

Cardboard Automata

Up, up, and around it goes! Discover how an automata combines simple machines to transfer energy and motion to animate an object.

TEKS:

SCI 3.6A: The student is expected to explore different forms of energy, including mechanical, light, sound, and thermal in everyday life.

SCI 3.6C: The student is expected to observe forces such as magnetism and gravity acting on objects.

SCI 4.6D: The student is expected to design a descriptive investigation to explore the effect of force on an object such as a push or a pull, gravity, friction, or magnetism.

Materials:

- Cardboard
 - 4 6 x 3-inch pieces
 - 4 1 x 1-inch pieces
 - 1 3 x 3-inch piece
 - 1 4 x 4-inch piece
- Craft foam sheet – can be purchased [here](#)
- Hot glue gun and hot glue sticks
- Masking tape
- Nail
- Pencil
- Scissors
- Straw
- Washers or nuts (as weights)
- 3 wooden skewers
- Optional: decorative materials like pom-poms, felt, craft foam, gems, pipe cleaners, etc.

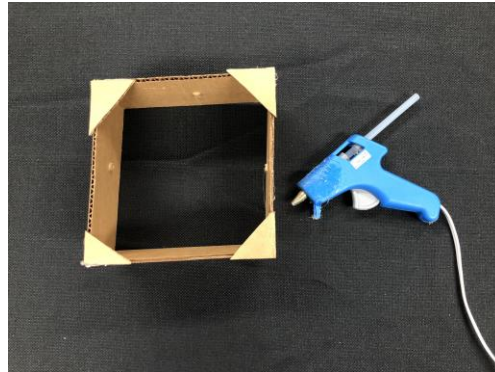
How To:

Creating the Automata Frame

1. Cut four 6 x 3-inch cardboard pieces and form a 6 x 6 x 3-inch cardboard frame. Use a hot glue gun and hot glue to secure the 3-inch-long sides of the cardboard pieces to each other at right angles to form a square frame. **Safety: An adult should assist when using hot glue.**
2. Cut and prepare two 1 x 1-inch cardboard pieces. These will act as supports for your cardboard frame.

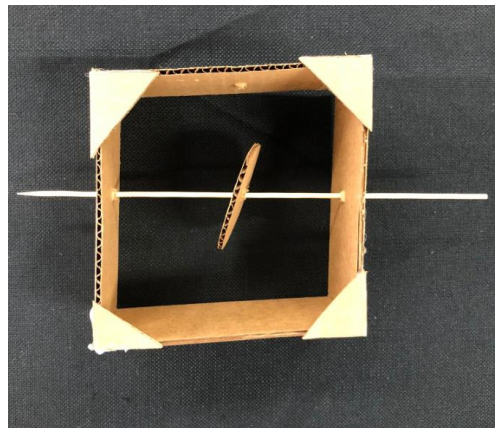
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3. Cut the two 1 x 1-inch square cardboard pieces in half along the diagonal to create four right triangles. Attach the triangles in the corners of the frame using hot glue to reinforce the frame. **Safety: An adult should assist when using hot glue.**



Creating the Round-and-Round Cam

1. On a 3 x 3-inch piece of cardboard, draw a circle with a diameter of about 2.5 inches. You can use a round container of a similar size to trace a perfect circle like a cup, yogurt container, or jar lid.
2. Cut the circle out from the cardboard. This is called the "cam."
3. Use the nail to poke a hole in the center of the cam. Slide a wooden skewer through the center of the cam once the hole is made. **Safety: Be careful pushing the nail and wooden skewer through the cardboard. Make sure to keep your hands away from the backside/area of the hole as it is being made.**
4. Use the nail to make two holes on the opposite sides of the cardboard frame. Position the holes, one on each side of the frame, about half-way from the top. Push the skewer through the holes to suspend the cam in between the top and bottom of the frame. **Safety: Be careful pushing the nail and wooden skewer through the cardboard. Make sure to keep your hands away from the backside/area of the hole as it is being made.**

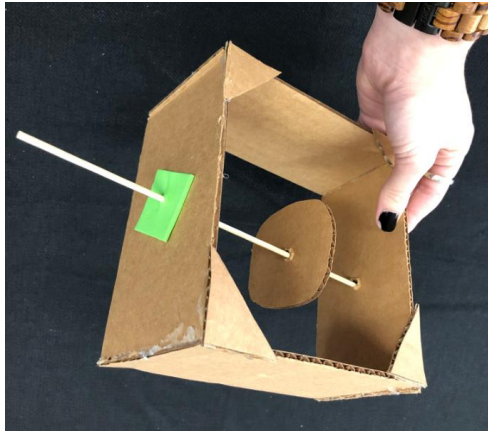


5. Cut out two small foam squares and slide them onto each end of the skewer until they are pushed against the outside of the cardboard frame on each side. These will act like stoppers to keep the skewer axle in position in the frame.

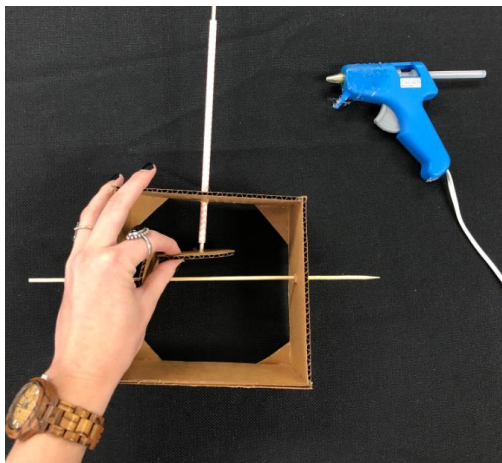
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6. Now use the nail to make a hole in the top of the frame. Position the hole near the center. Enlarge the hole by twisting a pencil into the opening. **Safety: Be careful pushing the nail and wooden skewer through the cardboard. Make sure to keep your hands away from the backside/area of the hole as it is being made.**
7. Slide a straw into the hole on the top of the frame. About 1 inch of the straw should extend below the top of the frame.
8. Use hot glue to secure the straw in the hole. **Safety: An adult should assist when using hot glue.**
9. Draw and cut another circle on a 4 x 4-inch piece of cardboard. This circle needs to be slightly larger than the cam and is called the "cam follower."
10. Slide a wooden skewer down through the straw. Push the cam follower onto the skewer end that is inside the frame. Hot glue the cam follower to the skewer. **Safety: An adult should assist when using hot glue.**



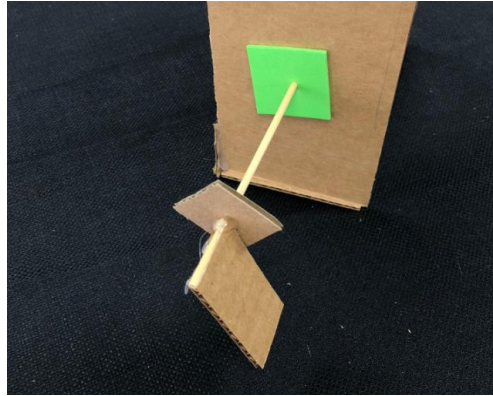
11. Position the cam and the cam follower to touch perpendicular to each other. Put hot glue on both sides of the cam to secure it in place on the skewer. **Safety: An adult should assist when using hot glue.**
12. If the cam follower does not fall onto the cam, attach a washer or nut to add a little weight. You can do this by removing the cam follower, adding a washer around the vertical skewer, and reattaching and hot gluing the cam follower back onto the skewer. **Safety: An adult should assist when using hot glue.**

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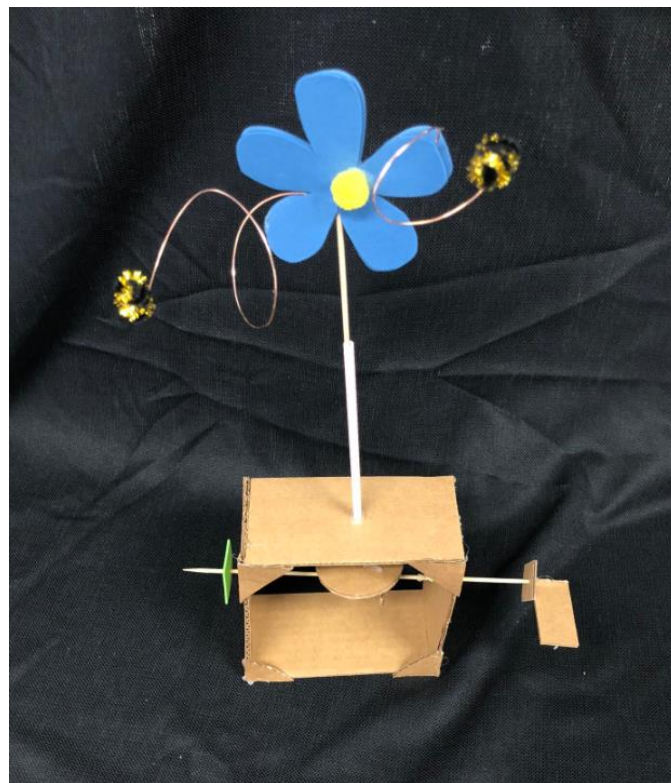
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13. Push the two pieces of square foam at each end of the cam skewer against the frame. Hot glue the squares to the skewer so the axle does not move side-to-side in the frame. Make sure not to glue the foam square or wooden skewer to the cardboard frame. **Safety: An adult should assist when using hot glue.**
14. Cut a small 1 x 1-inch square piece of cardboard, push it about 1 inch onto the free end of the horizontal cam skewer, and hot glue it to the skewer. Glue another 1 x 1-inch piece of cardboard to the free end of the horizontal cam skewer to make a handle. **Safety: An adult should assist when using hot glue.**



15. Turn the handle. Watch as this causes the cam to turn; the cam follower with the vertical skewer should spin.
16. Choose an object or create a design to attach to the top of the vertical skewer that can as you turn the handle. You can use leftover or new materials to create an animal, flower, insect, or other object. Enjoy watching your design spin atop your completed cardboard automata!



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STEM Explanation:

Cardboard automata are a creative and interactive way to explore simple machines and energy. When a force, a push or pull, is applied to an object, the object may or may not move based on the strength of all the forces acting on it. However, work is done when an object moves a distance due to a force. Simple machines are tools that are used to make work easier by requiring less input force over a long distance to create a bigger output. There are many types of simple machines like levers, pulleys, screws, and more. Cardboard automata combine multiple simple machines that work together to transfer energy and motion into an animated object. The spinning element turned by the handle and unique to the automata is called a cam. The cam follower moves according to the shape and position of the cam and gives the motion to the automata's animated objects. Through different designs and combinations of simple machines, an array of movements can be created to animate a cardboard automata. Explore further and try different cam shapes and sizes to engineer new motions on top of your cardboard automata!

Career Connection:

Mechanical engineers design machines using physics, mathematics, and engineering skills. Many work with moving parts of appliances such as refrigeration, automotives such as cars, robotics, and even roller coasters.

Resources:

https://www.exploratorium.edu/pie/downloads/Cardboard_Automata.pdf

<https://www.microsoft.com/en-us/research/wp-content/uploads/2016/12/toy.pdf>

<http://www.mechanical-toys.com/>

[https://www.amazon.com/Houseables-Supplies-Scrapbooking-Crafting-](https://www.amazon.com/Houseables-Supplies-Scrapbooking-Crafting-Halloween/dp/B07BH4BFSW/ref=sr_1_7_sspa?s=arts-crafts&ie=UTF8&qid=1528995916&sr=1-7-spons&keywords=6mm+foam+sheets+assorted+colors&psc=1)

[Halloween/dp/B07BH4BFSW/ref=sr_1_7_sspa?s=arts-crafts&ie=UTF8&qid=1528995916&sr=1-7-spons&keywords=6mm+foam+sheets+assorted+colors&psc=1](https://www.amazon.com/Houseables-Supplies-Scrapbooking-Crafting-Halloween/dp/B07BH4BFSW/ref=sr_1_7_sspa?s=arts-crafts&ie=UTF8&qid=1528995916&sr=1-7-spons&keywords=6mm+foam+sheets+assorted+colors&psc=1)

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