Spark Makerspace Woodshop Class:
Whale Automata

This collaborative program between the Lyman Allyn Art Museum and Spark Makerspace takes place in two parts. Participants will first visit the Lyman Allyn to explore Art in Play: Leo Jensen and learn more about kinetic art, some that are surprisingly familiar to our daily lives. The second session will take place at Spark where attendees will assemble and decorate a type of kinetic artwork known as an Automata.

This class will build a simple whale automaton in basic diorama form. There will be two moving parts: a see-sawing wave, and a spinning whale spout. A wooden frame with metal hand crank will drive the motion of the automaton.

Tool List:

- Scissors or craft knife
- Pen or pencil
- Awl
- Drill or drill press
- 1/16” drill bit
- 7/64” drill bit
- Needle-nosed pliers
- Hammer

Parts List:

ID	Part	Qty	Material
A	Spout	1 or 2	EVA foam
B	Whale	1	EVA foam
C	Wave	1	EVA foam
D	Drive wheels	2	EVA foam (3 layers)
E	Crank	1	3/32 aluminum rod
F	Sides	2	1/2” - 3/4” thick wood
G	Top/Bottom	2	1/2” - 3/4” thick wood
H	Wave Brace	1	Popsicle stick
J	Wave Support	1	0.041” SS lock wire, or similar
-	Pivot beads	4	8mm wooden bead
-	Actuator wires	2	0.041” SS lock wire, or similar
-	Nails	8	1 inch wire nails
-	Glue	-	Hot melt glue or CA glue

From Wikipedia:

An **automaton** is a relatively self-operating machine, or control mechanism designed to automatically follow a sequence of operations, or respond to predetermined instructions. Some **automata**, such as bellstrikers in mechanical clocks, are designed to give the illusion to the casual observer that they are operating under their own power or will, like a mechanical robot. The term has long been commonly associated with automated puppets that resemble moving humans or animals, built to impress and/or to entertain people.

Step A: Cut the Figures out of Foam

1. Locate the template sheet. Printed on light cardstock, it has parts labeled A through J (the letter I was not used to avoid confusion with the numeral 1).
2. Cut out the following templates carefully, using either scissors or a sharp craft knife.
    - A (spout)
    - B (whale)
    - C (waves)

    For each of these items, there is a recommended shape, and a "boundary box." You are welcome to modify the design of the parts within the size limits of the boundary boxes.
3. Trace the templates on the EVA foam sheets, and cut the shapes out of foam. To prevent marks from showing up on the front of the foam pieces, you may prefer to trace the templates face-down on the "back" of the foam sheet.
4. When tracing, you may choose to make one or two spouts. Because the spout spins, the drive wire will be visible on the back if only one spout is cut. It's up to you if you want your automaton to flaunt it's mechanical nature or not.
5. Cut out the spout(s), whale, and waves using scissors or a sharp craft knife.

Step B: Cut the Drive Wheels out of Foam

1. Locate the two circles labeled D on the template sheet. Two drive wheels are needed, but each wheel needs to made of three layers of foam. You can make the drive wheels in two different ways.

Method 1:

2. Trace six circles onto the foam using the D template.
3. Cut out all six circles
4. Take three of the circles, and glue them into a stack. The result should look like a large, thick coin.
5. Repeat Step 4 with the other three circles

Method 2:

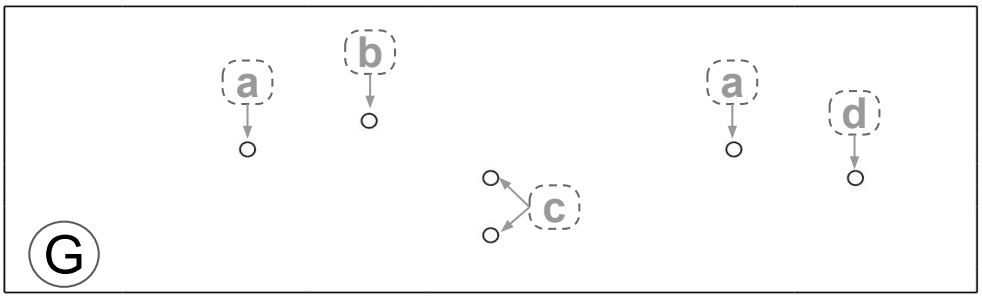
2. Cut three strips of foam about two inches by four inches.
3. Glue the three strips on top of each other to make a foam block three layers thick.
4. Trace two D template circles onto the block.
5. Cut the foam along the traced circles.

Whichever method you choose, remember that the drive wheels don't have to be perfect. Rough edges, minor misalignments, and slightly oblong circles will all add character to your automaton.

Step C: Drill the Frame Top

1. Find the part labeled G on the template sheet.
2. Cut out the template
3. Align the template with the wooden piece being used for the frame top.
4. Tape the template into place.
5. Using an awl, mark the center of the six holes by pricking the awl through the template into the wood.
6. Remove the template.
7. Using a 1/16-inch drill bit, drill the marked holes.
    - Of the six holes, only two of them need to be drilled all the way through the wood. In the diagram below, the holes marked with **b** and **d** should be drilled all the way through.
    - The remaining holes can be drilled 1/2 to 3/4 of the way through the wood. If you accidentally drill them through, your automaton will still work - it'll just be a little trickier to put it all together at the end.

If you are confident in your measuring abilities or like a challenge, you may choose to ignore Step 2 through Step 5. Instead, mark the holes using the measurements given on the template sheet.



Hole	Purpose
a	Whale support
b	Spout drive
c	Wave support
d	Wave drive

Step D: Cut and Drill the Wave Brace

1. Find the part labeled H on the template sheet.
2. Due to the size variation in popsicle sticks, it will usually be easier for you to line the popsicle stick up with the template sheet than to cut out the template. The decision is yours, however.
3. Line the rounded end of the template up with one end of the popsicle stick.
4. Mark the flat end of the template on the popsicle stick.
5. Mark the two hole locations on the popsicle stick. They do not have to be exact.
6. Cut the end of the popsicle stick with the wire cutters in the needle nosed pliers.
7. Using a 1/16-inch drill bit, drill the two holes through the wave brace.

Step E: Drill the Frame Sides

1. Find the part labeled F on the template sheet.
2. Cut out the template
3. Align the template with one of the wooden pieces being used for the frame sides.
4. Tape the template into place.
5. Using an awl, mark the center of the hole by pricking the awl through the template into the wood.
6. Remove the template.
7. Using a 7/64-inch drill bit, drill all the way through the side at the mark.
8. Repeat steps 3 through 7 on the other wooden frame side.

Step F: Bend the Wave Support

1. Find the part labeled J on the template sheet.
2. Start with a piece of wire about 3 inches long.
3. Bend the lock wire to match the shape of the template sheet
4. Cut the legs to length to match the template sheet.

Straightening wire

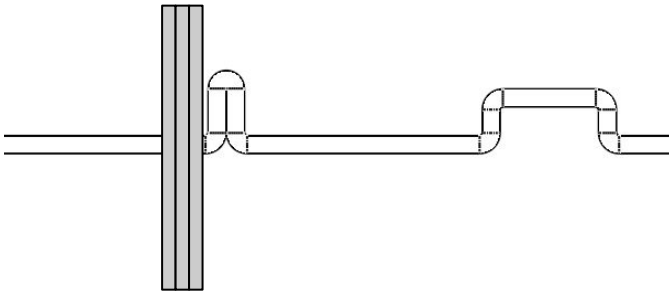
Most wire comes in a coil. The lock wire used in this project comes out of the package with a substantial twist and curl to it. To straighten most types of wire, start by anchoring one end solidly, using a clamp or vise. Use a heavy pair of pliers to yank firmly on the opposite end. The result may not be a perfectly straight wire, but is usually straight enough to use.

Step G: Bend the Crank

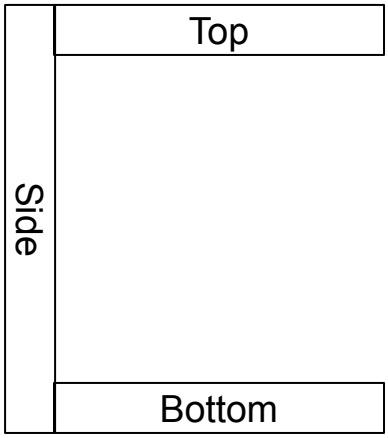
1. Find the part labeled E on the template sheet.
    - At this point, your template sheet is probably pretty chopped up. You may want to tape the portion of the sheet with Part E on it to the table. It will make the next steps easier.
2. Cut a piece of 3/32 aluminum rod to about a foot long.
3. There are two sets of bends shown; one narrow bump to the left, and one wide bump (with beads) to the right. Start with narrow bump.
4. Align the end of the rod with the left end of the template.
5. Using pliers, match the profile of the narrow bump as closely as possible.
6. Check to make sure the straight stretches of the rod are in line.
7. Using the template for guidance, make the two bends on the left side of the wide bump.
8. Slide two 8mm beads into place on the wide bump.
9. Make the last two bends on the right side of the wide bump.
10. Cut the crank ends to length using the pliers.

Step H: Install the Lower Drive Wheel

1. Find one of your three-layer drive wheels. It's probably buried under scraps and tools on the work table. Maybe over there to the left?
2. Locate the center of the circle, or pretty close to it, and poke it with an awl.
3. Push the tip of the awl all the way through the drive wheel.
4. Slide the drive wheel onto the end of the crank until it is flush against the narrow bump, like the image to the right (for clarity, the beads aren't shown on the big bump).
5. Using hot melt or CA glue, glue the drive wheel to the narrow bump.

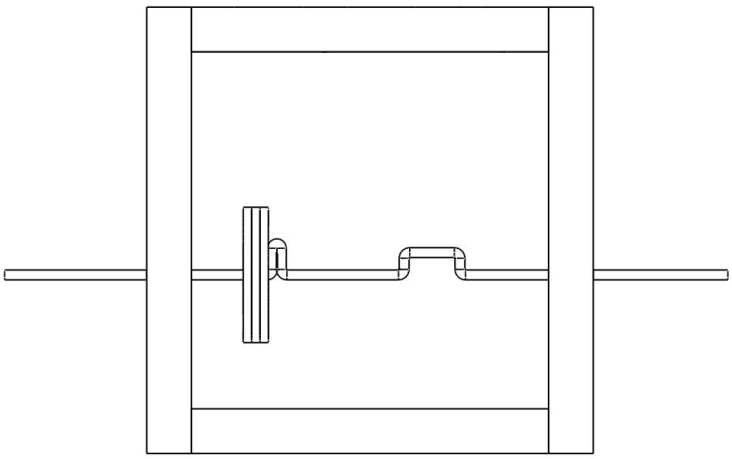


Step I: Partially Assemble the Frame



1. Locate the four frame pieces - the top, the two sides, and the bottom (which has no holes in it).
2. Take one side. Align it with top, as shown to the left.
3. Make sure the backs of both parts are facing the same direction.
    - The two center holes in the top, noted as **c** way back in Step C, should be towards the front
    - The partially drilled holes should face away from the frame bottom.
    - The hole in the side is closer to the back
4. Using two nails, nail the side to the top.
5. Using two nails, nail the side to the bottom.

Step J: Assemble the Crank and Frame

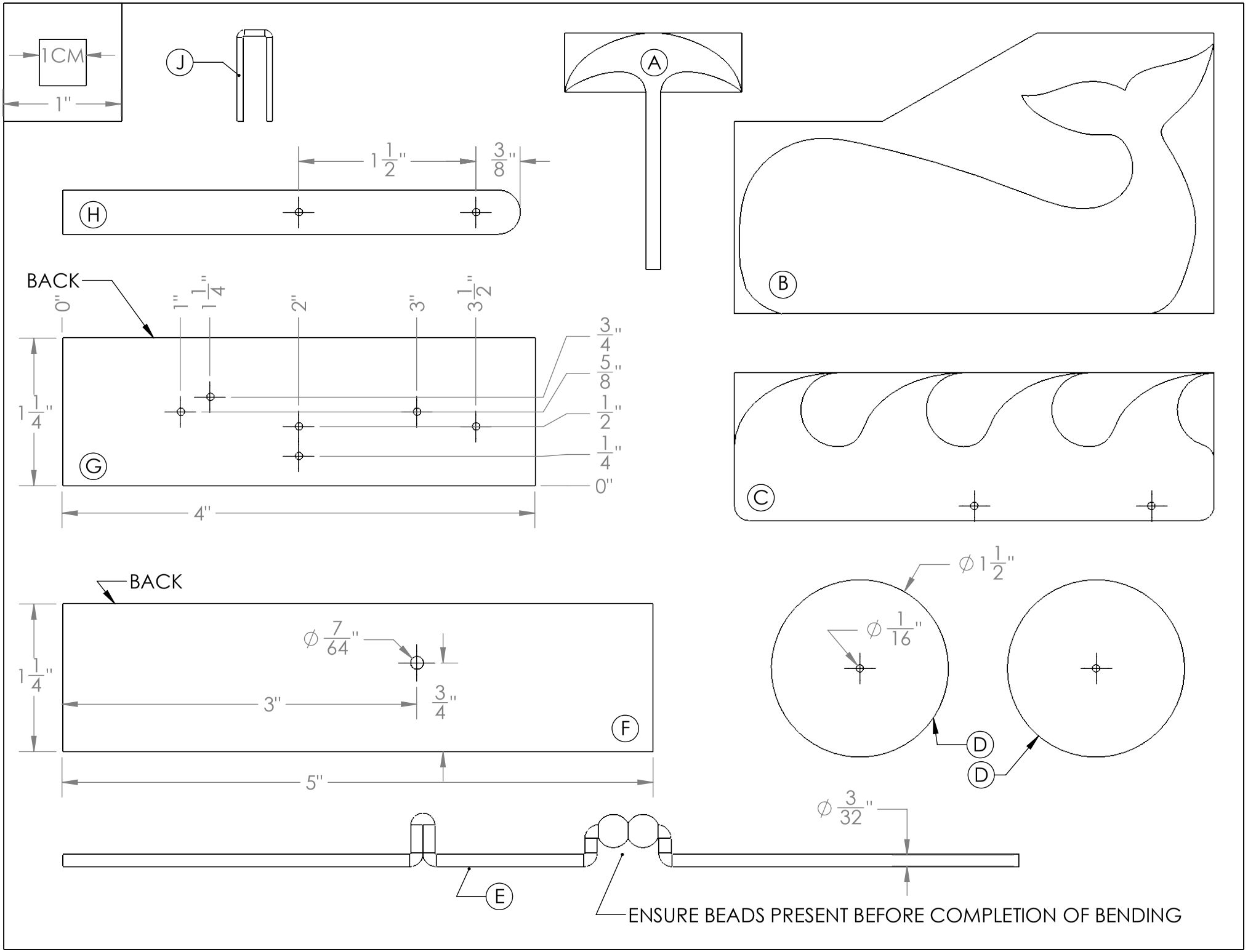


1. Insert the crank into the partially assembled frame in the orientation shown at left (beads not shown on the wide bump)
2. Alight the second frame side with the crank, frame top, and frame bottom.
3. Treat the crank carefully while nailing.
4. Using two nails, nail the side to the top.
5. Using two nails, nail the side to the bottom.

Step K: Install Everything Else

At this point, the main structure of your automaton is completed, and the rest of the steps are important but much more free-form. The instructor will help you work through the steps outlined below.

1) Wave:
   a) Glue the wave brace to the back of the wave
   b) Put the wave support through the wave and wave brace.
   c) Glue the wave brace into the frame
   d) Put the wave drive wire through top frame hole **d**.
   e) Bend the wave drive wire through the wave drive hole, and put a loop on the end to prevent it from sliding back through
   f) Put the drive end of the wave at the lowest possible position.
   g) Rotate the crank until the wide bump (with beads) is at the lowest position.
   h) Wrap the crank end of the wave drive wire around the center of the wide bump, between the beads.
   i) Cut the crank end of the wave drive wire as short as possible
2) Crank:
   a) Slide a wooden bead on each end of the crank, against the outside of the frame.
   b) Align the crank horizontally. When viewed from the front, the wave drive wire should be straight up and down.
   c) Bend the right side of the crank, outside the frame and bead, 90 degrees.
   d) Put a second 90 degree bend in the right side of the crank, to create the manual handle.
   e) Place a bend or loop in the opposite end of the crank, to prevent side-to-side travel.
3) Spout:
   a) Bend an “h” shape into the bottom end of the spout drive wire.
   b) Insert the spout drive wire through top frame hole b.
   c) Poke the center of the 2nd drive wheel with an awl
   d) Stick the 2nd drive wheel onto the bottom of the spout drive wire. It should sit atop the drive wheel on the crank.
   e) Determine the correct height for the spout, and bend a loop in the spout drive wire at the top. Trim any extra wire.
   f) Glue the spout(s) to the spout drive wire.
4) Whale:
   a) Cut two short pieces of wire, approximately 1-1/2 inches long.
   b) Put a short loop on each end.
   c) Glue the straight of the wire into top frame holes **a**.
   d) Position the whale and glue it to the wires.
5) ***Crank your automaton!***


1CM
1"
J
A
B
H
1 1/2"
3/8"
BACK
0"
1"
1 1/4"
2"
3"
3 1/2"
3/4"
5/8"
1/2"
1/4"
0"
1 1/4"
G
4"
C
BACK
1 1/4"
∅ 7/64"
3"
3/4"
F
5"
∅ 1 1/2"
∅ 1/16"
D
D
∅ 3/32"
E
ENSURE BEADS PRESENT BEFORE COMPLETION OF BENDING