

Miniature Marble Machine

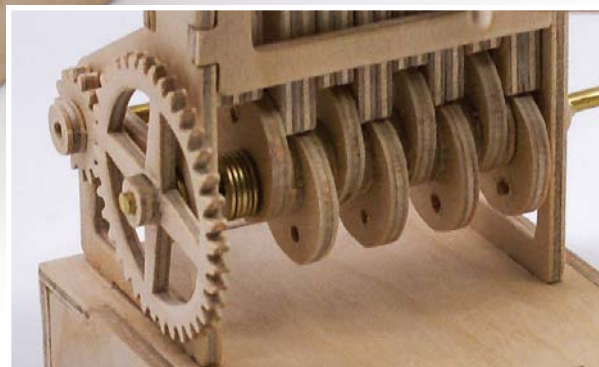


Precise cutting and simple assembly combine to create a fun tabletop toy

By Michael Henriksen
Cut by Rolf Beuttenmuller

This clever hand-cranked machine sends $\frac{1}{4}$ ", or 5mm, balls hurtling along a twisty track before stepping them back up to the top. For a miniature project like this, you need to cut accurately, especially on the tracks and the gears, for the project to work. But, if you take your time when cutting and fitting the pieces together, you should be able to create a working machine.

Note: The brass rods are sold in metric sizes, so I refer to them as such throughout. It is very helpful to dry-assemble all pieces and fit the cams, steps, and gears before gluing the pieces in place.



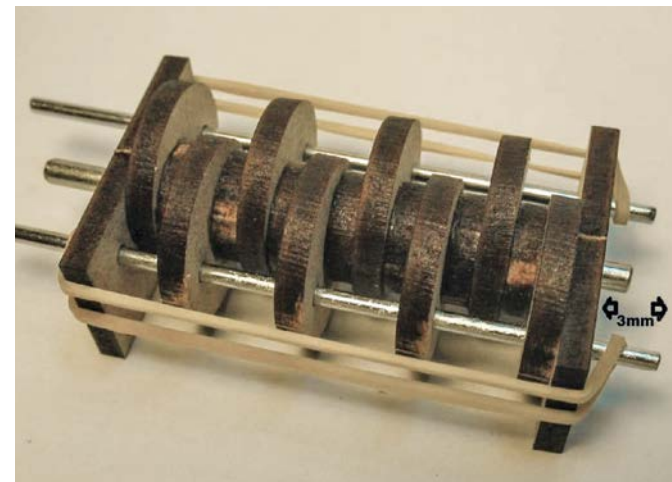
TIP

HANDLING STEEL BEARINGS

If you drop some of the steel ball bearings on the floor, do not use a magnet to pick them up. The balls can become magnetized, which will impair the operation of the machine.

MAKING THE MARBLE MACHINE

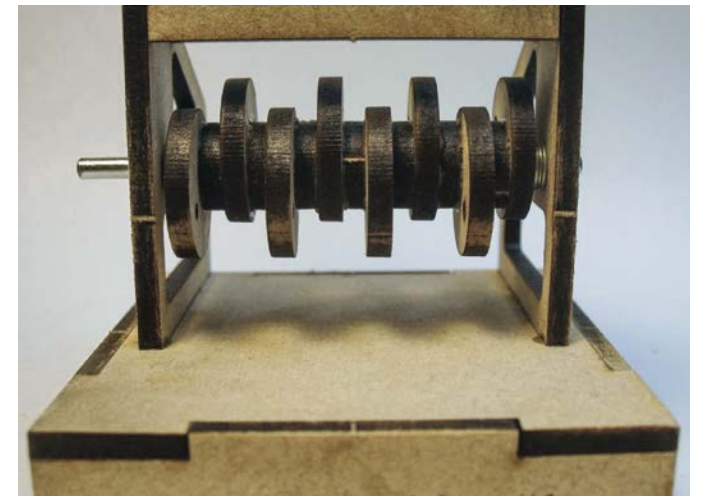
Step 1: Cut the pieces. Attach the patterns to the blanks. You must use $\frac{1}{16}$ " (2mm)-thick Baltic birch plywood for the tracks and associated pieces. I suggest stack-cutting the $\frac{1}{16}$ " (2mm) plywood with a thicker backing board. Not only does the backing board support the thin plywood, but it also slows down the speed at which you can cut, which allows you to cut more accurately. Be very careful when cutting the track spreaders, because they are very small and delicate. For the rest of the machine, I use $\frac{1}{8}$ " (3mm)-thick MDF or Baltic birch plywood. Cut all of the pieces, remove the patterns (acetone will dissolve the glue on the smallest and most delicate pieces), and sand off any fuzzies. Leave the track in its holder for the time being. Use a hacksaw or a cutoff wheel in a rotary tool to cut the brass rods to size. I use wood glue for most of the parts, but it's also possible to use CA glue, which dries faster, if you are careful.



Step 2: Assemble the camshaft. Beginning with a jig piece and then a cam, alternate the cams and spacers on a 3" (mm)-long 3mm axle. The axle should protrude $\frac{1}{8}$ " (3mm) from the jig. Align the cams in alternating directions and use two 2mm-diameter rods to hold them in place, and then add the other jig piece (the axle will protrude more at this end). Carefully separate the cams and spacers, apply glue between the pieces, and press all of them together. Do not glue the jigs. Use rubber bands to hold everything together as the glue dries.

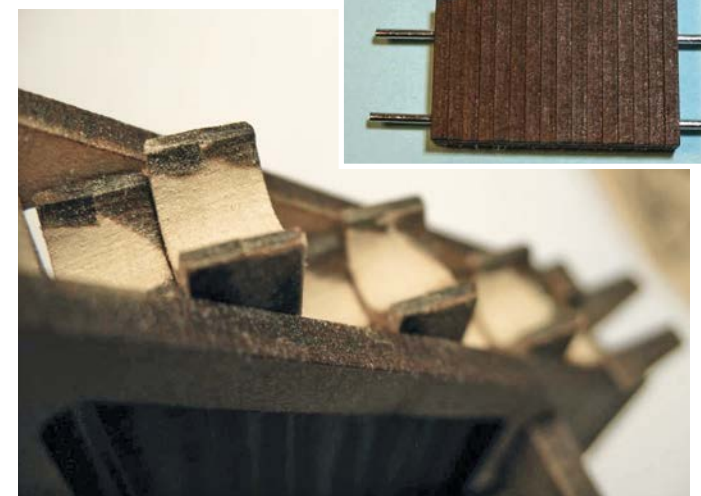
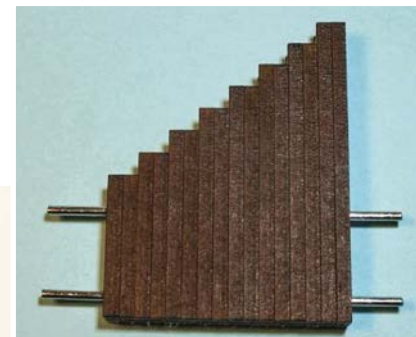


Place three or four washers on each end of the camshaft to achieve a proper fit between the frame uprights (Step 3).



Step 3: Assemble the base and frame. Note: When assembling the frame, use glue sparingly so it doesn't interfere with the movement of the steps later. Use the tabs and slots to assemble and glue the base. Dry-assemble the frame with the taller upright on the left and the shorter one on the right; match the flat and angled sides of the uprights. Place three or four washers on each end of the camshaft, slide it into the holes closest to the flat sides of the frame uprights with the 3mm axle end facing right, and check the fit. If there is a lot of play, add another washer, but the camshaft must not fit tightly between the frames. When the camshaft spins properly, glue the front and rear frame pieces in place. Glue the uprights to the base with the taller side on the left. Then, glue the track supports to the frame.

Each step is a pair of pieces glued together. The top of the steps are rounded to hold and lift the marbles.

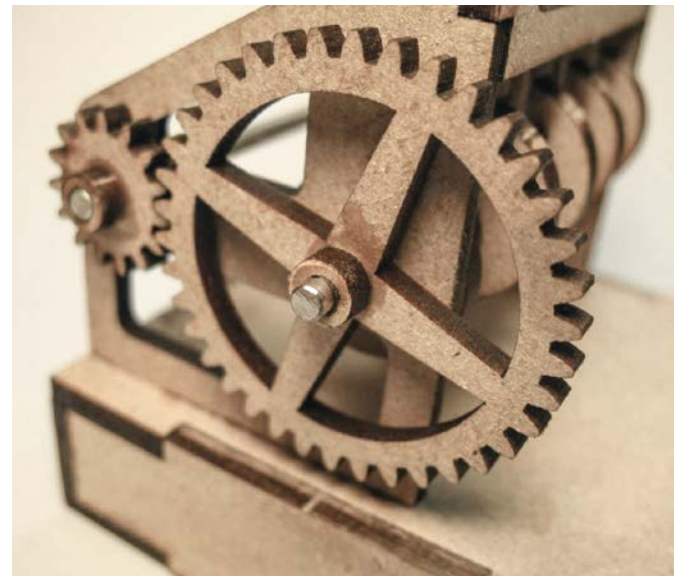


Step 4: Assemble the steps. Each step consists of two pieces. Match the pairs by height, apply wood glue to each pair, aligning the holes with 2mm rods; clamp and let dry. Sand the front and back of each step with fine-grit sandpaper.

Apply a light coat of varnish to the steps, and buff them with fine-grit sandpaper. Mark the front of each step, and then wrap sandpaper around a thin dowel or use a rotary tool with a small sanding drum to sand a 5° to 7° angle into the curved tops; the fronts of the steps should be higher than the backs. Periodically fit all of the steps into the frame, letting them drop into position on the cam, to ensure that each is still a bit taller than the next. If you sand off too much, attach a piece of scrap plywood to the bottom and sand it until the step sits correctly. If you sand the layers too thin, add a couple layers of tape to the side of the lower step. Fit the assembled steps into the frame as well, to ensure they slide smoothly up and down.



the glue dry, and repeat for the upper track support. Sand the tops of the uprights at an angle so the balls run smoothly off the steps.

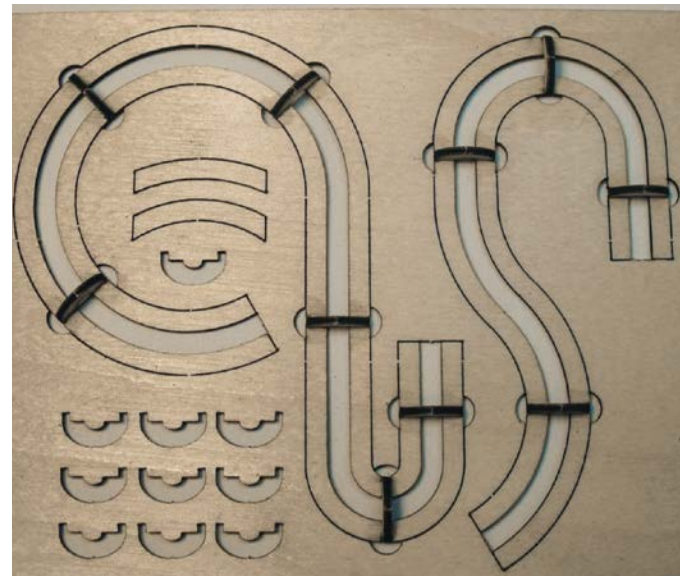


▲ Step 6: Finishing the machine. Place a washer on the protruding axle and add the large gear and doubler. Use a drop of CA glue between the gear and doubler to hold the gear on the axle; do not get glue in the hole in the upright.

Insert the 3mm crank arm shaft into the remaining holes in the uprights and place a washer at each end. Fit the small gear and a doubler on the shaft next to the large gear; align the gears and secure the small one to its shaft with a drop of CA glue. Glue together the crank handle pieces. Place a doubler and then the crank handle on the other side of the crank arm and secure them with a drop of CA glue. Glue a 1" (25mm)-long piece of 3mm rod into the remaining hole in the crank handle. Place the marble machine on a level surface, drop six to eight balls on the track, and crank away.

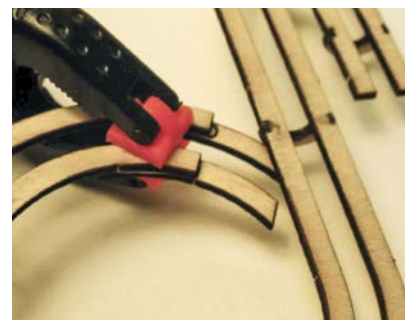


The cam-driven steps elevate the marbles to the top of the track, and gravity returns them to the base of the steps.



▲ Step 5: Assemble the track. Leave the tracks in the retaining sheet and use a sharp knife to cut the retaining tabs and remove the piece between the tracks. Turn the track blank over so the back is facing up. Place a glob of glue on scrap paper and dip the track spreaders into it before mounting them in the cutouts in the track. Allow the glue to dry, and then carefully cut the tracks free. Match the pointed ends of the track and glue the outside joiner (marked O) to

the under side of the outside track, clamp or weight, and let dry. Repeat for the inside joiner (marked I). Sand the transition smooth. Then, glue and clamp the track to the lower and side track supports. Let



Miniature marble machine alternate views



Michael Henriksen is 45 years old and lives in the Faroe Islands with his wife and daughter, midway between Iceland and Norway. He is an IT professional with a strong interest in kinetic art and all things mechanical. He started a business in 2012 to design, manufacture, and sell laser-cut kits for marble machines, garden railway rolling stock, Stirling engine kits, and other mechanical contraptions. He works with both traditional materials and modern composites.