

EQUIPMENT BUILD PLAN SOUND & WAVES

Chladni Plate Speaker Driver

A plate is bolted to a foam mount glued onto the cone of an ordinary speaker, so the speaker itself shakes the plate. As the frequency changes, salt or sand gathers along the lines that are not moving (the nodes), revealing a new pattern at each resonance. Commercial wave drivers cost \$200 or more; this one uses a discarded speaker, a foam ball and a milk jug.

Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.



DIFFICULTY Intermediate	BUILD TIME 1-2 hours
COST About \$10 (plus an amplifier you already own)	SAFETY Adult build / supervision
GOOD FOR Teachers, Makers, Families	

What it shows

Sprinkle salt on a plastic sheet, dial up a tone, and watch the grains rush into sharp geometric patterns.

Key ideas: standing waves, nodes and antinodes, resonance, frequency, vibration modes

Safety (Adult build / supervision). An adult should handle the soldering iron and hot glue gun; hot glue can melt foam and burn skin. The driver still works as a speaker and can be loud and piercing at some frequencies, so start with the volume low and raise it

slowly. Never plug a speaker into a headphone jack expecting it to drive the plate, and do not open up mains-powered amplifiers.

CONSTRUCTION

Build it

Materials

- ☐ **Speaker, about 8 in or larger** · 1
A discarded speaker is fine; even one with a slightly torn paper cone will work
- ☐ **Styrofoam ball (or a block of foam)** · 1
Cut in half so it fits inside the bottom third of the speaker cone
- ☐ **Bolt with wing nut and washer** · 1 set
The plate is clamped between the washer and the wing nut
- ☐ **Hookup wire** · 2 pieces, 8 in each
Only needed if the speaker has no leads
- ☐ **Plastic gallon milk jug** · 1
The bottom becomes the speaker stand
- ☐ **Thin plastic sheet, wood or light sheet metal** · Several pieces
Start with 10 × 10 in; Bruce also uses 12 × 12 in and 10 × 8 in plastic
- ☐ **Spray paint (optional)** · 1 can
Paint the underside of clear plastic a dark color so the salt shows up
- ☐ **Car wax** · A little
Polishing the top lets the grains slide freely
- ☐ **Fine sand or table salt** · 1 cup
- ☐ **Stereo amplifier and a sine-wave tone generator** · 1
Any free online or downloadable tone generator on a computer, tablet or phone; a computer alone does not have enough power to drive the speaker
- ☐ **Audio cables** · As needed
An adapter from the computer headphone jack to the amplifier input, and speaker wire from the amplifier to the driver

Tools

Hot glue gun

Soldering iron (or wire connectors)

Serrated knife or hacksaw blade for foam

Scissors or utility knife

Hair dryer (optional, for removing labels)

Drill (for the plate center hole)

1

Fit the foam mount

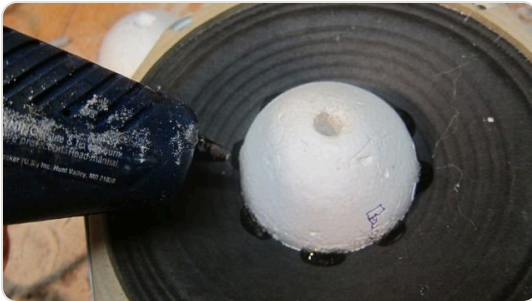
Cut the foam ball in half (or trim a block of foam) so it sits in the bottom third of the speaker cone, around the dust cap.



2

Glue the foam to the cone

Run a modest bead of hot glue where the foam meets the cone. Bruce uses only enough to hold it, so the speaker can be reclaimed later.



3

Set the bolt in the foam

Make a hole in the top of the foam a little larger than the bolt. Add hot glue a little at a time, since too much at once melts the foam; a splash of water cools it quickly, then dry it and add more. Push the bolt in head-down and keep adding glue until the hole is filled.

4

Add the washer

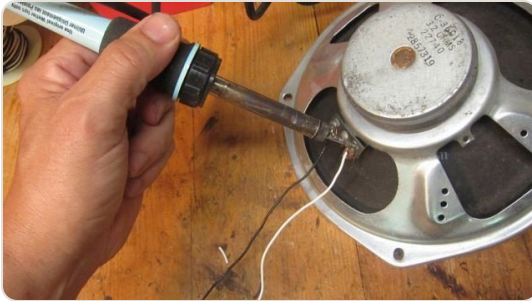
With the last layer of glue, press a washer onto the top of the foam around the bolt. The plate will sit on this washer and be clamped down by the wing nut.



5

Attach leads

If the speaker has no wires, solder an 8 in wire to each terminal (or attach them with connectors).



6

Make the stand

Cut the bottom off a gallon milk jug. Melt or poke two small holes in the side for the speaker wires, using a soldering iron tip or a hot glue gun nozzle (adult job). A hair dryer or a little WD-40 removes the label.



7

Seat the speaker

Thread the wires through the holes and set the speaker magnet-down in the jug. Because it rests loosely, you can tilt it back and forth until the plate sits level.



8

Prepare the plates

Cut plates about 10 × 10 in to start, then try other sizes and shapes such as a circle or a guitar-shaped soundboard. Drill a hole in the exact center for the bolt.



9

Finish the plates

Paint the underside of clear plastic a bold color so the white salt stands out, then polish the top with car wax so the grains slide easily.



10

Connect the electronics

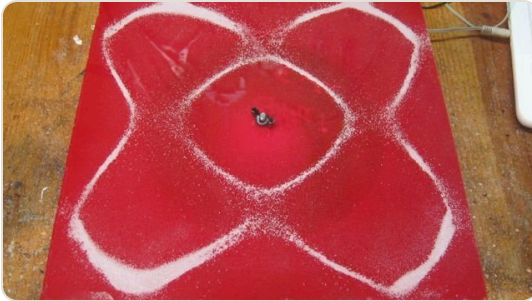
Run the tone generator into the amplifier input with an adapter cable, and connect the driver to the amplifier's speaker output. Bruce made his speaker lead from an old cable with the right plug for the back of his stereo.



11

Mount a plate and test

Place a plate on the washer, tighten the wing nut, and level it. Sprinkle salt evenly, start near 50 Hz with the volume low, and raise the frequency 1 to 10 Hz at a time until a pattern snaps into place.



THE PHYSICS

How it works

A thin plate can vibrate in many different shapes, called modes. Each mode happens at its own natural frequency. When the driver shakes the plate at one of those frequencies, the plate resonates and settles into a standing-wave pattern.

In a standing wave some regions move a lot (antinodes) and some lines barely move at all (nodes). Salt on a vibrating region is bounced around until it lands somewhere quiet, so the grains collect along the nodal lines and draw a map of the vibration.

Higher frequencies produce modes with more nodal lines, so the patterns become more detailed as you turn the frequency up. Between resonances the plate barely responds and the salt just jitters. Ernst Chladni first showed these figures around 1787 by bowing the edge of a metal plate with a violin bow.

Using it

- Sweep slowly upward from 50 Hz and have students sketch each pattern and record its frequency.
- Ask students to predict where the salt will end up before you turn the tone on, then discuss why it gathers where the plate is still.
- Compare plates of different sizes, shapes and materials at the same frequency.
- Connect the patterns to musical instruments: guitar and violin makers study the same modes in their soundboards.
- Keep the volume as low as possible; the driver also acts as a loudspeaker, so short bursts are kinder to everyone's ears.

GO FURTHER

Variations

- Plates cut from an old vinyl record: Bruce painted one to fill in the grooves and sanded it smooth with rubbing compound.
- Light sheet metal, about 24 gauge (roughly 1/64 in thick). Cut it carefully so it stays flat.
- Instrument shapes such as a guitar or violin face.
- Bruce built a small portable amplifier for workshops by mounting the amplifier board from a yard-sale set of computer speakers on a wooden base.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

Salt slides off to one side instead of forming a pattern

TRY THIS

The plate is not level. Tilt the speaker in the jug until the plate sits flat.

IF THIS HAPPENS

Very weak vibration

TRY THIS

Use a real amplifier rather than a headphone jack, and fine-tune the frequency in 1 Hz steps; resonances can be narrow.

IF THIS HAPPENS

Grains stick instead of moving

TRY THIS

Polish the plate with car wax and use dry, fine salt or sand.

IF THIS HAPPENS

Plate rattles against the mount

TRY THIS

Snug the wing nut down firmly so the plate and bolt move as one.