Mechanics

Homemade Rube Goldberg Machine **Primary Audience: Families**

Description: In this fun and, at times, hilarious force and motion activity, learners will use household objects to build a crazy contraption and see how far they can get a tennis ball to move. This is an excellent activity to explore all of the various forces that can act upon an object. Try visiting www.rube-goldberg.com for inspiration for your contraption.

Keywords: Energy, Force and Motion, Engineering

Concepts:

- **Kinetic energy** is energy that a body possesses as a result of its motion.
- **Potential energy** is stored energy. The energy is stored by doing work against a force such as gravity, a spring in a clockwork motor, or even an electromagnetic field.
- **Engineering** is the branch of science and technology concerned with the design, building, and use of engines, machines, and structures.

Materials:

- kitchen gadgets
- tools
- string
- rubber bands
- tennis ball or racquetball
- fasteners, like Velcro or tape
- lots of space!

Instructions:

Rube Goldberg Machines complete a simple task using a variety of simple and/or complex machines. Can you create your own machine capable of completing a simple task? How many different simple machines can you use in your design?

Start with a simple challenge; move a ball along a track to knock something over.

Once you've completed this simple task, challenge yourself and your friends to work

Mechanics
together to create a complex machine that completes 1-2 simple tasks. Be creative!

Possible Interactive Questions:

- Why did the ball sometimes roll off the side of the machine? How can you ensure that the ball stays on the machine for the entire run?
- What forces are acting on the marble as it travels through the machine? Can you affect these forces by altering other variables?

What's Going On?

Gravity is the driving force of many Rube Goldberg Machines. From the moment the ball passes the peak of the first hill, it is the acceleration due to gravity that brings it to the end. When the ball is released from the top of the hill, gravity pulls it down. The ball begins slowly, and then picks up speed as it approaches the bottom of the hill.

As the ball begins its descent from the hill, its velocity increases. This causes the ball to gain kinetic energy, which is the energy of motion. The faster the ball moves, the more kinetic energy the ball gains.

Energy cannot be created or destroyed, but it can be converted from one form to another. For the idealized machine, all energy is conserved through conservative forces, such as gravity. As the ball accelerates down a hill, potential energy is converted into kinetic energy. When the ball ascends another hill, the kinetic energy is converted into potential energy again. This is conservation of mechanical energy, and it continues throughout the entire machine.

Friction is the main cause of energy leaks in the system and the reason why mechanical energy is not fully conserved. Friction opposes motion by working in the opposite direction. The friction between the ball and its path as well as between the ball and the air take energy out of the system, slowing the ball and creating both heat and sound. This effect is most noticeable at the end of the machine as all remaining kinetic energy is taken out of the system and the ball comes to a stop. Because of the energy leaks due to friction, each successive hill, loop, turn, bounce, etc,within the machine must be shorter, smaller, easier, etc. than all the previous activities; otherwise the ball will not have enough energy to make it all the way.

Further Exploration:

1. Can you make your machine more complex? Invite the participants to utilize as much material as available to make the most exciting machine possible.

Relevant Ohio Science Content Standards:

- Science and Technology K-2 A: Explain why people, when building or making something, need to determine what it will be made of, how it will affect other people and the environment.

Mechanics

- 1.1: Explore that some kinds of materials are better suited than others for making something new (e.g., the building materials used in the Three Little Pigs).

- Science and Technology K-2 B: Explain that to construct something requires planning, communication, problem solving and tools.
  - 2.4: Communicate orally, pictorially, or in written form the design process used to make something.
- Science and Technology 3-5 B: Describe and illustrate the design process.
  - 3.4: Use a simple design process to solve a problem (e.g., identify a problem, identify possible solutions and design a solution).
  - 3.5: Describe possible solutions to a design problem (e.g., how to hold down paper in the wind).
  - 4.3: Describe, illustrate and evaluate the design process used to solve a problem.
  - 5.2: Revise an existing design used to solve a problem based on peer review.
- Science and Technology 6-8 B: Design a solution or product taking into account needs and constraints (e.g., cost, time, trade-offs, properties of materials, safety and aesthetics).
  - 6.5: Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
  - 7.4: Design and build a product or create a solution to a problem given two constraints (e.g., limits of cost and time for design and production or supply of materials and environmental effects).
  - 8.3: Design and build a product or create a solution to a problem given more than two constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
  - 8.4: Evaluate the overall effectiveness of a product design or solution.
- Physical Sciences 9-10 Explain the movement of objects by applying Newton's three laws of motion.
  - Demonstrate the ways in which frictional forces constrain the motion of objects (e.g. a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).