Circular Motion

Force & Dynamics · 7 questions · step-by-step answers at the end

Name: Date: Score: / 7

USEFUL EQUATIONS

$a_c = v^2 / r \quad \Sigma F_{\text{in}} = mv^2 / r \quad T = 2\pi r / v \quad v = r\omega$

Questions

Show your working in the space under each question.

1. What is the minimum speed at the top of a vertical loop of radius 4.0 m?

2. A 1200 kg car rounds a flat curve of radius 50 m at 15 m/s. (a) What net force is needed? (b) What is the minimum coefficient of static friction?

3. A car rounds a curve at twice its previous speed. By what factor must the friction force increase?

4. A conical pendulum: a 1.0 m string makes 30° with the vertical. Find the speed of the bob.

5. What is the minimum speed at the top of a vertical circle of radius 1.0 m to keep the water in a swung bucket?

6. What is the minimum speed at the top of a 10 m radius loop?

7. A ball on a string moves in a horizontal circle. The string breaks. Which way does the ball go?

Step-by-step answers

Circular Motion

1. At the minimum, N = 0 and gravity alone provides the centripetal force: $mg = mv^2/r$, so $v = \sqrt{(gr)} = \sqrt{(9.8 \times 4.0)} \approx$ **6.3 m/s**.

2. 1. $a_c = v^2/r = 15^2/50 = 4.5$ m/s².

2. $F_{net} = ma_c = (1200)(4.5) =$ **5400 N**, toward the centre. Static friction between the tyres and the road supplies it.

3. The maximum friction is $\mu_s mg$, so $\mu_s mg \geq mv^2/r \rightarrow \mu_s \geq v^2/(rg) = 225/(50 \times 9.8) =$ **0.46**.

Answer: (a) 5400 N inward (b) $\mu_s \geq 0.46$

3. $F \propto v^2$, so by a factor of **4**.

4. $r = L \sin\theta = 0.5$ m; $\tan\theta = v^2/(rg)$, so $v = \sqrt{(0.5 \times 9.8 \times \tan 30°)} \approx$ **1.7 m/s**.

5. $v = \sqrt{(gr)} = \sqrt{9.8} \approx$ **3.1 m/s**.

6. $v = \sqrt{(gr)} = \sqrt{98} \approx$ **9.9 m/s**.

7. **Along the tangent**, in the direction of its velocity at that moment, not outward.