

Fabricate and Assemble a Working Automaton!

Grade Span

6-8

Subject Area

- Math
- English Language Arts

Materials

- Fab@School Maker Studio
- Digital fabricator or scissors
- Printer
- 110 lb cardstock
- Glue
- Colored pencils or markers

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This automaton model is a simple machine that moves a piston up and down when the handle on the front is turned. It uses a mixture of simple 2D and complex 3D parts, and demonstrates various concepts in papercraft and engineering. Have fun building the automaton from this guide, and use what you learn to change the design and make your own machines!

This model is an intermediate challenge to assemble. There are thirteen parts, and a few tricky moves during construction that become easier as you learn how to build with paper.

The complete parts list includes:

- 1 box frame
- 1 crank shaft
- 3 cam ovals
- 2 clover-shaped crank handles with holes + 1 without hole
- 2 circular back plates with holes + 1 without hole
- 1 diaphragm
- 1 piston

Objectives

- Students will use Fab@School Maker Studio to fabricate and assemble a hand-cranked automaton that bobs up and down.
- Students may then experiment by modifying the design or creating their own.

Big Idea

Systems depend on each other to become sustainable.

Driving Question

How can simple machines facilitate animation?

Learning Standards

CCSS

- [CCSS.ELA-LITERACY.RST.6-8.3](#)

NGSS

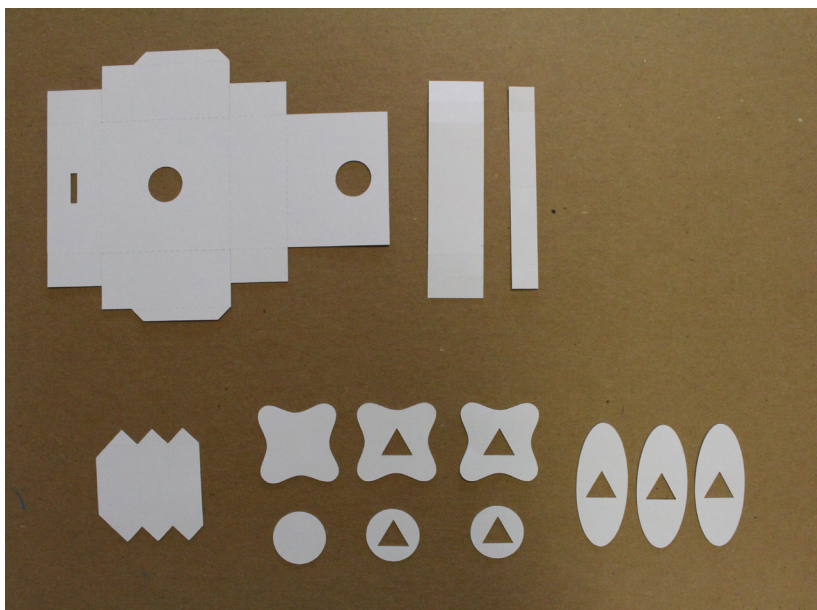
- [MS.FORCES AND INTERACTIONS](#)
- [PS2.A](#)
- [MS.ENGINEERING DESIGN](#)
- [ETS1.C](#)

MA DLCS

- [6-8.DTC.a.4](#)

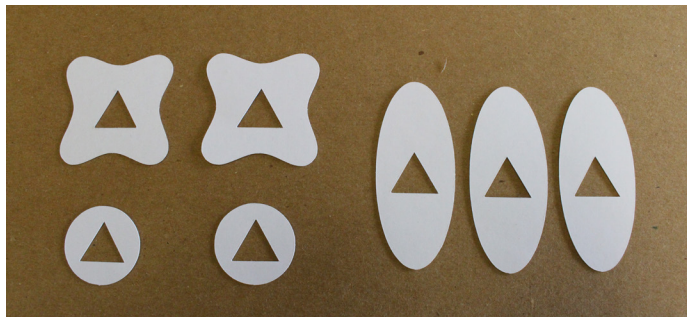
Step 1 - Fabricate the Automaton

1. From the **Main Menu** screen, select **Ready-Made Projects** and choose the tab for **3D Stuff**. Locate the **Automaton** file and select **Open**. The automaton parts will open in the **Edit Screen**.
2. Click the **Fabricate** icon. Be sure the FabPrintServer app is running and your digital fabricator is connected, turned on, and selected at the top of the Fabricate dialog. Place the cardstock on the sticky side of the mat as shown in the dialog. Follow the directions and click **Send to Cutter**.
3. When the project has finished fabricating, unload the mat and paper, and carefully peel the individual automaton parts from the mat. Your automaton model is now ready for assembly!

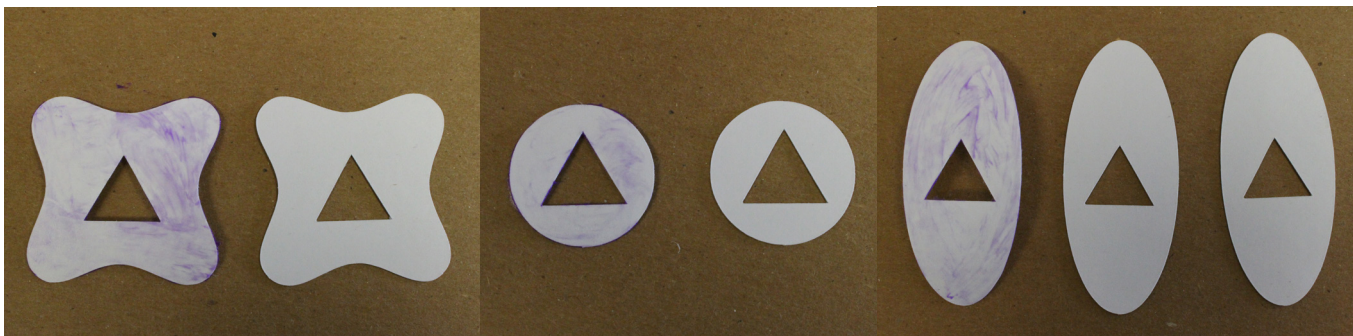


Step 2 - Assemble the Automaton

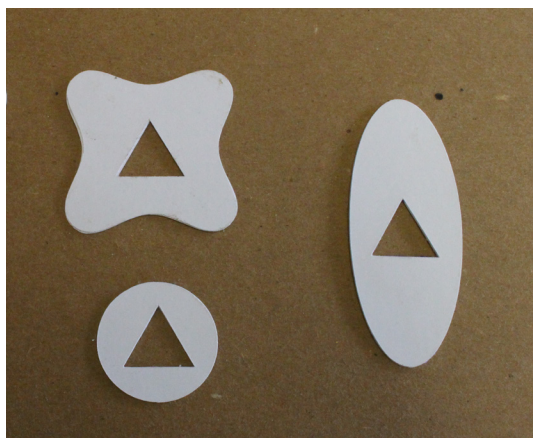
1. Locate and arrange the parts pictured below. There are two clovers with triangular holes, two circles with triangular holes, and three ovals with triangular holes.



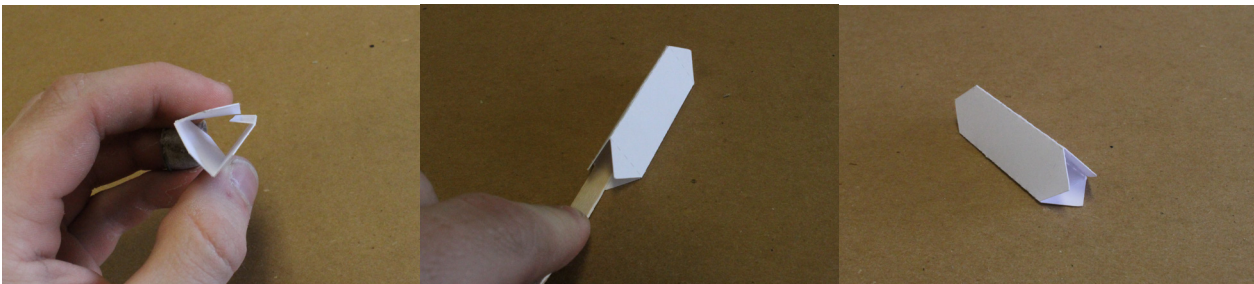
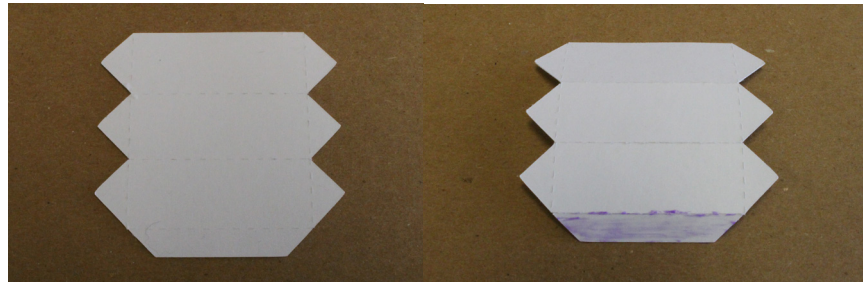
2. Take one of the two clovers, and coat one side in glue. Press both clovers together, making sure the triangular holes in the center are aligned. This creates a thicker piece. Continue this same process for the two circular and three oval pieces.



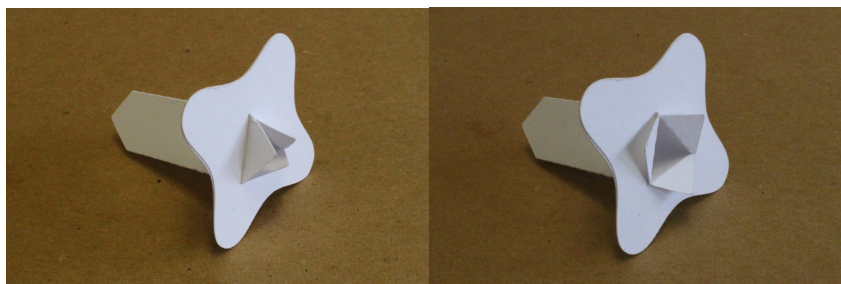
When you are done, you will be left with three thick pieces. The clover piece will be the crank handle for turning the shaft, the circle piece will be a backing plate to keep the shaft connected to the body of the automaton, and the oval is a cam that will push the piston up and down as it spins on the shaft.



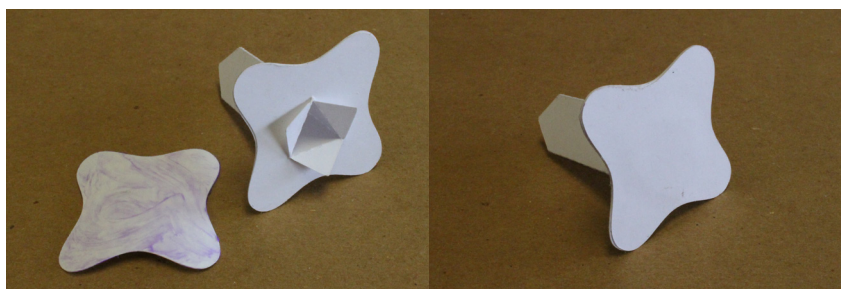
3. Locate the piece pictured below. This part is going to be folded into a triangular prism. Fold the three longest perforations along the length of the piece. Coat the long tab in glue and fold the piece so that the tab sticks to the inside of the shaft along the long edge opposite the tab. You can use a thin tool, like a Popsicle stick, to press the glued tab onto the inside of the shaft.



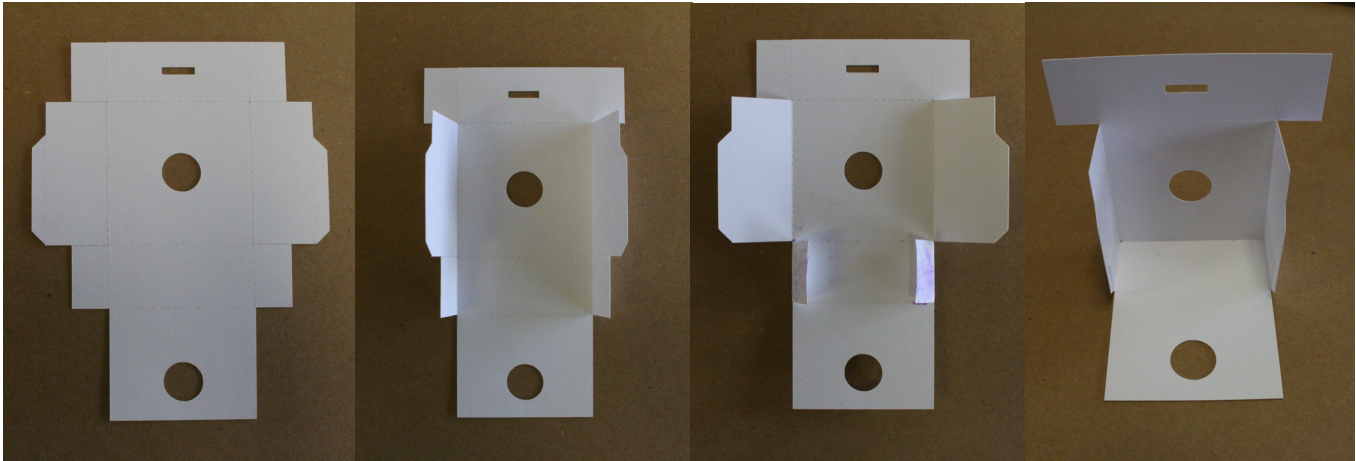
4. Insert the triangular shaft into the triangular hole of the clover shaped handle. The fit is tight, so be careful and patient. Fold the three small tabs on the end of the shaft outwards. With the tabs keeping the clover handle from falling off, push the handle as far to the edge of the shaft as possible, so that the tabs can lie flat against the handle.



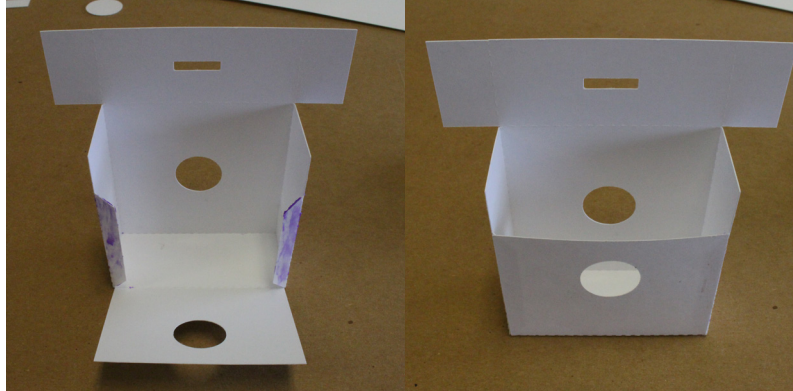
Locate the clover shaped piece without a hole, and coat one side in glue. Press this piece onto the clover handle on the shaft, squeezing the tabs in between. The shaft is now ready for a later step.



5. Locate the box frame piece pictured below. Fold the two wide panels on either side of the square center, and the smaller rectangular tabs underneath. Glue the backsides of the rectangular tabs. Fold along the perforation underneath the square center so that the folded panels on the sides form a corner. Press the glued rectangular tabs onto the bottom of the folded side panels.



6. Fold up the front face of the box frame, and fold the two tabs on either side. Coat the tabs in glue, fold the front panel so that you can press the two tabs onto the front panel to create the box.



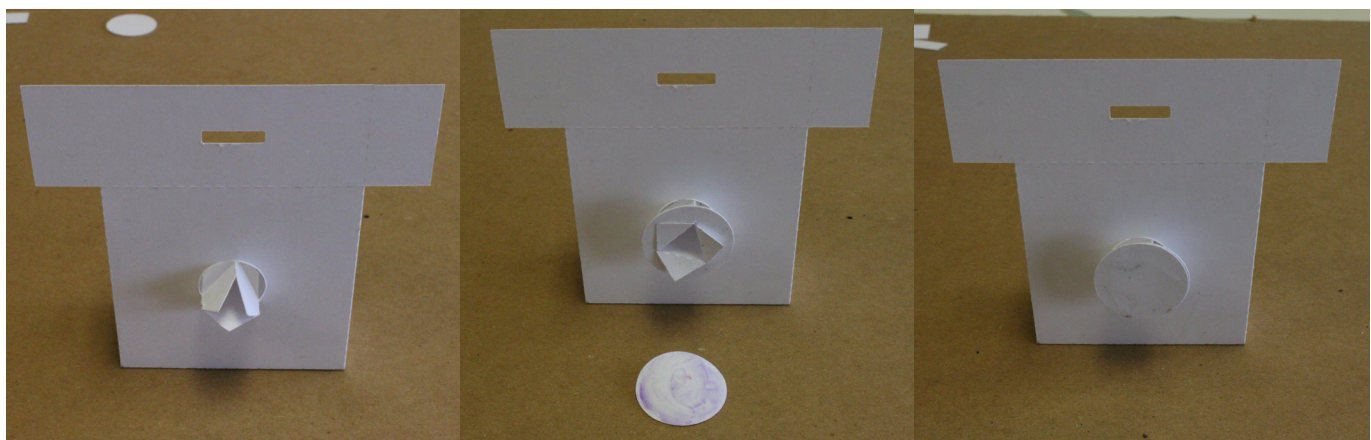
7. Insert the assembled shaft and handle from Step 4 into the circular hole on the front of the box frame. Only insert the shaft so that the tip reaches the center of the box frame. The circular hole is a tight fit, so insert the shaft carefully and rotate it once to create a flush fit.

With the tip of the shaft in the center of the box, insert the shaft into the triangular hole of the oval cam piece. Carefully push the shaft through the front circular hole, triangular cam hole, and back circular hole.

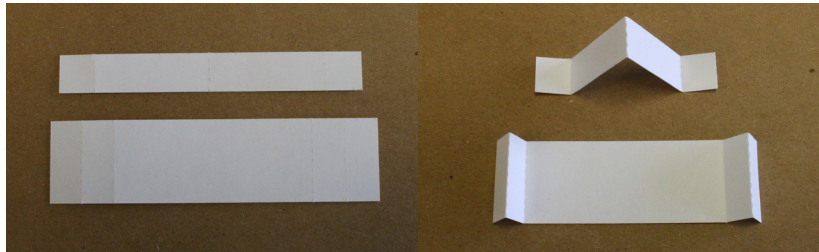


8. Flip the box frame around to face the back side. Locate the thick circular piece from Step 2 and insert the end of the shaft into the triangular hole. The fit is tight, so be careful and patient. Fold the three small tabs on the end of the shaft outwards. With the tabs keeping the circular plate from falling off, push the circular plate as far to the edge of the shaft as possible, so that the tabs can lie flat against the handle.

Locate the circular plate without a hole, and coat one side in glue. Press this piece onto the circular plate on the shaft, squeezing the tabs in between. The shaft is now completely installed into the box frame, and can not be removed.



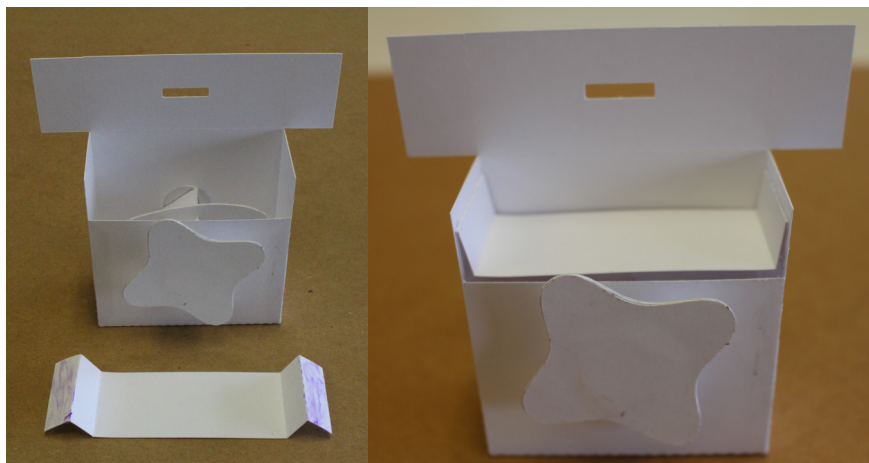
9. Locate the two pieces pictured below. The wider rectangle is a diaphragm that the cam pushes up from underneath. The thinner rectangle is the piston, which rides the diaphragm and pokes out from the box frame once fully assembled. Fold the two pieces along the perforation lines as shown.



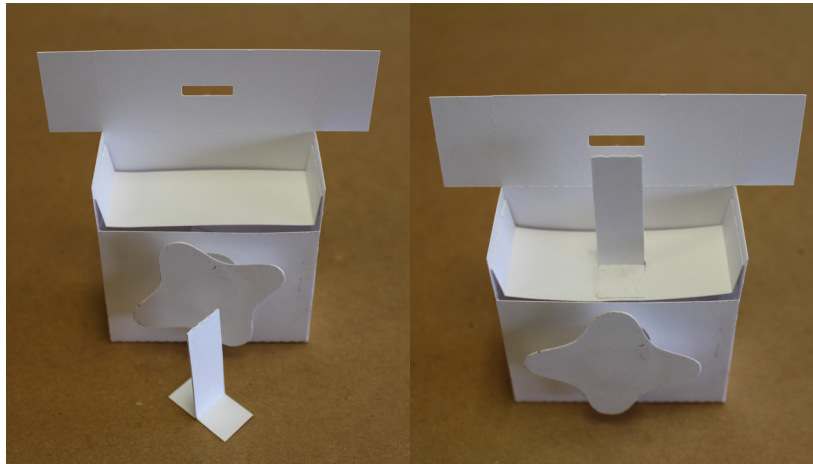
10. Coat one of the longer rectangular sections of the piston with glue. Fold the piston in half along the middle fold and press the halves together. The final piece will look like a rectangle with two feet.



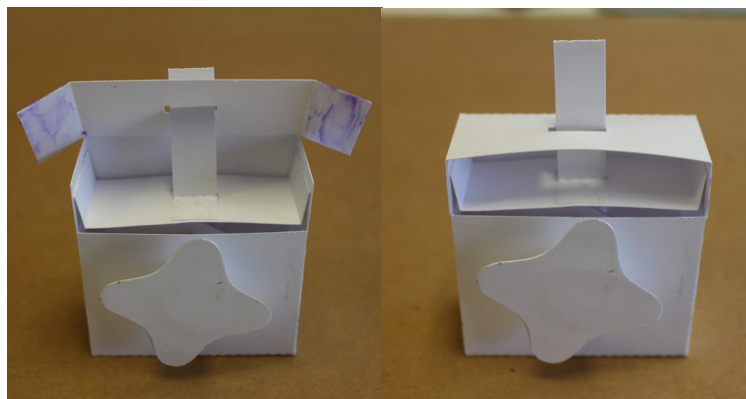
11. Coat the rectangular edges on either end of the diaphragm with glue. Attach the diaphragm to the inside of the box frame so that the middle of the diaphragm sits right over the cam at its lowest point. Study the pictures below and notice the position of the cam and glued diaphragm.



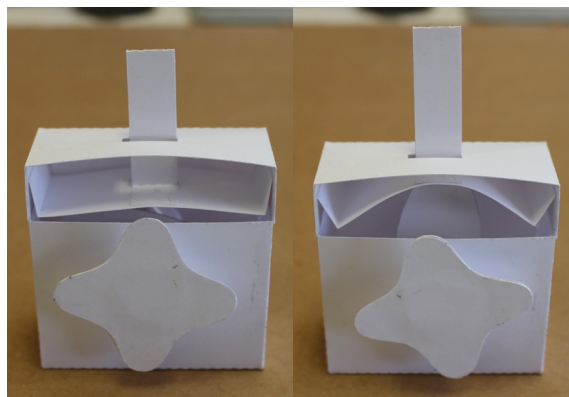
12. Coat the feet of the piston with glue and attach it to the diaphragm as pictured. Make sure that the piston is positioned so that it can fit through the hole on the lid of the box frame.



13. Fold the lid of the box frame and the two rectangular tabs to either side. Coat the rectangular tabs on either side of the lid with glue. Fold the lid down on top of the box, making sure the piston is threaded through the hole on the lid. Press the rectangular tabs to the side of the box frame to glue the box frame shut.



Your automaton is now complete! You can turn the clover handle on the front to make the piston bob up and down.



Fab@School Maker Studio Tips

Magnetize: If you want shapes to automatically snap and create fold lines when you drag them together, be sure **Magnetize** tool is on. To learn more about the tool, have students watch the [Fab@School Maker Studio Shapes Tutorial video](#).

Edit Points: Customize shapes and lines by editing their control points with the white **Edit Point** arrow on the top toolbar. To learn more about edit points, have students watch the [Fab@School Maker Studio Line Tool Tutorial video](#).

Cut Fold Tab: Use the **Cut Fold Tab** tool on the left toolbar to change lines and shape edges into cuts, folds, or tabs. To learn more about cut fold tabs, have students watch the [Fab@School Maker Studio Cut Fold Tab Tool Tutorial video](#).

3D View: Expand the 3D View tool in the lower right to preview your folded construction. Note that the first shape you place will be the base and the construction will fold from that plane. Tabs don't show in 3D View.

But Wait, There's More

Customize your automaton!

Here is an example of how we customized our own automaton to create an animated scene from Peter H. Reynolds' book *The North Star*. The bobbing piston moves the boat up and down against the waves and starry sky. What scenes could you animate with this automaton? Can you design and fabricate the scene in Fab@School Maker Studio?



Add multiple pistons!

The shaft has only one cam on it, but is wide enough to fit more than one. Can you design an automaton that can push move more than one piston at once? How many different ways can you think of? What kinds of scenes could you animate with two or more moving parts?