Rollercoaster

Design: Part 2

Purpose:
Students explore the most basic physical principles of roller coasters, which are crucial to the initial design process for engineers who create roller coasters. They learn about the possibilities and limitations of roller coasters within the context of energy conservation, frictional losses and other physical principles. After the lesson, students should be able to analyze the motion of any existing gravity-driven coaster and design the basics of their own model roller coasters.

Materials:

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- Foam Pipe Insulation
- Marbles (one large, one small)
- Masking Tape
- Meter stick, for measurement only

Procedure:
An amusement park has decided to open a theme park to be located in Landis, NC. It is an exciting time for the citizens of Landis. Finally, this small town will be put on the map for something big. The residents are anxiously anticipating the grand opening of the amusement park. However, the operators of the amusement park need your help. They want to design a new roller coaster with a car that runs as smoothly as a marble would down the track. Your team has been hired to design this new roller coaster track for this theme park. Your task is to design a model of the track you would like to build for this amusement park. Your model must demonstrate the law of conservation of energy, gravity, friction, and especially kinetic and potential energy.

You are only allowed to use the materials that are provided to you. You will be testing your design with a marble. The operators require:

- Three separate roller coaster design sketches on paper that includes at least one loop and one funnel.
- The sketches must include labels of potential and kinetic energy.
- A name that catches peoples attention
- A color scheme.
- The coaster must meet all specifications, you will have up to 3 class periods to build the coaster and submit it on the final day for testing.

Specifications

- The marble must roll continuously once it is released.
- Only duct tape may be used.
- You may use the room, walls, tables, and floors, to create your design using the pipe insulation and tape to connect it.
- Coaster may not reach vertical height of more than 36 inches but not less than 28 inches.
- Coaster must have at least one loop.
- Coaster must have at least one curve
- Coaster must have a least two hill
- Timing begins when the marble is released from the starting device and ends when the marble crosses the finish line.
- Draw each of the roller coasters your team builds on a separate sheet of design paper.

- Label the hills with the correct height, greatest potential energy and greatest kinetic energy.
- Label where the transformation of potential to kinetic energy begins.

Presentation (Part 3)

1. Students will present their roller coasters. The marble must stay on the track for the entire run.
2. Students will answer the below discussion questions during their presentations.

Consider the following when designing their roller coasters: These questions will be asked during your presentation.

1. Can all the 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?

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2. Does the steepness of the hill count? Is it better to make the hills steep or not so steep? Why?

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3. How curvy should the tops of the hills and the valleys be? Should you design sharp turns or smooth turns? Why?

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4. What provides resistance on the roller coaster causing the tennis ball to slow down? How can this resistance be reduced?

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Part 4: Budget

You will need to create an expense report for your roller coaster. You will have to account for everything you use. If it is not in your budget then you <u>will not</u> be able to use it. You may adjust your budget as you create your design on paper. Complete budget, using the assigned table.

Part 5: (Individual)
Analysis: on a separate sheet of paper, complete the following questions. THIS MUST BE TYPED

1. Explain two to three forms of energy used by the roller coaster to transfer energy. And explain the difference between two of them.

2. What changes did you make between your original design of your roller coaster and the final working model?

3. Explain why (or why not) your marble was able to complete the roller coaster.

4. Relate the principle of "conservation of energy" in an analysis of a roller coaster rides from start to finish. Include in your discussion the names of all relevant energy forms and where and when on the ride energy transformations are occurring.

5. Imagine that you are among the first group of passengers to test out a newly constructed roller coaster. The slide down the first hill is thrilling, but before you get to the top of the second hill, you start sliding backward and get trapped between the first two hills. Discuss what practicalities the designer forgot to include in transforming his creation from the idealized blueprint to the real world.

6. Some roller coasters feature an upside- down "loop." Explain why these features are always placed at the beginning of the ride and never near the end.

7. It's all fun and games until somebody gets hurt. Imagine that you are designing the world's ultimate roller coaster. Describe the features you would incorporate into your design and explain what limits you would put on those features to prevent fun from becoming dangerous.

8. Engineers always have to go back and re- design their drawings, either due to costs, supplies of materials, or changes made by the client. Reflect back and discuss what changes did you need to make to improve your roller coaster?

You will present your roller coaster to Mrs. Lees. Grades will be appointed based on the rubric:

Name: ________________________________ Class Period: _____

Rollercoaster

Part 1:

Background:

Students explore the physics exploited by engineers in designing today's roller coasters, including potential and kinetic energy, friction and gravity. First, they learn that all true roller coasters are completely driven by the force of gravity and that the conversion between potential and kinetic energy is essential to all roller coasters. Second, they consider the role of friction in slowing down cars in roller coasters. Finally, they examine the acceleration of roller coaster cars as they travel around the track. During the associated activity, student's design, build and analyze model roller coasters they make using foam tubing and marbles (as the cars).

Purpose:

Students will be able to design, describe and show how to calculate PE and KE as a marble moves along a roller coaster track. In addition, students will be able to show the relationship between PE and KE and how they are related to the principle of conservation energy.

Materials:

Foam pipe insulation tubing	Large marble	Plastic cup
Small marble	Wall or desk	Meter Stick

Procedure 1:

Design 1:

1. Build a roller coaster that has an initial height of 40 cm. You must have one loop and the marble must not leave the track.
2. Time the large marble as it goes down the track.
3. Find the mass of the large marble. Record your results on your data table.
5. Repeat the procedure 3 times.
6. Calculate the PE and the KE of the large marble.
7. Repeat the steps for the small marble.

Procedure 2:

Design 2:

1. Change only the starting point or initial height of your roller coaster to 70 cm.
2. Time the large marble as it goes down the track.
3. Find the mass of the large marble. Record your results on your data table.
5. Repeat the procedure 3 times.
6. Calculate the PE and the KE of the large marble.
7. Repeat the steps for the small marble.

Date Table 1: Height of roller coaster ____________ cm   Convert to meters = _________

Marble size	Mass of marble (g)	Mass of marble in Kg	Time 1	Time 2	Time 3	Mean Time (s)	GPE (J)	KE (J)
Large								
Small								

Date Table 2: Height of roller coaster ____________ cm Convert to meters: _______

Marble size	Mass of marble (g)	Mass of marble in Kg	Time 1	Time 2	Time 3	Mean Time (s)	GPE (J)	KE (J)
Large								
Small								

Analysis:

Calculate the PE and KE for each marble at each height.

1. Gravitational Potential Energy

- Calculate PE = mgh =

2. Kinetic Energy

- Measure the length of the foam tube. d = __________
- Calculate the speed at which the marble leaves the roller coaster (use the average time in your calculation): v = d/t =
- Calculate KE = ½ mv^2 =

Name:____ Period:_______ Date:_______

Discussion Questions:

1. How does the mass of the marble change the travel time? Does your data support your answer? Justify your answer.

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   ____

2. When you increased the height of the track, did this change affect the travel time of your marble? Would it increase or decrease you travel time? Justify your answer.

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3. How does the gravitational potential energy of the marble at the top of each hill compare for both designs? Can you explain why there is a difference?

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   ____
   ____

4. How does the kinetic energy (KE) at the bottom of each hill compare for design I and design II? Can you explain why there is a difference?

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5. In the absence of friction and other sources of energy loss, how should the values for the marble's PE at the beginning and KE at the end compare?

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   ____
   ____

6. In realistic analyses, frictional effects and energy loss must be accounted for. Was there a big difference in the PE calculated and the KE calculated for **design I**? Explain why or why not. Was the difference bigger or smaller than you expected?

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7. For **design I**, calculate the energy lost as the marble went through the roller coaster. (Hint: PE = KE + energy lost)

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8. Describe as many possibilities as you can think of for energy to be lost as the marble makes its way through the roller coaster.

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Rubric:

Lab write up Part 1

20	Students completed all questions/ data tables in the lab write up. Answers were completed in complete sentences. Calculations were completed and units were placed in the correct place.	
15	Students missed 2 questions/ data table in the lab write up. 1- 2 answers were not complete sentences. 1- 2 Calculations were missing and/ or the units were missing.	
10	Students did not complete 3 or more questions/ data table in the lab write up. Answers were not completed in complete sentences. Calculations and units were missing.	

Part 2 Design Poster

20 points	Student submitted a drawing with all required PE and KE labeled, Drawing is neat and accurate. Measurements for height of loop, hill, distance between loops, starting point are given .All units are correctly placed.	
15 points	Student submitted a drawing however 2- 3 points are missing for: PE and KE labeled, Drawing is neat and accurate. Measurements for height of loop, hill, distance between loops, starting point are given .All units are correctly placed.	
10 points	Student submitted a drawing however more than 5 points are missing for: PE and KE labeled, Drawing is neat and accurate. Measurements for height of loop, hill, distance between loops, starting point are given .All units are correctly placed.	

Part 3: Individual write up

20 points	Students answered all 8 questions correctly. All answer were in complete sentences. **Answers are typed**	
15 points	Students answered 6- 8 questions correctly. 6- 8 answer were in complete sentences. **Work was not typed**	
10 points	Students answered 3- 4 questions correctly. Answers were not in complete sentences**. Work was not typed.**	