

Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
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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 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



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Answer space for question 1

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- 2** A particle has mass 6 kg. A single force $(24e^{-2t}\mathbf{i} - 12t^3\mathbf{j})$ newtons acts on the particle at time t seconds. No other forces act on the particle.
- (a)** Find the acceleration of the particle at time t . **[2 marks]**
- (b)** At time $t = 0$, the velocity of the particle is $(-7\mathbf{i} - 4\mathbf{j}) \text{ m s}^{-1}$.
Find the velocity of the particle at time t . **[4 marks]**
- (c)** Find the speed of the particle when $t = 0.5$. **[4 marks]**

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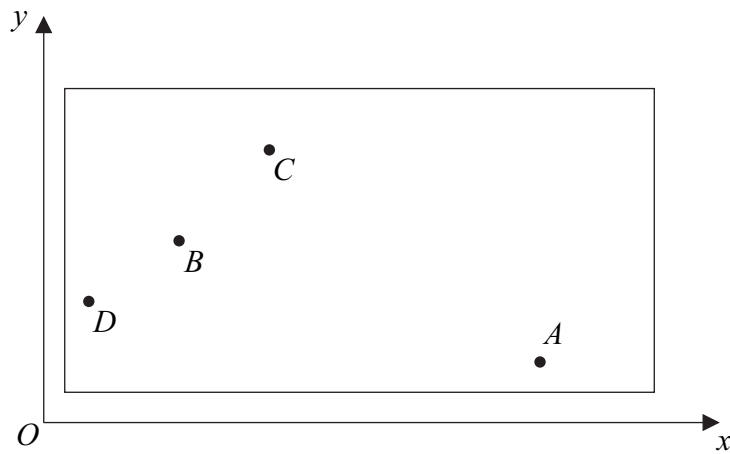
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3 Four tools are attached to a board.

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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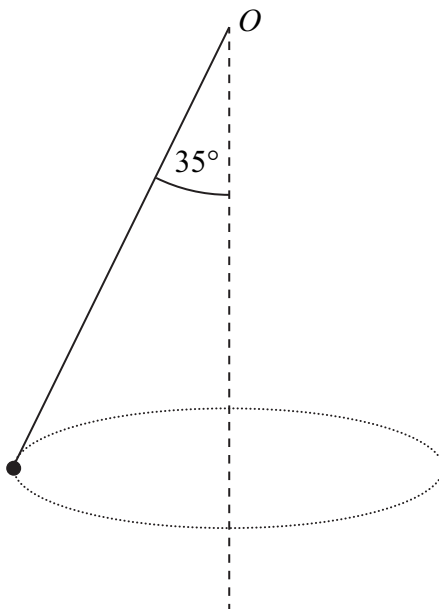
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- 4** A particle, of mass 0.8 kg , is attached to one end of a light inextensible string. The other end of the string is attached to the fixed point O . The particle is set in motion, so that it moves in a horizontal circle at constant speed, with the string at an angle of 35° 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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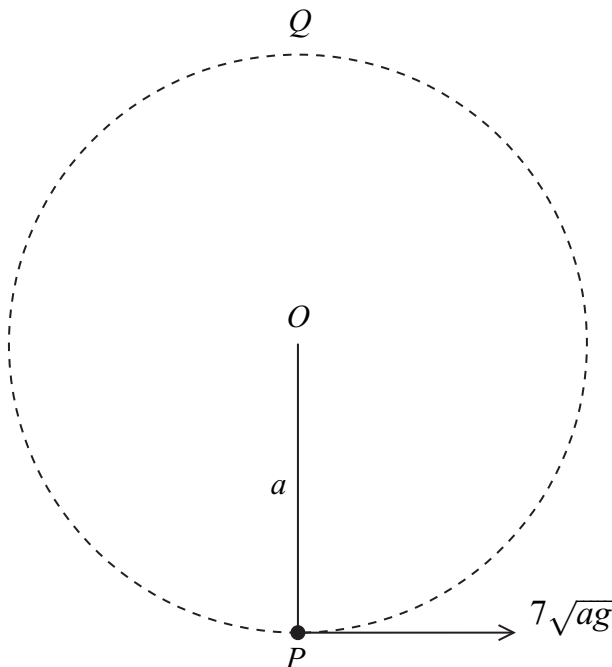
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5 A light inextensible string, of length a , has one end attached to a fixed point O . A particle, of mass m , is attached to the other end of the string. The particle is moving in a vertical circle with centre O . The point Q is the highest point 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^{-1} . 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^{-1} .

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^{-1} to zero.

[5 marks]

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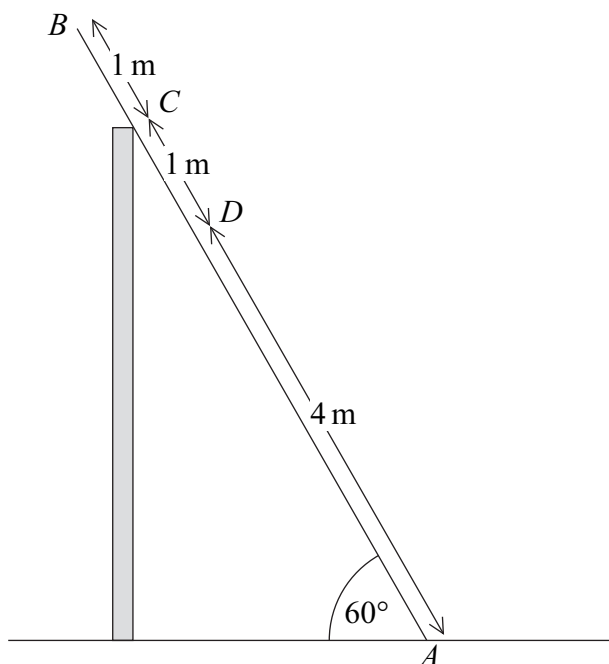
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7 A uniform ladder AB , of length 6 metres and mass 22 kg, rests with its foot, A , on rough horizontal ground. The ladder rests against the top of a smooth vertical wall at the point C , where the length AC is 5 metres. The vertical plane containing the ladder is perpendicular to the wall, and the angle between the ladder and the ground is 60° . 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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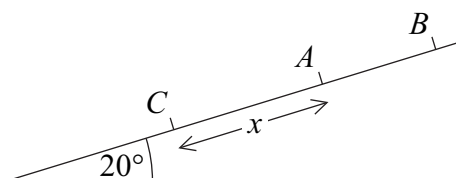
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8 An elastic string has natural length 1.5 metres and modulus of elasticity 120 newtons. One end of the string is attached to a fixed point, *A*, on a rough plane inclined at 20° to the horizontal. The other end of the elastic string is attached to 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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END OF QUESTIONS



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