Name:_________________________________

Roller Coaster Physics Lab

Background information:

Roller coasters have a long, fascinating history. The direct ancestors of roller coasters were monumental ice slides -- long, steep wooden slides covered in ice, some as high as 70 feet. Frenchmen imported the ice slide idea but because of the warmer climate the ice would melt. From there they began to build carts with wheels on tracks that eventually became more complex with multiple cars and more twists and turns.

A roller coaster is specifically engineered to invoke feelings of fright, height, speed, and weightlessness, without endangering its passengers. As you are building your own roller coasters out of tubing and marbles it will be important to remember what we have learned about energy. Objects in motion have energy, called Kinetic Energy (KE). KE is energy in motion. Any time something is moving, it has Kinetic Energy (KE). The faster it is going, the more KE it has. Gravity gives the marble energy to use for going down the hill. This is called Potential Energy (PE). It is the energy that your marble has at the top of the roller coaster hill before the marble falls. The steeper the hill, the more that gravity can pull the coaster down and the more KE can be released. When the marble is released the potential energy transforms into the energy of motion or kinetic energy. Throughout the marble's coaster ride it experiences a continual interchange of potential and kinetic energy as it rolls over the hills and through the loops, but at no time will the combination of the two be greater than the initial amount of potential energy at the marble's release height.

Key Question:

What roller coaster design will result in a more efficient transfer of gravitational potential energy (GPE) to kinetic energy (KE)?

Materials

- 1-3 meter section of ¾ inch inner diameter clear tubing
- 1 steel marble
- 1 cup (to catch the marble at the end of the track
- Masking tape
- Stopwatch
- Electronic balance
- 2 ring stands

Hypothesis:

If the curve of the track increases, then the efficiency of energy transfers from GPE to KE will **increase, decrease, remain the same** (circle one). Because____

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Procedure

Design 1:

- Design a **straight** roller coaster using clear tubing, masking tape, and a small steel marble. The roller coaster should begin near a high surface and end on the floor (Do not stand on chairs or tables). After your roller coaster has been built and tested, make the following measurements/calculations.
- Mass of marble: ___________ g = ___________ kg
- Choose h=0 m to be at table level, which means the table top has a potential of zero. Measure the height from which the marble is released (mark it): ___________ m
- Calculate GPE= mass$^{(kg)}$ times gravity times height $^{(m)}$ = mgh____________________ Joules. Show all of your formulas and work
- Measure the velocity (v=d/t) at which the marble leaves the roller coaster.
- Mark off a distance on a meter stick to measure the speed of the marble as it leaves the roller coaster. d=___________ m
- Release the marble from the height that you measured and time how long it takes the marble to travel the marked distance, d, on the floor. Make four measurements and take an average (find the best value) record this information in Data Table 1.

Design 2:

Design another roller coaster using the above procedure. This time make curves in the track. Once again, the roller coaster should begin near a high surface and end on the floor. Record your calculations and data in Data Table 1.

Design 3

Using the same procedure as the previous two roller coasters, design a third roller coaster. This time make even more curves in the track. The roller coaster should begin near a high surface and end on the floor. After your roller coaster has been built and tested, make the following measurements/calculations.

Data:

Data Table 1										
Trials	**Marble Mass (kg)**	**Height (m)**	**Length (m)**	**Time (s)**	**Time (s)**	**Time (s)**	**Average Time (s)**	**Velocity v=d/t**	**KE ½ mv^2**	**GPE mgh**
Design 1										
Design 2										
Design 3										

Graph:

Create a bar graph of your data. Graph your responding variable (joules) on the y-axis and your manipulated variable (roller coaster design on the x-axis). Make sure to: A) label of x and y-axis, B) units labeled for x and y-axis, C) determine an appropriate unit between tick marks, and D) title of graph.

Graph Title_______________________________________

Analysis Questions

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

2. In realistic analyses, frictional effects and energy loss must be accounted for. Was there a big difference in the GPE calculated and the KE calculated for **design 1**? Explain why or why not. Was the difference bigger or smaller than you expected?

3. For **design 1, design 2 and design 3**, calculate the energy lost as the marble went through the roller coaster. (Hint: GPE = KE + energy lost)

4. For **design 1, design 2 and design 3** calculate the percentage of available energy lost (energy lost/ GPE x100) during the ride.

5. Giving specific examples that relate to your roller coaster (**design I**), what were some of the ways that you observed energy being lost throughout the marble's journey?

6. Was there a big difference in the GPE calculated and KE calculated for **design 1 vs design 2 and design 1 vs design 3**? Explain why or why not. Was the difference bigger or smaller than you expected?

7. Which design proved for a more efficient transfer of energy? Why?

Conclusion

Citing the evidence from your lab write a conclusion answering the key question: What roller coaster design will result in a more efficient transfer of gravitational potential energy (GPE) to kinetic energy (KE)? (Remember a good conclusion cites all the available evidence and does not contain opinion)