

Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
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7	
8	
TOTAL	



General Certificate of Education  
Advanced Level Examination  
June 2014

## Mathematics

## MM2B

### Unit Mechanics 2B

Monday 23 June 2014 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 U N 1 4 M M 2 B 0 1

Answer **all** questions.

Answer each question in the space provided for that question.

**1** An eagle has caught a salmon of mass 3 kg to take to its nest. When the eagle is flying with speed  $8 \text{ m s}^{-1}$ , it drops the salmon. The salmon falls a vertical distance of 13 metres back into the sea.

The salmon is to be modelled as a particle. The salmon's weight is the only force that acts on it as it falls to the sea.

**(a)** Calculate the kinetic energy of the salmon when it is dropped by the eagle. **[2 marks]**

**(b)** Calculate the potential energy lost by the salmon as it falls to the sea. **[2 marks]**

**(c) (i)** Find the kinetic energy of the salmon when it reaches the sea. **[2 marks]**

**(ii)** Hence find the speed of the salmon when it reaches the sea. **[2 marks]**

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**Answer space for question 1**







QUESTION  
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**Answer space for question 2**

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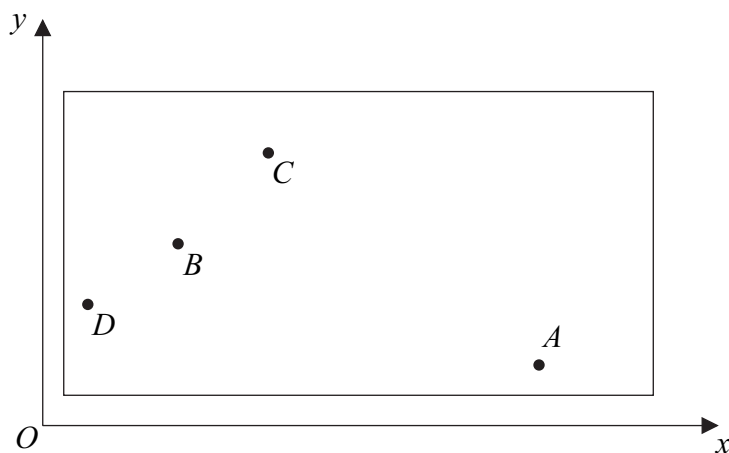
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3 Four tools are attached to a board.

The board is to be modelled as a uniform lamina and the four tools as four particles.

The diagram shows the lamina, the four particles  $A$ ,  $B$ ,  $C$  and  $D$ , and the  $x$  and  $y$  axes.



The lamina has mass 5 kg and its centre of mass is at the point  $(7, 6)$ .

Particle  $A$  has mass 4 kg and is at the point  $(11, 2)$ .

Particle  $B$  has mass 3 kg and is at the point  $(3, 6)$ .

Particle  $C$  has mass 7 kg and is at the point  $(5, 9)$ .

Particle  $D$  has mass 1 kg and is at the point  $(1, 4)$ .

Find the coordinates of the centre of mass of the system of board and tools.

[5 marks]

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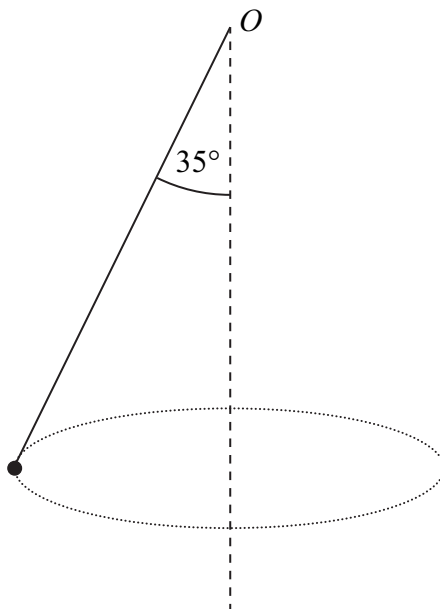
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- 4 A particle, of mass  $0.8 \text{ kg}$ , is attached to one end of a light inextensible string. The other end of the string is attached to the fixed point  $O$ . The particle is set in motion, so that it moves in a horizontal circle at constant speed, with the string at an angle of  $35^\circ$  to the vertical. The centre of this circle is vertically below  $O$ , as shown in the diagram.



The particle moves in a horizontal circle and completes 20 revolutions each minute.

- (a) Find the angular speed of the particle in radians per second. [2 marks]
- (b) Find the tension in the string. [3 marks]
- (c) Find the radius of the horizontal circle. [4 marks]

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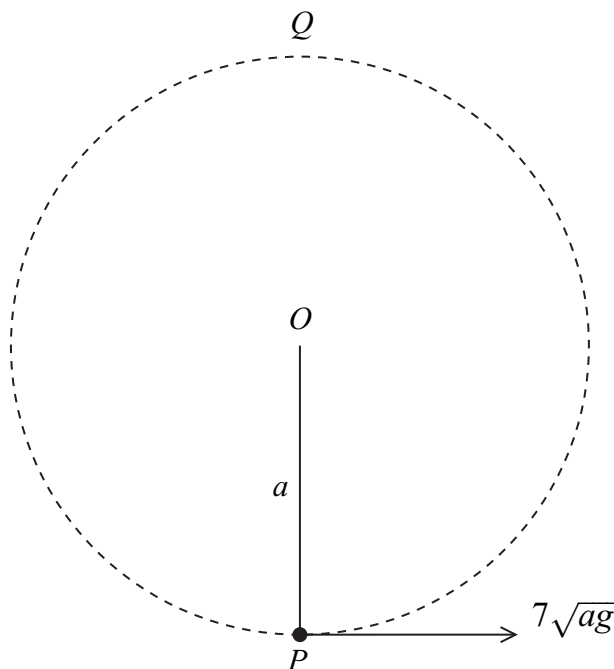
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- 5 A light inextensible string, of length  $a$ , has one end attached to a fixed point  $O$ . A particle, of mass  $m$ , is attached to the other end of the string. The particle is moving in a vertical circle with centre  $O$ . The point  $Q$  is the highest point of the particle's path. When the particle is at  $P$ , vertically below  $O$ , the string is taut and the particle is moving with speed  $7\sqrt{ag}$ , as shown in the diagram.



- (a) Find, in terms of  $g$  and  $a$ , the speed of the particle at the point  $Q$ . [4 marks]
- (b) Find, in terms of  $g$  and  $m$ , the tension in the string when the particle is at  $Q$ . [3 marks]

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- 6** A puck, of mass  $m$  kg, is moving in a straight line across smooth horizontal ice. At time  $t$  seconds, the puck has speed  $v$  m s<sup>-1</sup>. As the puck moves, it experiences an air resistance force of magnitude  $0.3mv^{\frac{1}{3}}$  newtons, until it comes to rest. No other horizontal forces act on the puck.

When  $t = 0$ , the speed of the puck is  $8$  m s<sup>-1</sup>.

Model the puck as a particle.

- (a)** Show that

$$v = (4 - 0.2t)^{\frac{3}{2}}$$

**[6 marks]**

- (b)** Find the value of  $t$  when the puck comes to rest.

**[2 marks]**

- (c)** Find the distance travelled by the puck as its speed decreases from  $8$  m s<sup>-1</sup> to zero.

**[5 marks]**

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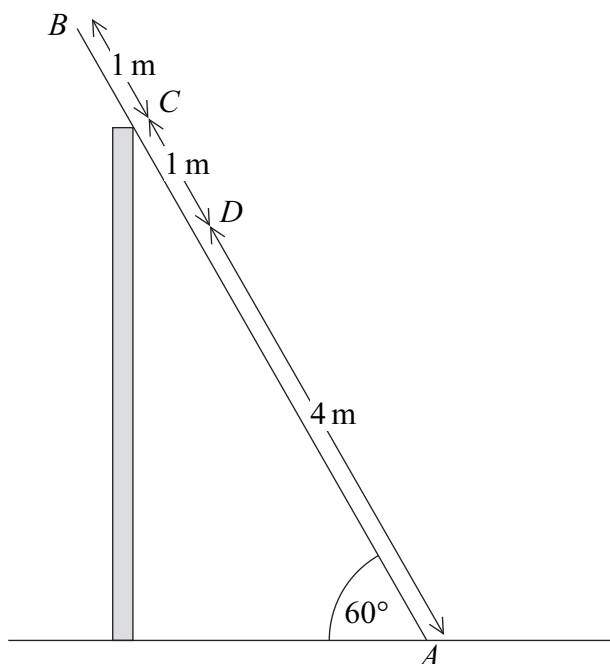
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7 A uniform ladder  $AB$ , of length 6 metres and mass 22 kg, rests with its foot,  $A$ , on rough horizontal ground. The ladder rests against the top of a smooth vertical wall at the point  $C$ , where the length  $AC$  is 5 metres. The vertical plane containing the ladder is perpendicular to the wall, and the angle between the ladder and the ground is  $60^\circ$ . A man, of mass 88 kg, is standing on the ladder.

The man may be modelled as a particle at the point  $D$ , where the length of  $AD$  is 4 metres.

The ladder is on the point of slipping.



- (a) Draw a diagram to show the forces acting on the ladder. [2 marks]
- (b) Find the coefficient of friction between the ladder and the horizontal ground. [6 marks]

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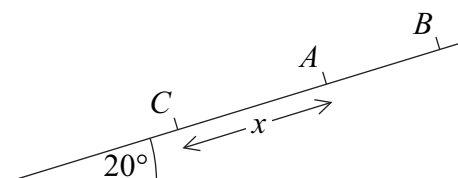




- 8** An elastic string has natural length 1.5 metres and modulus of elasticity 120 newtons. One end of the string is attached to a fixed point,  $A$ , on a rough plane inclined at  $20^\circ$  to the horizontal. The other end of the elastic string is attached to a particle of mass 4 kg. The coefficient of friction between the particle and the plane is 0.8.

The three points,  $A$ ,  $B$  and  $C$ , lie on a line of greatest slope.

The point  $C$  is  $x$  metres from  $A$ , as shown in the diagram. The particle is released from rest at  $C$  and moves up the plane.



- (a) Show that, as the particle moves up the plane, the frictional force acting on the particle is 29.5 N, correct to three significant figures. [3 marks]
- (b) The particle comes to rest for an instant at  $B$ , which is 2 metres from  $A$ .  
The particle then starts to move back towards  $A$ .
- (i) Find  $x$ . [8 marks]
- (ii) Find the acceleration of the particle as it starts to move back towards  $A$ . [4 marks]

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QUESTION  
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QUESTION  
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**END OF QUESTIONS**



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