Lesson Objectives

• Have a brief understanding of the history of the roller coaster
• Understand the level of engineering and physics required in the construction of roller coasters
• Use your understanding of conservation of energy to solve roller coaster problems
Physics terms and Laws

• Gravitational Potential Energy
• Kinetic Energy
• Friction (mostly neglected in problem solving)
• Air Resistance (mostly neglected in problem solving)
• Inertia
• Momentum
• Velocity
• Acceleration
• Centrifugal Force

Conservation of Energy

Newton’s First Law
(an object at rest will remain at Rest un less acted upon by a force)
Origins of the Roller Coaster

The roller coaster has its origins in St. Petersburg, Russia. The first roller coasters, known as the Russian Mountains were wood-framed ice slides down seventy foot high slopes in 16th century.
Evolution of the Roller Coaster

Railway companies, in search of ways to keep passenger usage up on the weekends, set up parks here at the end of the rail lines and introduced weekend and summer activities.

Coney Island was home to the Switchback Railway, which opened on June 16th, 1884. It America's first roller coaster!
The Modern Roller Coaster

- As Builders and developers of roller coasters began to understand the physics of roller coasters more, they created more extravagant, faster rides.
- Today's roller coasters are excellent feats of engineering and application of the laws of physics.
- According to the Roller Coaster database, there were 4,639 coasters in operation around the world in 2018 - 4,455 of them steel, 184 wooden.
Conservation of Energy

• Energy in any isolated system is completely conserved.

• The Law of Conservation of Energy states that “the kinetic, potential, and thermal energy within the system can be transformed into each other, but their sum cannot change.”

• Roller coasters are one of the most used explanation of the conservation of energy.
Roller Coaster Transfer of Energy

When frictional forces are small enough to be ignored, the transfer of energy between Gravitational Potential energy \( E_p \) and Kinetic Energy \( E_k \) can be used to calculate heights and speeds.

\[
E_T = E_p + E_k
\]

\( E_T \) is the total energy, \( E_p \) is the potential energy, and \( E_k \) is the kinetic energy.

Diagram:

- Work done \( = mgh \)
- Max PE = work done
- KE = 0
- Max KE
- PE = 0
- KE + PE = same
- Max KE
- PE = 0

• When frictional forces as small enough to be ignored, the transfer of energy between Gravitational Potential energy \( (E_p) \) and Kinetic Energy \( (E_k) \) can be used to calculate heights and speeds.
Roller Coaster Calculations

An 850 kg roller-coaster is released from rest at Point A of the track shown in the figure. Assume there is no friction or air resistance between Points A and C.

a) How fast is the roller-coaster moving at Point B?

b) What average force is required to bring the roller-coaster to a stop at Point D if the brakes are applied at Point C?
Roller Coaster Calculations

a) How fast is the 850 kg roller-coaster moving at Point B?

Find the Systems Total Energy
\[ E_T = E_p + E_k \]
\[ E_T = E_p + 0 \]
\[ = (850)(9.81)(140) \]
\[ = 1,167,390 \text{J} \]

Find out the Potential Energy on top of the second Hill
\[ E_p = mgh \]
\[ = (850)(9.81)(95) \]
\[ = 792,157.5 \text{J} \]

If energy is conserved then the rest is Ek
\[ E_k = 1167,390 \text{J} - 792,157.5 \text{J} \]
\[ = 375,232.5 \text{J} \]

Calculate velocity using Ek Equation
\[ \frac{1}{2}mv^2 = 375,232.5 \text{J} \]
\[ v^2 = \frac{2(375,232.5 \text{J})}{850 \text{kg}} \]
\[ = 882.9 \]
\[ V = 29.71 \text{m/s} \]
b) What average force is required to bring the roller-coaster to a stop at Point D if the brakes are applied at Point C?

\[ E_T = E_k(\text{at the end}) + E_p + W(\text{to stop the train, } W = Fs) \]

\[
\begin{align*}
1,167,390 & = 0 + (850)(9.81)(80) + F(120) \\
1,167.390 & = 667,080 + F(120) \\
(1,167,390 - 667,080) / 120 & = F
\end{align*}
\]

\[ F = 4,169.25J \]

\[ V = 0 \text{m/s} \]
Prep (Tuesday 26th)

• Roller coaster Sample Problems
• Online Quiz
• Review notes on Website