

Roller Coaster Physics Lesson 1

Manipulation of General Roller Coaster Equations

You may refer to the Table *Variables and their Units*

1. Potential Energy, PE , is given by the formula $PE = m_{mass} gh$.

a. Solve for h .

$$PE = m_{mass} gh$$

$$\frac{PE}{m_{mass} g} = \frac{\cancel{m_{mass}} \cancel{g} h}{\cancel{m_{mass}} \cancel{g}}$$

$$\frac{PE}{m_{mass} g} = h$$

- b. If the PE of a roller coaster car at the top of the first hill is 4,000,000 Newton-meters and the mass of the car and passengers is 6,000 kg, how high is the first hill?

$$h = \frac{PE}{m_{mass} g}$$

$$h = \frac{4000000 N \cdot m}{6000 kg \cdot 9.8 \frac{m}{sec^2}} = \frac{4000000 \frac{kg \cdot m}{sec^2} \cdot m}{58800 \frac{kg \cdot m}{sec^2}} = 68.03 m$$

2. Kinetic Energy, KE , is given by the formula $KE = \frac{1}{2} m_{mass} v^2$.

a. Solve for v .

$$KE = \frac{1}{2} m_{mass} v^2$$

$$2 \cdot (KE) = \cancel{2} \cdot \left(\frac{1}{\cancel{2}} m_{mass} v^2 \right)$$

$$2 \cdot KE = m_{mass} v^2$$

$$\frac{2 \cdot KE}{m_{mass}} = \frac{\cancel{m_{mass}} v^2}{\cancel{m_{mass}}}$$

$$v^2 = \frac{2 \cdot KE}{m_{mass}}$$

$$\sqrt{v^2} = \sqrt{\frac{2 \cdot KE}{m_{mass}}}$$

$$v = \sqrt{\frac{2 \cdot KE}{m_{mass}}}$$

- b. If the Kinetic Energy of the roller coaster car in question 1 is 4,000,000 Newton-meters at the bottom of the first hill, what is the velocity of the car?

$$v = \sqrt{\frac{2 \cdot 4000000 \text{ N} \cdot \text{m}}{6000 \text{ kg}}} = \sqrt{1.333.33 \frac{\cancel{\text{kg}} \cdot \text{m}}{\text{sec}^2} \cdot \text{m}} = \sqrt{1.333.33 \frac{\text{m}^2}{\text{sec}^2}}$$

$$v = 36.5 \frac{\text{m}}{\text{sec}}$$

3. If we assume that the PE at point 1 (top of hill) is equal to the KE at point 2 (bottom of hill), then :

$$\text{KE}_1 = \text{PE}_2$$

$$m_{\text{mass}} g h_1 = \frac{1}{2} m_{\text{mass}} v_2^2 .$$

- a. Solve for h_1 .

$$m_{\text{mass}} g h_1 = \frac{1}{2} m_{\text{mass}} v_2^2$$

$$\cancel{m_{\text{mass}}} g h_1 = \frac{1}{2} \cancel{m_{\text{mass}}} v_2^2$$

$$g h_1 = \frac{1}{2} v_2^2$$

$$\cancel{g} h_1 = \frac{1}{2} \frac{v_2^2}{\cancel{g}}$$

$$h_1 = \frac{v_2^2}{2g}$$

- b. If the velocity of the roller coaster car at the bottom of the first hill is $25 \frac{\text{m}}{\text{sec}}$, how high was the first hill (h_1) ?

$$h_1 = \frac{v_2^2}{2g}$$

$$h_1 = \frac{\left(25 \frac{\text{m}}{\text{sec}}\right)^2}{2 \cdot 9.8 \frac{\text{m}}{\text{sec}^2}} = 31.89 \frac{\frac{\text{m}^2}{\text{sec}^2}}{\frac{\text{m}}{\text{sec}}} = 31.89 \frac{\text{m}^2}{\text{sec}^2} \cdot \frac{\text{sec}}{\text{m}}$$

$$h_1 = 31.89 \frac{\text{m}}{\text{sec}}$$