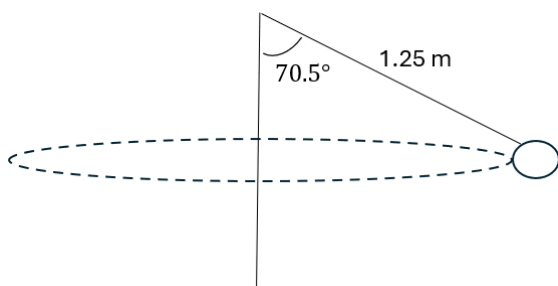


U3A1 Differentiator Questions SAMPLE - Solutions

A tennis ball is attached to the top of a pole by a 1.25 m piece of light string, as shown below. When James hits the ball, it moves in a horizontal circle. The mass of the ball is 85 g, and the string makes an angle of 70.5° with the pole. The effects of air resistance can be ignored.



a) Calculate the period of rotation of the tennis ball. (3 marks)

$$\tan(70.5^\circ) = \frac{F_c}{F_g}$$

$$F_c = F_g \tan(70.5^\circ)$$

$$F_c = 85 \times 10^{-3} \times 9.81 \tan(70.5^\circ)$$

$$F_c = 2.36 \text{ N (1 mark)}$$

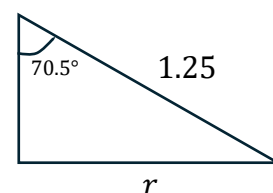
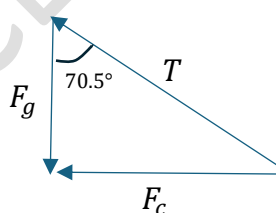
$$\sin(70.5^\circ) = \frac{r}{1.25}$$

$$r = 1.25 \sin(70.5^\circ) = 1.18 \text{ m (1 mark)}$$

$$F_c = \frac{4\pi^2 rm}{T^2}$$

$$2.36 = \frac{4\pi^2 \times 1.18 \times 85 \times 10^{-3}}{T^2}$$

$$T = 1.3 \text{ s (2 s.f.) (1 mark)}$$



b) The ball now travels around the circle at a higher speed. James notices that the angle between the pole and the string increases, but is always less than 90° . Explain this observation. (3 marks)

- As the ball's speed increases, the centripetal force (F_c) will increase. (1 mark)
- Using the vector triangle, $F_c = F_g \tan(\theta)$, so as the centripetal force increases, the angle between the pole (θ) and the string increases, since F_g is constant. (1 mark)

- However, the angle is always less than 90° because the gravitational force on the ball must be balanced by the vertical component of tension. (1 mark)

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