STEM Learning Module Template

PISA Team: Roller Coaster Dynamics

Name	Grade	School
Michelle Miller	3	Dr. MLK, Jr.
Helena Stanaback	4	Dr. MLK, Jr.
Latitia McReynolds	5	Dr. MLK, Jr.

Strand(s): Mathematics in Civil Engineering

Grade(s): 3-5

Key Math Terms: roller coaster, safety, experiment, physics, angle, acute angle, right angle, obtuse angle, slope, speed, height, distance, bar graph, landmark, maximum, minimum, median, mode, range, mean/average, ordered pair, perimeter, area, protractor, scale

Key Math Concepts:

- An angle is a figure that is formed by 2 rays or 2 line segments with a common endpoint called a vertex.
- An acute angle has a measure greater than 0 degrees and less than 90 degrees.
- A right angle is an angle that measures 90 degrees.
- An obtuse angle is an angle that measures more than 90 degrees and less than 180 degrees.
- A bar graph is a graph that shows relationships and data by the use of bars to represent quantities.
- Height is a measure of how tall something is.
- A landmark is a feature of a data set which includes median, mode, maximum, minimum, range, and mean/average.
- Maximum is the largest number in a set of data.

Key Math Concepts (cont'd):

- Minimum is the smallest number in a set of data.
- Mean/average is found by adding the numbers in the set and dividing the sum of the number of numbers.
- Median is the middle value in a set of data when the data are listed in order from least to greatest.
- Mode is the value or values that occur most often in a set of data.
- Range is the difference between the greatest and least values in a set of data.
- An ordered pair is a pair of numbers used to locate a point on a coordinate grid. The first number corresponds to a position along the horizontal axis, and the second number corresponds to a position along the vertical axis.
- Perimeter is the distance around a closed plane figure.
- Area is expressed in square units such as square miles, square inches, or square centimeters, and can be thought of as the approximate number of non-overlapping squares that will "tile" or "cover" the surface within a boundary.
- A protractor is a tool used for measuring or drawing angles.
- A scale is the ratio of the distance on a map, globe, or drawing to the actual distance.
- Speed is a rate that compares the distance traveled with the time taken to travel that distance.
- There is a relationship between the height of the first hill and the speed of the coaster.
- The shape of the first hill will determine how fast your coaster can safely travel on the track.
- The speed you are traveling determines the path you need to take to safely travel on the track.
- The second hill should help you maintain the thrill.
- The shape of the loop determines the speed it will take to safely get around the loop.

NJCCC Standards:

- **Number and Numerical Operations**
- 4.1A1 Use real-life experiences, physical materials and technology to construct meanings for numbers.
- 4.1B6 Count and perform simple computations with money.
- 4.1B7 Select pencil and paper, mental math, or a calculator as the appropriate computational method in a given situation depending on the context of numbers.
- **4.2 Geometry and Measurement**
- 4.2A4 Understand and apply concepts involving lines, angles, circles.
- 4.2C1 Locate and name points in the first quadrant on a coordinate grid.
- 4.2C2 Use coordinates to give or follow directions from one point to another on a map or grid.

NJCCC Standards:

- 4.2D2 Select and use appropriate standard units of measure and measurement tools to solve real-life problems.
- **4.4 Data Analysis, Probability & Discrete Mathematics**
- 4.4A1 Collect, generate, organize and display data in response to questions, claims or curiosity.
- 4.4A2 Read, interpret, construct, analyze, generate questions about, and draw inferences from displays of data.
- **4.5 Mathematical Process**
- 4.5A Problem Solving
- 4.5B Communication
- 4.5C Connections
- 4.5D Reasoning
- 4.5E Representations

5E's	Procedure	Assessment Attach all assessments	Materials/Handouts Attach all handouts
Engage Months: Sept/Oct	Key Questions: Did anyone go to an amusement during summer vacation? What kinds of rides did you see there? Did anyone ride a roller coaster?	Pretest- identifying and measuring angles, measuring to the nearest inch and half inch, Map scale conversions, finding area and perimeter, finding landmarks (max, min, median, range, mode, mean/average)	Chart paper markers "Roller Coaster" by Marla Frazee or Rollercoasters-I had so much fun, I almost puked by Marla Frazee Journals

	What makes a roller coaster a roller coaster? Key Concepts: Data analysis Procedure: * Students interview each other about their summer vacation. * Students collect data about summer activities. * Based on student results, a chart was created showing various rides at an amusement park (If no one mentions an amusement park then the teacher will tell about his/her trip to Great Adventure.) * Complete a Venn Diagram comparing and contrasting a roller coaster and a ferris wheel.	Students develop a hypothesis about how the height of the hill affects the speed and distance of the coaster.	What did you do last Summer? Questionnaire

Explore Months: Nov/Dec	Key Questions: What makes a good roller coaster design? Key Concepts: There is a relationship between the height of the first hill and the speed of the coaster. The shape of the first hill will determine how fast your coaster can safely travel on the track. The speed you are traveling determines the path you need to take to safely travel on the track. The second hill should help you maintain the thrill. The shape of the loop determines the speed it will take to safely get around the loop. Procedure: Students will go to the prescribed website and design their coaster.	Students will design their own roller coaster and test the safety of the design using the Annenberg/CPB Exhibits Design a Roller Coaster Website. Students will conduct experiments to help in designing a safe but exciting roller coaster and the design and create a cardboard "marble" roller coaster using paper, cardboard, and a marble using the following procedures:	Computer with internet connection www.learner.org/exhibits/parkphysics/coaster On-line Design Roller Coaster Worksheet Paper Cardboard Marble Scissors Tape Glue

Students will use materials to design the cardboard/paper track and use a marble to represent the roller coaster car.	**1.** Tell students they will be designing and constructing cardboard “marble” roller coasters that can have one hill or two hills, one loop or two loops or one hill and one loop. The marble in each design must start from the top of the first hill, roll up and down the other two hills, complete the loop and exit the end of the track. Each roller coaster will be judged in a class competition. The designs will be judged by how far the marble can go on the track without falling off and how basic or complex the design is. **2.** Have students consider the following when designing their roller coasters: • Can all the	Ruler Pencil Chart Paper

hills be the same height? If not, why? Can they get bigger or must they get smaller? How will you determine how big or how small the hills can be and still win this contest?

- Does the steepness of the hill count? Is it better to make the hills steep or not so steep? Why?
- How curvy should the tops of the hills and the valleys be? Should you design sharp turns or smooth turns? Why?
- What provides resistance on

the roller coaster causing the marble ball to slow down? How can this resistance be reduced?

Note: Leave students with enough time to make revisions to their original design—an important factor in the world of design and engineering.

3. Divide students into small groups and give each group the materials listed to create their coasters.

4. Judge the completed coasters using the rubric provided. The roller coaster with the greatest total points, whose marble successfully completed its journey, is the winner.

Explain Months: Jan/Feb	Key Questions: Why did your roller coaster design work? Why did it fail? Key Concepts: graphing on grid paper using coordinate points. Procedure: After teaching a mini-lesson on graphing and coordinate points, students will graph their roller coaster design on graph paper. Students then make a list of coordinates for their roller coaster design. Partners exchange their lists of coordinate points and try to recreate their partner's coaster design using their coordinate points. Students then cover the design in a piece of colored yarn.	Complete your "About your Coaster Design worksheet" Use yarn to create a 3-D picture of your roller coaster on graph paper.	About your coaster Worksheet Yarn Graph Paper Pencil Scissors Glue Stick

Elaborate Months: Mar/Apr	Key Questions: How is your roller coaster design using a marble similar or different to the roller coaster design using the K'nex? Key Concepts: Area and Perimeter Identifying Angles Procedure: Use the instructions on the box of K'nex to design the roller coaster.	Use K'nex to build a model coaster.	K'nex Screamin' Serpent Roller Coaster

Evaluate Months: May/June	Procedure: Give the students the Post Test. Have them re-read their original hypothesis and analyze it to see if their hypothesis was proven correct/incorrect. Explain. Have the students use the Design Rubric and judge the coaster designs and determine the winners for the awards for: Best Construction Function Aesthetic Teamwork Over-All	Post-test Re-evaluate hypothesis Judge the Coaster Challenge	Pre/Post Test Roller Coaster Design Rubric

Timeline: Create a timeline for this project.

Engage:
Sept/Oct – Pre-Test
Student Interview
Data Analysis
Read the Book “Roller Coaster”
Develop Hypothesis
Create KWL chart

Explore:
Nov/Dec - Play online Roller Coaster Design Challenge
Complete the “About your Design” worksheet
Cooperatively create Model Coaster using Engineering Design Process

Explain:
Jan/Feb - Analyze “About your Design” Worksheet Data
Create a 3-D Representation of Coaster Design on Graph Paper

Elaborate:
Mar/Apr - Build a model coaster out of K’nex
Find area and perimeter of coaster
Measure height of hills and loops

Evaluate:
May/June - Post-test
Re-evaluate hypothesis
Complete KWL chart