



ADVANCED GCE UNIT
MATHEMATICS

Mechanics 3

MONDAY 21 MAY 2007

4730/01

Morning

Time: 1 hour 30 minutes

Additional Materials: Answer Booklet (8 pages)
List of Formulae (MF1)

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- 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 $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is 72.

ADVICE TO CANDIDATES

- Read each question carefully and make sure you know what you have to do before starting your answer.
- **You are reminded of the need for clear presentation in your answers.**

This document consists of **4** printed pages.

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1 A particle P is moving with simple harmonic motion in a straight line. The period is 6.1 s and the amplitude is 3 m. Calculate, in either order,

(i) the maximum speed of P , [3]

(ii) the distance of P from the centre of motion when P has speed 2.5 m s^{-1} . [3]

2 A tennis ball of mass 0.057 kg has speed 10 m s^{-1} . The ball receives an impulse of magnitude 0.6 N s which reduces the speed of the ball to 7 m s^{-1} . Using an impulse-momentum triangle, or otherwise, find the angle the impulse makes with the original direction of motion of the ball. [7]

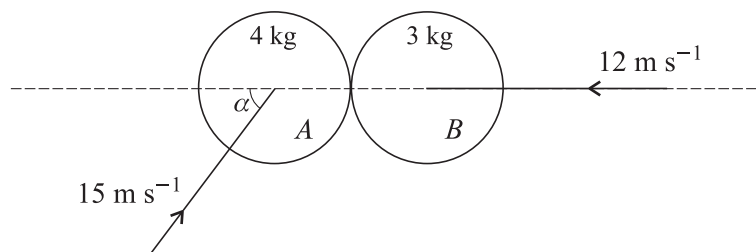
3 A particle P of mass 0.2 kg is projected horizontally with speed $u \text{ m s}^{-1}$ from a fixed point O on a smooth horizontal surface. P moves in a straight line and, at time $t \text{ s}$ after projection, P has speed $v \text{ m s}^{-1}$ and is $x \text{ m}$ from O . The only force acting on P has magnitude $0.4v^2 \text{ N}$ and is directed towards O .

(i) Show that $\frac{1}{v} \frac{dv}{dx} = -2$. [2]

(ii) Hence show that $v = ue^{-2x}$. [4]

(iii) Find u , given that $x = 2$ when $t = 4$. [4]

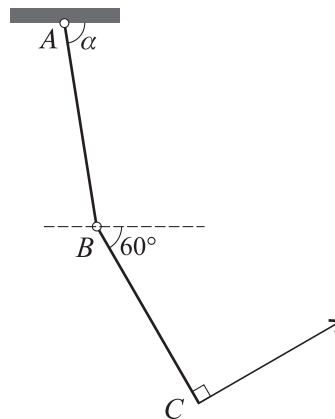
4



Two uniform smooth spheres A and B , of equal radius, have masses 4 kg and 3 kg respectively. They are moving on a horizontal surface, and they collide. Immediately before the collision, A is moving with speed 15 m s^{-1} at an angle α to the line of centres, where $\sin \alpha = 0.8$, and B is moving along the line of centres with speed 12 m s^{-1} (see diagram). The coefficient of restitution between the spheres is 0.5. Find the speed and direction of motion of each sphere after the collision. [10]

3

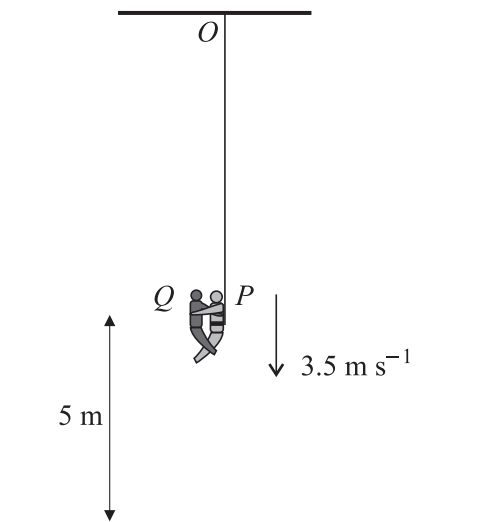
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Two uniform rods AB and BC , each of length 1.4 m and weight 80 N , are freely jointed to each other at B , and AB is freely jointed to a fixed point at A . They are held in equilibrium with AB at an angle α to the horizontal, and BC at an angle of 60° to the horizontal, by a light string, perpendicular to BC , attached to C (see diagram).

- (i) By taking moments about B for BC , calculate the tension in the string. Hence find the horizontal and vertical components of the force acting on BC at B . [7]
- (ii) Find α . [4]

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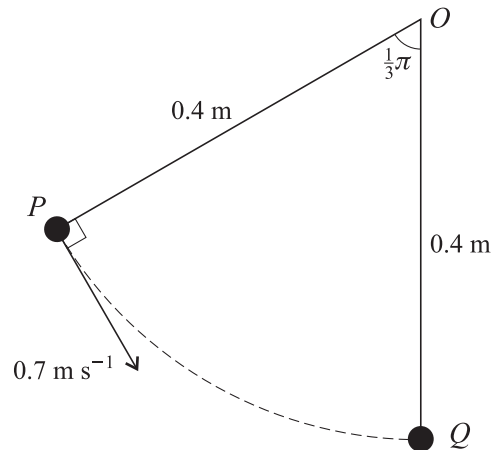


A circus performer P of mass 80 kg is suspended from a fixed point O by an elastic rope of natural length 5.25 m and modulus of elasticity 2058 N . P is in equilibrium at a point 5 m above a safety net. A second performer Q , also of mass 80 kg , falls freely under gravity from a point above P . P catches Q and together they begin to descend vertically with initial speed 3.5 m s^{-1} (see diagram). The performers are modelled as particles.

- (i) Show that, when P is in equilibrium, $OP = 7.25\text{ m}$. [3]
- (ii) Verify that P and Q together just reach the safety net. [5]
- (iii) At the lowest point of their motion P releases Q . Prove that P subsequently just reaches O . [3]
- (iv) State two additional modelling assumptions made when answering this question. [2]

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A particle P of mass 0.8 kg is attached to a fixed point O by a light inextensible string of length 0.4 m. A particle Q is suspended from O by an identical string. With the string OP taut and inclined at $\frac{1}{3}\pi$ radians to the vertical, P is projected with speed 0.7 m s $^{-1}$ in a direction perpendicular to the string so as to strike Q directly (see diagram). The coefficient of restitution between P and Q is $\frac{1}{7}$.

- (i) Calculate the tension in the string immediately after P is set in motion. [4]
- (ii) Immediately after P and Q collide they have equal speeds and are moving in opposite directions. Show that Q starts to move with speed 0.15 m s $^{-1}$. [4]
- (iii) Prove that before the second collision between P and Q , Q is moving with approximate simple harmonic motion. [5]
- (iv) Hence find the time interval between the first and second collisions of P and Q . [2]

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