

Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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9	
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 $g = 9.8 \text{ m s}^{-2}$, 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 3 M M 2 B 0 1

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)*

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QUESTION
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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 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)*

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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

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

where the vectors \mathbf{i} and \mathbf{j} are perpendicular unit vectors.

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

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

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

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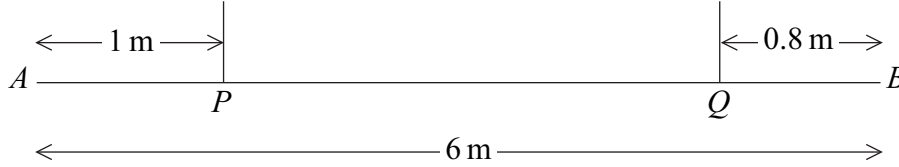
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4

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)

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5

Tom is travelling on a train which is moving at a constant speed of 15 m 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)

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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 $v \text{ m s}^{-1}$, and a resistance force of magnitude $40v$ newtons acts upon the car.

The mass of the car is 1600 kg.

(a) Show that $\frac{dv}{dt} = \frac{100 - v}{40}$. (2 marks)

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

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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 m s^{-1} . (6 marks)

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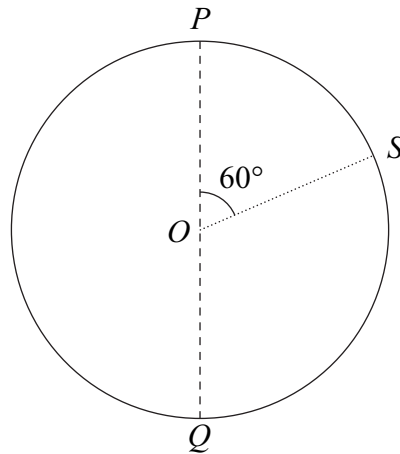
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- 8** A bead, of mass m , moves on a smooth circular ring, of radius a and centre O , which is fixed in a vertical plane. At P , the highest point on the ring, the speed of the bead is $2u$; at Q , the lowest point on the ring, the speed of the bead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

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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)*

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END OF QUESTIONS

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