Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
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TOTAL	

General Certificate of Education
Advanced Level Examination
June 2010

Mathematics MM2B

Unit Mechanics 2B

Friday 18 June 2010 1.30 pm to 3.00 pm

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 the questions in the spaces provided. 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.

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Answer **all** questions in the spaces provided.

1 A particle moves along a straight line through the origin. At time t, the displacement, s, of the particle from the origin is given by

$$s = 5t^2 + 3\cos 4t$$

Find the velocity of the particle at time t. *(3 marks)*

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2 John is at the top of a cliff, looking out over the sea. He throws a rock, of mass 3 kg, horizontally with a velocity of $4\,\mathrm{m\,s^{-1}}$.

The rock falls a vertical distance of 51 metres to reach the surface of the sea.

(a) Calculate the kinetic energy of the rock when it is thrown. *(2 marks)*

(b) Calculate the potential energy lost by the rock when it reaches the surface of the sea. *(2 marks)*

(c) (i) Find the kinetic energy of the rock when it reaches the surface of the sea.

(ii) Hence find the speed of the rock when it reaches the surface of the sea. *(4 marks)*

(d) State one modelling assumption which has been made. *(1 mark)*

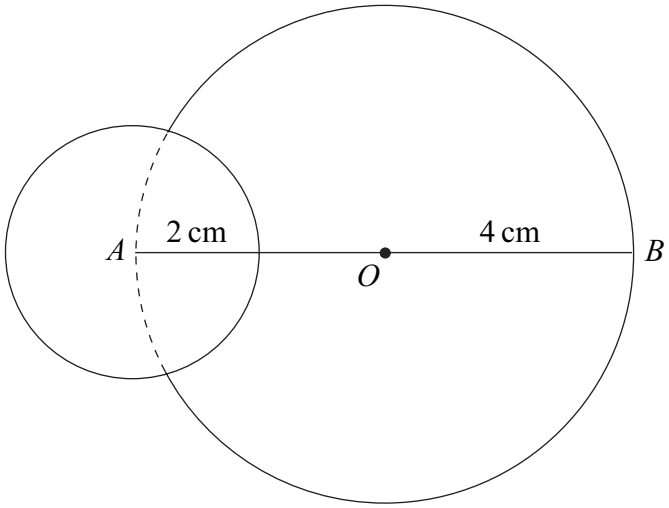
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3 A uniform circular lamina, of radius 4 cm and mass 0.4 kg, has a centre O, and AB is a diameter. To create a medal, a smaller uniform circular lamina, of radius 2 cm and mass 0.1 kg, is attached so that the centre of the smaller lamina is at the point A, as shown in the diagram.



(a) Explain why the centre of mass of the medal is on the line AB. *(1 mark)*

(b) Find the distance of the centre of mass of the medal from the point B. *(3 marks)*

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4 A particle has mass 200 kg and moves on a smooth horizontal plane. A single horizontal force, $\left(400\cos\left(\frac{\pi}{2}t\right)\mathbf{i} + 600t^2\,\mathbf{j}\right)$ newtons, acts on the particle at time t seconds.

The unit vectors **i** and **j** are directed east and north respectively.

(a) Find the acceleration of the particle at time t. *(2 marks)*

(b) When $t = 4$, the velocity of the particle is $(-3\mathbf{i} + 56\mathbf{j})\,\mathrm{m\,s^{-1}}$.

Find the velocity of the particle at time t. *(5 marks)*

(c) Find t when the particle is moving due west. *(3 marks)*

(d) Find the speed of the particle when it is moving due west. *(2 marks)*

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5 A particle is moving along a straight line. At time t, the velocity of the particle is v. The acceleration of the particle throughout the motion is $-\frac{\lambda}{v^{\frac{1}{4}}}$, where λ is a positive constant. The velocity of the particle is u when $t = 0$.

Find v in terms of u, λ and t. *(7 marks)*

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6 When a car, of mass 1200 kg, travels at a speed of $v\,\mathrm{m\,s^{-1}}$, it experiences a resistance force of magnitude $30v$ newtons.

The car has a maximum constant speed of $48\,\mathrm{m\,s^{-1}}$ on a straight horizontal road.

(a) Show that the maximum power of the car is 69 120 watts. *(2 marks)*

(b) The car is travelling along a straight horizontal road.

Find the maximum possible acceleration of the car when it is travelling at a speed of $40\,\mathrm{m\,s^{-1}}$. *(4 marks)*

(c) The car starts to descend a hill on a straight road which is inclined at an angle of 3° to the horizontal. Find the maximum possible constant speed of the car as it travels on this road down the hill. *(7 marks)*

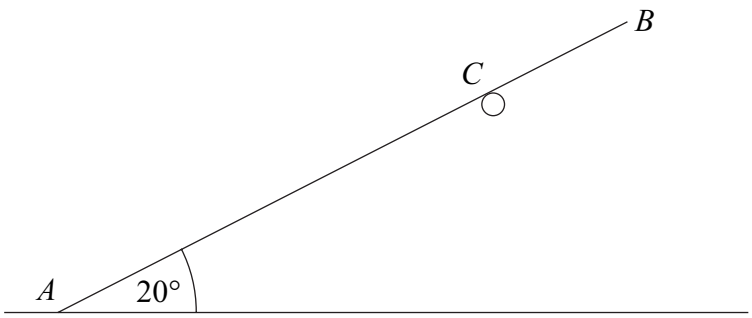
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7 A uniform rod AB, of length 4 m and mass 6 kg, rests in equilibrium with one end, A, on smooth horizontal ground. The rod rests on a rough horizontal peg at the point C, where AC is 3 m. The rod is inclined at an angle of 20° to the horizontal.



(a) Draw a diagram to show the forces acting on the rod. *(2 marks)*

(b) Find the magnitude of the normal reaction force between the rod and the ground. *(3 marks)*

(c) (i) Find the normal reaction acting on the rod at C.

(ii) Find the friction force acting on the rod at C. *(5 marks)*

(d) In this position, the rod is on the point of slipping.

Calculate the coefficient of friction between the rod and the peg. *(2 marks)*

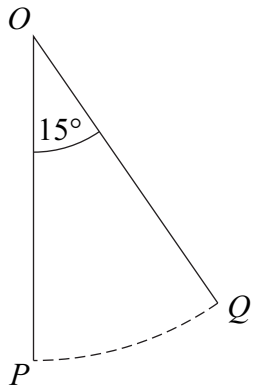
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8 A particle is attached to one end of a light inextensible string of length 3 metres. The other end of the string is attached to a fixed point O. The particle is set into motion horizontally at point P with speed v, so that it describes part of a vertical circle whose centre is O. The point P is vertically below O.



The particle first comes momentarily to rest at the point Q, where OQ makes an angle of 15° to the vertical.

(a) Find the value of v. *(4 marks)*

(b) When the particle is at rest at the point Q, the tension in the string is 22 newtons.

Find the mass of the particle. *(3 marks)*

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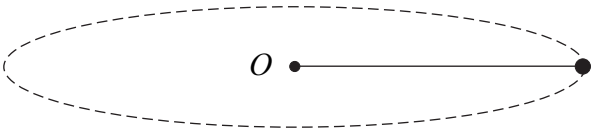
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9 A particle, of mass 8 kg, is attached to one end of a length of elastic string. The particle is placed on a smooth horizontal surface. The other end of the elastic string is attached to a point O fixed on the horizontal surface.

The elastic string has natural length 1.2 m and modulus of elasticity 192 N.



The particle is set in motion on the horizontal surface so that it moves in a circle, centre O, with constant speed $3\,\mathrm{m\,s^{-1}}$.

Find the radius of the circle. *(8 marks)*

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END OF QUESTIONS

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