Interactive Gumball Machine

Lesson Focus

Students explore potential and kinetic energy while working in teams to design and build an interactive gumball machine.

Lesson Synopsis

Students learn about the history of gumball machines and explore potential and kinetic energy while working in teams to build a gumball slide. Teams then design and build their own interactive gumball machine.

Age Levels

10-18

Objectives

- Explore potential and kinetic energy.
- Design & build an interactive gumball machine.
- Implement the engineering design process to solve the design challenge.

Anticipated Learner Outcomes

As a result of this activity, students will have:

- Explored potential and kinetic energy
- Designed & built a interactive gumball dispenser
- Implemented the engineering design process to solve the design challenge.

Lesson Activities

Students will begin this lesson by reading about the history of gumball machines. Next, students will work in teams to design and build a gumball slide. Students will contemplate the science behind the slide and answer questions about gravity, kinetic energy, and potential energy. Finally teams build upon their slides and design and build devices that will dispense gumballs in a fun and innovative way!

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- History of Gumball Machines (www.gumballs.com/history.html)
- TryEngineering (www.tryengineering.org)

Recommended Reading

- Vending Machines: An American Social History (ISBN: 978-0786413690)
- Vending Machines (ISBN: 978-0981960012)

Optional Writing Activity

- Have students write short stories about a "day in the life" of their gumball machine. Who does the gumball machine meet and what happens? How does the gumball machine change the lives of the kids who get a gumball from it?
- Students could also create an ad to draw more customers into the toy store. They should feature the interactive gumball machine in the ad. Why should kids come to this toy store? Why is the interactive gumball machine a must visit?

For Teachers: Teacher Resource

Lesson Goal

The goal of this lesson is for students to design a gumball slide. Teams then build upon their slides and design and build devices that will dispense gumballs in a fun and innovative way!

Lesson Objectives

- Explore potential and kinetic energy.
- Design & build an interactive gumball machine.
- Implement the engineering design process to solve the design challenge.

Materials

Activity 1: History of Gumball Machines

- History of Gumball Machines Worksheet

Activity 2 & 3: Gumball Slide & Interactive Gumball Machine

Put all the materials for activity 2 & 3 onto a resource table

- Cardboard Boxes
- 2 Liter Plastic Bottles
- Gumballs (or marbles to represent gumballs if your school does not allow gum)
- Paper Cups
- Popsicle sticks
- Dowels
- Skewers
- Clay
- Pipe cleaners
- Scissors
- Rubber Bands
- String
- Paper clips
- Binder clips
- Card stock and/or file folders
- Cardboard Pieces (cut up a few boxes into different size pieces)
- Masking tape
- Glue
- 6’ Tubing (pipe insulator cut in half lengthwise) – minimum of 1 per team
- Xacto Knife (For Teacher)
- Gumball Slide Worksheet
- Interactive Gumball Machine Worksheet
- Stopwatch (one per team for activity 2)
- Wastepaper basket (for younger children – activity 2)

For Teachers:

- **Time Needed**
  - Activity 1: History of The Gumball Machine (1/2 hour)
  - Activity 2: Gumball Slide (1 hour).
  - Activity 3: Interactive Gumball Machine (1-2 hours)

- **Procedure**

Activity 1: History of Gumball Machines (1/2 hour)

1. Read the history behind gumball machines and discuss as a lead into the main design challenge.
2. Ask students what kind of vending machines they have seen before and what kind of vending machines they would like to have at school or in the town/city.

Activity 2: Gumball Slide (1 hour)

1. Break students into teams of 3-4.
2. Set up a resource table with all of the materials for this activity and activity 3.
3. Explain to students that in preparation for an upcoming design challenge they will explore gravity and energy by making a gumball slide.
4. Hand out copies of the gumball slide challenge and discuss the criteria, constraints, and questions.
5. Have students work in teams to build their gumball slide. Give about 20 minutes to complete the task. (Note: for younger kids, use a wastepaper basket instead of cups to catch the gumballs)
6. Students will follow the engineering design process:
   - Brainstorm solution to the challenge
   - Choose best solution
   - Build the prototype
   - Test the prototype
   - Redesign prototype
   - Share the final design with class
7. Have each team demonstrate their slide and respond to questions.
   - What makes the gumball begin to move down the slide? (Gravity)
   - What kind of energy does the gumball have before you release it? (Potential energy)
   - What kind of energy does the gumball have after you release it? (Kinetic energy)
   - Where will you find the greatest amount of potential energy? Why? (The top of the slide, because it the highest point on the slide, PE=mgh)
   - Where will you find the greatest amount of kinetic energy? Why? (The bottom of the slide, because the gumball will be moving fastest there, $KE=1/2mv^2$)

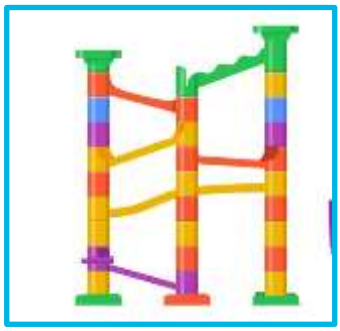
For Teachers (continued):

- Is the gumball doing work? Why? (Yes, it has force acting on it and moves a distance down the slide, W= fd)
- How did you make your gumball go faster down the slide? (Increase the slope of the slide or the length or both.)
- Where will you place your cup in order for the gumball to land in it? (This will be different for each team.)
- Why does the gumball want to keep going? (Momentum)
- How could you slow the gumball down? (Introduce friction)

Activity 3: Interactive Gumball Machine (1-2 hours)

1. Handout the interactive gumball machine design challenge and discuss.
2. Take time to discuss what interactive or interaction means. Ask student to define it and then provide some examples.
   - Interaction- is a kind of action that occurs as two or more objects have an effect upon one another.
   - Interactive- acting with each other.

   Example: Video Games- interaction between user and game. It is interactive because it requires the user to participate for the game to move forward.
3. To get students thinking about how their gumball machine will be interactive you could show the photos below:

	
This spiral gumball machine is fun to watch but is not interactive. How could you make it interactive?	This is an interactive marble game. The user moves the pieces with holes and slides to get the marble to the bottom.

4. Remind students to follow the engineering design process.
5. Students will share their final design with the class by sharing its name and demonstrating it.

Teacher Resource: Vocabulary

- **Motion:** A change in position of a body with respect to time as measured by a particular observer in a frame of reference.
- **Mass:** The quantity of matter in a body.
- **Weight:** The force of the gravitational attraction of the earth on the body.
- **Acceleration:** The rate at which an object changes its velocity. An object is accelerating if it is changing its speed or direction. An object is accelerating if it is changing its velocity (both speeding up of slowing down).
- **Gravity:** The force of attraction by which objects tend to fall toward the center of the earth.
- **Force:** A push or pull on an object resulting from an object's interaction with another object.
- **Friction:** A force that resists motion of an object.
- **Speed:** How fast an object is moving.
- **Velocity:** The rate at which an object changes its position.
- **Momentum:** Mass in motion. The amount of momentum depends on how much stuff is moving and how fast the stuff is moving.
- **Work:** Force acting on an object to move it across a distance. The formula for work is W = fd. [f= force applied to object, d = displacement of object]
- **Energy:** The capacity to do work. You do work when you use a force (push or a pull) to cause motion.
- **Potential Energy:** Energy of position. The amount of potential energy depends on the mass and the height of an object. The formula for potential energy is PE=mgh. [m = mass of object, g = acceleration due to gravity (9.8 m/s^2), h = height of object]
- **Kinetic Energy:** Energy of motion. All moving objects have kinetic energy. The amount of kinetic energy depends on the mass and speed of an object. The formula for kinetic energy is $KE=1/2mv^2$. [m = mass of object, v = velocity of object]

Student Resource: Gumball Slide Challenge

Challenge

Design a slide for your gumball to travel down as fast as possible and land in a cup.

Criteria & Constraints

- The gumball must stay on the "track."
- You cannot push the gumball to start.
- The gumball must land in a cup. (Where you place the cup is up to your team)
- The slide must be self-supporting (stand on its own).

Questions

- What makes the gumball begin to move down the slide?
- What kind of energy does the gumball have before you release it?
- What kind of energy does the gumball have after you release it?
- Where will you find the greatest amount of potential energy? Why?
- Where will you find the greatest amount of kinetic energy? Why?
- Is the gumball doing work? Why?
- How did you make your gumball go faster down the slide?
- Where did you have to place your cup in order for the gumball to land in it?
- Why does the gumball want to keep going?
- How could you slow the gumball down?

Student Worksheet:
Interactive Gumball Machine Design Challenge

Scenario

A local toy shop needs to attract more customers so they asked your class to help them by creating a special display that will be set up in the center of the store and will be fun for kids- an interactive gumball machine!

Design Challenge

Design and build a fun interactive gumball machine that will draw customers into the toy store.

Criteria

All designs must:

- keep the gumball on the track,
- have one interactive element,
- have a minimum of 1 loop,
- be self-supporting (stand on its own), and
- be as creative as possible.

Constraints

- You must use only the materials provided.

Student Worksheet (continued):

Team members:_____

Interactive Gumball Machine Name: _____

◆ Planning Stage

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your gumball machine. You'll need to determine what materials you want to use. Draw your design in the box below, and be sure to indicate the description and number of parts you plan to use.

Brainstorm designs for your gumball slide:

Choose your best design and sketch it here:

Student Worksheet (continued):

◆ Construction Phase

Build your gumball machine. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

◆ Testing Phase

Each team will test their gumball machine. If your design was not successful redesign and test again, until you are happy with it. Be sure to watch the tests of the other teams and observe how their different designs worked.

Sketch your Final Design

◆ Evaluation Phase

Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

Student Worksheet (continued):

Use this worksheet to evaluate your team's results in the Interactive Gumball Machine Lesson:

1. What went well?

2. What didn't go well?

3. What is your favorite element of your interactive gumball machine?

4. If you had time to redesign again, what changes would you make?

For Teachers: Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Motions and forces
- Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- History of science

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Motions and forces
- Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Historical perspectives

◆Next Generation Science Standards Grades 3-5 (Ages 8-11)

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Energy

Students who demonstrate understanding can:

- 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

For Teachers: Alignment to Curriculum Frameworks

◆Next Generation Science Standards Grades 3-5 (Ages 8-11)

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Energy

Students who demonstrate understanding can:

- MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆Standards for Technological Literacy - All Ages

Technology and Society

- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.