Question

The whole energy of a roller coaster (potential and kinetic) is:

$$E = E_{potential} + E_{kinetic} = m \cdot \left(gh + \frac{v^2}{2} \right).$$

At the beginning of the motion: $h = 40 \text{ m}$ and $v = 15 \text{ m} \cdot \text{s}^{-1}$. So, we will have:

$$E_1 = E_{potential} + E_{kinetic} = m \cdot \left(9.8 \cdot 40 + \frac{15^2}{2} \right) = 504.5 \cdot m.$$

At the moment when the roller coaster at a height of 5 meters above the ground we will have:

$$E_2 = E_{potential} + E_{kinetic} = m \cdot \left(9.8 \cdot 5 + \frac{v^2}{2} \right) = E_1 = 504.5 \cdot m.$$

So, we can find the velocity in this case:

$$E_2 = m \cdot \left(9.8 \cdot 5 + \frac{v^2}{2} \right) = 504.5 \cdot m \Rightarrow 9.8 \cdot 5 + \frac{v^2}{2} = 504.5 \Rightarrow$$

$$\Rightarrow \frac{v^2}{2} = 504.5 - 49 = 455.5 \Rightarrow v = \sqrt{2 \cdot 455.5} = 30.18 \text{ m} \cdot \text{s}^{-1}.$$

Answer: $30.18 \text{ m} \cdot \text{s}^{-1}$.