PHYSICS OF ROLLER COASTERS

Duration: 90 minutes
Institution: The Tech Museum of Innovation
Skill level/Age Level: 2nd -12th Grade
Group size: Variable, depending on space constraints; roughly 10-30 participants

INTRODUCTION

They love to ride them, now they'll love to build them! Students explore potential and kinetic energy and apply what they learn to build their own roller coasters made of foam tubing, tinker toys, and marbles.

KEY CONCEPTS AND/OR SUBJECT AREA

- Gravity
- Potential energy
- Kinetic energy
- Law of Conservation of Energy
- Iteration-toward-innovation design process

MATERIALS AND TOOLS

Essential Materials:

- 6' & 2' pieces of foam pipe insulation, cut in half length-wise to create an open track
- Tinker Toys
- Marbles
- Plastic cups
- Masking Tape
- Pencils
- Paper
- Pictures of roller coasters

Tools:

- Rulers
- Stopwatches
- Calculators

SET UP

On the instructors' table, set out the foam track, pictures of roller coasters, and any other supporting materials desired (customize the amount of scientific principles discussed based on participants skill/knowledge levels).

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Set out enough tables to support the number of participants; you'll want to break them into groups of around 4. Place a marble, plastic cup, box of Tinker Toys and a ruler on each table. For 8th-12th grade participants, include paper, pencils, a stopwatch and calculator on the tables.

HOW TO OR STEP-BY-STEP

1. Invite participants into the workshop area. Ask them to divide into groups of 4 and be seated. Discuss roller coasters with the participants; use this time to gauge the scientific knowledge of the groups. Here are some example question used by our lab instructors:
    a. Who likes roller coasters? Why do you like them? Why are they fun/scary?
    b. What makes them go fast? How does a roller coaster work? Does a motor push it?
2. Introduce the first design challenge and constraints. We begin with having the participants create "Jumping Marbles".
    a. Design a freestanding ramp for a marble to travel on that will allow it to jump and land in the plastic cup. Set a minimum distance; for example 50 cm from the end of the ramp to the cup.
    b. Constraints:
        i) You may not use human force to get the marble started on the track. (*No pushing!*)
        ii) Your roller coaster must be stable and supported using only the given materials.
        iii) Your roller coaster must be reliable; it must work 4 times in a row.
        iv) The distance of the jump is measured when the marble leaves the ramp.
        v) You have 15 minutes to build. (Adjust the build time based on the participants' abilities.)
3. Allow participants to build. Assist with any material requests but try to limit giving any design hints. Instead use guided inquiry to help them think critically about their design and reinforce the scientific concepts introduced.
4. After 15 minutes has elapsed, have participants demonstrate their creations. Have everyone gather to closely observe the tests. Ask questions to help prompt the participants' reflection. What design elements worked? Why? What challenges did they face? After everyone has tested have the groups return to their seats.
5. You can use this time to introduce more advanced scientific concepts, such as potential and kinetic energy, gravity, inertia, friction and the Law of Conservation of Energy.
6. Introduce the second design challenge "Incorporating a Loop".
    a. Design a freestanding roller coaster with at least one vertical loop that the marble will travel across (without falling off) and then land in the plastic cup. Students may use additional building materials. Students can use their existing ramp, or create a new one.
    b. Constraints:

i) The marble must complete the course while staying on the ramp.
ii) You may not use human force to start the marble on the track.
iii) Everyone in the group must participate.
iv) You have 15-20 minutes to construct your roller coaster.
v) Additional constrains for advanced groups:
   (1) Create 2-3 freestanding vertical loops.
   (2) End the roller coaster with a jump that lands in the cup.

7. After the build time has elapsed, have the participants demonstrate their creations. Have each group explain their design strategy and where their track has the most potential and kinetic energy. Ask questions to help prompt the participants' reflection. How did you change your original design? What affect did this/these change(s) have upon the performance of your roller coaster? If you had more time what would you add, change, or do differently?
8. Recap with the participants. Emphasize that they have all worked as an engineer: prototyping, testing, revising and learning from others.

MATERIALS SOURCES

Foam tubing can be purchased from your local hardware store.

KEYWORDS

- Roller Coaster
- Indoor
- Tinker Toys
- Non-consumable materials

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