

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



General Certificate of Education  
Advanced Level Examination  
June 2014

# Mathematics

# MM03

## Unit Mechanics 3

Friday 6 June 2014 1.30 pm to 3.00 pm

**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 4 M M 0 3 0 1

Answer **all** questions.

Answer each question in the space provided for that question.

- 1** A tennis ball is projected from a point  $O$  with a velocity of  $(4\sqrt{3}\mathbf{i} + 4\mathbf{j}) \text{ m s}^{-1}$ , where  $\mathbf{i}$  and  $\mathbf{j}$  are horizontal and vertical unit vectors respectively. The ball travels in a vertical plane through  $O$  which is 30 cm above the horizontal surface of a tennis court. During its flight, the horizontal and upward vertical distances of the ball from  $O$  are  $x$  metres and  $y$  metres respectively.

Model the ball as a particle.

- (a)** Show that, during the flight, the equation of the trajectory of the ball is given by

$$y = \frac{x}{\sqrt{3}} - \frac{49x^2}{480}$$

**[4 marks]**

- (b)** The ball hits a vertical net at a point  $A$ . The net is at a horizontal distance of 4 m from  $O$ .

Determine the height of the point  $A$ , above the surface of the tennis court. Give your answer to the nearest centimetre.

**[2 marks]**

- (c)** State a modelling assumption, other than the ball being a particle, that you need to make to answer this question.

**[1 mark]**

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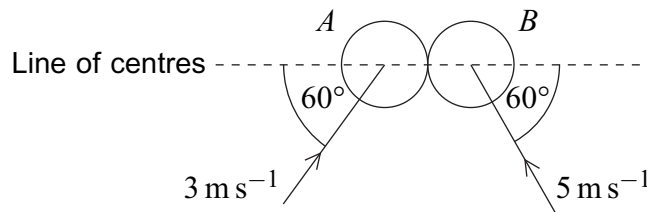
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- 6** Two smooth spheres,  $A$  and  $B$ , have equal radii and masses  $2\text{ kg}$  and  $4\text{ kg}$  respectively.

The spheres are moving on a smooth horizontal surface and collide. As they collide,  $A$  has velocity  $3\text{ m s}^{-1}$  at an angle of  $60^\circ$  to the line of centres of the spheres, and  $B$  has velocity  $5\text{ m s}^{-1}$  at an angle of  $60^\circ$  to the line of centres, as shown in the diagram.



Just after the collision,  $B$  moves in a direction perpendicular to the line of centres.

- (a) Find the speed of  $A$  immediately after the collision. **[6 marks]**
- (b) Find the acute angle, correct to the nearest degree, between the velocity of  $A$  and the line of centres immediately after the collision. **[2 marks]**
- (c) Find the coefficient of restitution between the spheres. **[2 marks]**
- (d) Find the magnitude of the impulse exerted on  $B$  during the collision. **[2 marks]**

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- 7 Two small smooth spheres,  $A$  and  $B$ , are the same size and have masses  $2m$  and  $m$  respectively. Initially, the spheres are at rest on a smooth horizontal surface. The sphere  $A$  receives an impulse of magnitude  $J$  and moves with speed  $2u$  directly towards  $B$ .

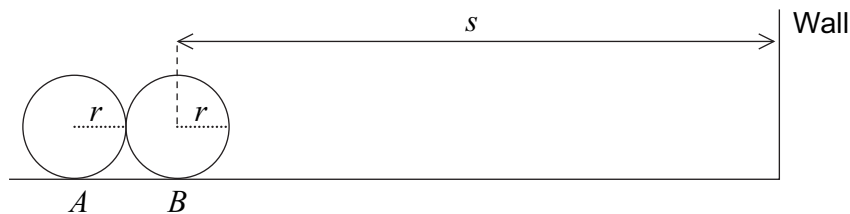
(a) Find  $J$  in terms of  $m$  and  $u$ .

[2 marks]

(b) The sphere  $A$  collides directly with  $B$ . The coefficient of restitution between  $A$  and  $B$  is  $\frac{2}{3}$ . Find, in terms of  $u$ , the speeds of  $A$  and  $B$  immediately after the collision.

[5 marks]

(c) At the instant of collision, the centre of  $B$  is at a distance  $s$  from a fixed smooth vertical wall which is at right angles to the direction of motion of  $A$  and  $B$ , as shown in the diagram.

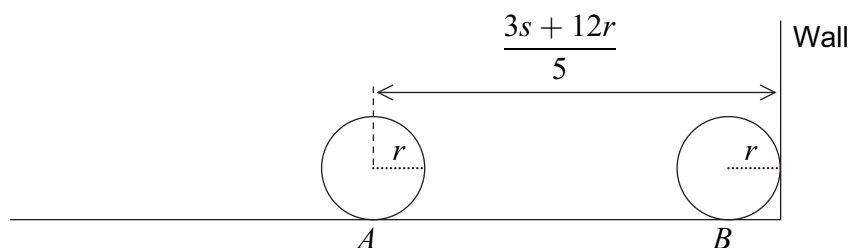


Subsequently,  $B$  collides with the wall. The radius of each sphere is  $r$ .

Show that the distance of the centre of  $A$  from the wall at the instant that  $B$  hits the wall is  $\frac{3s + 12r}{5}$ .

[4 marks]

(d) The diagram below shows the positions of  $A$  and  $B$  when  $B$  hits the wall.



The sphere  $B$  collides with  $A$  again after rebounding from the wall. The coefficient of restitution between  $B$  and the wall is  $\frac{2}{5}$ .

Find the distance of the **centre of  $B$**  from the wall at the instant when  $A$  and  $B$  collide again.

[4 marks]



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**END OF QUESTIONS**



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