OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2640

Mechanics 4

Friday **28 MAY 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 3 printed pages and 1 blank page.

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1 Two flywheels P and Q are rotating, in opposite directions, about the same fixed axis. The angular speed of P is 25 rad s^{-1} and the angular speed of Q is 30 rad s^{-1}. The flywheels lock together, and after this they both rotate with angular speed 10 rad s^{-1} in the direction in which P was originally rotating. The moment of inertia of P about the axis is 0.64 kg m^2. Find the moment of inertia of Q about the axis. [4]

2 A uniform rectangular lamina has mass m and sides of length $3a$ and $4a$, and rotates freely about a fixed horizontal axis. The axis is perpendicular to the lamina and passes through a corner. The lamina makes small oscillations in its own plane, as a compound pendulum.

(i) Find the moment of inertia of the lamina about the axis. [3]

(ii) Find the approximate period of the small oscillations. [3]

3 The region between the curve $y = x\sqrt{(3 - x)}$ and the x-axis for $0 \leqslant x \leqslant 3$ is rotated through 2π radians about the x-axis to form a uniform solid of revolution. Find the x-coordinate of the centre of mass of this solid. [6]

4 A uniform solid sphere, of mass 14 kg and radius 0.25 m, is rotating about a fixed axis which is a diameter of the sphere. A couple of constant moment 4.2 N m about the axis, acting in the direction of rotation, is applied to the sphere.

(i) Find the angular acceleration of the sphere. [3]

During a time interval of 30 seconds the sphere rotates through 7500 radians.

(ii) Find the angular speed of the sphere at the start of the time interval. [2]

(iii) Find the angular speed of the sphere at the end of the time interval. [2]

(iv) Find the work done by the couple during the time interval. [2]

5 Two aircraft A and B are flying horizontally at the same height. A has constant velocity 240 m s^{-1} in the direction with bearing 025°, and B has constant velocity 185 m s^{-1} in the direction with bearing 310°.

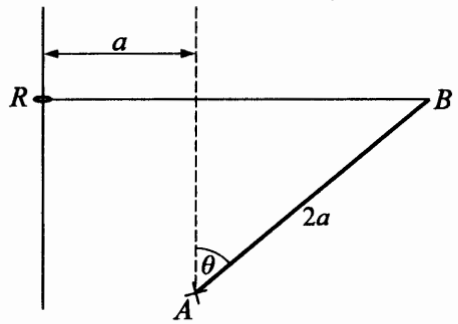
(i) Find the magnitude and direction of the velocity of A relative to B. [5]

Initially A is 4500 m due west of B. For the instant during the subsequent motion when A and B are closest together, find

(ii) the distance between A and B, [3]

(iii) the bearing of A from B. [2]

6



A uniform rod AB, of mass m and length $2a$, is free to rotate in a vertical plane about a fixed horizontal axis through A. A light elastic string has natural length a and modulus of elasticity mg; one end is attached to B and the other end is attached to a light ring R which can slide along a smooth vertical wire. The wire is in the same vertical plane as AB, and is at a distance a from A. The rod AB makes an angle θ with the upward vertical, where $0 < \theta < \frac{1}{2}\pi$ (see diagram).

(i) Give a reason why the string RB is always horizontal. [1]

(ii) By considering potential energy, find the value of θ for which the system is in equilibrium. [6]

(iii) Determine whether this position of equilibrium is stable or unstable. [4]

7 A uniform rod AB has mass m and length $2a$. The point P on the rod is such that $AP = \frac{2}{3}a$.

(i) Prove by integration that the moment of inertia of the rod about an axis through P perpendicular to AB is $\frac{4}{9}ma^2$. [4]

The axis through P is fixed and horizontal, and the rod can rotate without resistance in a vertical plane about this axis. The rod is released from rest in a horizontal position. Find, in terms of m and g,

(ii) the force acting on the rod at P immediately after the release of the rod, [5]

(iii) the force acting on the rod at P at an instant in the subsequent motion when B is vertically below P. [5]