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Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

A-level MATHEMATICS

Unit Mechanics 2B

Monday 25 June 2018

Morning

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

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.

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

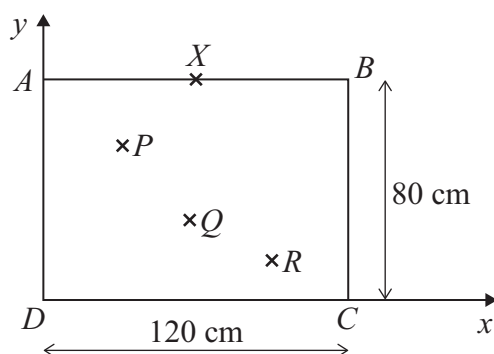


Answer **all** questions.

Answer each question in the space provided for that question.

- 1 A uniform rectangular lamina $ABCD$ has mass 7 kg. It has one side AB of length 120 cm and another side BC of length 80 cm and is used as a display board for a small zoo.

Three small animal shapes are positioned on the lamina at the points P , Q and R as shown in the diagram.



Not drawn to scale

Coordinate axes are drawn as shown with the origin at the point D . The three animal shapes are to be treated as particles at the points as below.

Lion of mass 6 kg at the point P , which has coordinates $(20, 60)$.

Giraffe of mass 3 kg at the point Q , which has coordinates $(60, 30)$.

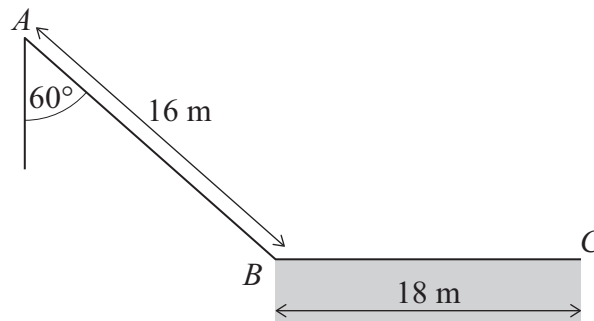
Crocodile of mass 4 kg at the point R , which has coordinates $(80, 20)$.

- (a) Find the distance of the centre of mass of the display board with the animals attached
- from the line AD . **[3 marks]**
 - from the line DC . **[2 marks]**
- (b) The display board is suspended by a rope from a point X which is the midpoint of AB . It is required that in equilibrium the display board will hang so that AB is horizontal. To ensure this, a zebra will be fixed to a point on BC . Find the mass of the zebra. **[4 marks]**



2

A slide in a water park may be modelled as a smooth slope, AB , of length 16 metres inclined at an angle of 60° to the vertical. At the bottom of the slope there is a rough horizontal surface, BC , of length 18 metres.



Jay, a child of mass 21 kg, slides down the slope and then along the horizontal surface. At A his velocity is 2 m s^{-1} and the coefficient of friction between Jay and the rough horizontal surface BC is μ .

Assume that no energy is lost at B and that air resistance is to be ignored.

- (a) Calculate the kinetic energy of Jay at A . [2 marks]
- (b) By using conservation of energy:
- (i) find the kinetic energy of Jay when he reaches B ; [3 marks]
- (ii) find the speed of Jay when he reaches B . [2 marks]
- (c) Jay comes to rest when he reaches C .
Find μ . [3 marks]

QUESTION
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REFERENCE

Answer space for question 2



3 A particle, of mass 2 kg, moves in a horizontal plane under the action of a resultant force, \mathbf{F} newtons.

The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. At time t seconds, the velocity of the particle, $\mathbf{v} \text{ m s}^{-1}$, is given by

$$\mathbf{v} = (12t - t^3)\mathbf{i} - 6e^{-2t}\mathbf{j} \quad (t \geq 0)$$

(a) Find an expression for the acceleration of the particle at time t .

[2 marks]

(b) (i) Find an expression for \mathbf{F} at time t .

[2 marks]

(ii) Find the magnitude of \mathbf{F} when $t = 0$.

[2 marks]

(c) Find the value of t when \mathbf{F} acts due north.

[2 marks]

(d) When $t = 0$, the particle is at the point with position vector $4\mathbf{i} - 2\mathbf{j}$

Find the position vector, \mathbf{r} metres, of the particle at time t .

[5 marks]

QUESTION
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Answer space for question 3



QUESTION
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REFERENCE

Answer space for question 3

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Turn over ►



4 A car, of mass 900 kg, travels around a roundabout on a horizontal, circular path at a constant speed of 12 m s^{-1} . The radius of its circular path is 80 metres. Assume that there is no resistance to the motion of the car and that the car can be modelled as a particle.

(a) A frictional force, directed towards the centre of the car's circular path, acts on the car as it moves. Show that the magnitude of this frictional force is 1620 N. **[2 marks]**

(b) The coefficient of friction between the car and the road is μ .
Find the least possible value of μ . **[2 marks]**

QUESTION
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Answer space for question 4



5 A car has a maximum power of 32 kilowatts.

When the car is moving at a speed of $v \text{ m s}^{-1}$, a total resistance force of magnitude kv newtons acts on the car where k is a constant.

- (a) When the car is moving along a straight horizontal road, the maximum speed of the car is 40 m s^{-1} .

Show that $k = 20$

[2 marks]

- (b) When the car is travelling at 18 m s^{-1} the car starts to travel down a slope which is inclined at an angle θ to the horizontal, where $\sin \theta = 0.1$

The power exerted by the car's engine is reduced to zero. After the power exerted by the car has been reduced to zero for t seconds, its speed is $v \text{ m s}^{-1}$.

The mass of the car is 600 kg.

- (i) Show that $\frac{dv}{dt} = \frac{3g - v}{30}$

[3 marks]

- (ii) Find t in terms of v and g .

[5 marks]

- (iii) Hence find the time for the speed of the car to increase from 18 m s^{-1} to 22 m s^{-1} .

Give your answer to 3 significant figures.

[3 marks]

QUESTION
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Answer space for question 5

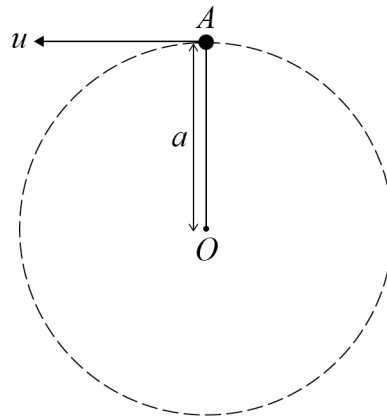


- 6** A small bead, of mass m , is attached by a light inextensible string, of length a , to a fixed point O .

The string is taut and the bead is held at a point A , where A is vertically above O .

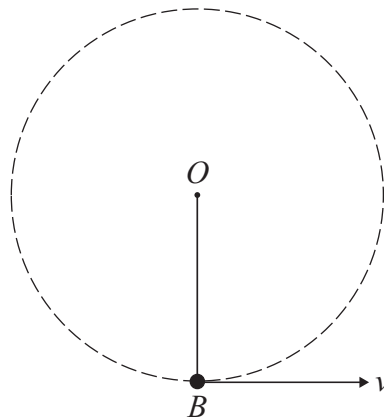
The bead is set into vertical circular motion with an initial horizontal velocity, u , as shown in **Figure 1**. The string does not become slack in the subsequent motion.

Figure 1



The speed of the bead at the point B where B is vertically below O is v , as shown in **Figure 2**.

Figure 2



The ratio of the tensions in the string when the bead is at the two points A and B is $5 : 7$.

- (a) Find u in terms of a and g .

[6 marks]

- (b) Find the ratio $u : v$

[2 marks]



QUESTION
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2 3

7 A particle, P , of mass 8 kg is resting on a rough horizontal plane.

The particle is attached to one end of a light elastic string AP of natural length 2 metres and modulus of elasticity 160 N . It is also attached to another light elastic string BP of natural length 3 metres and modulus of elasticity 240 N . The points A and B are fixed on the horizontal plane 7 metres apart.

- (a)** The particle is held at the point C where the length of AC is 2 metres and the length of BC is 5 metres . The points A , B and C are in a straight line.

Show that the total elastic energy of the two strings when the particle is in this position is 160 J .

[2 marks]

- (b)** The particle is released from rest at point C . The coefficient of friction between the particle and the rough plane is μ . In the subsequent motion, and before the particle first comes to rest, the particle has speed $v\text{ m s}^{-1}$ when it is $x\text{ metres}$ from C .

Find v in terms of x , μ and g .

[5 marks]

- (c)** Find the value of x , in terms of μ and g , when the speed of the particle is a maximum.

[2 marks]

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Answer space for question 7



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Answer space for question 8

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