

EQUIPMENT BUILD PLAN

MATTER

Buoyancy of Sand Vibrating Tub

A small battery motor with a lopsided wooden arm shakes a plastic tub of sand. The vibration lets the sand grains flow like a fluid, so low-density objects buried in it rise to the surface and dense objects sink, exactly as Archimedes' principle predicts. A shaken jar version takes five minutes; the motorized tub makes the effect smooth and repeatable.

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



<div>DIFFICULTY</div> <div>Intermediate</div>	<div>BUILD TIME</div> <div>2-3 hours</div>
<div>COST</div> <div>About \$15-25</div>	<div>SAFETY</div> <div>Adult build / supervision</div>
<div>GOOD FOR</div> <div>Teachers, Makers, Families</div>	

What it shows

Switch on the motor and buried ping-pong balls pop up through solid sand while steel balls on top sink out of sight.

Key ideas: buoyancy, density, Archimedes' principle, friction, granular materials

Safety (Adult build / supervision). An adult should do the drilling and soldering. The wooden arm spins fast and can fly off if it fits loosely; keep fingers and faces clear when the motor is running. The tub runs on a battery pack only. Wash hands after handling lead sinkers, or use steel balls and nuts instead.

CONSTRUCTION

Build it

Materials

- ☐ **Small toy DC motor** · 1
About 1 in diameter
- ☐ **Thin-walled, flexible plastic container** · 1
1 gallon or larger: an ice cream tub, a 1 1/2 gallon bleach bottle, milk jug, 2 gallon juice bottle or toy bucket
- ☐ **Scrap wood block** · 1 piece, 2-3 in square
Thick enough to hold the motor
- ☐ **Wood for legs** · 4 pieces, 5 in long
- ☐ **Plywood, 1/4 in** · 1 piece for the base
Square, round or hexagonal
- ☐ **Small wooden strips for the vibrator arms** · 3-4
Different sizes to test
- ☐ **Wood screws, 1/2 in long** · 12
- ☐ **Bolts, 1 1/2 in, with nuts** · 2
Terminals for the power leads
- ☐ **Battery holder for 3 or 4 D cells** · 1
Two cells are not energetic enough

- ☐ **D cells** · 3 or 4
- ☐ **Alligator clips** · 2
- ☐ **Hook-up wire** · about 2 ft
To extend the motor leads
- ☐ **Masking or duct tape** · 1 roll
- ☐ **Sand** · about 1/2 gallon
- ☐ **Light objects: ping-pong balls, foam peanuts, foam bits, fishing bobbers** · several
- ☐ **Dense objects: steel balls, iron nuts, paper clips, fishing sinkers** · several

Tools

Drill

Spade bit, 15/16 in (1 in also works)

Drill bit, 1/16 in

Larger drill bit for countersinking

Screwdriver

Scissors

Sandpaper

Soldering iron and solder

Saw

1

Try the jar version first

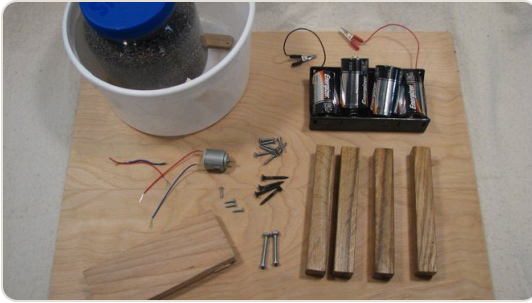
Put about 3 inches of sand in a large plastic jar. Bury a ping-pong ball and some foam bits, set a steel ball or nut on top, cap the jar and shake it. With a little practice you will find the right direction and force.



2

Gather the materials

Collect the container, motor, wood, screws, battery holder and clips.



3

Drill the motor block

Drill a 15/16 in hole (1 in also works) into a scrap of wood, then cut the wood to a 2-3 in square around the hole. Sand it smooth.



4

Fit the motor

Press the motor into the hole so its bottom is flush with the block. It must fit very snugly; if it is loose, wrap a turn of tape around the motor first.



5

Cut the tub

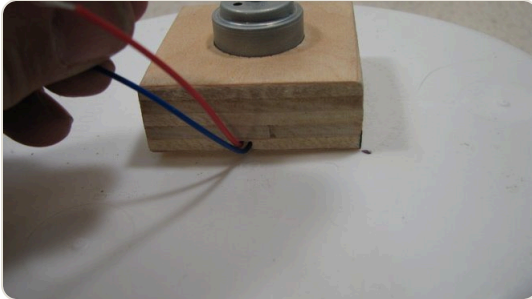
Cut the top off the plastic container with scissors, leaving a bottom section about 3 inches high. Sand the cut edge smooth.



6

Attach the motor block

Center the block on the outside bottom of the tub, motor shaft pointing away from the tub, and tape it in place. Then fasten it with four short screws driven from inside the tub.



7

Make the vibrator arms

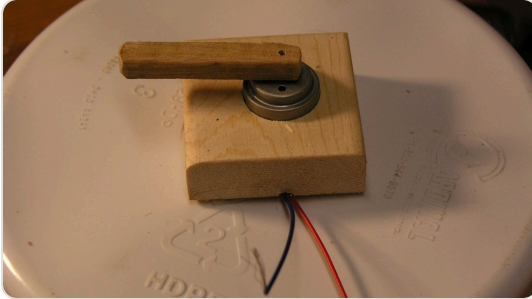
Drill a 1/16 in hole near one end of several small wood strips, giving each a different size or hole position. Each must press tightly onto the motor shaft; if one is loose, drill a new hole one size smaller.



8

Mount an arm

Press one arm onto the motor shaft. Because it is off-center, it shakes the whole tub as it spins.



9

Build the stand

Cut a base from 1/4 in plywood. Drill a hole for each leg, sized so the screw passes through easily, and countersink it. Screw the four 5 in legs to the base loosely.



10

Attach the tub to the legs

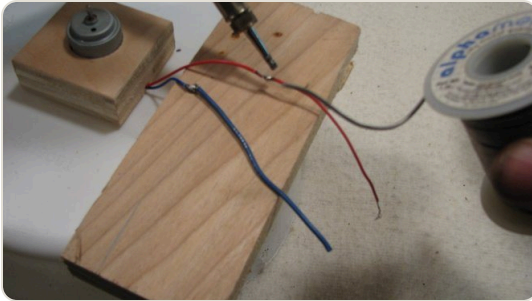
Set the tub between the legs, high enough that the motor arm will not hit the table. Drill two holes through the tub wall at each leg and fasten the tub to each leg with two screws.



11

Extend the motor leads

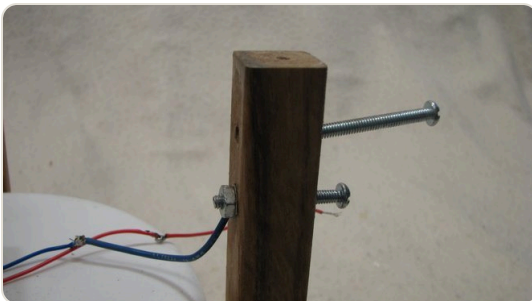
Remove the plywood base to make wiring easier. Solder extension wires to the motor leads if they will not reach the nearest leg.



12

Add the terminal bolts

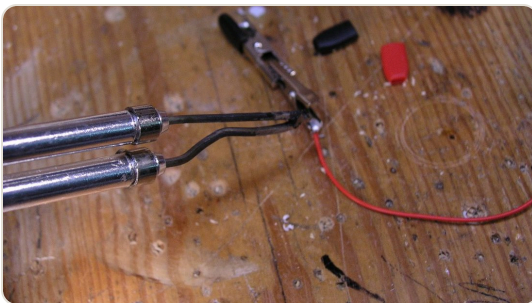
Drill two holes, slightly smaller than the bolts, in the leg nearest the motor wires. Thread in two 1 1/2 in bolts and attach one motor wire to each with a nut. Tape the wires to the tub so they stay clear of the spinning arm.



13

Prepare the power leads

Attach an alligator clip to each wire of the battery holder, by screw terminal or solder.



14

Reassemble loosely

Screw the base back on but do not tighten the screws: the legs must be free to wiggle so the tub can vibrate.



15

Add sand and test

Pour in the sand, bury light objects, and set dense ones on top. Clip the battery leads to the bolts to start the motor, and try each wooden arm to see which gives the best motion.



THE PHYSICS

How it works

Whether an object sinks or floats depends on its density compared with the fluid around it. Archimedes' principle says the fluid pushes up on an object with a force equal to the weight of the fluid it displaces.

Dry sand is made of solid grains, but a container of sand also has an overall density, about 1.5 to 1.6 grams per cubic centimeter. A ping-pong ball or foam peanut is far less dense; a steel ball is far more dense.

When sand sits still, friction between the grains locks them in place, so nothing moves. Vibration keeps the grains slightly separated and moving, which cuts that friction and lets

Using it

- Show the tub with the steel balls on top and ask what will happen when it starts shaking. Then run it and let the ping-pong balls surprise everyone.
- Have students predict sink or rise for a mix of objects, such as a golf ball, a cork, a marble, a plastic bottle cap, then test.
- Compare the vibrating sand with a tub of water: which objects behave the same way in both?

the sand flow like a liquid. Now buoyancy wins: light objects are pushed up and dense objects sink.

The same process happens slowly in nature. Light litter buried at the beach can work its way back to the surface over weeks or months as waves, wind and footsteps jostle the sand.

- Try the different wooden arms and observe: small arms vibrate faster with smaller motion; larger arms vibrate slower with larger motion. Which works best, and why?
- Discuss real examples: why buried trash returns to the beach surface, and why loose soil shaken in an earthquake can let buildings sink (liquefaction).

GO FURTHER

Variations

- The simple version is just a large plastic jar of sand shaken by hand.
- Bruce also built a larger version from a 5 gallon bucket driven by a plug-in motor. That version is not covered here because it runs on household current; the battery tub shows the same effect.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

The tub barely vibrates.

TRY THIS

Make sure the leg screws are loose, use 3 or 4 D cells rather than 2, and try a larger or more off-center wooden arm.

IF THIS HAPPENS

The wooden arm flies off the shaft.

TRY THIS

Stop the motor and drill a new arm with a smaller hole so it grips tightly.

IF THIS HAPPENS

The motor hits the table.

TRY THIS

Move the tub higher on the legs or use longer legs.

IF THIS HAPPENS

Light objects do not rise.

TRY THIS

Bury them only an inch or two deep at first, and make sure the sand is dry.

IF THIS HAPPENS

The motor wobbles in its block.

TRY THIS

Wrap a layer of tape around the motor so it fits tightly in the hole.

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