

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Level Examination
June 2011

Mathematics

MM03

Unit Mechanics 3

Wednesday 22 June 2011 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 the questions in the spaces provided. 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.

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



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Answer **all** questions in the spaces provided.

- 1** A ball of mass 0.2 kg is hit directly by a bat. Just before the impact, the ball is travelling horizontally with speed 18 m s^{-1} . Just after the impact, the ball is travelling horizontally with speed 32 m s^{-1} in the opposite direction.
- (a)** Find the magnitude of the impulse exerted on the ball. (2 marks)
- (b)** At time t seconds after the ball first comes into contact with the bat, the force exerted by the bat on the ball is $k(0.9t - 10t^2)$ newtons, where k is a constant and $0 \leq t \leq 0.09$. The bat stays in contact with the ball for 0.09 seconds.
- Find the value of k . (4 marks)

QUESTION
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The time, t , for a single vibration of a piece of taut string is believed to depend on

such that

$$t = kl^\alpha F^\beta q^\gamma$$

where α , β and γ are constants.

By using dimensional analysis, find the values of α , β and γ . (5 marks)

QUESTION	PART	REFERENCE
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3 (In this question, use $g = 10 \text{ m s}^{-2}$.)

A golf ball is hit from a point O on a horizontal golf course with a velocity of 40 m s^{-1} at an angle of elevation θ . The golf ball travels in a vertical plane through O . During its flight, the horizontal and upward vertical distances of the golf ball from O are x and y metres respectively.

(a) Show that the equation of the trajectory of the golf ball during its flight is given by

$$x^2 \tan^2 \theta - 320x \tan \theta + (x^2 + 320y) = 0 \quad (6 \text{ marks})$$

(b) (i) The golf ball hits the top of a tree, which has a vertical height of 8 m and is at a horizontal distance of 150 m from O .

Find the two possible values of θ . (5 marks)

(ii) Which value of θ gives the shortest possible time for the golf ball to travel from O to the top of the tree? Give a reason for your choice of θ . (2 marks)

QUESTION	PART	REFERENCE
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QUESTION	PART	REFERENCE
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A helicopter, A , is travelling in the direction of the vector $-2\mathbf{i} + 3\mathbf{j} + 6\mathbf{k}$ with constant speed 140 km h^{-1} . Another helicopter, B , is travelling in the direction of the vector $2\mathbf{i} - \mathbf{j} + 2\mathbf{k}$ with constant speed 60 km h^{-1} .

- Write down the position vector of A relative to B , t hours after they leave their initial positions. (2 marks)

- (c)** Find the distance between A and B when they are closest together. (8 marks)

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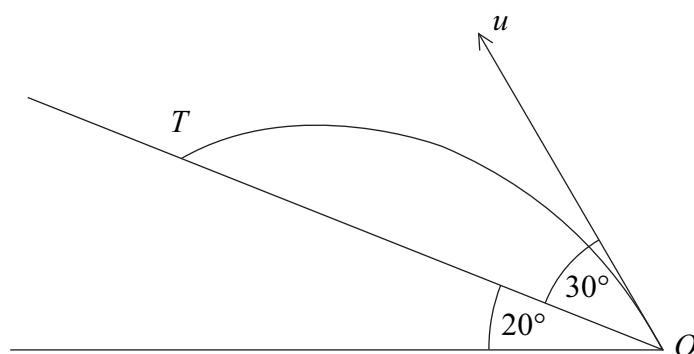
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6

A projectile is fired from a point O on a plane which is inclined at an angle of 20° to the horizontal. The projectile is fired up the plane with velocity $u \text{ m s}^{-1}$ at an angle of 30° to the inclined plane. The projectile travels in a vertical plane containing a line of greatest slope of the inclined plane.

The projectile hits a target T on the inclined plane.



- (a)** Given that $OT = 200$ m, determine the value of u . (7 marks)
- (b)** Find the greatest perpendicular distance of the projectile from the inclined plane. (4 marks)

QUESTION	PART	REFERENCE
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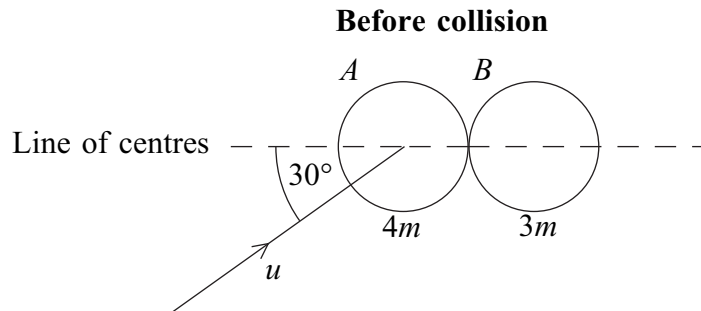
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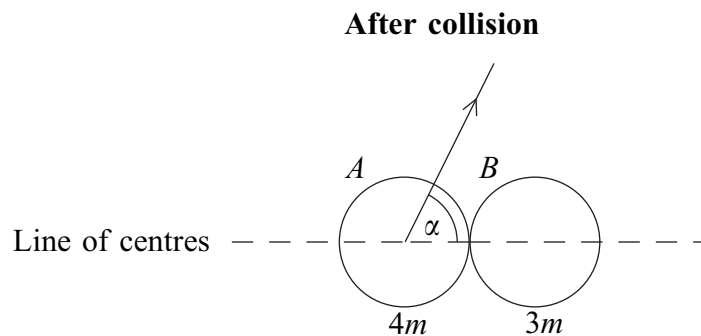
7

Two smooth spheres, A and B , have equal radii and masses $4m$ and $3m$ respectively. The sphere A is moving on a smooth horizontal surface and collides with the sphere B , which is stationary on the same surface.

Just before the collision, A is moving with speed u at an angle of 30° to the line of centres, as shown in the diagram below.



Immediately after the collision, the direction of motion of A makes an angle α with the line of centres, as shown in the diagram below.



The coefficient of restitution between the spheres is $\frac{5}{9}$.

- (a) Find the value of α . (10 marks)
- (b) Find, in terms of m and u , the magnitude of the impulse exerted on B during the collision. (3 marks)

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QUESTION
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END OF QUESTIONS



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ANSWER IN THE SPACES PROVIDED**

