OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS 4763

Mechanics 3

Monday **22 MAY 2006** Morning 1 hour 30 minutes

Additional materials:
8 page answer booklet
Graph paper
MEI Examination Formulae and Tables (MF2)

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by g $\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use g = 9.8.

INFORMATION FOR CANDIDATES

- The number 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.
- The total number of marks for this paper is 72.

This question paper consists of 5 printed pages and 3 blank pages.

Registered Charity 1066969
[Turn over

1 **(a)** **(i)** Find the dimensions of power. [3]

In a particle accelerator operating at power P, a charged sphere of radius r and density ρ has its speed increased from u to $2u$ over a distance x. A student derives the formula

$$x = \frac{28\pi r^3 u^2 \rho}{9P}.$$

(ii) Show that this formula is not dimensionally consistent. [5]

(iii) Given that there is only one error in this formula for x, obtain the correct formula. [3]

(b) A light elastic string, with natural length 1.6 m and stiffness 150 N m^{-1}, is stretched between fixed points A and B which are 2.4 m apart on a smooth horizontal surface.

(i) Find the energy stored in the string. [2]

A particle is attached to the mid-point of the string. The particle is given a horizontal velocity of 10 m s^{-1} perpendicular to AB (see Fig. 1.1), and it comes instantaneously to rest after travelling a distance of 0.9 m (see Fig. 1.2).

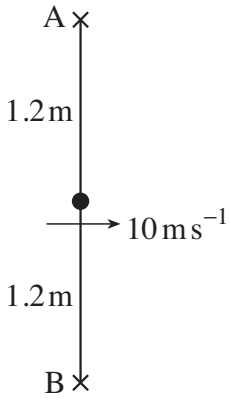

Fig. 1.1

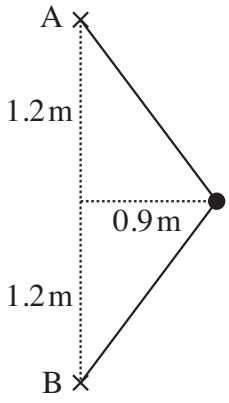

Fig. 1.2

(ii) Find the mass of the particle. [5]

2 **(a)** A particle P of mass 0.6 kg is connected to a fixed point by a light inextensible string of length 2.8 m. The particle P moves in a horizontal circle as a conical pendulum, with the string making a constant angle of 55° with the vertical.

(i) Find the tension in the string. [2]

(ii) Find the speed of P. [4]

(b) A turntable has a rough horizontal surface, and it can rotate about a vertical axis through its centre O. While the turntable is stationary, a small object Q of mass 0.5 kg is placed on the turntable at a distance of 1.4 m from O. The turntable then begins to rotate, with a constant angular acceleration of 1.12 rad s^{-2}. Let ω rad s^{-1} be the angular speed of the turntable.

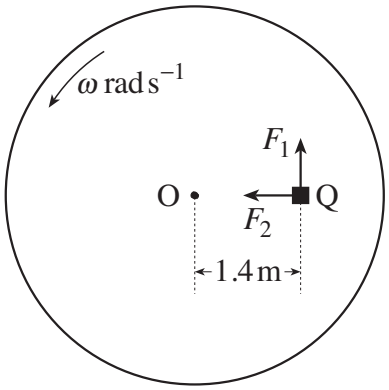

Fig. 2

(i) Given that Q does not slip, find the components F_1 and F_2 of the frictional force acting on Q perpendicular and parallel to QO (see Fig. 2). Give your answers in terms of ω where appropriate. [4]

The coefficient of friction between Q and the turntable is 0.65.

(ii) Find the value of ω when Q is about to slip. [5]

(iii) Find the angle which the frictional force makes with QO when Q is about to slip. [3]

[Turn over

3 A fixed point A is 12 m vertically above a fixed point B. A light elastic string, with natural length 3 m and modulus of elasticity 1323 N, has one end attached to A and the other end attached to a particle P of mass 15 kg. Another light elastic string, with natural length 4.5 m and modulus of elasticity 1323 N, has one end attached to B and the other end attached to P.

(i) Verify that, in the equilibrium position, AP = 5 m. [3]

The particle P now moves vertically, with both strings AP and BP remaining taut throughout the motion. The displacement of P above the equilibrium position is denoted by x m (see Fig. 3).

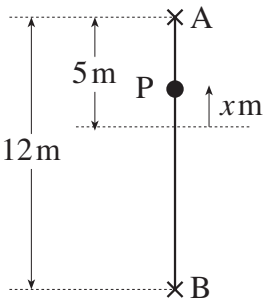

Fig. 3

(ii) Show that the tension in the string AP is $441(2-x)$ N and find the tension in the string BP. [3]

(iii) Show that the motion of P is simple harmonic, and state the period. [4]

The minimum length of AP during the motion is 3.5 m.

(iv) Find the maximum length of AP. [1]

(v) Find the speed of P when AP = 4.1 m. [3]

(vi) Find the time taken for AP to increase from 3.5 m to 4.5 m. [4]

4 The region bounded by the curve $y = \sqrt{x}$, the x-axis and the lines $x = 1$ and $x = 4$ is rotated through 2π radians about the x-axis to form a uniform solid of revolution.

(i) Find the x-coordinate of the centre of mass of this solid. [6]

From this solid, the cylinder with radius 1 and length 3 with its axis along the x-axis (from $x = 1$ to $x = 4$) is removed.

(ii) Show that the centre of mass of the remaining object, Q, has x-coordinate 3. [5]

This object Q has weight 96 N and it is supported, with its axis of symmetry horizontal, by a string passing through the cylindrical hole and attached to fixed points A and B (see Fig. 4). AB is horizontal and the sections of the string attached to A and B are vertical. There is sufficient friction to prevent slipping.

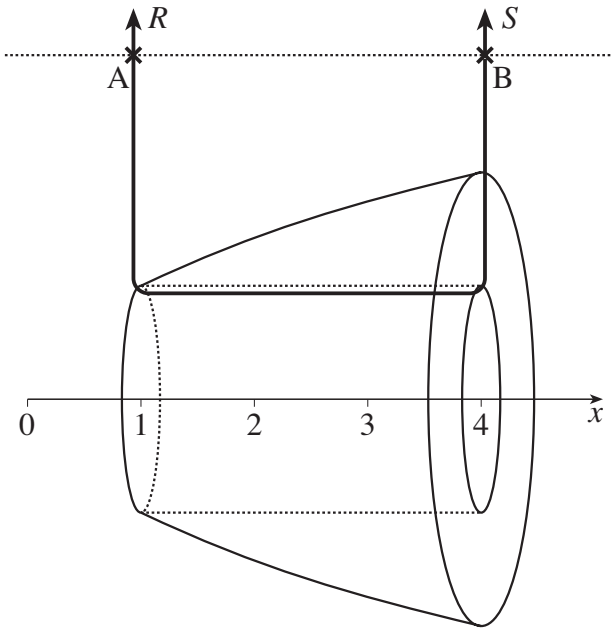

Fig. 4

(iii) Find the support forces, R and S, acting on the string at A and B

(A) when the string is light, [4]

(B) when the string is heavy and uniform with a total weight of 6 N. [3]

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