CARDBOARD AUTOMATA

Cardboard automata is a type of mechanical sculpture made of simple materials that lets you bring stories to life. As you build you can explore simple machine elements such as cams, levers, and linkages in a playful way. Making this version of automata lets you quickly get started in building functional mechanisms as your mechanical sculpture ideas develop.

TRY IT!

Gather these materials for building your automata

Small cardboard box (approximately 6" x 6")

Thick foamie sheet - 6mm thick craft foamies for the cams and cam followers

Skewer sticks

Paper drinking straw

Masking tape

Scissors

Hot glue gun and glue stick

Washers and nuts (for weight)

Sharpened pencil

Nail or wood screw
(for poking holes in the cardboard)

the tinkering studio

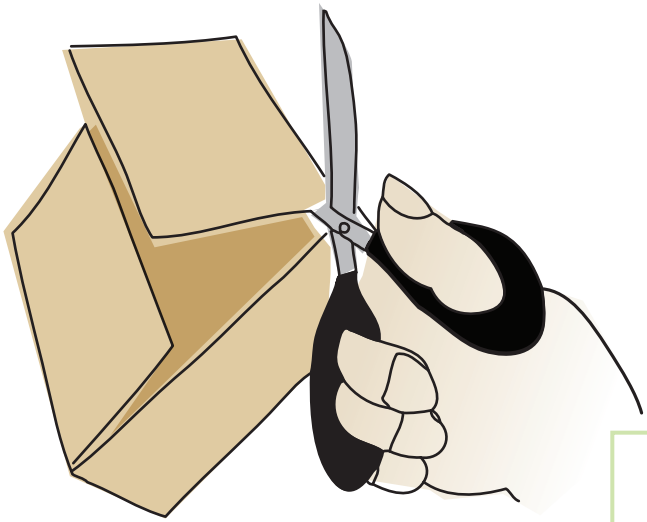
exploratorium

General materials:

Additionally, you will need materials to create the narrative on top of your construction. You can use thinner foam sheets to create this, and materials such as feathers, corks, googly eyes, colored felt, and pompons are other fun things that help tell a story or decorate it.

GETTING STARTED

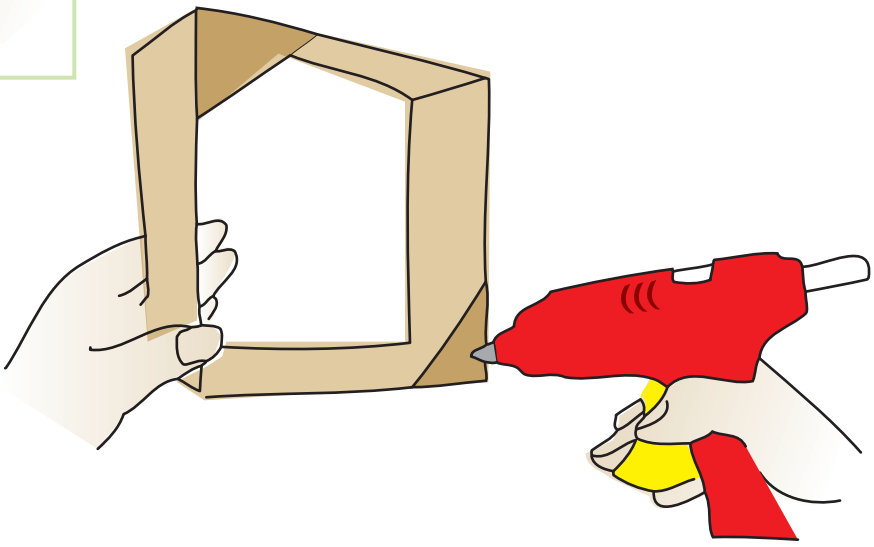
Make a frame:



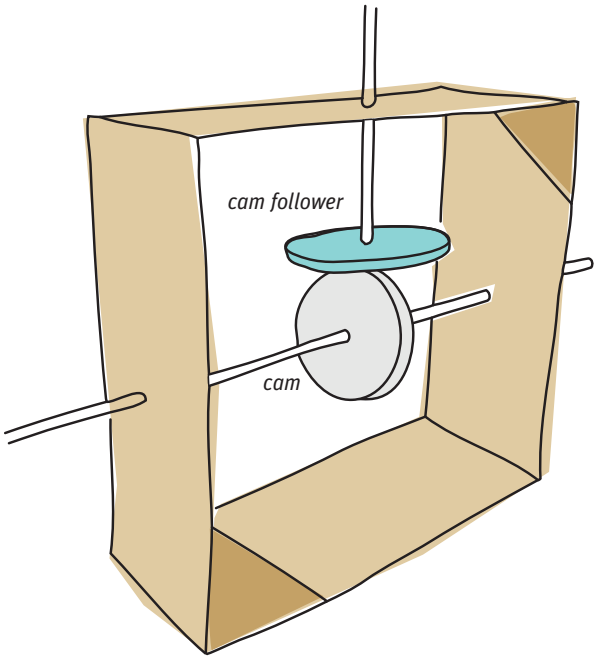
Remove the top and bottom flaps of the cardboard box to make an open square. Save these pieces of cardboard as they will be useful for other parts!

We usually cut a square box in half, creating two frames approximately 3" wide.

To stabilize your box cut four cardboard triangles and hot glue them in opposite corners of the box. Tape can substitute for hot glue but it won't be as permanent.



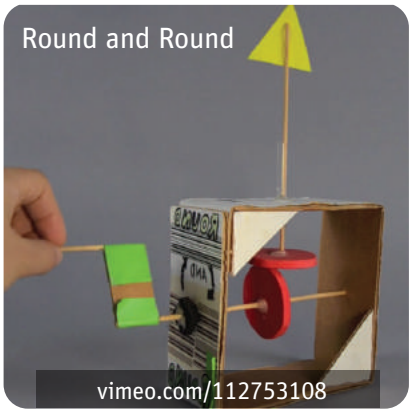
Choose a motion

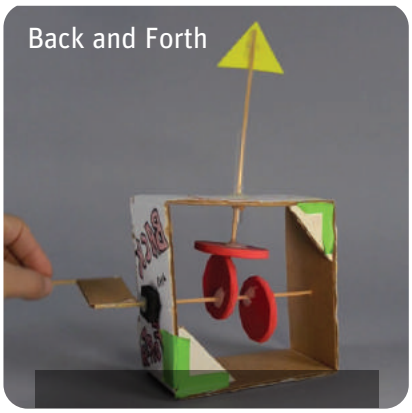


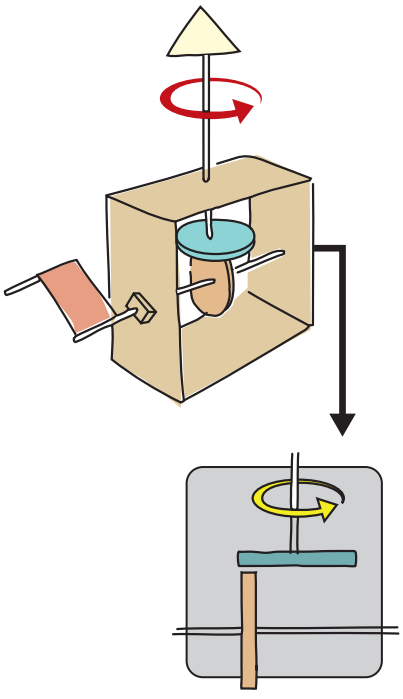
The spinning element that you turn with the handle is called a cam. The element that sits on top of the cam will move according to the shape and position of the cam, and is called a cam follower. The cam follower transmits its motion to the elements on top of the box to animate your sculpture.

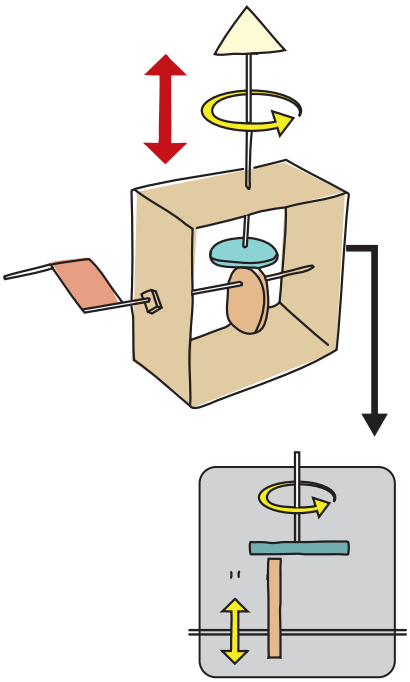
The way you align the cams and cam followers will affect the motion of your animated elements. Some simple to achieve movements are:

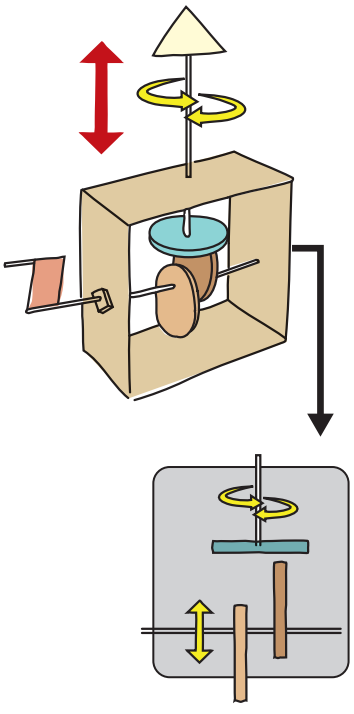
- Round and Round
- Up and Down + Round and Round
- Back and Forth





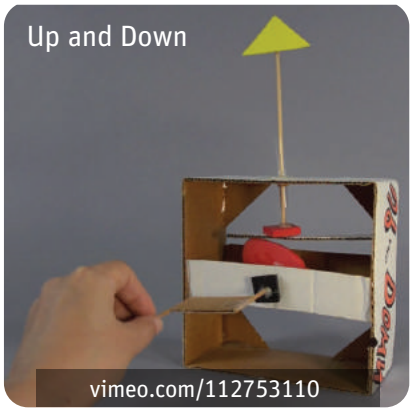


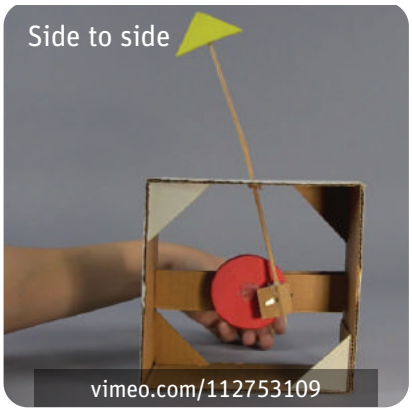


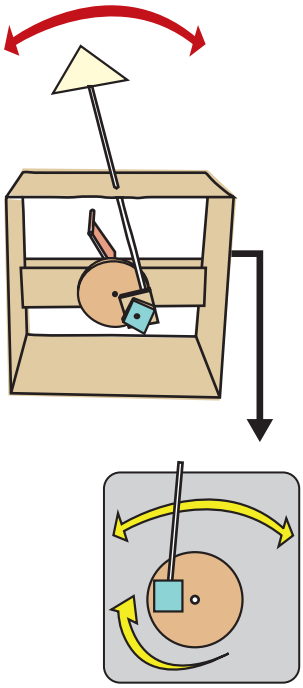


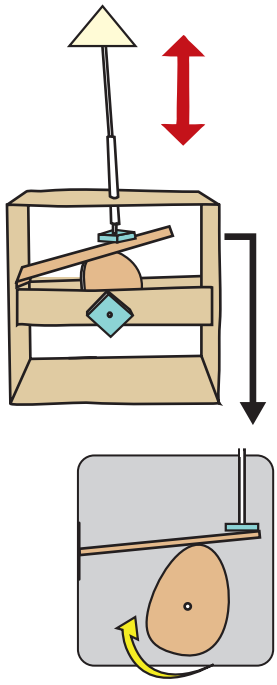
You can also try some more complex but satisfying motions:

- Up and Down
- Side to side



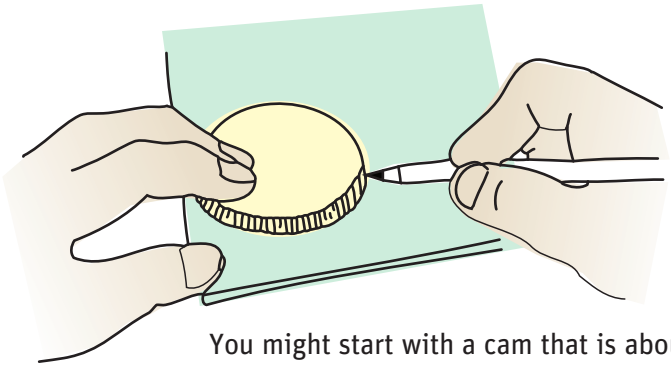




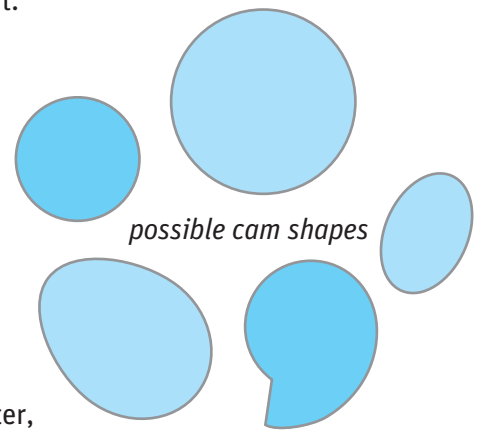


Make the mechanism

Draw your cam and cam follower on the thick foamie sheet and cut them out. (you can use a yogurt cup or a circular container to trace a circle.)



You might start with a cam that is about 2.5” in diameter, then experiment with other sizes based on your design.

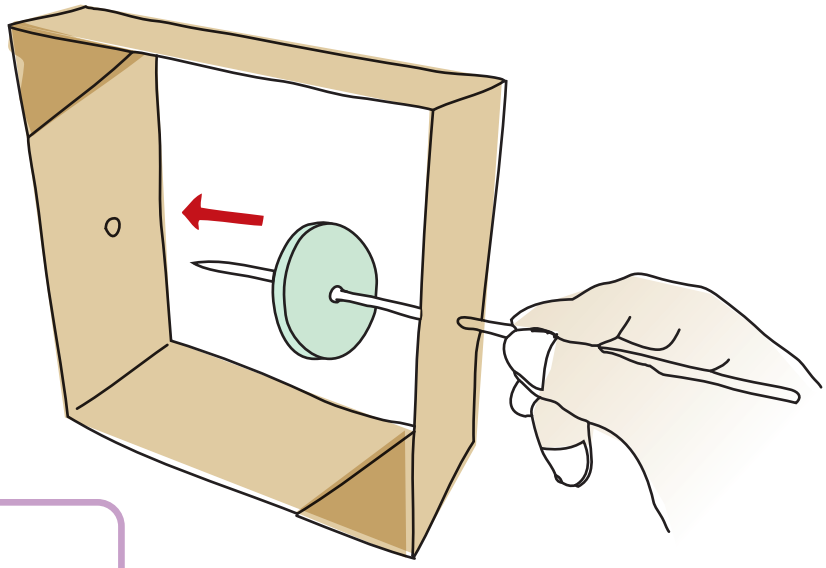


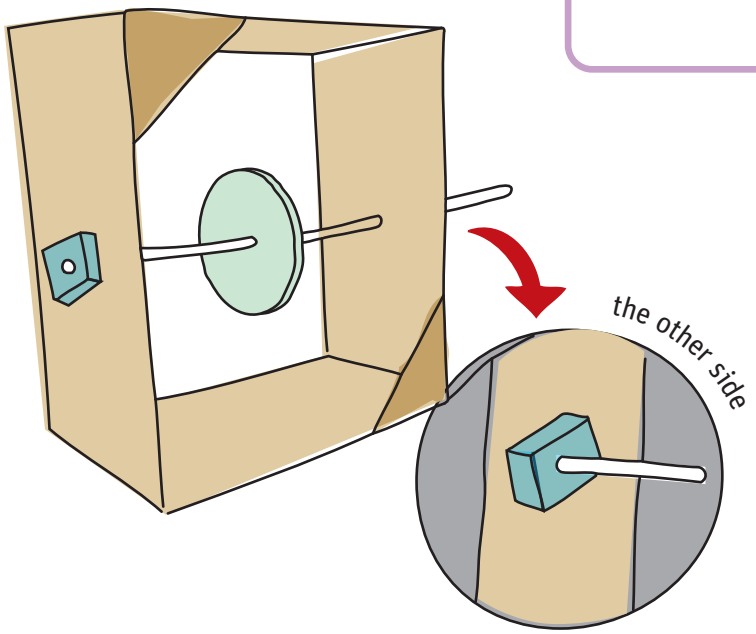
possible cam shapes

Tip: *Cut the cams smoothly and make sure the cam follower is a little bigger than the cam. As you make more automata, experiment with different shapes and sizes to see how they affect the automata motion.*

Put your cam on a skewer stick inside the frame.

Tip: *Start the holes in the frame using a nail or screw, and make sure the cam clears the top and bottom of the frame. Don't glue the cam yet!*



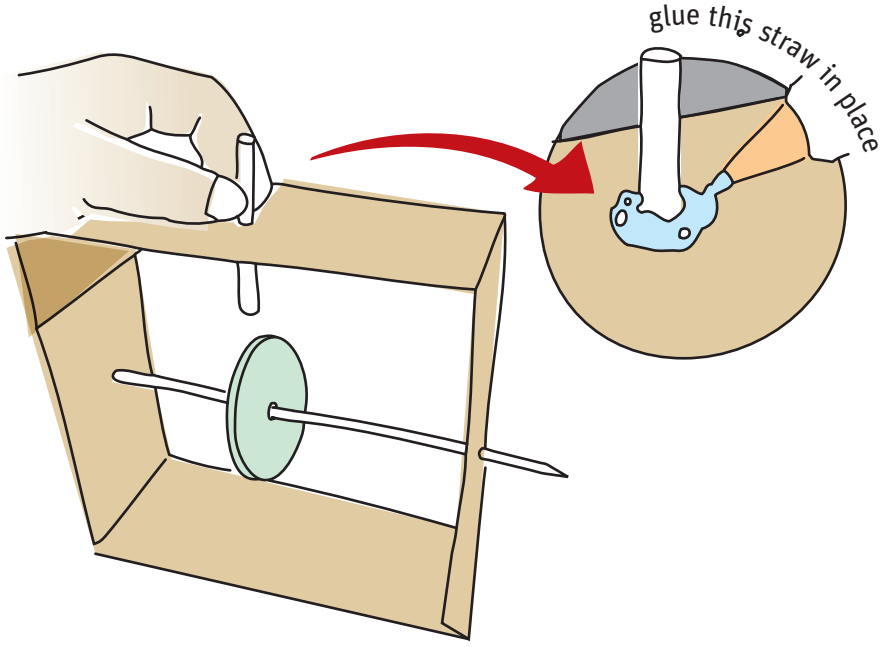


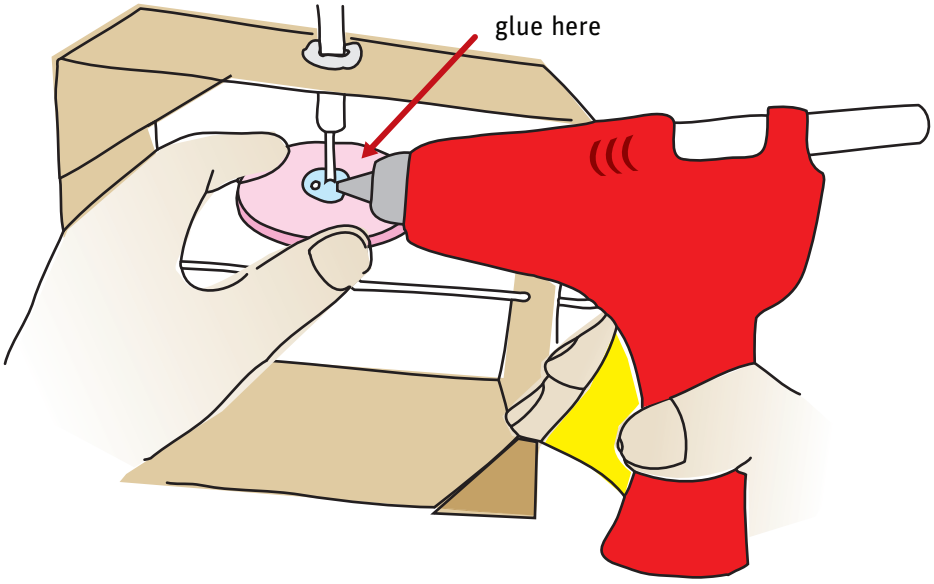
Cut small foam or cardboard squares and push them on each end of the skewer stick to hold your axle in place.

Tip: *Don't glue these in place yet!*

Poke a hole in the top of the frame where you want your cam follower to be located, and insert a piece of drinking straw. The straw should extend both above and below the frame, so it will stabilize the upright skewer stick. Carefully glue the drinking straw in place.

Tip: *The tip of a pencil is a good tool to gradually enlarge the hole so that the drinking straw just fits without falling through.*



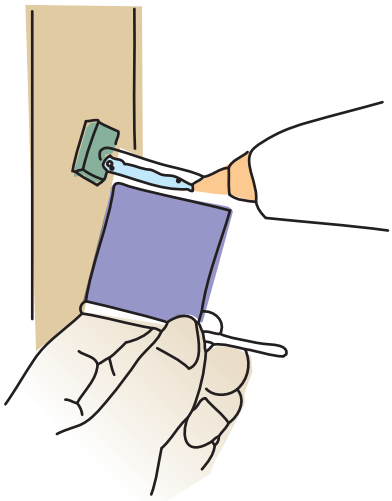


Insert a skewer stick through the straw, then glue your cam follower at the bottom end. Glue your cam follower on the end of a skewer stick and put it through the straw.

Tip: *If the cam follower does not fall down on the cam, attach a washer or nut to add a little weight before you glue it to the stick. Feel free to change the position of the cam under the skewer stick as this may change the motion.*

Test your mechanism

Adjust your cam under the cam follower until you get the motion you like, then GLUE the cam into place on the skewer stick axle.



Make the handle

Glue a small rectangle cut from the cardboard box flap to the skewer stick axle.

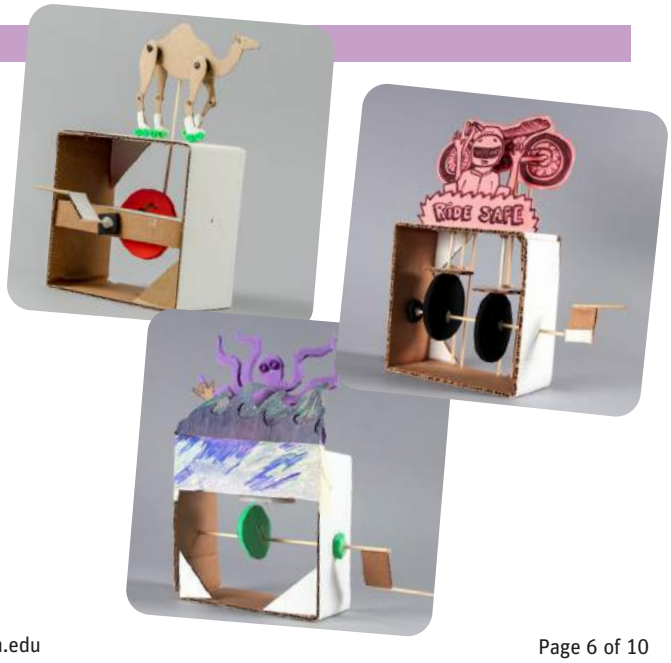
Glue a second piece of skewer stick to the end of the rectangle to make a handle.

Make your story

Once it's working, take another close look and imagine what might move on top of your box. Think of things that spin, bounce, or jump.

When you decide what it should be, make the sculpture out of the rest of your materials.

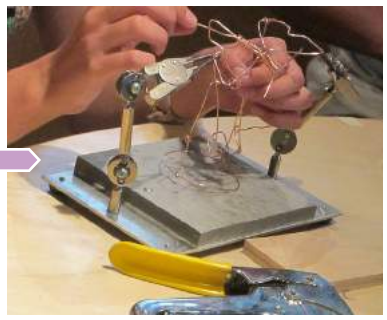
As you continue to experiment with different cardboard automata you can decide to start either by coming up with a new idea for a story on top and then figure out what mechanism can make that motion or continue to make the mechanism first and then decide what your sculpture will be.



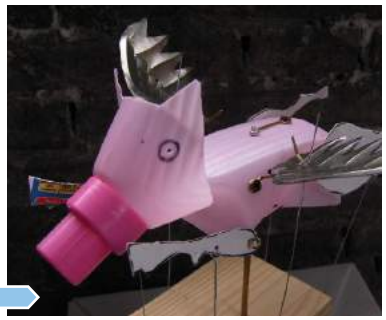
TAKE IT FURTHER

Wood is a great alternative to cardboard for building automata. For these automata, we use a wooden frame for the cardboard box, dowels for the sticks, and screws and nails instead of hot glue. Cutting circles and shapes in wood might be challenging, but you will build your woodworking skills while you make automata (or use pre-cut wooden shapes from craft stores).

Wire automata is another way to explore simple machine elements. Spend some time bending wire to make sculptures before diving into automata. Use copper wire so that you can solder wire joints if needed. You can learn how to make cranks, linkages, and handles out of wire then you can add decorative materials or wood pieces to your wire mechanism.



You can also scrounge for parts from recycling bins to make automata with. You might use old plastic bottles and aluminum cans, or walk around your house to find materials that you want to use for your automata. Making automata from found objects is a bit challenging but you will find that the techniques from cardboard, wire, wood automata come in handy and can be applied in many ways.



EDUCATOR ADDENDUM

A note on our philosophy:

The Tinkering Studio is based on a constructivist theory of learning, which asserts that knowledge is not simply transmitted from teacher to learner, but actively constructed by the mind of the learner. Constructionism suggests that learners are more likely to make new ideas while actively engaged in making an external artifact. The Tinkering Studio supports the construction of knowledge within the context of building personally meaningful artifacts. We design opportunities for people to "think with their hands" in order to construct meaning and understanding.

Decisions and designs that support a tinkering experience

Tinkering Studio activities and investigations are designed to encourage learners to complexify their thinking over time. The variety of materials and variables available for experimentation allow for learners to enter at a point where they are comfortable starting, and then alter and refine their designs as they develop new ideas. Tinkering activities are often fun, whimsical, inspired, and surprising, here are a few of the the goals that we have for Cardboard Automata activity:

STEM (science, technology, engineering, and mathematics) education is a means, not an end in itself
Building cardboard automata is a playful and inventive approach to learning about simple machines. Learners naturally explore levers, cams, cam followers, linkages, and other mechanisms, as a means to make their mechanisms work.

Science and art connections
This activity is a good example of integrating science and art into an activity. For learners, the narrative and decorative aspects of the automata are as important as the mechanical elements. Making automata takes a lot of time, but going back and forth between the narrative and the mechanism throughout the activity will make the automata very unique and personally meaningful for learners.

Activities and investigations encourage learners to complexify their thinking over time
The motion of automata depends on various factors such as the size and shape of the cams, the position of the axles, and number of cams and cam followers. Exploring in those factors is a good starting point to understanding simple mechanisms. Introducing other elements such as gears, linkages, and springs will add complexity to the activity and enable learners to explore endless possibilities for creating mechanical motions in automata.

Environment (the elements of the space that support tinkering)

In the Tinkering Studio there are many things that we keep in mind when setting up an environment for a successful tinkering activity.

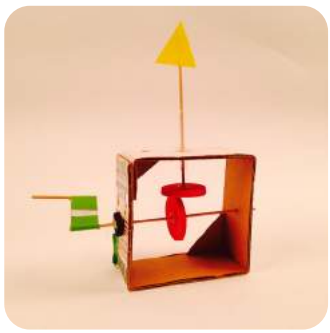
Create an Inviting Space
Since learners often work with us for an extended period of time, so we try to create a warm and welcoming workspace with comfortable seating, sturdy worktables, and good lighting. We often display exhibits, or examples from past projects and current activities throughout the space to seed ideas and provide an introduction to what is happening that day. Materials are easily accessible and in close proximity to the tinkerers, and we often work at large, communal activity stations to enable cross-talk and invite collaboration between participants, allowing them to look to each other for answers and solutions.

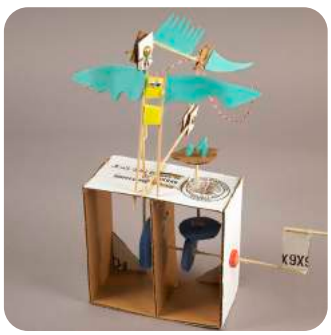
Automata examples in the space
In making Cardboard Automata, providing clear and easy to follow examples of different types of motion is crucial. We usually prepare five different examples that move in interesting ways:

- Round and round
- Up and down, and around
- Up and down, back and forth
- Straight up and down
- Side to side

It might be helpful for you to make each example with the same basic shape on top (like a circle or triangle), that way participants can focus on the differences in the motion. It also helps to name each motion for the purpose of better explanation like “Round and round” “Up and down” or “Side to side” on the frame of automata.

In addition, it’s helpful to have a selection of examples of completed automata that span the range of complexity and “achievability” with the same set of materials on the table. Be sure to set aside plenty of time for playing around and building cardboard automata before the activity so that you can display more inspiring examples that you create.





Facilitation (the things we say and do to support learning through tinkering)

Facilitation is a way of teaching where you support the learner's own investigations, questions, and ideas within the framework of an activity. In the Tinkering Studio, we strive to practice a kind of facilitation that respects the individual path of the learner. As facilitators, we watch and wait until the precise moment to jump in and offer a hint, a material, or a new way of looking at a problem. As educators, we allow learners to feel frustration and encounter moments of failure as they work with real materials to try to solve their own challenges.

There are many ways that the facilitator can influence the interactions with participants in an activity. We help people get started with the activity by giving a quick sense of the goals. We invite them into the space, and introduce the materials and tools they might use. We spark interest and sustain learner's engagement by asking questions about their work and responding to their answers. We support multiple outcomes of the activity and are open to the possibility of new ideas, different solutions, and changing goals of the individual learners. We try to practice a style of facilitation where we are not teachers who transmit knowledge to passive learners, but rather are guides and co-learners on a path to understanding.

For Cardboard Automata it is important that you try building your own a few times before sharing this activity with others. There are several small steps involved in building Cardboard Automata that will make a big difference later on if you know what to expect. By building automata yourself, you will encounter most of the frustrating points that participants are likely to run into, and you will know how to get unstuck. That way, you will be better able to help other people past these "sticking points".

A few common things to watch for:

The box got bent or squashed.

Make sure that learners add a triangle shape in the corners to make the box square. Making a sturdy box is a good start to make a functional mechanism.

The axle (a horizontal skewer stick) keeps sliding

Use little foamie bushings at the end of axles to keep the skewer from sliding out.

The sculpture doesn't go up and down

Try adding weights, such as a washer, to the cam follower to ensure a smooth motion. Using gravity helps.

The vertical skewer stick is wobbly

Maybe you've forgot to add a piece of straw? Cut a length of straw that will keep the vertical axle in place while still allowing for the full range of up and down motion of the automata.

Tip: *In order to make things move it is important to understand which parts must be attached firmly and which connections should be loose. You may want to leave gluing the cam and cam follower to the skewer for the last step, after many iterations of creating and adjusting motions.*

You may find that the most difficult thing to facilitate is the transition between the construction of the mechanical part and the creation of moving narrative part. Some people get the technical part down first and then think about what it does, while others have an idea of what they want it to do first and figure out the mechanism later. It's important to consider both strategies, and go back and forth between the mechanism and narrative throughout the activity to create the automata.

Making cardboard automata is one of the more step-by-step activities in the Tinkering Studio, but we like to focus on the process of rapid prototyping, so it is important to figure out each of these steps together with the participants.

Consider the layout of the Space

In contrast with many of our activities Cardboard Automata benefits from an initial step-by-step coaching on how to put together the structure of the box that sustains the cams and followers. In order to work well not only does the box need to be sturdy and fairly square, but the axles on the cams and followers need to be centered and at right angles with each other. There are several small steps like this that make a big difference.

RELATED TINKERING ACTIVITIES

Activity Connections
Try these related activities to develop your own repertoire of tinkering experiences.

Toy Take-Apart: Collect discarded mechanical stuffed toys and dissect them to find battery packs, switches, sensors, and motor-driven mechanical elements. You can test the things that you find inside, repair broken toys, or repurpose them using your imagination and a few tools to create new and original playthings.
https://tinkering.exploratorium.edu/toy-take-apart

Marble Machines: Create your own ball-run contraption made from familiar materials. Try experimenting with motion and build the contraption to send a rolling marble through tubes and funnels, across tracks and bumpers into a catch at the end.
https://tinkering.exploratorium.edu/marble-machines

Chain Reaction: Build a contraption in a domino-style chain reaction that will trigger the next contraption! Make your machine comical and whimsical using variety of materials such as bowling ball, pulleys, slow motors, mechanical toys, cowboy hats, balloons, ropes, mousetraps, gears, and more.
https://tinkering.exploratorium.edu/chain-reaction

ARTIST CONNECTIONS

inspiring connections to the Cardboard Automata activity

Cardboard Automata is inspired by the **Cabaret Mechanical Theater**, a group of automata builders based in England. Artists like Paul Spooner, Keith Newstead, and Carlos Zapata build beautiful narrative pieces using elegant mechanisms based on cams, gears, springs, and linkages.

http://www.cabaret.co.uk/

Arthur Ganson is a self-taught engineer, and the creator of intricate, whimsical machines. He makes mechanical art demonstrations and Rube Goldberg machines with existential themes. Ganson's work appeals to viewers of all ages, and has been featured in an animated children's television show. He has invented mass-produced children's toys, and hosts an annual competition to make Rube Goldberg chain reaction machines.

http://arthurganson.com/