

EQUIPMENT BUILD PLAN

ELECTRICITY & MAGNETISM

Rheostat Speed-Control Board

This board carries two homemade rheostats, a coil of resistance wire and the graphite core of a pencil split lengthwise, wired in series with a battery and a toy motor. Moving a clip along either one changes how much resistance is in the circuit, which changes the motor's speed. It shows what is going on inside a toy car's speed control or a light dimmer.

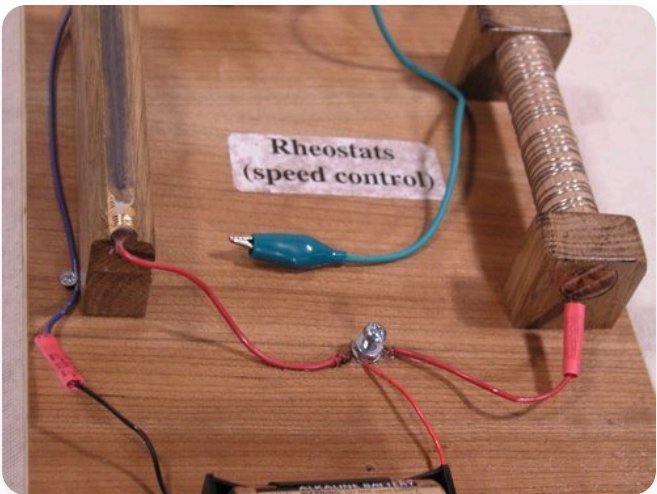
Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.

What it shows

Slide a clip along a coil of wire or a split pencil and watch a little motor speed up and slow down, just like a dimmer switch.

Key ideas: resistance, current, voltage, series circuits, variable resistors

Safety (Adult build / supervision). An adult should do the sawing, drilling and soldering. Never clip directly across the battery with no motor or bulb in the circuit: a short length of resistance wire can get hot enough to burn fingers. Disconnect the battery when the board is not in use.



DIFFICULTY	BUILD TIME
Intermediate	2-3 hours
COST	SAFETY
About \$10-15	Adult build / supervision
GOOD FOR	
Teachers, Makers	

Build it

Materials

- ☐ **Wood base** · about 7 × 10 in
- ☐ **Resistance wire (nichrome)** · length found by testing, several feet
Available from hobby and science suppliers
- ☐ **Wooden dowel** · about 6 in
Coil form for the resistance wire
- ☐ **Scrap wood blocks** · 2
End supports for the dowel
- ☐ **Wooden pencil** · 1
Split lengthwise to expose the graphite
- ☐ **Wood strip the length of the pencil** · 1
Support for the pencil
- ☐ **Toy DC motor (or a small bulb and base)** · 1
A wheel or tape flag on the shaft makes speed changes easy to see
- ☐ **Battery holder and cells** · 1
Bruce used a 2 D-cell holder
- ☐ **Small bolt with nut** · 1
Terminal for the sliding lead
- ☐ **Insulated hookup wire** · a few feet
- ☐ **Ring terminal, butt-splice connector and alligator clip** · 1 each
For the sliding lead
- ☐ **Wood screws** · 4-6

Tools

Saw (hand saw or band saw)

Drill with bits sized for the dowel and small wires

Belt sander or coarse sandpaper

Wire strippers

Pliers or crimping tool

Soldering iron and solder

Screwdriver

Glue

1

Find the length of resistance wire you need

Before building, connect a battery, the motor and a long piece of resistance wire in series. Slide one connection along the wire and note how long a piece it takes to make a clear change in the motor's speed. That is the length to wind.

2

Notch the dowel

Cut a series of shallow notches along the dowel. They catch each turn of wire so the coil can be wound tightly without the turns touching each other.

3

Make the end supports

Drill a hole the size of the dowel into a piece of scrap wood, then cut the block off; make two. Drill a small hole in the dowel near one end, push the start of the wire through it, and slip on one support block.

4

Wind the coil

Wind the resistance wire tightly around the dowel, seating each turn in a notch. At the far end, drill another small hole through the dowel, pass the wire through to lock it, and fit the second support block.

5

Mount the coil

Decide where the coil goes on the board, drill pilot holes up through the base, and fasten the support blocks from underneath with wood screws.

6

Prepare the pencil rheostat

Cut a support strip the same length as the pencil and screw it to the base from underneath. Split the pencil lengthwise with a saw, or sand one side away on a belt sander, until a long stripe of graphite is exposed, then glue it to the support.

7

Connect to the graphite

Drill a small hole into the end of the pencil's graphite core, push a stripped wire into it so it touches the graphite, and glue it in place.

8

Wire the board

Solder the pencil's wire to one battery lead, and continue that same lead to one end of the resistance coil, joining it with a crimp connector. Extend the other battery lead to one terminal of the motor. Run the motor's second terminal to a bolt on the board.

9

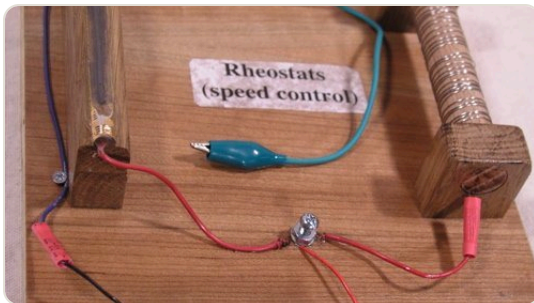
Make the sliding lead

Crimp a ring terminal on one end of a wire and bolt it to the motor's bolt. Put an alligator clip on the other end. Touching the clip's tip to the coil or the graphite completes the circuit through more or less of the resistive material.

10

Test it

Touch the clip near the connected end of the coil or pencil and the motor should run fast; slide it away and the motor slows. Swap in a small bulb, or add one as a second load, to show dimming.



THE PHYSICS

How it works

Resistance wire and graphite are both poor conductors compared with copper. The longer the stretch of either material the current must pass through, the greater its resistance.

The rheostat is in series with the motor, so the battery's voltage is shared between them. When the clip is close to the connected end, the rheostat has little resistance, the motor gets nearly the full voltage, and a large current flows. Slide the clip farther away and the added resistance cuts the current and takes a bigger share of the voltage, leaving less for the motor, so it slows.

The energy the rheostat takes from the circuit becomes heat in the wire or graphite. That is why simple rheostats waste energy, and why modern dimmers and speed controls use

Using it

- Ask students how a toy car's speed dial or a room's dimmer switch might work, then let them find out with the board.
- Compare the two rheostats: which gives finer control, and which needs a longer path to make the same change?
- Swap the motor for a bulb and slide the clip slowly to show dimming.
- Have students sketch the circuit and mark where the current goes for different clip positions.
- Add a meter (if you have one) across the motor to show its

electronics that switch the power on and off rapidly instead.

voltage dropping as the clip moves away.

GO FURTHER

Variations

- Use a small bulb instead of the motor, or mount both on the board with a choice of loads.
- Make a pencil-only version as a quick student activity: a split pencil, a battery, a bulb and two clip leads.
- Try pencils of different hardness (HB, 2B, 6B) and compare how much they dim the bulb.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

Motor speed barely changes

TRY THIS

Use a longer piece of resistance wire or a thinner gauge, and make sure the clip is making contact with bare wire or exposed graphite.

IF THIS HAPPENS

Motor will not run at all through the graphite

TRY THIS

Check the wire glued into the end of the pencil is touching the graphite, and start with the clip close to that end.

IF THIS HAPPENS

Coil turns short together

TRY THIS

Make sure each turn sits in its own notch; turns that touch skip part of the wire and reduce the resistance.