

# Earthquake Shake Table

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The document below describes how to build an inexpensive shake table to simulate ground motion during an earthquake. The table is ideal for having students design Popsicle stick buildings to minimize damage during an earthquake. The table is also an excellent mechanism to study the resonance frequencies of buildings using the BOSS (Building Oscillation Seismic Simulation) Model published by AGU/Fema in their Seismic Sleuths publication.

## PART I: Base of Earthquake Table

### Materials Needed:

| Qty.    | Size          | Material                     |
|---------|---------------|------------------------------|
| 1       | 20" x 40"     | 1/2" Plywood                 |
| 2       | 40" length    | 2 x 4                        |
| 2       | 46" length    | 2 x 4                        |
| 2       | 20" length    | 7/8" diameter PVC pipe       |
| 2       | 21.5" length  | 7/8" diameter wooden dowel   |
| 4       |               | 7/8" metal washer            |
| 8       | 4" length     | 1/4" carriage bolt           |
| 8       |               | Rubber sleeves               |
| 4       | 4" length     | Ceiling hooks (with threads) |
| Several | 1 5/8" length | Drywall screws               |
| Several | 3/4" length   | Drywall screws               |

Note: All ceiling hooks and carriage bolts are centered on the 2 x 4 lengths.

**Step 1:** Attach 2 x 4s to 20" x 40" plywood piece using drywall screws (Fig. 1). Carriage bolts are attached to the inside 46" length 2 x 4 at distances of 10.5", 13.5", 22.5" and 25.5" from the end that extends beyond the plywood base and should be countersunk to allow the 2 x 4s to lie flat on a countertop (Fig. 2). Place rubber sleeves over carriage bolts to prevent wear on wooden dowels.

**Step 2:** Prepare to attach PVC pipe by first drilling three holes in the PVC. Two should be located 2" from each end and one at the midpoint of the pipe. These holes should only be drilled through one side of the PVC pipe. They will allow you to secure the pipe to the base later by serving as "windows" for the screws. These holes help the platform to glide more smoothly than if screws were sticking up a little on the top of the PVC pipe. Again center the pipes on the outer 2 x 4 and inset 2" from each of plywood sheet (Fig. 2).

**Step 3:** Ceiling hooks are attached to the inner 2 x 4 at distances of 3" and 33" measured from the end that extends beyond the plywood base (Fig. 3).

**Step 4:** After assembling the base of the table, place the metal washers on each end of the wooden dowels. These dowels should be placed inside the bolt "fences". Do not secure these dowels! They will be the part that the platform will move back and forth on (Fig. 4)

## **PART II: The Shake Platform**

### **Materials Needed:**

| <b>Qty.</b> | <b>Size</b> | <b>Material</b>              |
|-------------|-------------|------------------------------|
| 1           | 20" x 20"   | 1/2" Plywood                 |
| 2           | 20" length  | 2 x 4                        |
| 4           | 4" length   | Ceiling hooks (with threads) |
| Several     |             | Drywall screws               |

**Step 1:** Attach the two 2 x 4s to the edges of the plywood with drywall screws and place the ceiling hooks 5" in from the edge of the plywood and centered on the 2 x 4s (Fig. 5).

**Step 2:** After assembly is complete, the table should be secured on top of the base by hooking 2 large rubber bands around each pair of hooks. The table platform should be able to roll back and forth over the wooden dowels (Fig. 6).

### **PART III: The Drill Mechanism**

Materials Needed:

| <b>Qty.</b> | <b>Size</b>       | <b>Material</b>                |
|-------------|-------------------|--------------------------------|
| 1           | 6" length         | 2x4 with 5/16" hole            |
| Box         | 7" x 11" x 2 3/4" | 1/2" Plywood                   |
| Several     | 3/4" length       | Drywall screws                 |
| 2           | 2 1/2" x 5/8"     | Corner brackets                |
| 4           | 1 1/2" x 5/8"     | Corner brackets                |
| 1           | 13" length        | Metal strap (armature)         |
| 2           | 1 1/4"            | Carriage bolts with wing nuts  |
| 1           | 12" x 2"          | Brass strap for securing drill |
| 1           | 1/2"              | Variable speed electric drill  |

**Step 1:** Cut a 7" x 11" piece of 1/2" plywood and attach to base using drywall screws (Fig. 7).

**Step 2:** Construct the walls of the box and attach to box base using corner brackets (Fig. 8). Note an additional 1 3/4" x 7" x 1/2" strip of wood is used to reinforce each short side of the box.

**Step 3:** Attach the 6" length of 2 x 4 with the 5/16" hole (1.5" from top of 2 x 4) using drywall screws and corner brackets (Fig. 9).

**Step 4:** Screw down top of box and attach electric drill using the carriage bolts with wing nuts and the brass strap as shown in Figures 9 - 11.

### **Part IV: Crank Mechanism**

Materials Needed:

| <b>Qty.</b> | <b>Size</b>   | <b>Material</b>                  |
|-------------|---------------|----------------------------------|
| 1           | 3 – 3 1/2"    | 1/4" thick Aluminum disk         |
| 1           | 3 1/2" length | 5/16" Hex bolt with nuts         |
| 1           | 1 1/4"        | 1/4" Hex bolt with nuts          |
| 1           | 1 3/4" length | 5/16" Hex bolt, nuts and washers |

**Step 1:** Assemble the crank mechanism using Figures 12 - 14 as a guide. The center hole of the aluminum disk should be tapped and threaded for securing hex bolt to disk (Fig. 12).

**Step 2:** Attach armature to aluminum disk and shake platform. Hole for attachment of the armature to the disk should be approximately  $\frac{1}{2}$ " from center of disk and  $\frac{5}{16}$ " diameter (Fig. 12 and 13). Use the  $\frac{1}{4}$ " hex bolt for attachment of the armature to shake platform (Fig. 14). Note the twist in the armature for strength.

**Step 3:** Lock hex bolt in electric drill.

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**Figures 15 and 16** show the final product. When using the shake table, secure it to the table it is resting on using clamps. This will prevent the shake table from walking when the drill is at high RPMs. Expect to pay approximately \$100 for a good drill. The rest of the materials should not exceed \$25. The aluminum disk may require some machine time and this cost will vary. Therefore, Labor charges have not been calculated.



Figure 1. Underside of base showing locations of 2 x 4s.

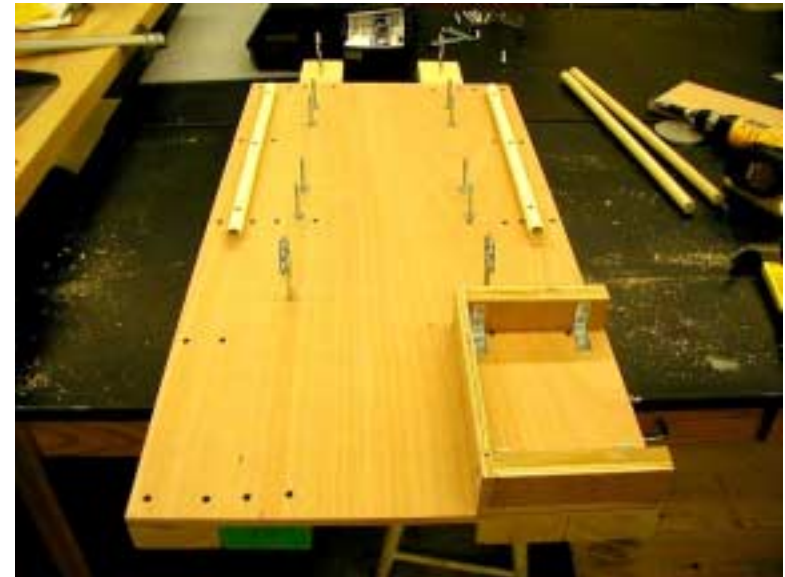


Figure 3. Top view of base showing positions of ceiling hooks. Partially complete box for drill also shown.

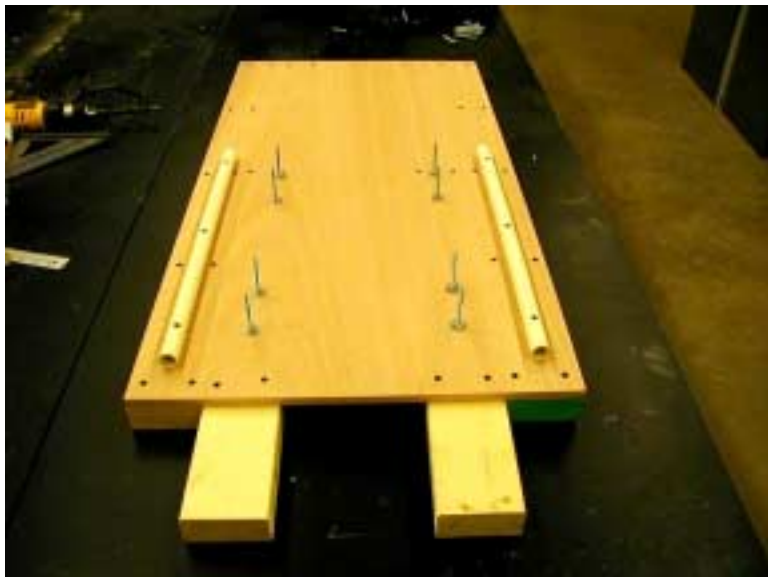


Figure 2. Top view of base showing positions of PVC pipes and carriage bolts.



Figure 4. Top view of table showing locations of wooden dowels. Note washers attached to dowels.



Figure 5. Assembled shaking platform with ceiling hooks attached.



Figure 7. Base of box for drill mechanism.



Figure 6. Shaking platform properly attached to the base.



Figure 8. Box partially assembled showing corner brackets.



Figure 9. End on view of 6" 2 x 4 attached to box.



Figure 11. Similar view as Figure 10.



Figure 10. Strapping assembly for electrical drill.



Figure 12. Close up of aluminum disk and armature.



Figure 13. View looking down disk assembly.



Figure 14. View of armature attached to shaking platform and aluminum disk. Note twist in armature for strength.



Figure 15. Assembled shake table with Popsicle stick building. Note c-clamp securing the table to the table upon which it rests.

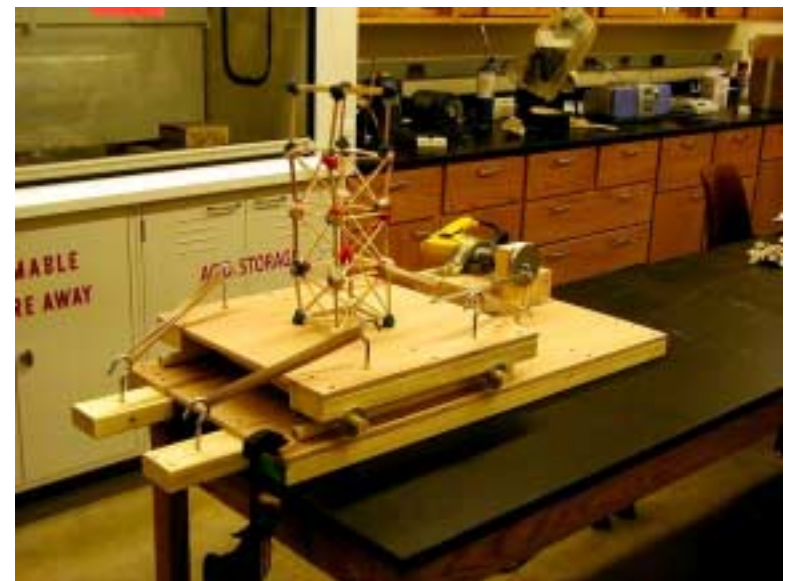


Figure 16. Opposite view of shake table.