OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2639

Mechanics 3

Tuesday **25 JANUARY 2005** Morning 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
List of Formulae (MF8)

TIME 1 hour 20 minutes

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.
- Where a numerical value for the acceleration due to gravity is needed, use $9.8\,\mathrm{m\,s^{-2}}$.
- You are permitted to use a graphic 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 60.
- Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.
- **You are reminded of the need for clear presentation in your answers.**

This question paper consists of 4 printed pages.

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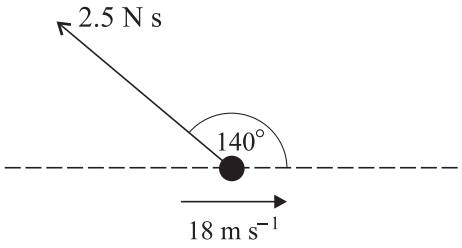
1



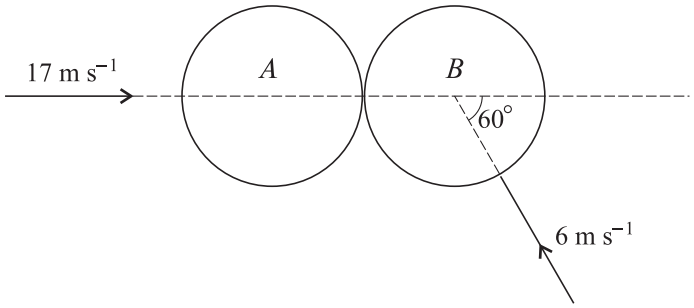
A hockey ball of mass 0.2 kg is moving with speed 18 m s^{-1} when it is hit by a stick. The ball receives an impulse of 2.5 N s at an angle of 140° to its initial direction of motion (see diagram). Find the speed of the ball immediately after it has been hit. [4]

2 A particle of mass m is moving in a complete vertical circle of radius a on the smooth inside surface of a fixed hollow sphere of internal radius a. Air resistance may be neglected. Show that

(i) when the particle is at the highest point of the circle, its speed is at least $\sqrt{(ag)}$, [2]

(ii) when the particle is at the lowest point of the circle, the normal reaction acting on the particle is at least $6mg$. [5]

3



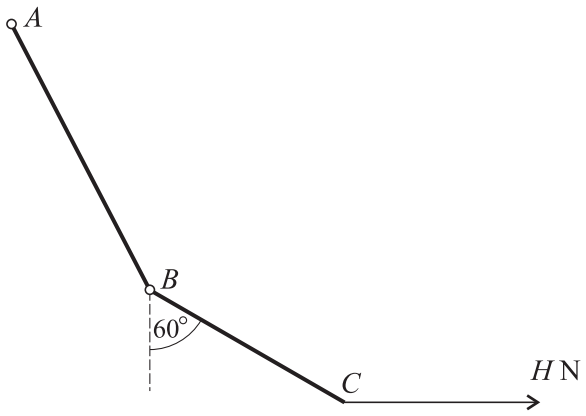
Two smooth spheres A and B, of equal masses and equal radii, are moving on a horizontal surface when they collide. Immediately before the collision, A has velocity 17 m s^{-1} along the line of centres, and B has velocity 6 m s^{-1} at an angle of 60° to the line of centres (see diagram). The coefficient of restitution between the spheres is 0.6. Find the speed of each sphere immediately after the collision. [8]

4 Two fixed points P and Q are 0.9 m apart on a smooth horizontal table. A particle X of mass m kg is connected to P by a spring of natural length 0.4 m and modulus of elasticity 60 N. The particle X is also connected to Q by a spring of natural length 0.5 m and modulus of elasticity 45 N. The particle X is moving along part of the line PQ, and air resistance may be neglected.

(i) Show that the motion of X is simple harmonic. [5]

(ii) Given that X is oscillating with period 0.48 s, find m. [3]

5



Two uniform rods AB and BC are freely jointed to each other at B, and AB is freely jointed to a fixed point at A. A horizontal force H newtons is applied at C and the rods are in equilibrium in a vertical plane with BC making an angle of 60° with the downward vertical (see diagram). The rod AB has length 1.6 m and weight 24 N; the rod BC has length 1.2 m and weight 18 N.

(i) Find H. [3]

(ii) Find the horizontal and vertical components of the force acting on AB at B. [2]

(iii) Find the angle which AB makes with the vertical. [4]

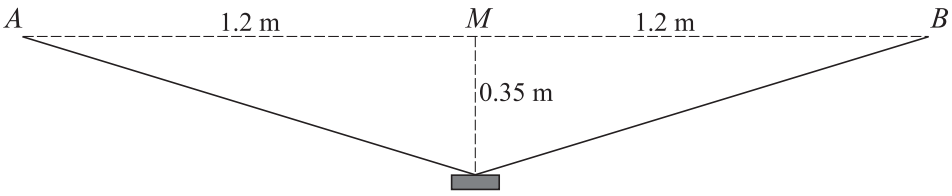
6 A stone of mass 0.1 kg is thrown vertically downwards with initial speed $6\,\mathrm{m\,s^{-1}}$ from a bridge over a river. After t seconds the speed of the stone is $v\,\mathrm{m\,s^{-1}}$. While the stone is falling the only forces acting on it are its weight and air resistance of magnitude $0.02v$ newtons.

(i) Show by integration that $v = 49 - 43\mathrm{e}^{-0.2t}$. [7]

(ii) Given that the stone reaches the river 2.5 s after being thrown, find the height of the bridge above the river. [4]

[Question 7 is printed overleaf.]

7



A brick of mass m kg is attached to two elastic strings, each having natural length 0.8 m and modulus of elasticity 112 N. The other ends of the strings are attached to fixed points A and B which are 2.4 m apart on the same horizontal level. The brick hangs in equilibrium 0.35 m vertically below M, the mid-point of AB (see diagram).

(i) Show that $m = 3.6$. [4]

While in this equilibrium position, the brick is given an impulse so that it begins to move with speed $3\,\text{m}\,\text{s}^{-1}$ vertically upwards.

(ii) Find the speed of the brick when it passes through M. [6]

(iii) State three modelling assumptions you have made when answering this question. [3]

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