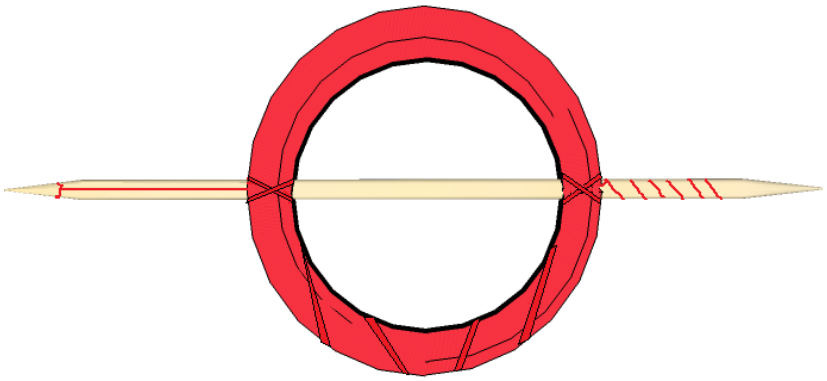
SIMPLE MOTOR

The simplest coil motor - a coil on a toothpick!



Curriculum topics

- Electromagnetism
- Motors
- Experimental Variables
- Energy and Matter

Subjects

- Physical Science
- Engineering

Grade range: 4 – 12

Serves: Each kit can be used for individual students or small groups depending on the intended outcomes determined by the facilitator.

Who we are: Resource Area for Teaching (RAFT) helps educators transform the learning experience by inspiring joy through hands-on learning.

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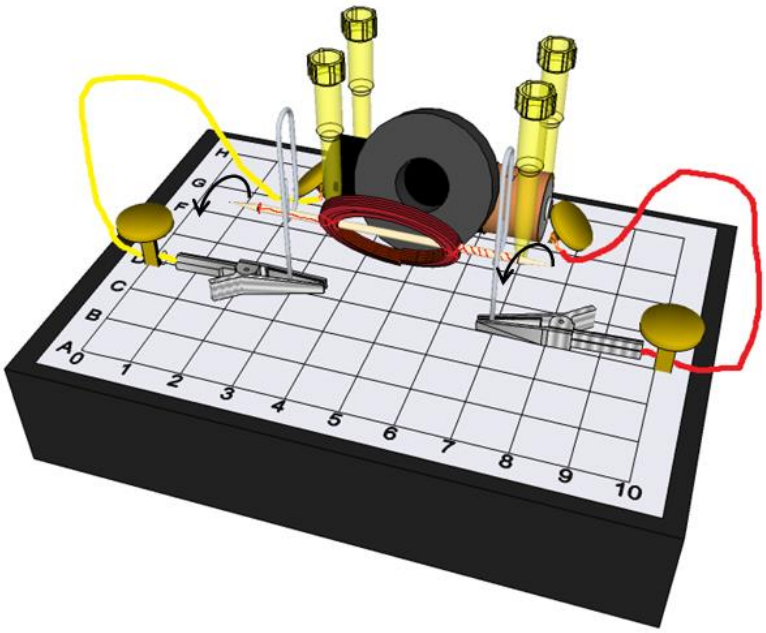
Skewer a coil of magnet wire to create a simple spinning motor! A spinning rotor needs an axle that is rigid with the ends in perfect alignment. This is difficult to arrange with wire that is flexible enough to form a coil, but automatically provided by a toothpick! The motor converts electrical energy into kinetic energy – the energy of motion.



Materials required per motor

- Foam base (x1)
- Paper grid (x1)
- Plastic pipette tips (x4)
- Alligator test leads, precut and stripped (x2)
- Toothpick (x1)
- Brass paper fasteners, 1” long (x4)
- Magnet wire coil, 28 gauge (x1)
- Mini light bulb (x1)
- Paper clips, regular size (x2)
- Ring magnet (x1)
- Sandpaper, fine grit (x1)
- Piece of cardstock (x1)
- **NOT INCLUDED:** Battery (x1), AA, AAA, C or D

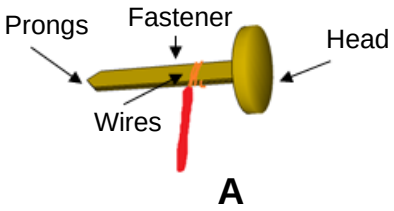
Set-Up

1 Place the paper grid on foam. Insert a pipette tip 1/3 of the way into the foam block through the paper at (3, H) and (7, H) (see right).

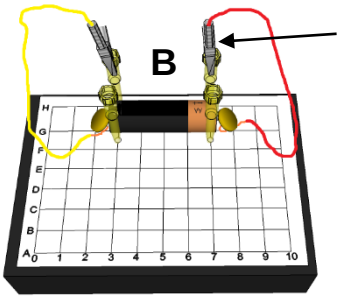
2 Place a battery on row G against the 2 inserted pipette tips. Insert a pipette tip on column 3 and on column 7 right next to the battery as shown.

3 Remove the insulation from the end of one alligator test lead. Twist the exposed fine wires to give them a rope-like appearance. Repeat with 2nd alligator test lead.

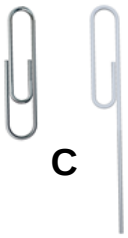
4 Insert the twisted wires of one test lead in between the prongs of a brass paper fastener, near the head of the fastener. Wrap the bare wires several times around the 2 prongs. Repeat for the other lead and a 2nd fastener (see **A** below).



A



B


C

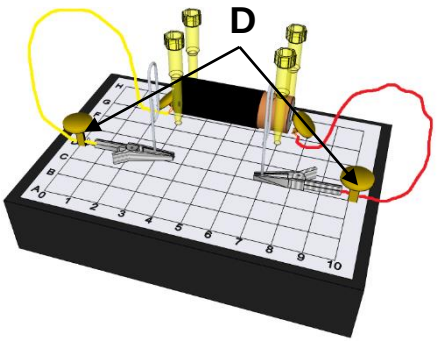
5 Insert the prongs of one of the wrapped fasteners at a point close to one end of the battery and at a slight angle toward the battery. Push the fastener into the foam block until the head of the fastener contacts the metal end of the battery. Repeat with the other wrapped fastener at the other end of the battery (**B**). Make sure to keep clips from touching.

6 To test the connection to the battery, touch the alligator clips to the bare leads of the light bulb (1.5 - 2.5 volt). The bulb should light. Finish by attaching clips to separate pipette tips (**B**).

7 Unbend the outer end of two paperclips as shown in (**C**). Insert the pointed ends of the paperclips 3/4” into the foam at the points (3, D) and (7, D). Turn the paperclips so the short side is nearest the battery with the loop openings facing each other.

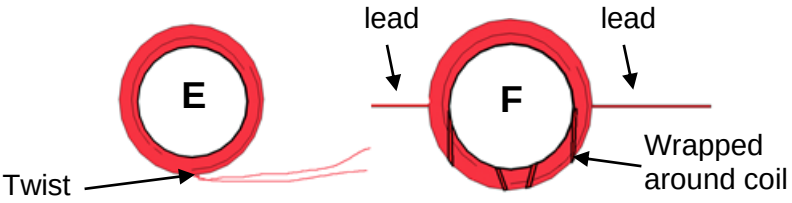
8 Attach an alligator clip from step 6 above to the nearest paperclip just above where the paperclip enters the foam block. Repeat for the other alligator clip and paperclip.

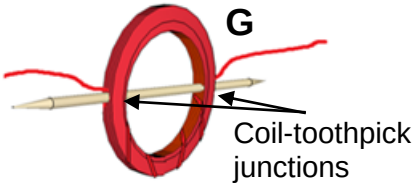
9 Spread the prongs of another brass fastener and insert the prongs into the foam on both sides of the wire near the back of the alligator clip to hold the lead in place (**D**). Repeat for the other fastener and clip.



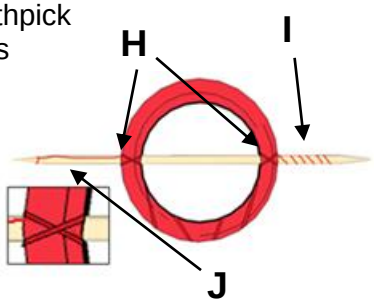
10 Carefully hold the coil and sand the loose leads starting about 3/8" from the coil to the ends until a bright "new penny" copper color is seen on all sides. Lay the loose end of the magnet wire on a card and rub sandpaper over the wire. **Rotate wire to sand all sides.**

11 Twist the loose leads together near the coil (**E**). Wrap one of the loose leads around the coil, moving away from the twisted ends (**F**). Repeat with the other coil lead but going in the other direction around the coil. Stop when the lead is on the opposite side of the coil.





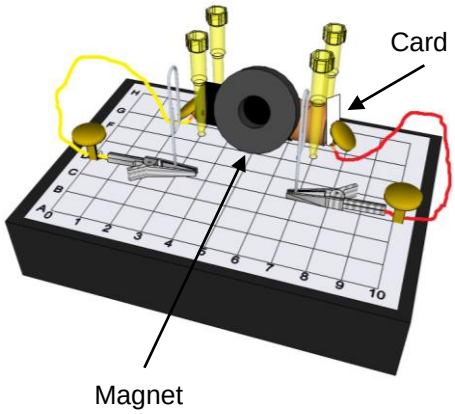
12 Insert the toothpick into the coils so the toothpick bisects the coil at points just below the leads (**G**). Wrap the leads in an x-pattern around the coil and toothpick junctions (**H**). Wrap the longer lead around the toothpick going away from the coil (**I**).



13 Lay the other lead alongside the length of the toothpick, making a gentle ¼ turn as the wire reaches the tip of the toothpick. Make a few tight turns of the lead at the very tip to hold the wire in place along the toothpick. Cut off any excess wire.

14 Put a card in between the flat end of the battery and the head of the fastener. Lay the ring magnet against the side of the battery facing the paperclips (see right).

15 Insert the ends of the toothpick into the loops of the paperclips and adjust as needed so the toothpick is parallel to the foam block and the coil can spin freely (see title page).



To do and notice

1 Remove the card and press the fastener head toward the battery to make a good contact. Give the coil a quick spin. If the circuit works, the coil will continue to spin. The position of the bare wire along the length of the toothpick, in relation to the coil's opening, may need to be adjusted so that the wire touches the paperclip, completing the circuit, when the coil faces the magnet.

2 **Troubleshooting**: Having the coil spin well will require some "fine tuning." Adjustments can include reversing the side of the magnet that faces the coil, slightly turning the paperclips so the loops touch different parts of the bare wires on the toothpick and moving the loops around one end of the toothpick closer together or farther apart. Check to see if there is anything keeping the coil from spinning smoothly.

Core Content Skills:

Science & Engineering (NGSS)

Definitions of Energy

Conservation and Transfer of Energy

Energy in Chemical Processes

Forces and Interactions

Defining Engineering Problems

Planning and Carrying Out Investigations

Applying Scientific Ideas to Solve Design Problems

The Science Behind the Activity

The coil becomes an electromagnet when a conductive path (circuit) is created from one end of the battery, through the wires, paperclips, and coil, to the other end of the battery.

When electrons move along the loops of wire a magnetic field is created around the coil. That magnetic field disappears when the electrons stop moving due to a break in the circuit. If the magnetic pole of the energized coil is facing the same magnetic pole ("like pole") of the permanent magnet, then the pivoting coil will rotate as it is repelled away from the magnet. If the coil were constantly connected to the battery, then once the opposite magnetic poles faced each other, the attractive forces between the coil and magnet would stop the coil from turning. In order to continue spinning the conductive path must be broken when the opposite poles face each other.

The Simple Motor rotor has a spiral lead on one side that effectively creates a continuous electrical contact to the paperclip as the rotor spins. To break the circuit, the other end of the rotor has a straight wire running along one side of the toothpick. When the straight wire touches the paperclip, the circuit is completed, and the coil energized. When the straight wire moves away from touching the paperclip, as the rotor turns, then only the wooden toothpick, an insulator, touches the paperclip, breaking the circuit and de-energizing the coil.

Reuse

This kit uses 100% reusable materials designed for other uses. To continue making a positive impact in reducing waste, reuse these materials in other projects. Any unused materials can be collected and delivered back to RAFT.

Feedback

Please comment on this kit by taking this short survey: http://bit.ly/RAFTkitsurvey. Let us know of any material concerns such as missing, broken, or poorly fitting parts as well as improvements or other suggestions.

Learn more

- Try placing a second magnet on the opposite side of the coil.
- Try orient the poles of the magnets to speed up the spinning coil.
- Try connecting 2 batteries in the circuit in series and/or parallel.

Resources

- How electric motors work - https://bit.ly/2REDq1q
- YouTube (3:53), Electric motors explained - https://bit.ly/2Vd1URI