Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
June 2013

Mathematics MM2B

Unit Mechanics 2B

Thursday 13 June 2013 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 A particle, of mass 3 kg, moves along a straight line. At time t seconds, the displacement, s metres, of the particle from the origin is given by

$$s = 8t^3 + 15$$

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

(b) Find the magnitude of the resultant force acting on the particle when $t = 2$. *(4 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 Carol, a circus performer, is on a swing. She jumps off the swing and lands in a safety net. When Carol leaves the swing, she has a speed of $7\,\mathrm{m\,s^{-1}}$ and she is at a height of 8 metres above the safety net.

Carol is to be modelled as a particle of mass 52 kg being acted upon only by gravity.

(a) Find the kinetic energy of Carol when she leaves the swing. *(2 marks)*

(b) Show that the kinetic energy of Carol when she hits the net is 5350 J, correct to three significant figures. *(3 marks)*

(c) Find the speed of Carol when she hits the net. *(3 marks)*

QUESTION PART REFERENCE

Answer space for question 2

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QUESTION PART REFERENCE

Answer space for question 2

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3 A particle, of mass 10 kg, moves on a smooth horizontal plane. At time t seconds, the acceleration of the particle is given by

$$\{(40t + 3t^2)\,\mathbf{i} + 20\mathrm{e}^{-4t}\,\mathbf{j}\}\ \mathrm{m\,s^{-2}}$$

where the vectors **i** and **j** are perpendicular unit vectors.

(a) At time $t = 1$, the velocity of the particle is $(6\mathbf{i} - 5\mathrm{e}^{-4}\mathbf{j})\ \mathrm{m\,s^{-1}}$.

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

(b) Calculate the initial speed of the particle. *(3 marks)*

QUESTION PART REFERENCE

Answer space for question 3



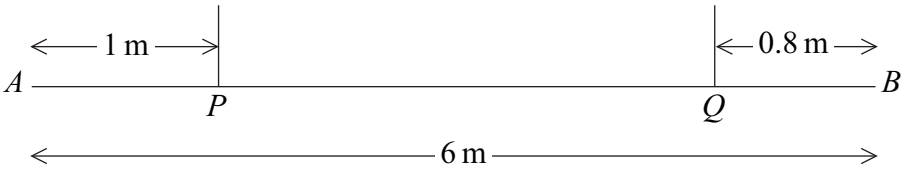
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QUESTION PART REFERENCE

Answer space for question 3

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4 A uniform plank AB, of length 6 m, has mass 25 kg. It is supported in equilibrium in a horizontal position by two vertical inextensible ropes. One of the ropes is attached to the plank at the point P and the other rope is attached to the plank at the point Q, where $AP = 1$ m and $QB = 0.8$ m, as shown in the diagram.



(a) (i) Find the tension in each rope. *(5 marks)*

(ii) State how you have used the fact that the plank is uniform in your solution. *(1 mark)*

(b) A particle of mass m kg is attached to the plank at point B, and the tension in each rope is now the same.

Find m. *(6 marks)*

QUESTION PART REFERENCE

Answer space for question 4

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QUESTION PART REFERENCE

Answer space for question 4

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5 Tom is travelling on a train which is moving at a constant speed of $15\,\text{m}\,\text{s}^{-1}$ on a horizontal track. Tom has placed his mobile phone on a rough horizontal table. The coefficient of friction between the phone and the table is 0.2.

The train moves round a bend of constant radius. The phone does not slide as the train travels round the bend.

Model the phone as a particle moving round part of a circle, with centre O and radius r metres.

Find the least possible value of r. *(4 marks)*

QUESTION PART REFERENCE

Answer space for question 5

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QUESTION PART REFERENCE

Answer space for question 5

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6 A car accelerates from rest along a straight horizontal road.

The car's engine produces a constant horizontal force of magnitude 4000 N.

At time t seconds, the speed of the car is $v\,\mathrm{m\,s^{-1}}$, and a resistance force of magnitude $40v$ newtons acts upon the car.

The mass of the car is 1600 kg.

(a) Show that $\dfrac{\mathrm{d}v}{\mathrm{d}t} = \dfrac{100 - v}{40}$. *(2 marks)*

(b) Find the velocity of the car at time t. *(6 marks)*

QUESTION PART REFERENCE

Answer space for question 6

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QUESTION PART REFERENCE

Answer space for question 6

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7 A train, of mass 22 tonnes, moves along a straight horizontal track. A constant resistance force of 5000 N acts on the train. The power output of the engine of the train is 240 kW.

Find the acceleration of the train when its speed is $20\,\mathrm{m\,s^{-1}}$. *(6 marks)*

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

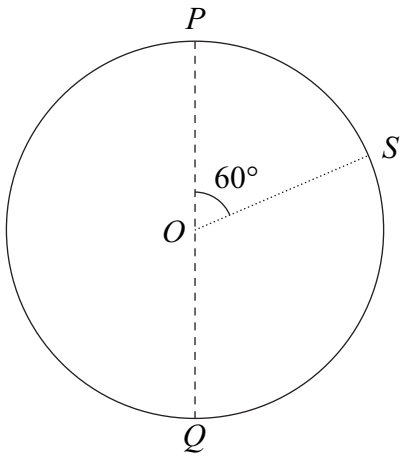
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8 A bead, of mass m, moves on a smooth circular ring, of radius a and centre O, which is fixed in a vertical plane. At P, the highest point on the ring, the speed of the bead is $2u$; at Q, the lowest point on the ring, the speed of the bead is $5u$.

(a) Show that $u = \sqrt{\frac{4ag}{21}}$. *(4 marks)*

(b) S is a point on the ring so that angle POS is 60°, as shown in the diagram.



Find, in terms of m and g, the magnitude of the reaction of the ring on the bead when the bead is at S. *(5 marks)*

QUESTION PART REFERENCE

Answer space for question 8

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QUESTION PART REFERENCE

Answer space for question 8

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9 Two particles, A and B, are connected by a light elastic string that passes through a hole at a point O in a rough horizontal table. The edges of the hole are smooth. Particle A has a mass of 8 kg and particle B has a mass of 3 kg.

The elastic string has natural length 3 metres and modulus of elasticity 60 newtons.

Initially, particle A is held 3.5 metres from the point O on the surface of the table and particle B is held at a point 2 metres vertically below O.

The coefficient of friction between the table and particle A is 0.4.

The two particles are released from rest.

(a) (i) Show that initially particle A moves towards the hole in the table. *(3 marks)*

(ii) Show that initially particle B also moves towards the hole in the table. *(2 marks)*

(b) Calculate the **initial** elastic potential energy in the string. *(2 marks)*

(c) Particle A comes permanently to rest when it has moved 0.46 metres, at which time particle B is still moving upwards.

Calculate the distance that particle B has moved when it is at rest for the first time. *(7 marks)*

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

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Answer space for question 9

END OF QUESTIONS

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