| 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 | |

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.

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**

QUESTION PART REFERENCE

**Answer space for question 1**

**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

**Answer space for question 2**

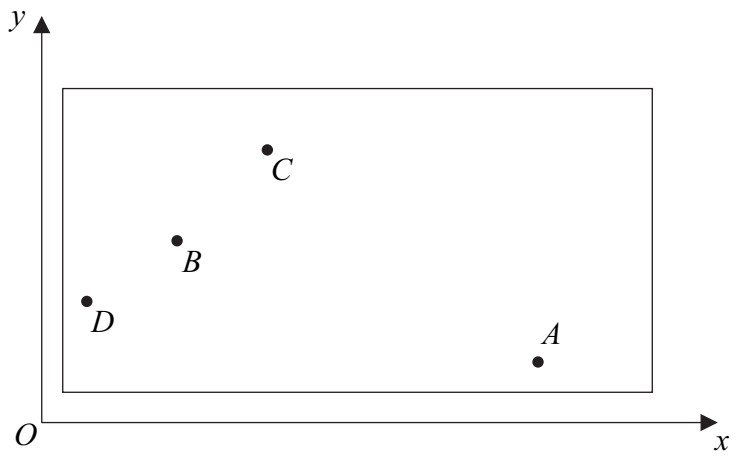
QUESTION PART REFERENCE

**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]**

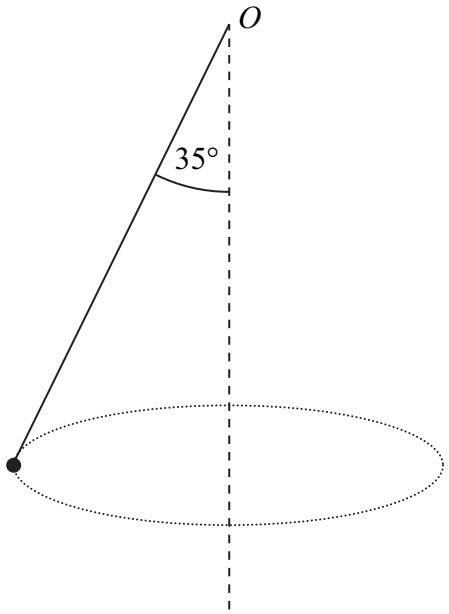
QUESTION PART REFERENCE

**Answer space for question 3**

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]**

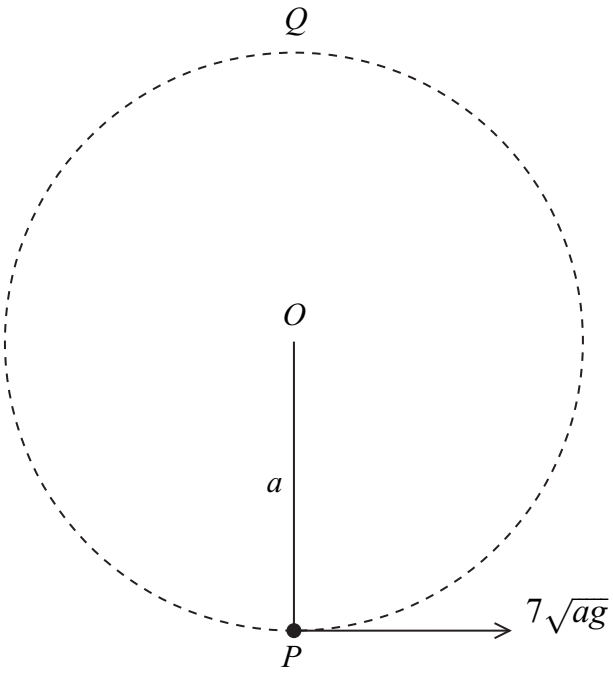
QUESTION PART REFERENCE

**Answer space for question 4**

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

**Answer space for question 5**

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

**Answer space for question 6**

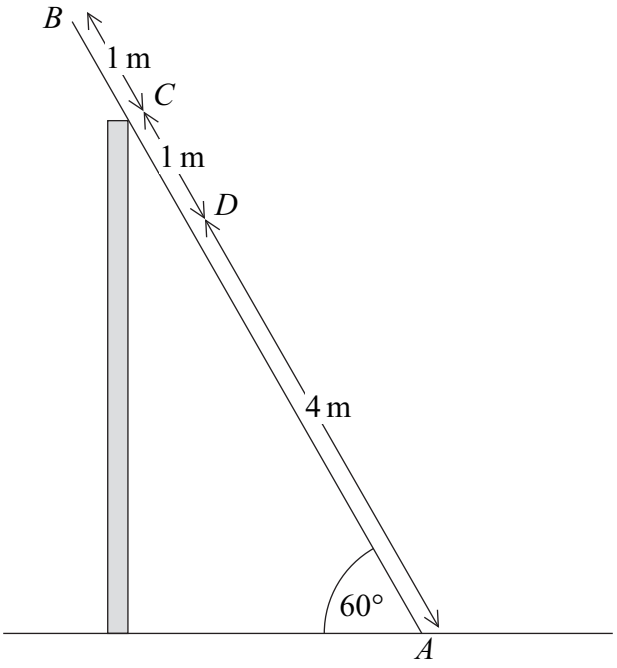
*QUESTION PART REFERENCE*

**Answer space for question 6**

**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]**

QUESTION PART REFERENCE

**Answer space for question 7**

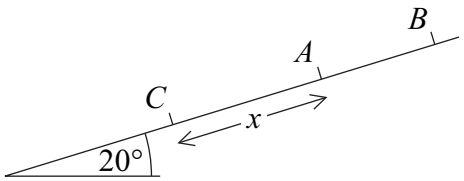
QUESTION PART REFERENCE

**Answer space for question 7**

**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

**Answer space for question 8**

QUESTION PART REFERENCE

**Answer space for question 8**

QUESTION PART REFERENCE

**Answer space for question 8**

QUESTION PART REFERENCE

**Answer space for question 8**

**END OF QUESTIONS**

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

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