

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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6	
7	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2013

Mathematics

MM04

Unit Mechanics 4

Friday 21 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.

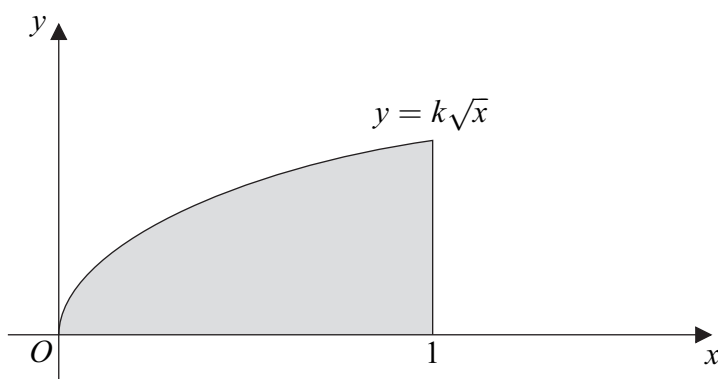


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Answer **all** questions.

Answer each question in the space provided for that question.

- 1** A uniform lamina is bounded by the positive x -axis, the line $x = 1$ and the curve with equation $y = k\sqrt{x}$, where $k > 0$. The lamina is shown in the diagram.



The area of the lamina is A square units.

- (a) Show that the x -coordinate of the centre of mass of the lamina is $\frac{2k}{5A}$. (3 marks)
- (b) Find, in terms of k and A , the y -coordinate of the centre of mass of the lamina. (3 marks)
- (c) Given that the centre of mass of the lamina lies on the line $y = x$, find the value of k . (2 marks)

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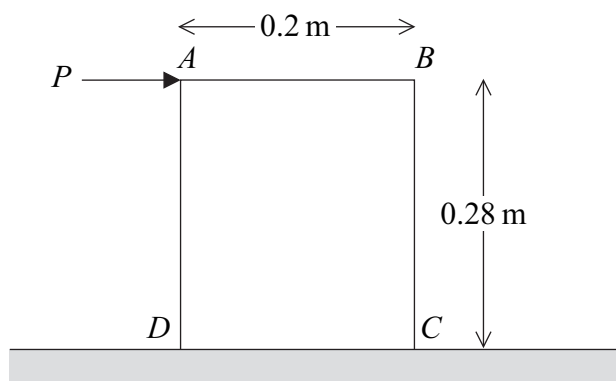
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- 3** A box of breakfast cereal, of total mass 0.4 kg , rests on a rough horizontal plane. It can be assumed that the centre of the mass of the box with its contents is on a vertical line through the centre of the box. The diagram shows a vertical cross section $ABCD$ through the centre of mass of the box and its contents, where $AB = 0.2 \text{ m}$ and $BC = 0.28 \text{ m}$. A horizontal force of magnitude P is applied at A , in the direction of AB .



The coefficient of friction between the box and the plane is μ . As P is gradually increased from zero, the box slides before it topples if, and only if, $\mu < k$. Find the value of k . (6 marks)

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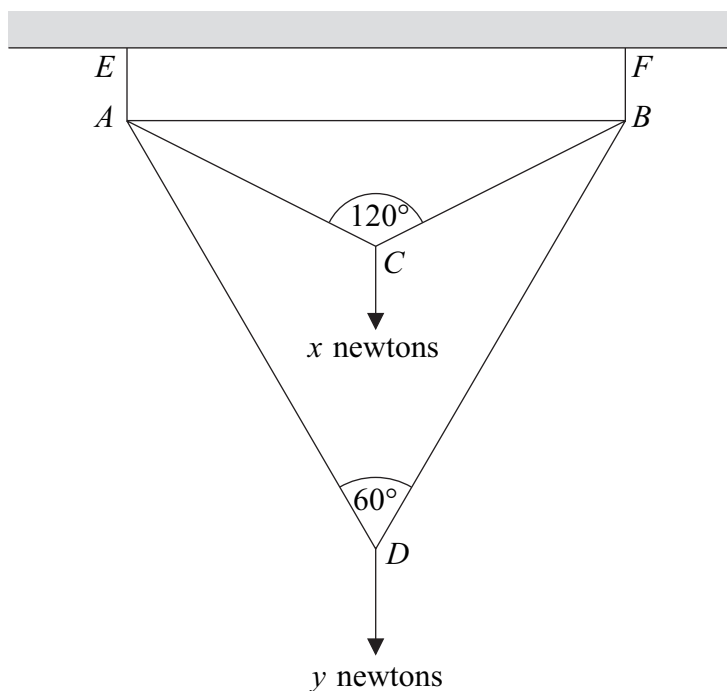
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- 4 A framework $ABCD$ consists of five light rods AB , AC , BC , AD and BD , which are smoothly jointed at A , B , C and D . The angle ACB is 120° and the angle ADB is 60° .

The framework is suspended from the fixed points E and F by strings EA and FB respectively. The rod AB is horizontal and D is vertically below C . The framework has a line of symmetry through C and D .

A force of x newtons is applied vertically downwards at C and a force of y newtons is applied vertically downwards at D . The system is in equilibrium.



The forces in the rods AC , AD , BC and BD are equal in magnitude.

- (a) Show that $x : y = 1 : \sqrt{3}$. (4 marks)
- (b) The tensions in the strings EA and FB are both 100 N.
- (i) Find the magnitude of the force in rod AC . (3 marks)
- (ii) Find the magnitude of the force in rod AB , stating whether the rod is in tension or compression. (3 marks)



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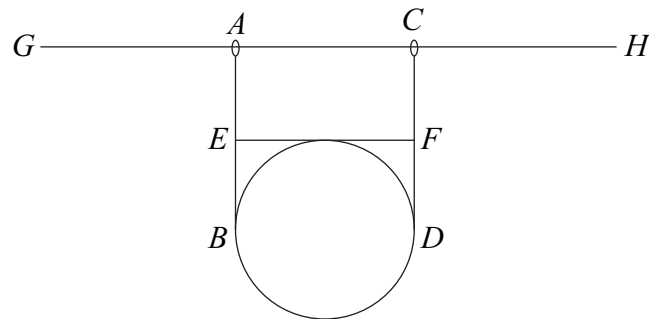
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- 5 (a)** A uniform circular disc has mass $20m$ and radius a .
- (i) Prove, by integration, that the moment of inertia of the disc about an axis through its centre and perpendicular to the plane of the disc is $10ma^2$. (5 marks)
- (ii) Hence determine the moment of inertia of the disc about a diameter, stating clearly any theorems that you use. (3 marks)
- (b)** A shop sign consists of a uniform circular disc of mass $20m$ and radius a , which is rigidly fixed to three rods AB , CD and EF . Each rod is of mass $2m$ and length $2a$. The rods are attached so that BD is a diameter of the disc; EF is a tangent to the disc, with A vertically above E and C vertically above F . The sign is suspended on a fixed horizontal pole GH by means of two small light rings which are attached to the sign at A and C , as shown in the diagram.



The sign can swing freely about the pole GH .

Find, in terms of m and a , the moment of inertia of the sign about GH . (6 marks)

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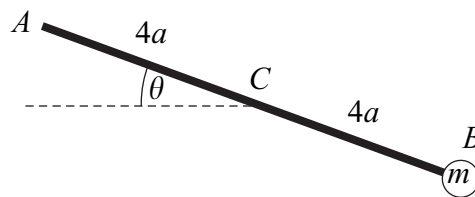
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- 7 A system consists of a uniform rod AB , of mass $3m$ and length $8a$, and a particle of mass m attached to the end B . The system can rotate freely about a fixed horizontal axis perpendicular to the rod AB . The axis passes through the point C , the mid-point of AB . The centre of mass of the system is G .
- (a) Show that $CG = a$. (2 marks)
- (b) Show that the moment of inertia of the system about the axis through C is $32ma^2$. (3 marks)
- (c) The system is held at rest in a horizontal position, as shown in **Figure 1**.

Figure 1

The system is released from rest and begins to rotate. At time t , the system has turned through an angle θ , as shown in **Figure 2**.

Figure 2

- (i) Show that the angular speed of the system at time t is

$$\sqrt{\frac{g \sin \theta}{4a}} \quad (4 \text{ marks})$$

- (ii) Find an expression, in terms of a , g and θ , for the angular acceleration of the system. (2 marks)
- (iii) The component of the reaction force perpendicular to the rod at C is Y .

The component of the reaction force parallel to the rod at C is X .

Find X and Y in terms of m , g and θ . (6 marks)



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