Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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7	
8	
TOTAL	

AQA

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 $g = 9.8\,\mathrm{m\,s^{-2}}$, 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.

Do not write outside the box

Answer **all** questions.

Answer each question in the space provided for that question.

1 An eagle has caught a salmon of mass $3\,\text{kg}$ 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]

QUESTION PART REFERENCE

Answer space for question 1

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QUESTION PART REFERENCE

Answer space for question 1

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2 A particle has mass $6\,\text{kg}$. A single force $(24\text{e}^{-2t}\mathbf{i} - 12t^3\mathbf{j})$ 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]

QUESTION PART REFERENCE

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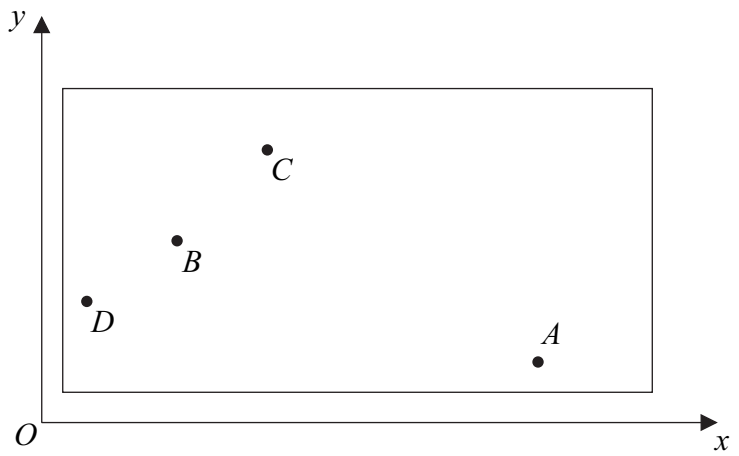
QUESTION PART REFERENCE

Answer space for question 2

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 $5\,\text{kg}$ and its centre of mass is at the point $(7, 6)$.

Particle A has mass $4\,\text{kg}$ and is at the point $(11, 2)$.
Particle B has mass $3\,\text{kg}$ and is at the point $(3, 6)$.
Particle C has mass $7\,\text{kg}$ and is at the point $(5, 9)$.
Particle D has mass $1\,\text{kg}$ and is at the point $(1, 4)$.

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

[5 marks]

QUESTION PART REFERENCE

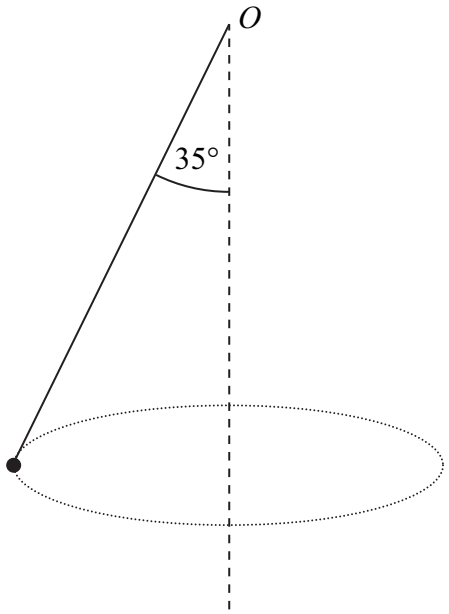
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QUESTION PART REFERENCE

Answer space for question 3

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 $35°$ 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]

QUESTION PART REFERENCE

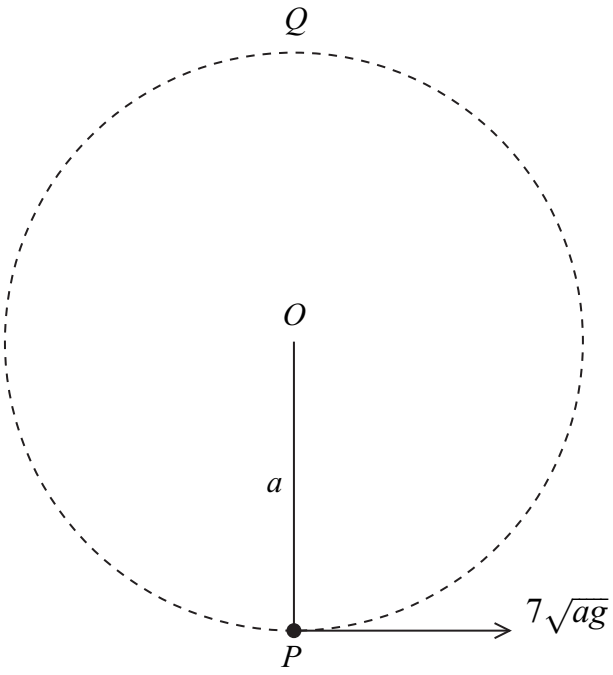
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QUESTION PART REFERENCE

Answer space for question 4

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]

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

Answer space for question 5

6 A puck, of mass $m\,\text{kg}$, is moving in a straight line across smooth horizontal ice. At time t seconds, the puck has speed $v\,\text{m s}^{-1}$. 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 $8\,\text{m s}^{-1}$.

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 $8\,\text{m s}^{-1}$ to zero.

[5 marks]

QUESTION PART REFERENCE

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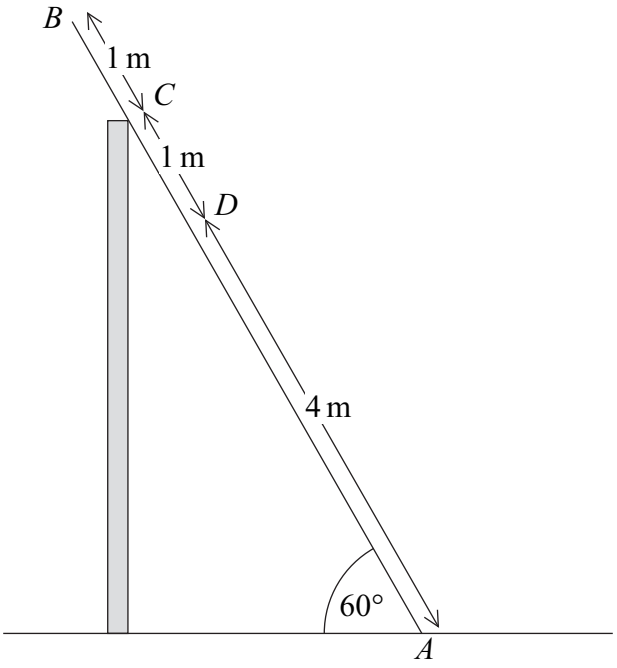
QUESTION PART REFERENCE

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7 A uniform ladder AB, of length 6 metres and mass $22\,\text{kg}$, 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 $88\,\text{kg}$, 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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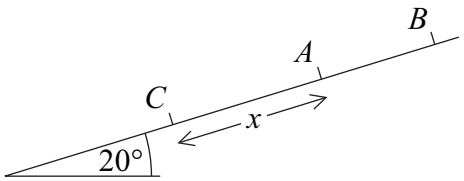


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8 An elastic string has natural length 1.5 metres and modulus of elasticity 120 newtons. One end of the string is attached to a fixed point, A, on a rough plane inclined at $20°$ to the horizontal. The other end of the elastic string is attached to a particle of mass $4\,\text{kg}$. 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 $29.5\,\text{N}$, 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]

QUESTION PART REFERENCE

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END OF QUESTIONS

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