

EQUIPMENT BUILD PLAN

ELECTRICITY & MAGNETISM

No-Magnet Motor (Double-Coil Motor)

This plan covers two motors. The first is the familiar simple motor: a hand-wound wire coil spinning on two supports above a magnet. The second takes the magnet away and puts an electromagnet in its place, a coil wound around a bolt and wired in series with the spinning coil. Building both lets students compare permanent magnets and electromagnets directly.

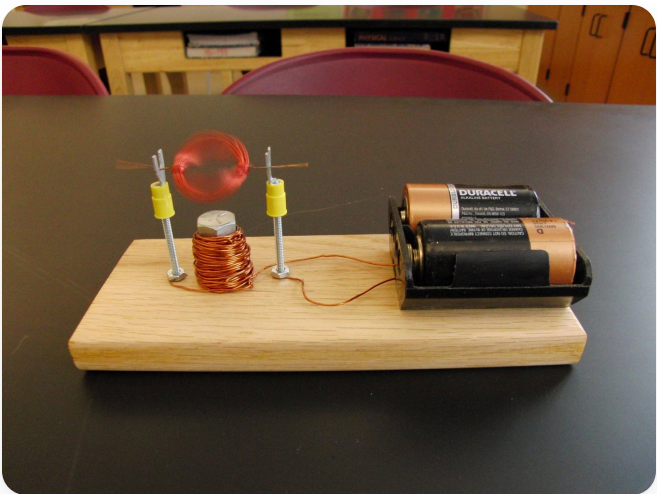
Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.

What it shows

Students who have built the classic coil-and-magnet motor are always surprised that it still spins when the magnet is swapped for a coil of wire around a bolt.

Key ideas: electromagnets, electric motors, magnetic attraction and repulsion, series circuits, commutation

Safety (Everyday care). Younger builders need an adult's help with scraping wire (the scissors edge is sharp) and with drilling the base. The circuit is close to a short circuit, so the wire and battery get warm: disconnect



DIFFICULTY	BUILD TIME
Beginner	30-45 minutes
COST	SAFETY
About \$5-10	Everyday care
GOOD FOR	
Teachers, Families, Makers	

ALSO IN BRUCE'S BOOK

A version of this device appears in *If You Build It, They Will Learn* (NSTA Press).

About the book

the battery whenever the motor is not running.

CONSTRUCTION

Build it

Materials

- ☐ **Enameled copper (magnet) wire for the spinning coil** · about 3 ft
About 22 gauge
- ☐ **C cell battery** · 1
Used as a winding form
- ☐ **Enameled copper wire for the bottom coil** · about 8 ft
- ☐ **Bolt, 5/8 in diameter, 2 in long** · 1
Steel core for the bottom coil
- ☐ **Bolts, about 3 1/2 in long, with nuts** · 2
Coil supports
- ☐ **Spade-type crimp wire clips** · 2
Their forks cradle the coil's axles
- ☐ **Battery holder (2 D cells)** · 1
- ☐ **Wood base** · about 4 × 8 in
- ☐ **Ceramic magnet** · 1
Only for the classic simple motor

Tools

Scissors (for scraping enamel)

Drill

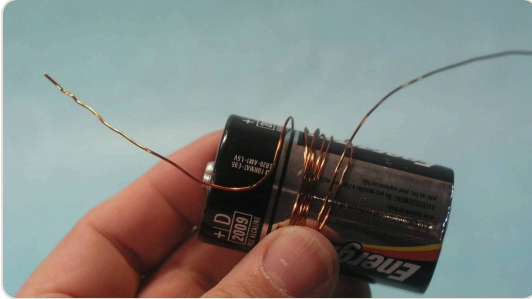
Screwdriver or wrench

Pliers

1

Wind the spinning coil

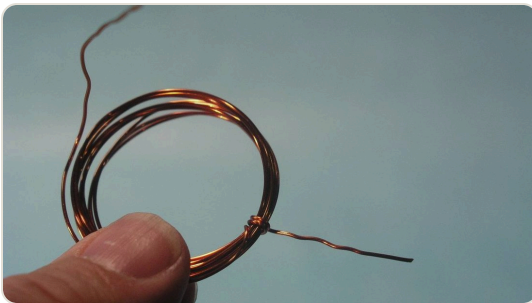
Straighten the wire. Bend the first 2 in to a right angle, hold that bent end against the side of a C cell with your thumb, and wrap the rest of the wire around the cell.



2

Tie off the coil

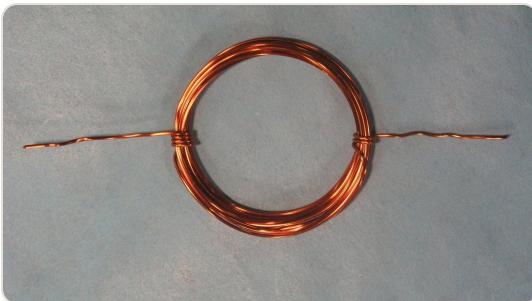
Slide the coil off the cell, pinching it together. Wrap the loose end two or three times around the coil to bind it, then wrap the starting end around the opposite side the same way, so the two ends stick straight out on opposite sides.



3

Straighten the axles

Check that the two ends line up directly across from each other. Trim them, or add an extra wrap, if they stick out more than about an inch, and straighten them carefully. Kinks make the coil wobble.



4

Scrape one axle completely

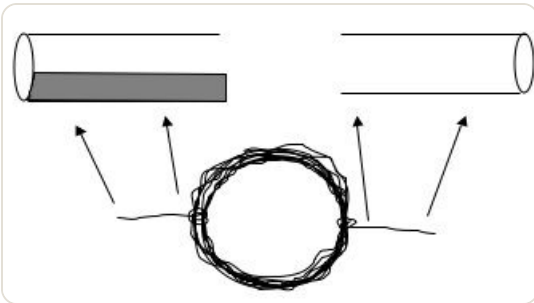
Lay one end flat on a hard surface and scrape all the enamel off its full length with the edge of the scissors, turning the coil as you go.



5

Scrape the other axle on one side only

Hold the coil upright and lay the other end on the hard surface. Scrape only the top half of this wire along its full length, leaving the bottom half coated. This half-scraped end is what makes the motor work.



6

Make the bottom coil

Drill a hole in the base and screw the 2 in bolt into it. Wind the 8 ft of wire around the bolt, leaving about 5 in free at each end, and scrape the enamel off both ends.



7

Mount the supports

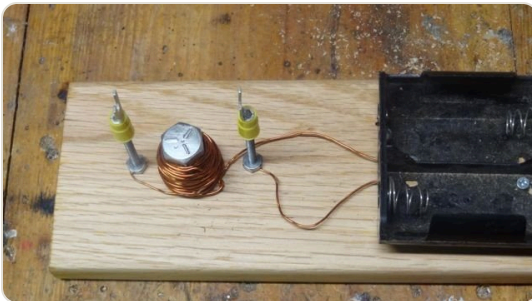
Drill two holes on either side of the bolt and screw in the two long bolts. Fasten a spade clip to the top of each one with its fork facing up to cradle the coil. Mount the battery holder on the base.



8

Wire the coils in series

Connect one battery lead to one support. Connect the other battery lead to one end of the bottom coil. Connect the other end of the bottom coil to the second support. Current now flows through both coils in turn.



9

Set the coil and start it

Rest the spinning coil's axles in the spade forks and adjust the supports so the coil sits level, close above the bolt without touching it. Give it a gentle spin to start it.



10

Try the classic version too

For the simple motor, set a ceramic magnet on the base under the coil and connect the battery straight to the two supports. Students should build and understand this version first.

THE PHYSICS

How it works

When current flows through the spinning coil, it becomes an electromagnet with a north and a south face. The magnet below (or the bolt electromagnet) attracts one face and repels the other, giving the coil a push.

If the current stayed on all the time, the coil would just swing until its faces lined up with the magnet and stop. The half-scraped axle prevents that. For half of each turn the bare metal touches the support and the coil is pushed; for the other half the enamel insulates it, the current switches off, and the coil coasts around on its momentum until the bare side touches again. Real motors do the same job with a commutator.

In the double-coil motor, the bottom coil wound around a steel bolt is an electromagnet. Because the two coils are in series, the bottom coil is magnetized only during the same half-turn the top coil is, which is exactly when the push is needed.

GO FURTHER

Variations

Using it

- Build the simple motor first as a class activity. Bruce has used printed step handouts, a large step-by-step poster, a guided build where everyone does each step together, or simply a finished model and a pile of materials.
- Hold a contest to see whose motor runs longest. Coils tend to jump off their supports, so have students brainstorm and test ways to keep them seated.
- After the simple motor, ask: could the permanent magnet be replaced with another coil? Let students try their own designs before showing the double-coil motor; many will power the bottom coil from its own battery.
- Discussion questions: How are the two motors alike and different? Trace the path of the current through the double-coil motor from start to finish. What are the advantages and disadvantages of this design? Which motor needs more electricity to run?

- Students' own designs that use a separate battery to keep the bottom coil energized all the time.
- Try a bottom coil with more turns, or without the steel bolt, and compare how well the motor runs.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

Coil twitches but will not spin

TRY THIS

Check the half-scraped axle: only one side should be bare. Give it a spin to start it.

IF THIS HAPPENS

Nothing happens at all

TRY THIS

Make sure all wire ends are scraped completely bare where they connect, and that the battery is fresh.

IF THIS HAPPENS

Coil wobbles or jumps off

TRY THIS

Straighten the axles, make sure they line up across the coil, and level the supports.

IF THIS HAPPENS

Double-coil motor is weak

TRY THIS

Lower the spinning coil closer to the bolt without letting it touch, and use fresh batteries.