the YMCA MARBLE ROLLERCOASTERS

Work in groups to create functional tube-tastic marble rollercoasters. Explore gravity, speed and friction through various construction challenges.

SYNOPSIS: Students employ engineering and collaboration skills to build a roller coaster with specific characteristics to understand:

- **Relationship b/t potential and kinetic energy**
- **Transformation of energy from one type to another**
- **Gravitational potential**
- **Law of Conservation of Energy**

MATERIALS: Each group needs:

- **2-meter (6 foot) long foam tube (1/2" pipe insulation) cut in half lengthwise (Usually, one side of the tube comes perforated, making it easy to use scissors or a utility knife to cut through the perforation and the other side of the tube to form two halves, essentially making two long channels perfectly shaped to hold marbles; thus, one cut tube provides the track material for two groups; see Figures 1 and 2.)**
- **glass marble**
- **wooden marble**
- **steel marble**
- **paper or plastic cup**
- **rolls of painters tape**
- **set of markers, crayons or pencils**
- **blank sheet of paper**
- **stopwatch**

INTRODUCTION (5 MINUTES):

Has anyone ever been on a rollercoaster? Does anyone know how roller coasters work?
You might think that the roller coaster cars have engines inside them that push them along the track like an automobile. While that is true of a few roller coasters, most roller coasters use gravity to move along the track.

Do any of you remember riding a roller coaster that started out with a big hill?
If you looked closely enough, you would see in the middle of the track on that first hill, a chain. You might have even felt it "catch" to the cars. That chain hooks on to the bottom of the cars and pulls them to the top of that first hill, which is always the highest point on a roller coaster. Once the cars are at the top of that hill, they are released from the chain and coast through the rest of the track, which is where the name roller coaster comes from.

Today we are investigating Roller Coaster Physics... so what is physics? What are some key words included in defining physics?
Physics is the science that deals with matter, energy, motion, and force. Physics is the natural science that involves the study of matter and its motion through space and time, along with related concepts such as energy and force. More broadly, it is the general analysis of nature, conducted in order to understand how the universe behaves.

Explain what we're doing today: Today we will be exploring how roller coasters move through space and time while transforming energy due to motion and force. You all will be working together in groups to build mini-rollercoasters. You will need to communicate with your group, and harness your creativity and perseverance. The goal today is for you all to explore and think about different types of energy and energy transformations, through the designing and testing of roller coasters. You all will spend most of your time building and testing your rollercoasters. For the first 10 minutes, you will be able to explore designs, mandatorily including ONE loop of any and/or different sizes. Feel free to adhere the pipe to the chairs, wall, and table. After 10 minutes of exploration, you will all come back to your seats, facing the middle, and we will have a discussion about the discoveries you made in your exploration period. Then we will dive into your challenges.
Questions?

EXPLORATION: (10 MINUTES)

Groups receive 3 half-pipe insulation tubes, 1 yard of tape, and 2 ball bearings. Groups explore different sizes of loops and note the changes they have to make to their coaster in order for the ball bearing to successfully complete the included loop, without the ball bearing leaving the track.

INTERMISSION/PROCESSING: (5 MINUTES)

What are some things you discovered or noticed in your explorations? What are some types of energy involved in rollercoasters?
(kinetic, potential, gravitational potential, etc.)
How do rollercoaster and trains differ, or alike?
Trains consist of a series of connected cars that move on tracks like trains, but trains' power source self-created (burning fuels, for example). For most of the ride, a coaster is moved by gravity and momentum. To build this momentum, the coaster must begin at the top of a hill/incline, or it must be given powerful launch (EX: elastic potential or push by engine).

LET'S LOOK AT THIS SYSTEM:

DO loop demo, discussing energy from one point to another.

Energy in a system, like a roller coaster, may take on various forms. What do we mean by system? A certain amount of energy involved, can be transformed but the amount stays the same. What does the law of conservation of energy state? Energy may neither be created nor destroyed. Therefore the sum of all the energies in the system is a constant. What does that mean, the sum of all the energies in the system is a constant? Restate the meaning of the LoCoE.

Let's apply what we have been discussing into your challenges...
Give challenge and parameters...

CHALLENGE: (20 MINUTES)

Give challenge and parameters...

For the sake of this activity, the physics behind roller coasters will be simply divided into 4 main parts:

1. **HEIGHT: of starting point and peaks, in accordance with the amountof gravitational potential energy (GPE)**
2. **Loop-to-loop: 8" diameter single loop challenge, double loop challenge (students need 4 pipes)**
3. **Hill with jump: 2" gap between hill and landing spot on track**
4. **Slowing to stop: use given available materials for friction to bring coaster to a stop at the end**

CLEAN-UP: (5 MINUTES)

Students disassemble coasters and return materials.