Rolling Motion & Rotational Energy

Rotation · 7 questions · step-by-step answers at the end

Name: Date: Score: / 7

USEFUL EQUATIONS

$v_{cm} = \omega R$ $K = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$ $v = \sqrt{(2gh/(1 + \beta))}$ $a = g \sin\theta / (1 + \beta)$

Questions

Show your working in the space under each question.

1. A hoop rolls from rest down the same 1.4 m high ramp. What is its speed at the bottom?

2. A solid sphere rolls without slipping from rest down a ramp 1.4 m high. How fast is it moving at the bottom? Compare it with a frictionless sliding block.

3. What fraction of a rolling solid disk's kinetic energy is rotational?

4. What fraction of a rolling hoop's kinetic energy is rotational?

5. If a rolling sphere's mass doubles, how does its speed at the bottom of a ramp change?

6. A solid sphere rolls at 4 m/s. Find its total KE per kg.

7. A wheel rolls at 5 m/s. How fast are its top and bottom points moving relative to the ground?

Step-by-step answers

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1. For a hoop $\beta = 1$, so $v = \sqrt{(gh)} = \sqrt{(9.8 \times 1.4)} \approx$ **3.7 m/s**.

2. 1. For a solid sphere, $I = (2/5)MR^2$, so $\beta = 0.4$.
2. Energy: $Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}(0.4MR^2)(v/R)^2 = 0.7Mv^2$.
3. $v = \sqrt{(gh/0.7)} = \sqrt{(10gh/7)} = \sqrt{(10 \times 9.8 \times 1.4 / 7)} =$ **4.4 m/s**.
4. A sliding block gets $\sqrt{(2gh)} = 5.2$ m/s. The sphere is slower because 2/7 of its energy goes into spinning.

Answer: 4.4 m/s (sphere) vs 5.2 m/s (block)

3. $K_{rot}/K = \frac{1}{2}\beta/(\frac{1}{2}(1 + \beta))$ with $\beta = \frac{1}{2}$: **1/3**.

4. $\beta = 1$, so the KE splits equally: **½**.

5. **Not at all**: mass cancels.

6. $K = \frac{1}{2}v^2(1 + 2/5) = 0.7 \times 16 =$ **11.2 J/kg**.

7. Top **10 m/s**; bottom (contact point) **0**.