

GCE Examinations

Mechanics

Module M3

Advanced Subsidiary / Advanced Level

Paper E

Time: 1 hour 30 minutes

Instructions and Information

Candidates may use any calculator except those with a facility for symbolic algebra and/or calculus.

Full marks may be obtained for answers to ALL questions.

Mathematical and statistical formulae and tables are available.

This paper has 7 questions.

When a numerical value of g is required, use $g = 9.8 \text{ m s}^{-2}$.

Advice to Candidates

You must show sufficient working to make your methods clear to an examiner. Answers without working will gain no credit.



Written by Shaun Armstrong & Chris Huffer

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1. The velocity, \mathbf{v} cm s^{-1} , at time t seconds, of a radio-controlled toy is modelled by the formula

$$\mathbf{v} = e^{2t}\mathbf{i} + 2t\mathbf{j},$$

where \mathbf{i} and \mathbf{j} are perpendicular unit vectors.

- (a) Find the acceleration of the toy in terms of t . (2 marks)
- (b) Find, correct to 2 significant figures, the time at which the acceleration of the toy is parallel to the vector $(4\mathbf{i} + \mathbf{j})$. (4 marks)
- (c) Explain why this model is unlikely to be realistic for large values of t . (1 mark)
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2. A particle P of mass 0.4 kg is moving in a straight line through a fixed point O .

At time t seconds after it passes through O , the distance OP is x metres and the resultant force acting on P is of magnitude $(5 + 4e^{-x})$ N in the direction OP .

When $x = 1$, P is at the point A .

- (a) Find, correct to 3 significant figures, the work done in moving P from O to A . (4 marks)

Given that P passes through O with speed 2 m s^{-1} ,

- (b) find, correct to 3 significant figures, the speed of P as it passes through A . (4 marks)
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- 3.

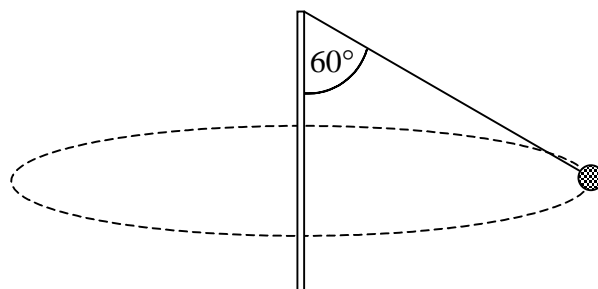


Fig. 1

A popular racket game involves a tennis ball of mass 0.1 kg which is attached to one end of a light inextensible string. The other end of the string is attached to the top of a fixed rigid pole.

A boy strikes the ball such that it moves in a horizontal circle with angular speed 4 rad s^{-1} and the string makes an angle of 60° with the downward vertical as shown in Figure 1.

- (a) Find the tension in the string. (3 marks)
- (b) Find the length of the string. (5 marks)
-

4. A particle moves with simple harmonic motion along a straight line.

When the particle is 3 cm from its centre of motion it has a speed of 8 cm s^{-1} and an acceleration of magnitude 12 cm s^{-2} .

- (a) Show that the period of the motion is π seconds. **(4 marks)**
- (b) Find the amplitude of the motion. **(3 marks)**
- (c) Hence, find the greatest speed of the particle. **(2 marks)**

5. A physics student is set the task of finding the mass of an object without using a set of scales. She decides to use a light elastic string of natural length 2 m and modulus of elasticity 280 N attached to two points A and B which are on the same horizontal level and 2.4 m apart.

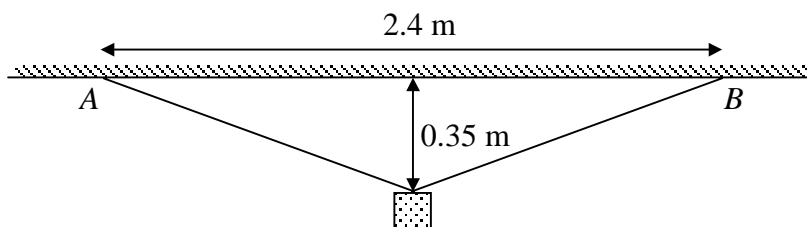


Fig. 2

She attaches the object to the midpoint of the string so that it hangs in equilibrium 0.35 m below AB as shown in Figure 2.

- (a) Explain why it is reasonable to assume that the tensions in each half of the string are equal. **(1 mark)**
- (b) Find the mass of the object. **(7 marks)**
- (c) Find the elastic potential energy of the string when the object is suspended from it. **(2 marks)**

Turn over

6.

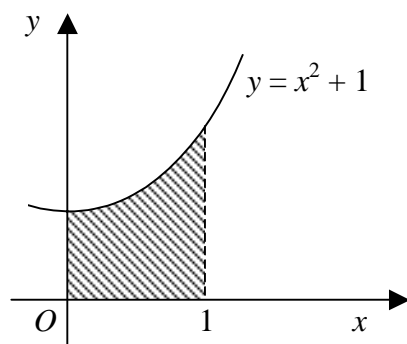


Fig. 3

Figure 3 shows part of the curve $y = x^2 + 1$. The shaded region enclosed by the curve, the coordinate axes and the line $x = 1$ is rotated through 360° about the x -axis.

- (a) Find the coordinates of the centre of mass of the solid obtained. **(10 marks)**

The solid is suspended from a point on its larger circular rim and hangs in equilibrium.

- (b) Find, correct to the nearest degree, the acute angle which the plane surfaces of the solid make with the vertical.

(3 marks)

7. A particle of mass 0.5 kg is hanging vertically at one end of a light inextensible string of length 0.6 m. The other end of the string is attached to a fixed point.

The particle is given an initial horizontal speed of $u \text{ m s}^{-1}$.

- (a) Show that the particle will perform complete circles if $u \geq \sqrt{3g}$. **(8 marks)**

Given that $u = 5$,

- (b) find, correct to the nearest degree, the angle through which the string turns before it becomes slack,

(7 marks)

- (c) find, correct to the nearest centimetre, the greatest height the particle reaches above its position when the string becomes slack.

(5 marks)

END