Thrills and Spills

Big Idea: The laws of physic must be considered when building anything, so…

Driving Question: How do the laws of physics apply to roller coasters?

Design Challenge: You have been hired by Kings Dominion to design the most thrilling, fastest rollercoaster the park has to offer. Using what you know from physics, design a rollercoaster that shows your understanding of the Law of Conservation of Energy, Mechanical Energy (Potential + Kinetic) and Energy Transformations.

Essential Questions:

- How do Newton's Laws of Motion apply to rollercoasters?
- How is mechanical energy (potential + kinetic) demonstrated in rollercoasters?
- How is energy transformation demonstrated in rollercoasters?

Rules (Criteria) for rollercoaster:

	Track must touch the floor at least once
	Cart (marble) must land in the cup (track cannot touch cup) • Cup cannot fall over (this would harm your passengers)
	Cup should be free standing (nothing should be holding the cup down)
	Track must have at least 2 loops
	Demonstrate Newton's 3 Laws of Motion (Law 1, Law 2, Law 3)
	Demonstrate Mechanical Energy (Potential + Kinetic)
	Demonstrate a MINIMUM of 4 energy transformations

Materials:

Masking Tape
2 6-foot pieces of insulation foam tubing
Meter Stick/Ruler

Additional supplies must be approved by the teacher.

When designing anything

(especially something like a rollercoaster),

it's always good to do research.

Research Guidelines

Using the materials provided/approved conduct each experiment challenge below. Be sure to record **ALL** of the following in your research log.

- Sketch of rollercoaster
- Rise measurements (hill heights in inches) of rollercoaster track
- Run measurements (downhill lengths in inches) of rollercoaster track
- Diameter of loop(s) created on roller coaster track
- **CHANGES OR MODIFICATIONS** to roller coaster track and **WHY**
- Start and end position of the "coaster cart" (marble) for trials
- Label potential and kinetic energy
- Answers to the questions for each experiment

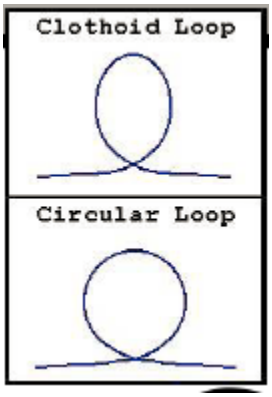
REMEMBER these experiments help you RESEARCH the physics behind rollercoasters so that you can build the perfect one for Kings Dominion. TAKE GOOD NOTES TO HELP YOU!

Research Experiment #1 – What is Potential & Kinetic Energy?

Goal: Define Potential and kinetic energy and determine how they affect each other.

Experiment A: Create a two hill roller coaster with your materials where the "cart" (marble) makes it safely to the end of the track WITHOUT stopping or falling off.

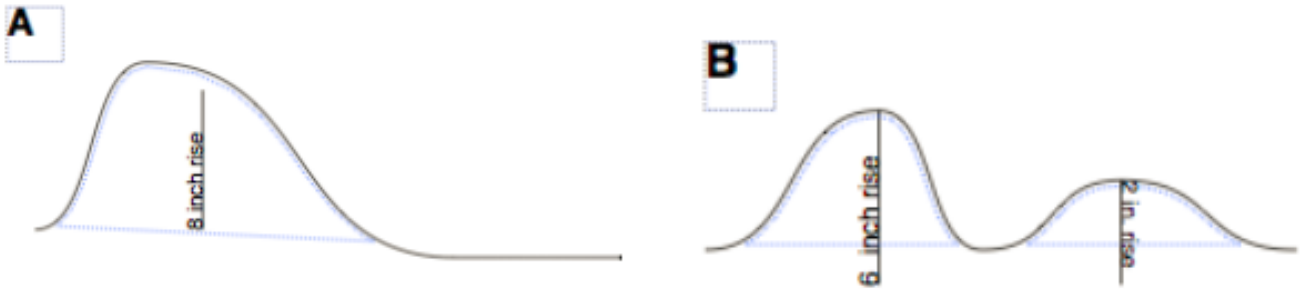
Experiment B: Create a rollercoaster with a **circular** loop then one with a **clothoid** loop where the "cart" makes it to the end of the track without stopping or falling off.



Research Experiment #2 – What is Friction?

Goal: Experiment with using friction to create a safe roller coaster design

Experiment A: Does a length of track the same distance take longer to travel if it has multiple hills?



1.) Create the two roller coasters with the specifications above out of 12 feet of insulation foam.
2.) Create a hypothesis.
3.) Make sure your starting point and ending point are exactly the same length of track.
4.) Predict which track takes longer to travel.
5.) Test each track with two trial runs and time the cart from start to finish.
6.) Record results.

Experiment B: Which material makes the best friction for slowing down a coaster cart?

1.) Use roller coaster design A as your test track. Be sure you have a set start and finish line.
2.) Create a hypothesis.
3.) Place three strips of one of the materials on the track before the finish line.
4.) Place a piece of Styrofoam barrier at the end of the track.
5.) Send a cart down the track and measure how far the barrier is moved.
6.) Repeat the procedure with each material and record your results in your research log.

Team Design Challenge – Rollercoaster Ride

Client: Kings Dominion **Desired Product: Rollercoaster**

General Information:

Kings Dominion is looking to add a new rollercoaster to their theme park. They would like for the rollercoaster to be a fun and exciting ride that also teaches its guests about the Law of Conservation of Energy, Mechanical Energy (Potential + Kinetic) and Energy Transformations. YOU have been chosen to create the new contraption by the deadline…

THURSDAY, DECEMBER 20, 2018

Research Log

Engineer:

Fellow Engineers:

Coaster Name:

Research Experiment #1 – What is Potential & Kinetic Energy?

Define and create a picture to explain…

TERMS	DEFINITIONS	PICTURE
Potential Energy		
Kinetic Energy		
Mechanical Energy		
Conservation of Energy		

Experiment A:

SKETCH: (include start/end position of "cart" & label potential & kinetic energy)

Rise Measurements:

Run Measurements:

Analysis Questions: (write in COMPLETE SENTENCES)

1. What relationship is there between potential and kinetic energy?

2. What happens when too much potential energy is used in the design? Explain any MODIFICATIONS that were needed.

Experiment B:

SKETCH 1: **(include start/end position of "cart" & label potential & kinetic energy)**

SKETCH 2: **(include start/end position of "cart" & label potential & kinetic energy)**

Rise Measurements:

Run Measurements:

Diameter of clothoid loop:

Diameter of circular loop:

Analysis Questions: (write in COMPLETE SENTENCES)

1. Which loop requires more potential energy? Why?

2. What modifications were made? Explain.

Research Experiment #2 – What is Friction?

Experiment A:

Hypothesis:_____

_____

SKETCH 1: **(include start/end position of "cart" & label potential & kinetic energy)**

Rise Measurements:

Run Measurements:

SKETCH 2: **(include start/end position of "cart" & label potential & kinetic energy)**

Rise Measurements:

Run Measurements:

Rollercoaster	Trial 1	Trial 2	Trial 3
Coaster 1			
Coaster 2			

Analysis Questions: (write in COMPLETE SENTENCES)

1. Did one track take longer to travel? Give a scientific explanation.

2. What modifications were made? Explain.

Experiment B:

Hypothesis:_____

_____

SKETCH: (include start/end position of "cart" & label potential & kinetic energy)

Rise Measurements:

Run Measurements:

Item	Cart completed full track	Barrier displaced	Time of travel for cart
Felt			
Paper			
Construction Paper			
Team choice _____			

Analysis Questions: (write in COMPLETE SENTENCES)

1. Which material worked best to stop/slow the "cart?" Explain.

2. What modifications were made? Explain.

Team Design Challenge - Rollercoaster Ride

Identify the Problem: (describe the challenge, criteria, limits/constraints)

Research summary: (describe the research; how is this going to aid in your design)

Design: (complete a DETAILED sketch/description of your design and label potential and kinetic energy; start/end point of "cart") – HINT: this is your original idea (aka…your brainstorm idea)

Materials: List ALL

Rise Measurements:

Run Measurements:

Diameter of clothoid loop:

Diameter of circular loop:

Create/Build/Try it Out: (Was your design successful? Explain why or why not. Use drawings, words, or diagrams as necessary)

Make it Better: (How could the team make your design better? Use drawings, words, or diagrams as necessary)

Communicating Results

Analysis Questions: (write in COMPLETE SENTENCES)

1. Explain how the following are represented in your rollercoaster (create drawings, diagrams to help)
    a. Newton's 1st Law of Motion

    b. Newton's 2nd Law of Motion

    c. Newton's 3rd Law of Motion

    d. Mechanical Energy (Potential + Kinetic)

    e. Energy Transformation

    f. Law of Conservation of Energy

    g. As a team of engineers, create a technology based product that communicates the following…
        i. Demonstration of "cart" traveling successfully through rollercoaster w/ safe stop.
        ii. Pictures showing where the MAXIMUM potential & kinetic energy are found on your coaster.
        iii. Pictures showing where the MINIMUM potential & kinetic energy are found on your coaster.
        iv. Pictures showing a MINIMUM of 4 energy transformations
        v. Team selfie with rollercoaster

Thrills & Spills:
Team Design Challenge Rubric

Engineers:

CRITERIA	POINTS
Research Log (Research Experiment #1) **Chart (at top)**	_____/8
Research Log - Research Experiment #1 (Experiment A)	_____/13
Research Log - Research Experiment #1 (Experiment B)	_____/20
Research Log - Research Experiment #2 (Experiment A)	_____/30
Research Log Research Experiment #2 (Experiment B)	_____/29
Research Log Total	_____/100
Design Challenge – Rollercoaster setup • Track must touch the floor at least once • Cart (marble) must land in the cup (track cannot touch cup) - Cup cannot fall over (this would harm your passengers) • Cup should be free standing (nothing should be holding the cup down) • Track must have at least 2 loops • Demonstrate Newton's 3 Laws of Motion (Law 1, Law 2, Law 3) • Demonstrate Mechanical Energy (Potential + Kinetic) • Demonstrate a MINIMUM of 4 energy transformations	_____/10
Design Challenge – Write up	_____/30
Design Challenge Total	_____/40
Communicating Results (a-f)	_____/30
Communicating Results (g-technology product) • Demonstration of "cart" traveling successfully through rollercoaster w/ safe stop. • Pictures showing where the **MAXIMUM** potential & kinetic energy are found on your coaster. • Pictures showing where the **MINIMUM** potential & kinetic energy are found on your coaster. • Pictures showing a **MINIMUM** of 4 energy transformations • Team selfie with rollercoaster	_____/30
Communicating Results Total	_____/60
PROJECT TOTAL	_____/200