

BUILD UNDERSTANDING: MOTORS

Don't fill out this sheet, and don't copy these questions into your lab notes. Instead, use this sheet as a guide to build your understanding of the operation of your motor. Then, in your lab notes, give a stand-alone explanation of how the motor works in your own words.

I. Basics

- A. Play with the motor until you get it working (spinning continually).

You may need to gently rotate the coil to get it started.

Try making the coil spin in both directions. Does one direction work better?



- B. Locate the disc-shaped magnet under the coil. These magnets are extremely strong: keep them away from electronic devices.

Determine the orientation of the disc magnet (which pole faces up?) and visualize the magnetic field of the disc magnet in the space around the coil.

- C. The coil is made of copper wire with a clear enamel coating, similar to clear nail polish.

- In some places, the clear enamel coating has been sanded off, exposing bare wire underneath.
- Bare wire can make electrical contact with the metal frame that holds the coil. Enamel-covered wire does not make electrical contact.
- See photos: the darker copper color is where the enamel is intact, and the lighter parts are bare wire.



1. Visually inspect your own coil to find where the coating has been sanded off and where it is still intact.
2. For what orientations of the coil will there be a current through it due to the battery? (You can check your answer with an ammeter.)
3. Visually inspect your own coil to figure out which way current flows around the loop when it is connected to the battery.



II. Interacting magnets

One way to understand the operation of the motor is to recognize that a loop of current-carrying wire is a magnet.

- A. When current flows around your coil from the battery, which direction is the north pole of the coil?
- B. Describe the interaction between the coil and the disc magnets when there is current in the coil. Do the disc magnets tend to attract the coil, repel it, cause it to align, have no effect, or something else?
- C. Describe the interaction between the coil and the disc magnets when there is *no* current in the coil. Do the disc magnets tend to attract the coil, repel it, cause it to align, have no effect, or something else?

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- D. Imagine the coil spinning slowly so that the current turns on and off due to the half-coated wire.
1. At what points in the cycle will the disc magnet *increase* the motion of the coil?
 2. At what points in the cycle will the disc magnet *decrease* the motion of the coil?
 3. At what points in the cycle will the disc magnet *have no effect on* the motion of the coil?
- E. Synthesize the above ideas into a coherent explanation of the motor that answers the question: *How does it continually spin on its own?*

III. Lorentz force

Another way to understand the operation of the motor is to recall that magnetic fields exert forces on current-carrying wires. When current flows around your coil from the battery, there is a force on each part of the coil from the magnetic field of the disc magnets, given by the formula for the Lorentz force: $\vec{F} = i\vec{L} \times \vec{B}$ (or, equivalently, $\vec{F} = q\vec{v} \times \vec{B}$).

- A. Imagine the coil in one of the orientations for which current flows through the coil.
1. Choose a short segment of your coil.
 - a. At that location, what is the direction of the magnetic field of the disc magnet?
 - b. When the coil has current through it, what is the direction of the Lorentz force on that segment?
 2. Repeat for other segments of the coil. What is the *net* effect of the disc magnet on the coil when there is current through the coil?
- B. Imagine the coil spinning slowly so that the current turns on and off due to the half-coated wire.
1. At what points in the cycle will the Lorentz force *increase* the motion of the coil?
 2. At what points in the cycle will the Lorentz force *decrease* the motion of the coil?
 3. At what points in the cycle will there be *no* Lorentz force on coil?
- C. Synthesize the above ideas into a coherent explanation of the motor that answers the question: *How does it continually spin on its own?*