Berkeley Engineers and Mentors

Falling with Style: Moment of Inertia Design Challenge

Lesson Type: Engineering + Building
Target Grade: Elementary/High School
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Brief Overview/Challenge

The challenge is to build a "top" that falls to the ground *as slowly as possible*. The goal of this lesson is to teach students about gravity and the principles behind rotational moment of inertia. Also the students will work through the engineering design process.

Teaching Goals

- Learn about gravity
- Learn about rotational moment of inertia
- Work through the engineering design process

Agenda

- **Introduction** (5 min)
  - Introduce the design challenge. Build a device that unrolls as slowly as possible.
  - Show them a basic design with a skewer and two small cardboard sides.
- **Build** (20 min)
  - Distribute materials after introduction.
  - Every group, or individual student if they want to work alone, gets a skewer. They can request other materials.
- **Test** (10 min)
  - Test the students' designs
  - Review what went well
- **Rebuild** (10 min)
  - Have the students modify their designs to make them better.
- **Final Test** (10 min)
  - Test the students' designs
- **Recap** (5 min)
  - Go over what went well and what didn't go well for the building

Materials

- Skewers or straws 20 per class.
- Cardboard 4 - 5 square feet per class.
- Paper 20 sheets per class
- Tape 2 rolls per class
- Scissors 2 per class
- String 3 feet per student
- Assorted weights. Wood, plastic, or metal blocks.

Procedure/Tips for building

- Tape the string to the skewer and wind it around the skewer.
- Putting mass as far from the center as possible will increase moment of inertia.
- The string must be placed at the center of the skewer and mass must be balanced on both sides of the skewer to that the string unrolls

Material to Teach

- Moment of inertia equals mr^2. The students can think about it as a lever in reverse.
- Gravity, it pulls everything down. Its force is a result of the masses of the two objects involved.
- Use the analogy of the ice skater. They pull their arms inwards when they want to speed up their rotation.
- The reason why something at a larger radius have more inertia is because it need to travel a larger arc to move the same angle.
- There is a fine balance between adding more stuff to increase the moment of inertia and making it fall faster with increased weight.

Background for Mentors

- Acceleration of the device will be determined by energy balance
- Mass of device x gravity – Moment of inertia x angular acceleration = Mass of device x acceleration
- Moment of Inertia = mass x Radius^2
- Because of the skewers tiny diameter, you can ignore its force.
- The focus of the lesson was to learn about moment of inertia, if you want to restrict your student's ability to use air resistance that might be good.

Summary Materials Table

- For Logistics' convenience, have a summary materials table for each modules at the very end of the lesson on a separate page
- Make sure to include a vendor link or picture to ensure that logistics buys exactly what you want

Material	Amount per Class	Expected $$	Vendor (or online link)
Tape	2		
Skewers or	20		

straws.			
Cardboard	8 square feet		
String	50 feet or 3 feet per student		
Paper	20 Sheets		
Scissors	2		