

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	



General Certificate of Education  
Advanced Level Examination  
January 2011

# Mathematics

# MM2B

## Unit Mechanics 2B

Wednesday 26 January 2011 1.30 pm to 3.00 pm

**For this paper you must have:**

- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

### Time allowed

- 1 hour 30 minutes

### Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take  $g = 9.8 \text{ m s}^{-2}$ , unless stated otherwise.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

### Advice

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



J A N 1 1 M M 2 B 0 1

Answer **all** questions in the spaces provided.

**1** The velocity of a particle at time  $t$  seconds is  $\mathbf{v} \text{ m s}^{-1}$ , where

$$\mathbf{v} = (4 + 3t^2)\mathbf{i} + (12 - 8t)\mathbf{j}$$

**(a)** When  $t = 0$ , the particle is at the point with position vector  $(5\mathbf{i} - 7\mathbf{j}) \text{ m}$ .

Find the position vector,  $\mathbf{r}$  metres, of the particle at time  $t$ . *(4 marks)*

**(b)** Find the acceleration of the particle at time  $t$ . *(2 marks)*

**(c)** The particle has mass 2 kg.

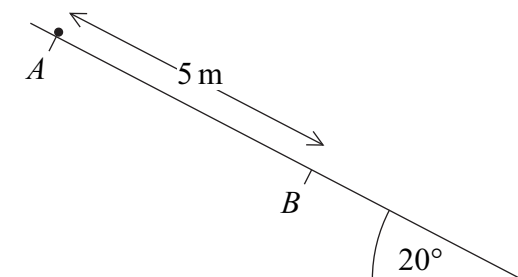
Find the magnitude of the force acting on the particle when  $t = 1$ . *(4 marks)*

QUESTION  
PART  
REFERENCE





- 2** A particle is placed on a smooth plane which is inclined at an angle of  $20^\circ$  to the horizontal. The particle, of mass  $4\text{ kg}$ , is released from rest at a point  $A$  and travels down the plane, passing through a point  $B$ . The distance  $AB$  is  $5\text{ m}$ .



- (a) Find the potential energy lost as the particle moves from point  $A$  to point  $B$ . (2 marks)
- (b) Hence write down the kinetic energy of the particle when it reaches point  $B$ . (1 mark)
- (c) Hence find the speed of the particle when it reaches point  $B$ . (2 marks)

QUESTION  
PART  
REFERENCE

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



QUESTION  
PART  
REFERENCE

Lined area for writing answers, consisting of a vertical margin line on the left and horizontal dotted lines across the page.

Turn over ►



**3**

A pump is being used to empty a flooded basement.

In one minute, 400 litres of water are pumped out of the basement.

The water is raised 8 metres and is ejected through a pipe at a speed of  $2\text{ m s}^{-1}$ .

The mass of 400 litres of water is 400 kg.

- (a)** Calculate the gain in potential energy of the 400 litres of water. *(1 mark)*
- (b)** Calculate the gain in kinetic energy of the 400 litres of water. *(1 mark)*
- (c)** Hence calculate the power of the pump, giving your answer in watts. *(2 marks)*

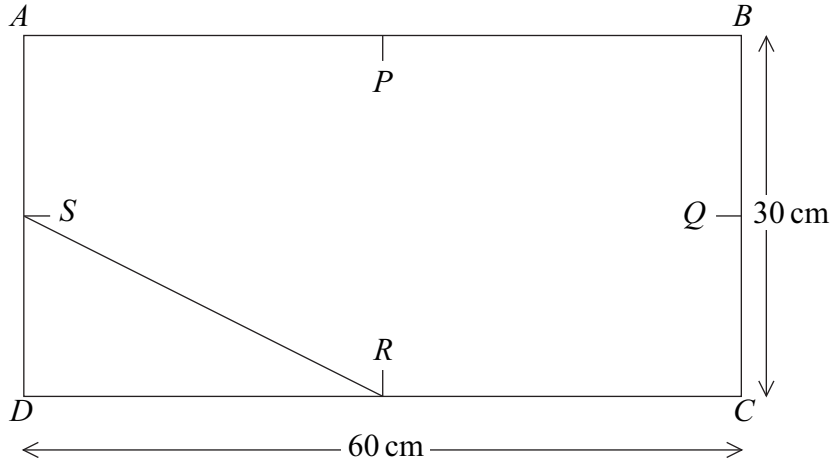
QUESTION  
PART  
REFERENCE






**4** A uniform rectangular lamina  $ABCD$  has a mass of 5 kg. The side  $AB$  has length 60 cm and the side  $BC$  has length 30 cm. The points  $P$ ,  $Q$ ,  $R$  and  $S$  are the mid-points of the sides, as shown in the diagram below.

A uniform triangular lamina  $SRD$ , of mass 4 kg, is fixed to the rectangular lamina to form a shop sign. The centre of mass of the triangular lamina  $SRD$  is 10 cm from the side  $AD$  and 5 cm from the side  $DC$ .



- (a) Find the distance of the centre of mass of the shop sign from  $AD$ . (3 marks)
- (b) Find the distance of the centre of mass of the shop sign from  $AB$ . (3 marks)
- (c) The shop sign is freely suspended from  $P$ .

Find the angle between  $AB$  and the horizontal when the shop sign is in equilibrium. (4 marks)

- (d) To ensure that the side  $AB$  is horizontal when the shop sign is freely suspended from point  $P$ , a particle of mass  $m$  kg is attached to the shop sign at point  $B$ .

Calculate  $m$ . (3 marks)

- (e) Explain how you have used the fact that the rectangular lamina  $ABCD$  is uniform in your solution to this question. (1 mark)

QUESTION  
PART  
REFERENCE

.....

.....

.....

.....

.....





QUESTION  
PART  
REFERENCE

Turn over ▶









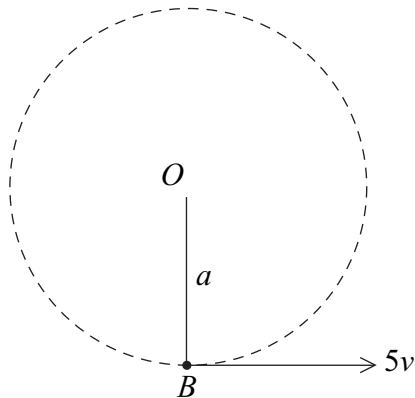
QUESTION  
PART  
REFERENCE

Handwriting practice area with horizontal dotted lines.

Turn over ►



- 6 A light inextensible string, of length  $a$ , has one end attached to a fixed point  $O$ . A small bead, of mass  $m$ , is attached to the other end of the string. The bead is moving in a vertical circle, centre  $O$ . When the bead is at  $B$ , vertically below  $O$ , the string is taut and the bead is moving with speed  $5v$ .



- (a) The speed of the bead at the highest point of its path is  $3v$ .  
Find  $v$  in terms of  $a$  and  $g$ . (4 marks)
- (b) Find the ratio of the greatest tension to the least tension in the string, as the bead travels around its circular path. (5 marks)

QUESTION  
PART  
REFERENCE

A series of horizontal dotted lines for writing the solution.



QUESTION  
PART  
REFERENCE

Lined writing area with a vertical margin on the left and horizontal dotted lines.



1 5

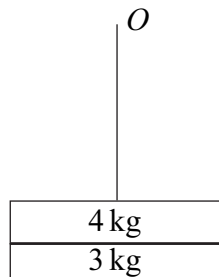
Turn over ▶

**7 (a)** An elastic string has natural length  $l$  and modulus of elasticity  $\lambda$ . The string is stretched from length  $l$  to length  $l + e$ .

Show, by integration, that the work done in stretching the string is  $\frac{\lambda e^2}{2l}$ . (3 marks)

**(b)** A block, of mass 4 kg, is attached to one end of a light elastic string. The string has natural length 2 m and modulus of elasticity 196 N. The other end of the string is attached to a fixed point  $O$ .

**(i)** A second block, of mass 3 kg, is attached to the 4 kg block and the system hangs in equilibrium, as shown in the diagram.



Find the extension in the string. (3 marks)

**(ii)** The block of mass 3 kg becomes detached from the 4 kg block and falls to the ground. The 4 kg block now begins to move vertically upwards.

Find the extension of the string when the 4 kg block is next at rest. (6 marks)

**(iii)** Find the extension of the string when the speed of the 4 kg block is a maximum.

(3 marks)

QUESTION  
PART  
REFERENCE

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....





QUESTION  
PART  
REFERENCE

Grid of horizontal dotted lines for writing answers.



Turn over ▶





**8** Vicky has mass 65 kg and is skydiving. She steps out of a helicopter and falls vertically. She then waits a short period of time before opening her parachute. The parachute opens at time  $t = 0$  when her speed is  $19.6 \text{ m s}^{-1}$ , and she then experiences an air resistance force of magnitude  $260v$  newtons, where  $v \text{ m s}^{-1}$  is her speed at time  $t$  seconds.

**(a)** When  $t > 0$ :

**(i)** show that the resultant downward force acting on Vicky is

$$65(9.8 - 4v) \text{ newtons} \quad (1 \text{ mark})$$

**(ii)** show that  $\frac{dv}{dt} = -4(v - 2.45)$ . (2 marks)

**(b)** By showing that  $\int \frac{1}{v - 2.45} dv = - \int 4 dt$ , find  $v$  in terms of  $t$ . (5 marks)

QUESTION  
PART  
REFERENCE





**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**



**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**



**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**

