

**ADVANCED GCE  
MATHEMATICS**

Mechanics 2

**4729**

**QUESTION PAPER**

Candidates answer on the printed answer book.

**OCR supplied materials:**

- Printed answer book 4729
- List of Formulae (MF1)

**Other materials required:**

- Scientific or graphical calculator

**Monday 10 January 2011  
Morning**

**Duration:** 1 hour 30 minutes

**INSTRUCTIONS TO CANDIDATES**

These instructions are the same on the printed answer book and the question paper.

- The question paper will be found in the centre of the printed answer book.
- Write your name, centre number and candidate number in the spaces provided on the printed answer book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the printed answer book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by  $g \text{ m s}^{-2}$ . Unless otherwise instructed, when a numerical value is needed, use  $g = 9.8$ .

**INFORMATION FOR CANDIDATES**

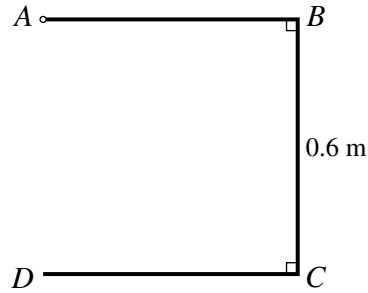
This information is the same on the printed answer book and the question paper.

- The number of marks is given in brackets [ ] at the end of each question or part question on the question paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The printed answer book consists of **12** pages. The question paper consists of **4** pages. Any blank pages are indicated.

**INSTRUCTION TO EXAMS OFFICER / INVIGILATOR**

- Do not send this question paper for marking; it should be retained in the centre or destroyed.

1



A uniform square frame  $ABCD$  has sides of length  $0.6\text{ m}$ . The side  $AD$  is removed from the frame, and the open frame  $ABCD$  is attached at  $A$  to a fixed point (see diagram).

- (i) Calculate the distance of the centre of mass of the open frame from  $A$ . [5]

The open frame rotates about  $A$  in the plane  $ABCD$  with angular speed  $3\text{ rad s}^{-1}$ .

- (ii) Calculate the speed of the centre of mass of the open frame. [2]

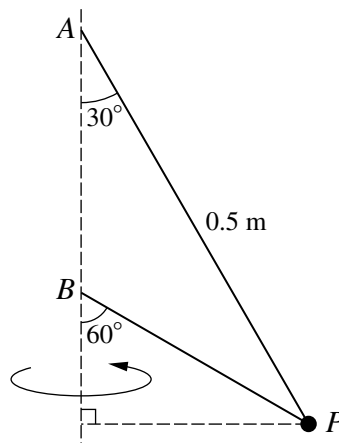
- 2 The resistance to the motion of a car is  $kv^{\frac{3}{2}}\text{ N}$ , where  $v\text{ m s}^{-1}$  is the car's speed and  $k$  is a constant. The power exerted by the car's engine is  $15\,000\text{ W}$ , and the car has constant speed  $25\text{ m s}^{-1}$  along a horizontal road.

- (i) Show that  $k = 4.8$ . [3]

With the engine operating at a much lower power, the car descends a hill of inclination  $\alpha$ , where  $\sin \alpha = \frac{1}{15}$ . At an instant when the speed of the car is  $16\text{ m s}^{-1}$ , its acceleration is  $0.3\text{ m s}^{-2}$ .

- (ii) Given that the mass of the car is  $700\text{ kg}$ , calculate the power of the engine. [5]

3



A particle  $P$  of mass  $0.4\text{ kg}$  is attached to one end of each of two light inextensible strings which are both taut. The other end of the longer string is attached to a fixed point  $A$ , and the other end of the shorter string is attached to a fixed point  $B$ , which is vertically below  $A$ . The string  $AP$  makes an angle of  $30^\circ$  with the vertical and is  $0.5\text{ m}$  long. The string  $BP$  makes an angle of  $60^\circ$  with the vertical.  $P$  moves with constant angular speed in a horizontal circle with centre vertically below  $B$  (see diagram). The tension in the string  $AP$  is twice the tension in the string  $BP$ . Calculate

- (i) the tension in each string, [4]

- (ii) the angular speed of  $P$ . [4]

4 A block of mass 25 kg is dragged 30 m up a slope inclined at  $5^\circ$  to the horizontal by a rope inclined at  $20^\circ$  to the slope. The tension in the rope is 100 N and the resistance to the motion of the block is 70 N. The block is initially at rest. Calculate

(i) the work done by the tension in the rope, [2]

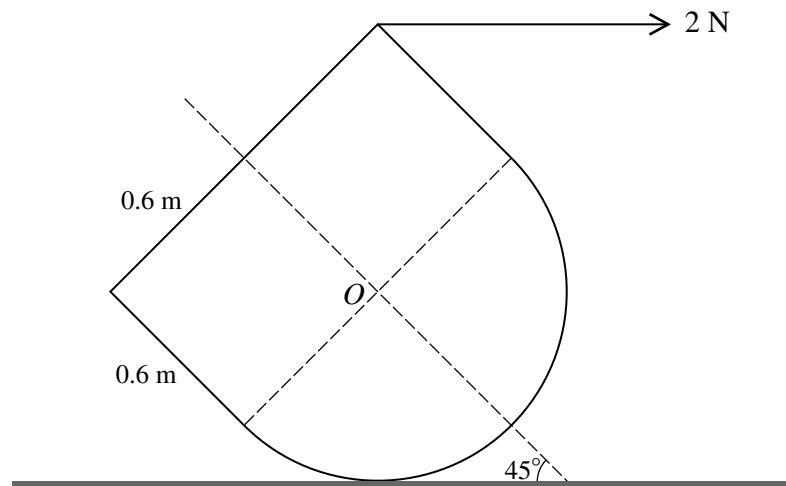
(ii) the change in the potential energy of the block, [2]

(iii) the speed of the block after it has moved 30 m up the slope. [4]

5 A uniform solid is made of a hemisphere with centre  $O$  and radius 0.6 m, and a cylinder of radius 0.6 m and height 0.6 m. The plane face of the hemisphere and a plane face of the cylinder coincide. (The formula for the volume of a sphere is  $\frac{4}{3}\pi r^3$ .)

(i) Show that the distance of the centre of mass of the solid from  $O$  is 0.09 m. [5]

(ii)



The solid is placed with the curved surface of the hemisphere on a rough horizontal surface and the axis inclined at  $45^\circ$  to the horizontal. The equilibrium of the solid is maintained by a horizontal force of 2 N applied to the highest point on the circumference of its plane face (see diagram). Calculate

(a) the mass of the solid, [4]

(b) the set of possible values of the coefficient of friction between the surface and the solid. [3]

[Questions 6 and 7 are printed overleaf.]

- 6 A small ball  $B$  is projected with speed  $14 \text{ m s}^{-1}$  at an angle of elevation  $30^\circ$  from a point  $O$  on a horizontal plane, and moves freely under gravity.

(i) Calculate the height of  $B$  above the plane when moving horizontally. [2]

$B$  has mass  $0.4 \text{ kg}$ . At the instant when  $B$  is moving horizontally it receives an impulse of magnitude  $I \text{ N s}$  in its direction of motion which immediately increases the speed of  $B$  to  $15 \text{ m s}^{-1}$ .

(ii) Calculate  $I$ . [3]

For the instant when  $B$  returns to the plane, calculate

(iii) the speed and direction of motion of  $B$ , [4]

(iv) the time of flight, and the distance of  $B$  from  $O$ . [5]

- 7 Three small smooth spheres  $A$ ,  $B$  and  $C$  of masses  $0.2 \text{ kg}$ ,  $0.7 \text{ kg}$  and  $m \text{ kg}$  respectively are free to move in a straight line on a smooth horizontal table. Initially  $B$  and  $C$  are stationary and  $A$  is moving with velocity  $1.8 \text{ m s}^{-1}$  directly towards  $B$ . The coefficient of restitution for the collision between  $A$  and  $B$  is  $e$ . Immediately after this collision the speed of  $A$  is greater than the speed of  $B$ .

(i) Calculate the set of possible values of  $e$ . [9]

It is now given that the speed of  $B$  immediately after the collision with  $A$  is  $0.75 \text{ m s}^{-1}$ .  $B$  continues its motion and strikes  $C$  directly in a perfectly elastic collision.  $B$  has speed  $0.25 \text{ m s}^{-1}$  immediately after its collision with  $C$ .

(ii) Calculate the two possible values of  $m$ . [6]

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Candidate forename		Candidate surname	
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Centre number						Candidate number				
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<b>1 (i)</b>	
<b>1 (ii)</b>	

<b>2 (i)</b>	

<b>2 (ii)</b>	

<b>3 (i)</b>	
<b>3 (ii)</b>	



<b>4 (i)</b>	
<b>4 (ii)</b>	
<b>4 (iii)</b>	

<b>5 (i)</b>	
<b>5 (ii) (a)</b>	

<b>5 (ii) (a)</b>	<b>(continued)</b>
<b>5 (ii) (b)</b>	

<b>6 (i)</b>	
<b>6 (ii)</b>	
<b>6 (iii)</b>	

<b>6 (iii)</b>	<b>(continued)</b>
<b>6 (iv)</b>	



<b>7 (i)</b>	<b>(continued)</b>
<b>7 (ii)</b>	

<b>7 (ii)</b>	<b>(continued)</b>



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