OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2640

Mechanics 4

Wednesday **21 JANUARY 2004** Afternoon 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.

Registered Charity Number: 1066969
[Turn over

1 A wheel is rotating about a fixed axis, and is slowing down with constant angular deceleration $0.3\,\text{rad}\,\text{s}^{-2}$.

(i) Find the angle the wheel turns through as its angular speed changes from $8\,\text{rad}\,\text{s}^{-1}$ to $5\,\text{rad}\,\text{s}^{-1}$. [2]

(ii) Find the time taken for the wheel to make its final complete revolution before coming to rest. [3]

2 A rod AB of variable density has length 2 m. At a distance x metres from A, the rod has mass per unit length $(0.7 - 0.3x)\,\text{kg}\,\text{m}^{-1}$. Find the distance of the centre of mass of the rod from A. [5]

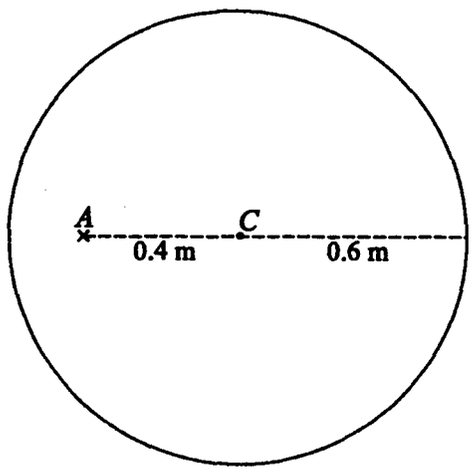
3 From a speedboat, a ship is sighted on a bearing of 045°. The ship has constant velocity $8\,\text{m}\,\text{s}^{-1}$ in the direction with bearing 120°. The speedboat travels in a straight line with constant speed $15\,\text{m}\,\text{s}^{-1}$ and intercepts the ship.

(i) Find the bearing of the course of the speedboat. [4]

(ii) Find the magnitude of the velocity of the ship relative to the speedboat. [3]

4 The region between the curve $y = \dfrac{x^2}{a}$ and the x-axis for $0 \leqslant x \leqslant a$ is occupied by a uniform lamina with mass m. Show that the moment of inertia of this lamina about the x-axis is $\frac{1}{7}ma^2$. [7]

5



A uniform circular disc has mass 4 kg, radius 0.6 m and centre C. The disc can rotate in a vertical plane about a fixed horizontal axis which is perpendicular to the disc and which passes through the point A on the disc, where $AC = 0.4$ m. A frictional couple of constant moment 4.8 N m opposes the motion. The disc is released from rest with AC horizontal (see diagram).

(i) Find the moment of inertia of the disc about the axis through A. [2]

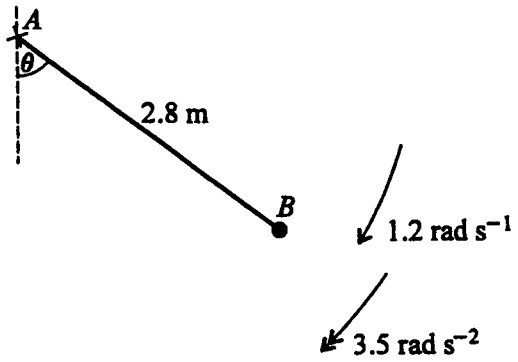
(ii) Find the angular acceleration of the disc immediately after it is released. [3]

(iii) Find the angular speed of the disc when C is first vertically below A. [4]

6 A rigid body consists of a uniform rod AB, of mass 15 kg and length 2.8 m, with a particle of mass 5 kg attached at B. The body rotates without resistance in a vertical plane about a fixed horizontal axis through A.

(i) Find the distance of the centre of mass of the body from A. [2]

(ii) Find the moment of inertia of the body about the axis. [2]



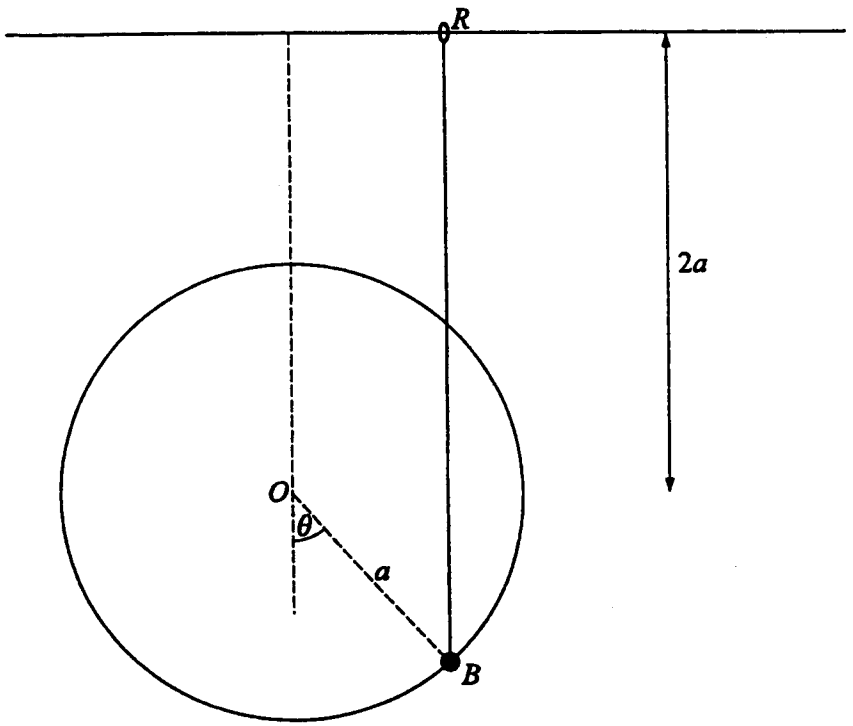
At one instant, AB makes an acute angle θ with the downward vertical, the angular speed of the body is $1.2\,\text{rad}\,\text{s}^{-1}$ and the angular acceleration of the body is $3.5\,\text{rad}\,\text{s}^{-2}$ (see diagram).

(iii) Show that $\sin\theta = 0.8$. [3]

(iv) Find the components, parallel and perpendicular to BA, of the force acting on the body at A. [6]

[Question 7 is printed overleaf.]

7



A small bead B, of mass m, slides on a smooth circular hoop of radius a and centre O which is fixed in a vertical plane. A light elastic string has natural length $2a$ and modulus of elasticity mg; one end is attached to B, and the other end is attached to a light ring R which slides along a smooth horizontal wire. The wire is in the same vertical plane as the hoop, and at a distance $2a$ above O. The elastic string BR is always vertical, and OB makes an angle θ with the downward vertical (see diagram).

(i) Show that $\theta = 0$ is a position of stable equilibrium. [7]

(ii) Find the approximate period of small oscillations about the equilibrium position $\theta = 0$. [7]