OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS 2609

Mechanics 3

Friday **21 JANUARY 2005** Afternoon 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
MEI Examination Formulae and Tables (MF12)

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** questions.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The allocation of marks is given in brackets [ ] at the end of each question or part question.
- You are advised that an answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- Where a numerical value for the acceleration due to gravity is needed, use g = 9.8 m s^{-2} unless otherwise instructed.
- The total number of marks for this paper is 60.

This question paper consists of 4 printed pages.

© OCR 2005 [R/100/3625] Registered Charity 1066969

1 Each of two light elastic strings, AB and BC, has modulus 20 N. AB has natural length 0.5 m and BC has natural length 0.8 m. The strings are both attached at B to a particle of mass 0.75 kg. The ends A and C are fixed to points on a smooth horizontal table such that AC = 2 m, as shown in Fig. 1.

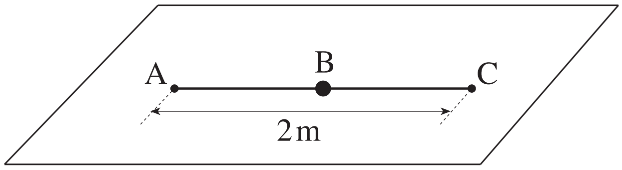

Fig. 1

Initially the particle is held at the mid-point of AC and released from rest.

(i) Find the tension in each string before release and calculate the acceleration of the particle immediately after it is released. [5]

The particle is now moved to the position where it is in equilibrium. The extension in AB is e m.

(ii) Calculate e. [4]

The particle is now held at A and released from rest.

(iii) Show that in the subsequent motion BC becomes slack. Calculate the furthest distance of the particle from A. [6]

2 A simple pendulum consists of a light inextensible string AB of length l with the end A fixed and a particle of mass m attached to B. The pendulum oscillates with period T.

(i) It is suggested that T is proportional to a product of powers of m, l and g. Use dimensional analysis to find this relationship. [4]

The angle that the string makes with the downward vertical at time t is θ. The particle is released from rest with the string taut and $\theta = \theta_0$.

(ii) Use the equation of motion of the particle to find the angular acceleration, $\ddot{\theta}$, in terms of θ, l and g. [3]

The angle θ_0 is chosen so that θ remains small throughout the motion.

(iii) Use the small angle approximation for $\sin\theta$ to show that the particle performs approximate angular simple harmonic motion. State the period of the motion and verify that it is consistent with your answer to part **(i)**. [4]

(iv) Calculate the proportion of time for which the particle travels faster than half of its maximum speed. [4]

3 Michael is attempting to make a small car do a 'loop-the-loop' on a smooth toy racing track. He propels a car of mass m kg towards a section of the track in the form of a vertical circle of radius 0.2 m and the car enters the circle at its lowest point with a speed of $2.8\,\mathrm{m\,s^{-1}}$. During the motion around the circle the angle the car has turned through is denoted by θ, as shown in Fig. 3.

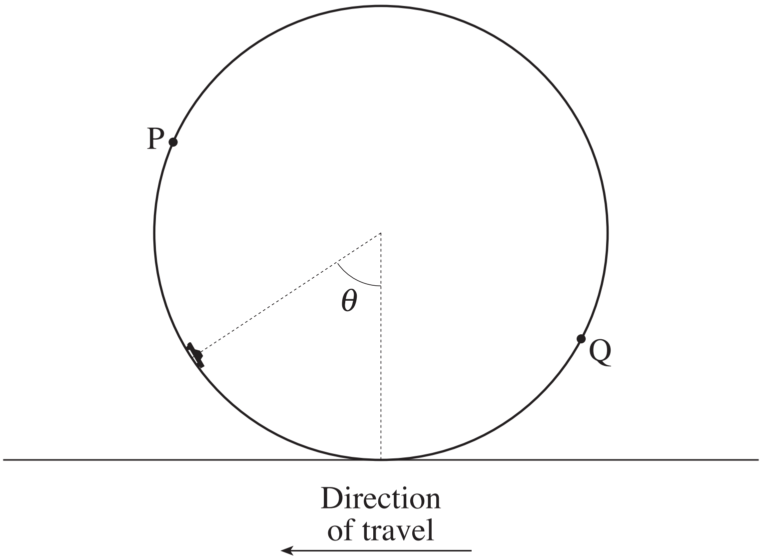

Fig. 3

(i) Show that the speed, $v\,\mathrm{m\,s^{-1}}$, of the car is given by $v^2 = 3.92(1 + \cos\theta)$. Hence show that the reaction of the track on the car, R N, is given by $R = 9.8m(2 + 3\cos\theta)$. [7]

The car leaves the track at the point P where $\theta = \alpha$.

(ii) Calculate α. [2]

(iii) Calculate the speed of the car at P and hence calculate the greatest height of the car above the level of P. [3]

The car hits the track at the point Q which is $\frac{22}{135}$ m below the level of the centre of the circle.

(iv) Calculate the speed with which the car hits the track at Q. [3]

4 Fig. 4.1 shows a uniform lamina OAB in the shape of the region between the curve $y = 4x - x^3$ and the x-axis. The point G is the centre of mass of the lamina.

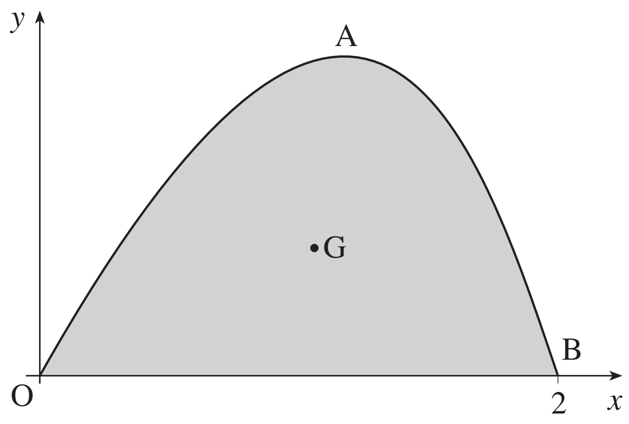

Fig. 4.1

(i) Show that G has coordinates $(\frac{16}{15}, \frac{128}{105})$. [11]

OAB is suspended by wires at O and B and hangs in equilibrium in a vertical plane with OB horizontal. The wire at B is at 60° to the horizontal and the wire at O is at α° to the horizontal, as shown in Fig. 4.2.

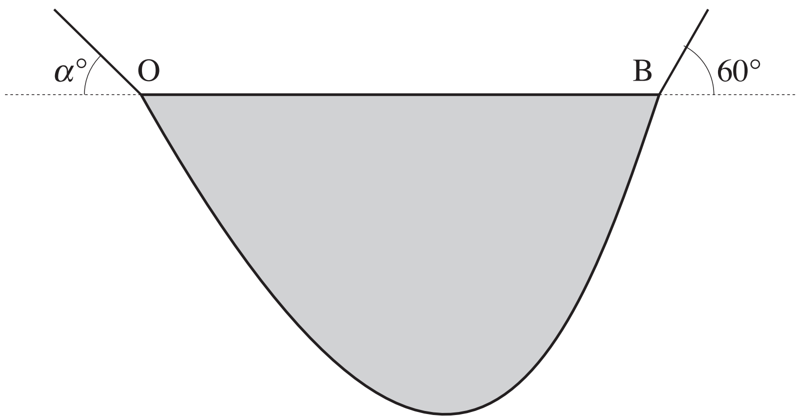

Fig. 4.2

(ii) Calculate α. [4]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (OCR) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

OCR is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.