagram to show the forces acting on the block. *(1 mark)*

(b) Show that the normal reaction force between the block and the plane has magnitude 6.36 newtons, correct to three significant figures. *(3 marks)*

(c) The coefficient of friction between the block and the plane is 0.25. Find the magnitude of the frictional force acting on the block during its motion. *(2 marks)*

(d) The tension in the rope is 5.6 newtons. Find the acceleration of the block. *(4 marks)*

**5** A small block $P$ is attached to another small block $Q$ by a light inextensible string. The block $P$ rests on a rough horizontal surface and the string hangs over a smooth peg so that $Q$ hangs freely, as shown in the diagram.




The block $P$ has mass 0.4 kg and the coefficient of friction between $P$ and the surface is 0.5.

The block $Q$ has mass 0.3 kg.

The system is released from rest and $Q$ moves vertically downwards.

(a) (i) Draw a diagram to show the forces acting on $P$. *(1 mark)*

(ii) Show that the frictional force between $P$ and the surface has magnitude 1.96 newtons. *(2 marks)*

(b) By forming an equation of motion for each block, show that the magnitude of the acceleration of each block is $1.4\,\mathrm{m\,s^{-2}}$. *(5 marks)*

(c) Find the speed of the blocks after 3 seconds of motion. *(2 marks)*

(d) After 3 seconds of motion, the string breaks. The blocks continue to move. Comment on how the speed of each block will change in the subsequent motion. For each block, give a reason for your answer. *(4 marks)*

**6** 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.

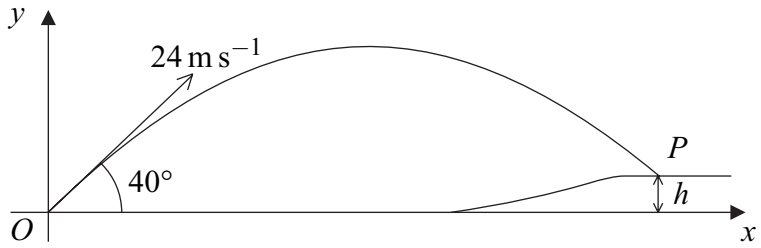
(a) A particle moves from $A$ to $B$ with constant velocity $(\mathbf{i} - 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. Calculate the time that the particle takes to move from $A$ to $B$. *(3 marks)*

(b) The particle then moves from $B$ to a point $C$ with a constant acceleration of $2\mathbf{j}\,\mathrm{m\,s^{-2}}$. 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)*

**7** A golf ball is struck from a point $O$ with velocity $24\,\mathrm{m\,s^{-1}}$ 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)*

**8** Two particles, $A$ and $B$, are moving on a smooth horizontal surface.

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

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

(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 $\begin{bmatrix} k \\ 1 \end{bmatrix}\mathrm{m\,s^{-1}}$, where $k$ is a constant.

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

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

**END OF QUESTIONS**

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