

Shake Table

This version of the Shake Table draws on elements from the following:

- a shop project and write-up shared by Pier Sun Ho during the Summer 2001 Exploratorium Teacher Institute, which in turn was based on a shake table shown on the Exploratorium website (<http://www.exploratorium.edu/faultline/ls/buildingsc.html>)
- modifications developed by Teacher Institute shop staff members in the 2002 Institute
- a RAFT shake table write-up by Coral Clark
- modifications developed by Carey Linder in the 2003 Institute

As evidenced in the comments above, the Shake Table design is continually evolving. For this reason, it is possible that the design or materials being used by the TI Summer Institute shop staff may differ slightly from this writeup.

Please let the shop staff know if you have an idea for a modification which you feel improves the present design.

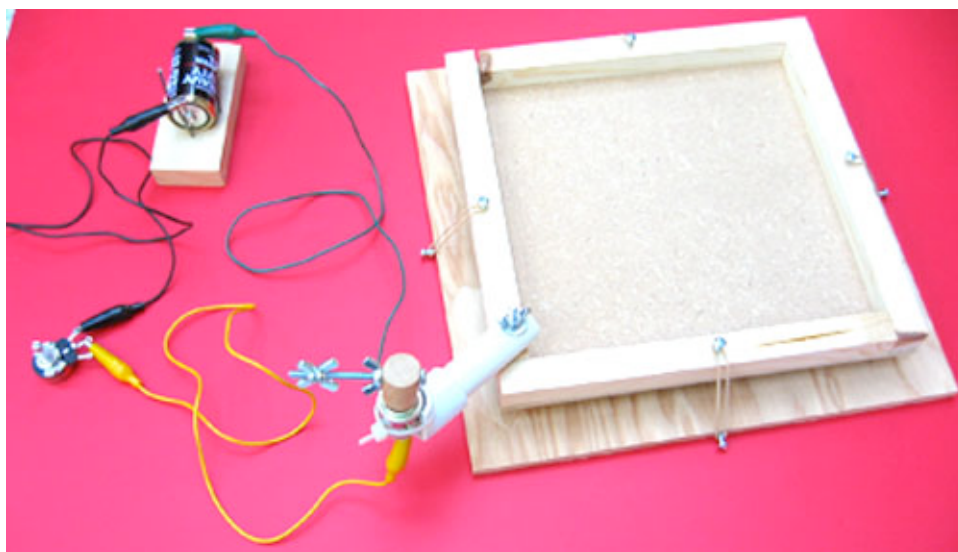


Figure 1

Materials

- | | |
|--|--|
| 1 piece plywood, 3/8" or thicker, 12" x 12" | 2 machine screws, 10 - 24 x 2 1/2" long |
| 1 piece masonite, 1/8" thick, 10" x 10" | 4 wing nuts, 10 - 24 |
| 4 pieces wood, 3/4" x 3/4", 9 1/4" long | 2 flat steel washers, 1/4" |
| 8 sheet metal screws, #6 x 5/8", pan head, Phillips | wood block, 2" x 4" x 3/4" |
| (optional) 8 additional sheet metal screws, #6 x 5/8", pan head, Phillips (not necessary if you use hot glue in Assembly step 3 below) | 4 finishing nails, 1 1/2" |
| 4 rubber bands, #16 | 1 potentiometer, 25 ohm (Radio Shack 271-265) |
| 4 plastic film can lids | 3 alligator clip leads (Radio Shack 278-1157) |
| 4 marbles | electric drill |
| 1 PVC pipe, 1/2", Schedule 40, 3 in long | 3/16" drill bit |
| 1 PVC elbow, 1/2" | 7/64" drill bit |
| 1 small electric motor (Radio Shack 273-223, 1.5 - 3 volts dc) | 1/16" drill bit |
| 1 cable tie, 7.5" | screwdriver |
| 1 wooden dowel, 3/4" diameter x 1" long | hot glue gun and hot glue sticks |
| | battery, 1.5 volt, D cell |
| | masking tape or clamps (to hold bottom down if you don't want to do this manually) |

Assembly

1. Hot-glue the four film can lids to the base, with the bottoms of the lids facing upward. Place the lids so that they will be under the top when the top is in place. Our design has the lids placed 3 inches inside the edges of the base, so that they will be 2 inches inside the edges of the top. See Figure 2.
2. Place a marble in each lid. See Figures 2 and 3.

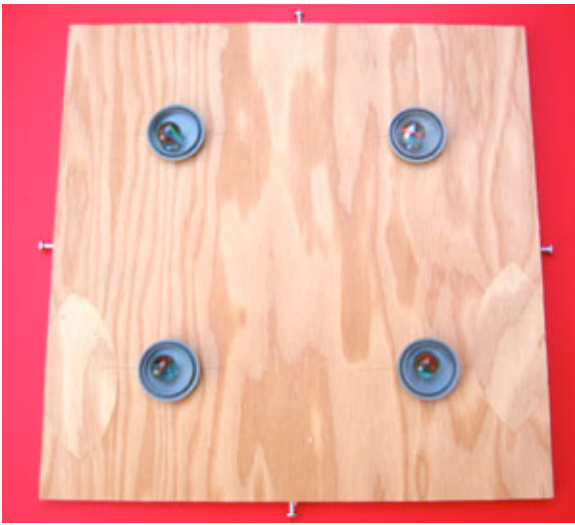


Figure 2



Figure 3

3. Attach the four pieces of wood around the edge of the masonite top with hot glue. See Figures 1, and 4. NOTE: Hot glue will likely hold despite the shaking, but you can use screws if you wish (see Materials list). For screws, drill $7/64$ " pilot holes through the masonite and into the wood, and screw the masonite to the wood rims from the bottom.
4. Put a screw horizontally into the middle of each of the edges of the base, and vertically into the middle of each of the top rims. See Figures 4 and 5. Use pilot holes ($7/64$ "), especially on the edges of the base.



Figure 4



Figure 5

5. Lay the top on the marbles, and put a rubber band around each pair of screws. See Figures 4, 5 and 6.

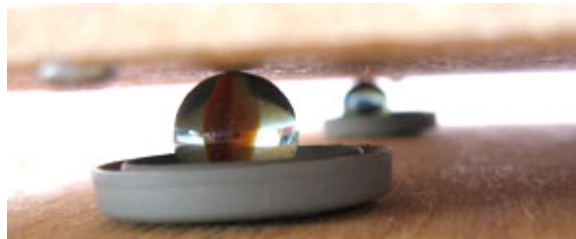


Figure 6

6. Use a band saw to cut the PVC elbow as shown in Figure 7 (ask the shop staff to show you how to do this safely if you haven't done this sort of work before).
7. Drill a 1/16" hole in one end of the wooden dowel, and a 3/16" hole across the dowel near the other end.
8. Assemble the dowel, machine screw, and 3 wing nuts as shown in Figure 8.



Figure 7

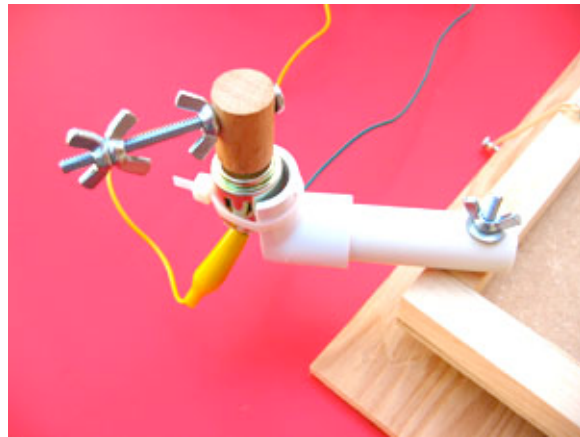


Figure 8

9. Hold the motor so that the short end of the shaft (which protrudes from the plastic end cap) is resting on a hard surface and the long shaft on the other end is sticking straight up from the motor. Press the **DOWEL DOWN ONTO THE MOTOR SHAFT** so that the shaft fits into the hole. (**CAUTION:** If the fit is tight and you try to push the **motor shaft down into the dowel**, you may pop the motor right out of its casing!)
10. Drill a 3/16" hole through the PVC pipe near one end, and through the top of the wood rim near one corner. Use a machine screw and 2 washers to attach the pipe to the top of the table. See Figure 8.
11. Use the cable tie to attach the motor to the elbow, and then attach the PVC elbow and motor assembly to the PVC pipe. See Figure 8.
12. Make a battery holder as shown in Figure 9.
13. Use the alligator clip leads to hook up the battery, motor and potentiometer in a series circuit. See Figure 1. The clips should be attached to the middle tab and either of the end tabs on the potentiometer. See Figure 10.



Figure 9



Figure 10

14. You may find that performance will be improved by restraining the bottom when the table is vibrating. This can be done by holding the bottom down with your hands, taping the bottom down, or clamping it down.

Notes and Comments

- to obtain the table motion that suits your purpose, experiment with the speed and position of the motor, and with the amount and location of mass on the machine screw "eccentric"
- the motor assembly is adjustable -- you can pivot the PVC pipe around the screw through the cardboard top, allowing the position of the whole motor assembly to be changed -- also, the elbow rotates on the end of the pipe, allowing the machine screw "eccentric" to rotate in a horizontal or vertical circle, or in between
- the motor speed is adjusted with the potentiometer
- if you want higher motor speeds than you can get with a single D cell (1.5 volts), try two D cells in series (3 volts)
- the amount and location of mass on the eccentric can be adjusted with the two outer wing nuts – you can use two, one, or zero, and you can even add small washers between the wing nuts – you can also adjust the location of the two wing nuts either closer in or farther out on the machine screw
- suggestions have been made that using rubber balls instead of marbles in the film can lids will make the operation quieter, and that using larger marbles or balls as bearings might also be considered
- you are certainly encouraged to create improved versions of the shake table -- if you come up with an improved design, or develop activities that work particularly well, please let us know!

To Do and Notice

Students can design and build structures, and test them on the shake table (straws, toothpicks, pasta, or bamboo skewers are a few possibilities for structural members; small marshmallows, spice drops, and paper clips are a few possibilities for joiners). You can also use building blocks, Lego bricks, Lincoln Logs, etc. to build structures, or you can just stand narrow, tall objects (e.g., marker pens, paper towel tubes, etc.) on the table.

Look for the presence of resonance as the table shakes. For a particular motor adjustment there may be certain places where a structure may be almost still, while at other places it vibrates wildly; or for a given location of a certain structure there may be a particular motor adjustment that causes notable vibration and another adjustment that causes almost no vibration; or one structure may topple under conditions that hardly cause another to vibrate.

Use a small container of wet sand to demonstrate liquefaction. Place an object in the container to see if it will "sink."

Demonstrate the principle of a seismograph by taping a strip of paper to the shake table, and then moving a pen straight along the paper while the table is vibrating. (Roller- ball or fiber-tip pens work well, since you don't have to exert much pressure to get them to mark.)

Simulate molecular motion using beads, ball bearings, small pieces of PVC, marbles, small rubber balls, etc.