

Centre Number						Candidate Number				
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Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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9	
TOTAL	



General Certificate of Education  
Advanced Level Examination  
January 2013

# Mathematics

# MM2B

## Unit Mechanics 2B

Monday 28 January 2013 9.00 am to 10.30 am

**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 each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- 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.
- You do not necessarily need to use all the space provided.



J A N 1 3 M M 2 B 0 1

Answer **all** questions.

Answer each question in the space provided for that question.

- 1** Tim is playing cricket. He hits a ball at a point  $A$ . The speed of the ball immediately after being hit is  $11 \text{ m s}^{-1}$ .
- The ball strikes a tree at a point  $B$ . The height of  $B$  is 5 metres above the height of  $A$ .
- The ball is to be modelled as a particle of mass  $0.16 \text{ kg}$  being acted upon only by gravity.
- (a)** Calculate the initial kinetic energy of the ball. *(2 marks)*
- (b)** Calculate the potential energy gained by the ball as it moves from the point  $A$  to the point  $B$ . *(2 marks)*
- (c) (i)** Find the kinetic energy of the ball immediately before it strikes the tree. *(2 marks)*
- (ii)** Hence find the speed of the ball immediately before it strikes the tree. *(2 marks)*

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**2** A particle moves in a horizontal plane. The vectors **i** and **j** are perpendicular unit vectors in the horizontal plane. At time  $t$  seconds, the velocity of the particle,  $\mathbf{v} \text{ m s}^{-1}$ , is given by

$$\mathbf{v} = 12 \cos\left(\frac{\pi}{3}t\right)\mathbf{i} - 9t^2\mathbf{j}$$

- (a) Find an expression for the acceleration of the particle at time  $t$ . (2 marks)
  
- (b) The particle, which has mass 4 kg, moves under the action of a single force, **F** newtons.
  - (i) Find an expression for the force **F** in terms of  $t$ . (2 marks)
  - (ii) Find the magnitude of **F** when  $t = 3$ . (2 marks)
  
- (c) When  $t = 3$ , the particle is at the point with position vector  $(4\mathbf{i} - 2\mathbf{j}) \text{ m}$ .  
Find the position vector, **r** metres, of the particle at time  $t$ . (5 marks)

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**3** A van, of mass 1500 kg, travels at a constant speed of  $22 \text{ m s}^{-1}$  up a slope inclined at an angle  $\theta$  to the horizontal, where  $\sin \theta = \frac{1}{25}$ .

The van experiences a resistance force of 8 000 N.

Find the power output of the van's engine, giving your answer in kilowatts.  
*(5 marks)*

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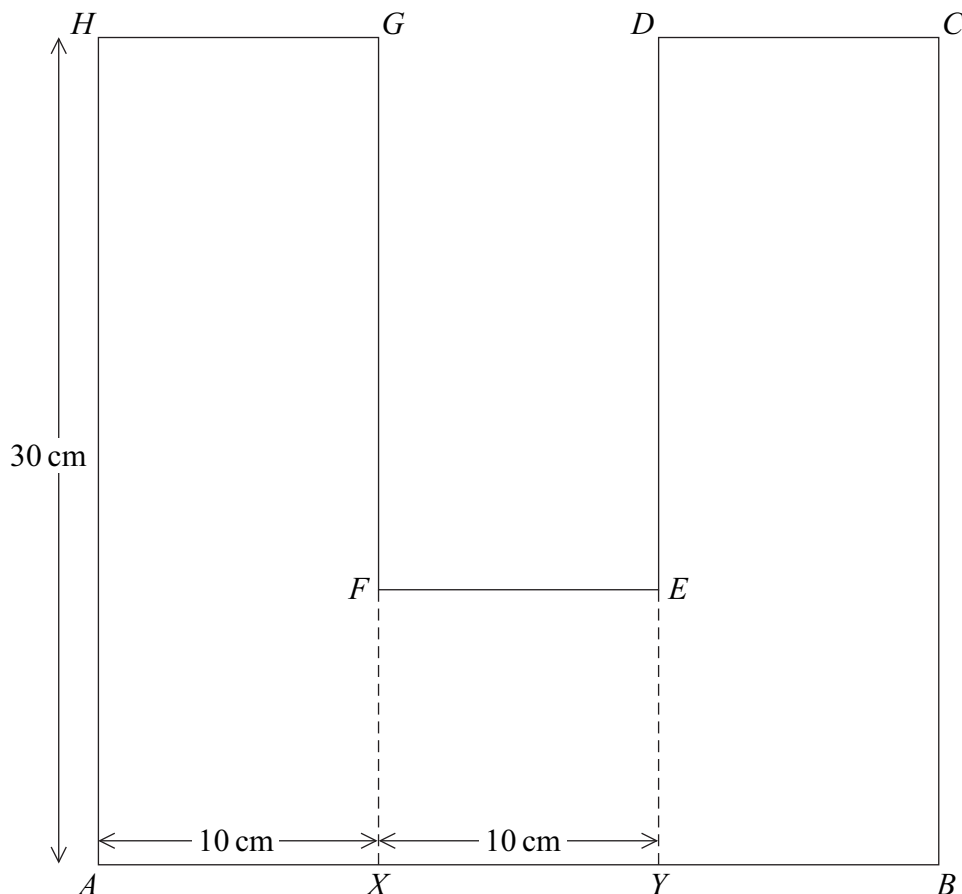
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4

The diagram shows a uniform lamina which is in the shape of two identical rectangles  $AXGH$  and  $YBCD$  and a square  $XYEF$ , arranged as shown.

The length of  $AX$  is 10 cm, the length of  $XY$  is 10 cm and the length of  $AH$  is 30 cm.



- (a) Explain why the centre of mass of the lamina is 15 cm from  $AH$ . (1 mark)
- (b) Find the distance of the centre of mass of the lamina from  $AB$ . (3 marks)
- (c) The lamina is freely suspended from the point  $H$ .

Find, to the nearest degree, the angle between  $HG$  and the horizontal when the lamina is in equilibrium. (4 marks)





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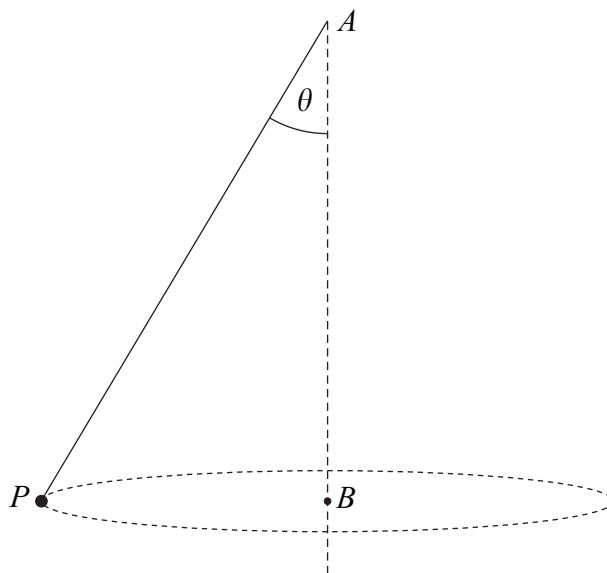
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**6** A light inextensible string has one end attached to a particle,  $P$ , of mass 2 kg. The other end of the string is attached to the fixed point  $A$ . The point  $A$  is vertically above the point  $B$ . The particle moves at a constant speed in a horizontal circle of radius 0.8 m and centre  $B$ . The tension in the string is 34 N.

The string is inclined at an angle  $\theta$  to the vertical, as shown in the diagram.



- (a) Find the angle  $\theta$ . (3 marks)
- (b) Find the speed of the particle. (3 marks)
- (c) Find the time taken for the particle to make one complete revolution. (2 marks)

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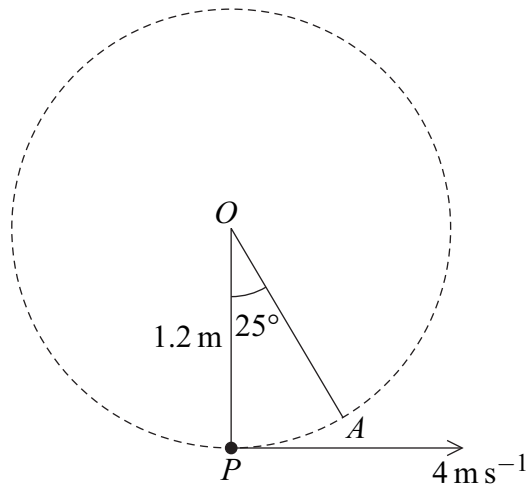
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- 7 A small ball, of mass 3 kg, is suspended from a fixed point  $O$  by a light inextensible string of length 1.2 m. Initially, the string is taut and the ball is at the point  $P$ , vertically below  $O$ . The ball is then set into motion with an initial horizontal velocity of  $4 \text{ m s}^{-1}$ .

The ball moves in a vertical circle, centre  $O$ . The point  $A$ , on the circle, is such that angle  $AOP$  is  $25^\circ$ , as shown in the diagram.



- (a) Find the speed of the ball at the point  $A$ . (4 marks)
- (b) Find the tension in the string when the ball is at the point  $A$ . (3 marks)

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**8 (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 particle, of mass 5 kg, is attached to one end of a light elastic string. The other end of the string is attached to a fixed point  $O$ .

The string has natural length 1.6 m and modulus of elasticity 392 N.

**(i)** Find the extension of the string when the particle hangs in equilibrium. (2 marks)

**(ii)** The particle is pulled down to a point  $A$ , which is 2.2 m below the point  $O$ .

Calculate the elastic potential energy in the string. (3 marks)

**(iii)** The particle is released when it is at rest at the point  $A$ .

Calculate the distance of the particle from the point  $A$  when its speed first reaches  $0.8 \text{ m s}^{-1}$ . (5 marks)

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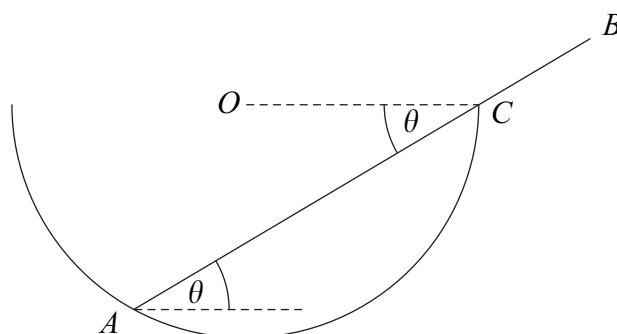
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- 9** A smooth hollow hemisphere, of radius  $a$  and centre  $O$ , is fixed so that its rim is in a horizontal plane. A smooth uniform rod  $AB$ , of mass  $m$ , is in equilibrium, with one end  $A$  resting on the inside of the hemisphere and the point  $C$  on the rod being in contact with the rim of the hemisphere. The rod, of length  $l$ , is inclined at an angle  $\theta$  to the horizontal, as shown in the diagram.



- (a) Explain why the reaction between the rod and the hemisphere at point  $A$  acts through  $O$ . (1 mark)
- (b) Draw a diagram to show the forces acting on the rod. (2 marks)
- (c) Show that  $l = \frac{4a \cos 2\theta}{\cos \theta}$ . (5 marks)

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**END OF QUESTIONS**

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