Micro Automata

Category: Physics: Force & Motion

Type: Make & Take

Rough Parts List:

1	Clear plastic cup, large
2	Bamboo skewers
1	Straw
2-4	Circles made from cardboard, foamcore, bottlecaps, etc.
	Cardboard or foam core scraps for handles and stopper pieces
	Decorations for tops

Tools List:

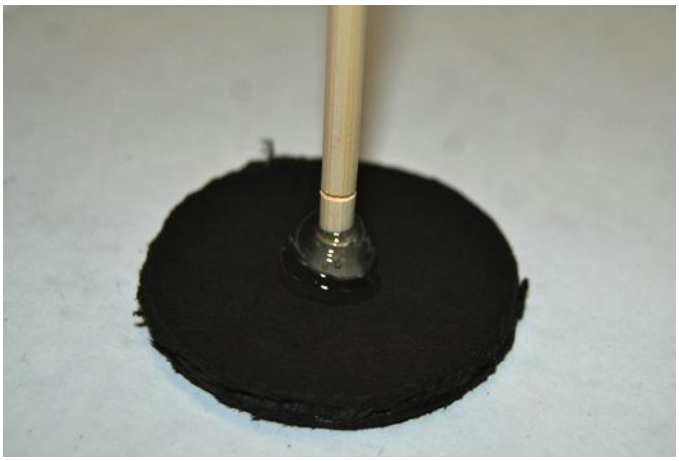
Screwdriver
Scissors
Hot glue gun

Video: www.youtube.com/watch?v=g4S2G14d_vM&feature=plcp

How To:

Punch 2 holes into the sides and
1 hole through the bottom of a cup.
Use a screwdriver or the tip of a glue gun to punch the holes.

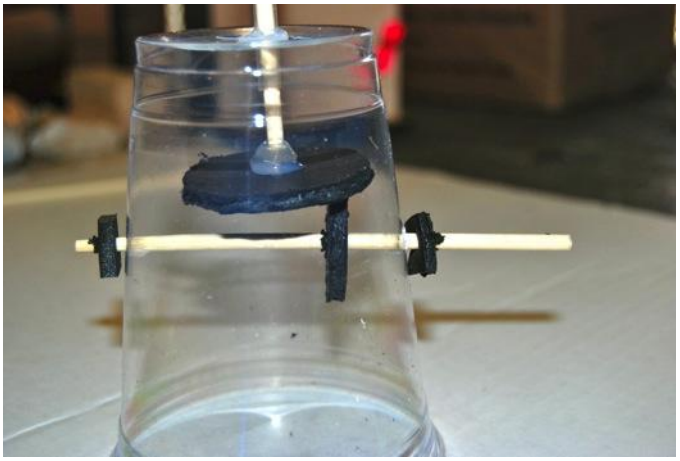
Cut 2" of straw, stick it through the hole in the bottom of the cup, and glue it into place.



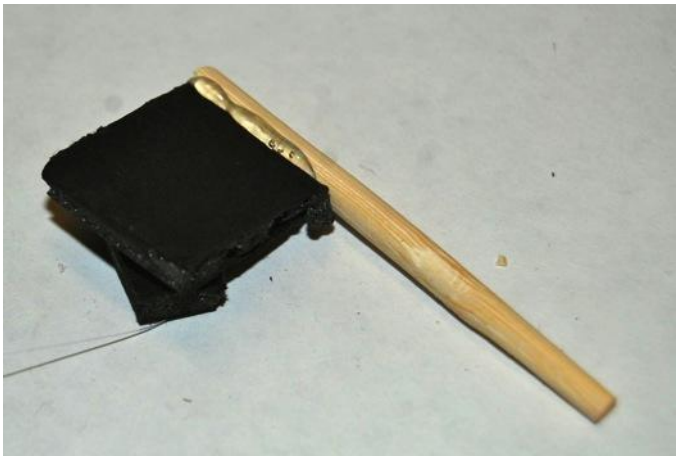
Glue a circle onto the tip of a bamboo skewer and stick the skewer through the straw in the bottom of the cup.

Trim excess length off the skewer.

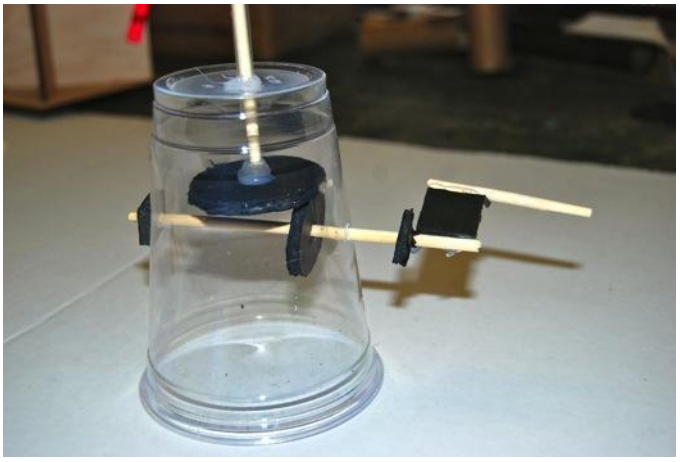
Slide a skewer through a side hole, through a circle, and then through the 2nd side hole. This is the crankshaft.



Slide stopper pieces of foam core or cardboard onto both ends of the crankshaft.



Build a handle by gluing foam core or cardboard to one end of a bamboo skewer.



Glue the handle to the crankshaft. You have just created a crank!

Decorate the top of the bamboo skewer.

Turn the crank and watch your creation move! Create different effects by placing the bottom circle in different locations.

Fine Points:

→ To make sure your skewer lines up, after making one hole in the side of the cup, insert the skewer into the cup until it touches the other side, and mark the position of the second hole so the skewer is parallel to the top of the cup.

→ To build a model that moves up and down without turning, place the skewer through the bottom circle off-center. When turning the crank, make sure the bottom circle touches the very middle of the top circle.

→ To build a model that moves up and down and turns around, place the skewer through the bottom circle off-center and have the bottom circle touch near the edge of the top circle when turning the crank.

Concepts Involved:

- The wheel and axle is a simple machine that can act as a lever to provide mechanical advantage. A crank allows you to turn a wheel and/or axle by providing a force at a distance from the center.
- Cranks can convert circular movement into up and down (reciprocating) motion.
- Forces applied to the edges of wheels can result in a mechanical advantage, which is the multiplication of the original force applied. Likewise, forces applied to the shaft of a wheel can create an advantage of distance, which means you may have to provide a larger force, but the resulting motion is over a larger distance.

Focus Questions:

1. How would your machine move if you used a larger circle on the crank shaft? A smaller circle?
2. Try turning the skewer without the handle. Is it easier or more difficult to turn? Does your automaton move slower or quicker? What if you had a bigger handle?
3. How would your automaton move if you had used smooth, slippery circles? Rough, bumpy circles?
4. Do you have any toys that move? How do they move? Can you build something similar?

Elaboration:

Automata are self-operating machines that typically consist of a clockwork statue or scene and were first created centuries ago in Europe and Asia. In many ways they were the direct ancestor of what became electro-mechanical robots. Many modern toys use electric motors to achieve movement, but they still rely upon gears and other principles of simple machines. For our purposes, the automaton is a good way to explore the machine's function of converting one form of energy and motion to another. They are also a way to teach simple mechanical problem solving skills.

The bottom circle inside the plastic cup on the crank is referred to as a cam. A cam is a mechanical linkage that transforms rotary motion into linear motion, or vice versa. A car engine is a familiar machine that converts the up and down (reciprocating) motion of the pistons to rotary motion to drive the car's wheels. For this automaton, using a cam that grips the other circle well (higher friction coefficient) results in a more efficient machine and less mechanical energy lost.

The handle is a type of crank that utilizes torque. Torque is the tendency of a force to rotate an object around an axis. Torque is directly proportional to the product of the force applied and the length of the lever arm, which is the distance between the axis and point of force application. If we didn't use a handle, the automaton would be more difficult to turn. A door swinging on its hinges is an example of rotational motion. Try to open a door by pushing it very close to the hinged edge. Another thing rotating on a door is the handle itself. A larger handle makes it easier to turn because the lever arm - the crank - is longer.

Links to k-12 CA Content Standards:

Grades k-8 Standard Set Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other strands, students should develop their own questions and perform investigations.

Grades k-12 Mathematical Reasoning:

1.0 Students make decisions about how to approach problems:
1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
1.2 Determine when and how to break a problem into simpler parts.

2.0 Students use strategies, skills, and concepts in finding solutions:
2.1 Use estimation to verify the reasonableness of calculated results.
2.2 Apply strategies and results from simpler problems to more complex problems.
2.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

3.0 Students move beyond a particular problem by generalizing to other situations:
3.1 Evaluate the reasonableness of the solution in the context of the original situation.
3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
3.3 Develop generalizations of the results obtained and apply them in other circumstances.

Grade 2 Standard Set 1. Physical Sciences:

The motion of objects can be observed and measured.

1.c Students know the way to change how something is moving by giving it a push or a pull. The size of the change is related to the strength or the amount of force or the push or pull.

1.d Students know tools and machines are used to apply pushes and pulls (forces) to make things move.

Grade 3 Standard Set 1. Physical Sciences (Energy and Matter):

1.c Students know machines and living things convert stored energy to motion and heat.

1.d Students know energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.

Grade 8 Standard Set 2. Forces:

2.a Students know a force has both direction and magnitude.