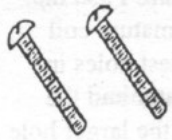
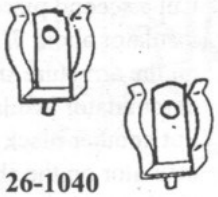
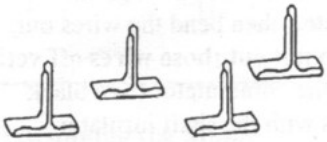
10-135 Toy Motor Assembly Instructions



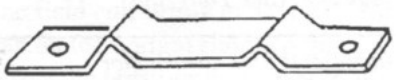
Round head Screw (2) - 20-1101



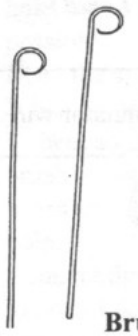
Battery Clips (2) - 26-1040
You supply one AA battery



Paper Fasteners (2) - 29-1038

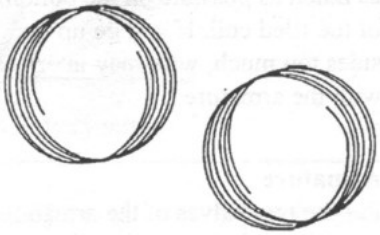


Field pole - 51-1352



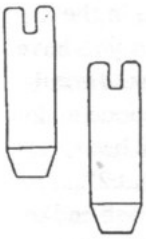
Brushes (2) - 33-0135

Mounting Bracket - 51-1358



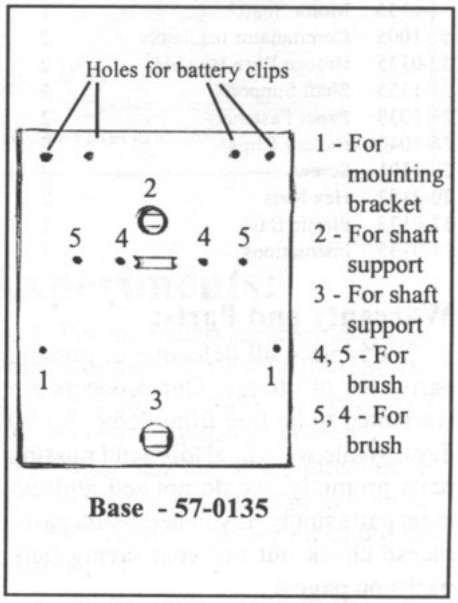
2 coils - 26-9123

Motor Shaft - 31-0135

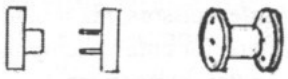


2 Shaft Supports or Uprights - 51-1355

2 hex nuts - 20-2102

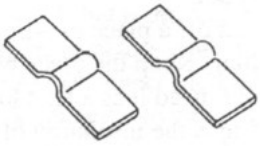


Base - 57-0135



Commutators (2) - 57-1005

Insulating Tubing (D) - 26-9214



Armature halves (2)- 51-1350

How to Teach with Toy Motor:

Concepts Taught: Energy conservation. Transformation from electrical to mechanical energy. Motor vs. Generator. Electromagnetic Fields: field magnet, armature, commutator, brushes. Direct and alternating currents. Motor/generator differences and similarities.

Curriculum Fit: PS/Energy: Energy Transformation. PS/Electricity and Magnetism: Grades 9 - 10

Science First would like to thank **Del Brown, Vocational Eduction Teacher** at **Burley Junior High School, Burley, Idaho** for critiquing and revising our Toy Motor Kit instructions. Since Del has been teaching with our Toy Motor since our early days and in fact still has a sample of our earliest kit, complete with cardboard base, the instructions which follow have been thoroughly classroom tested. Please let us know if you have suggestions of your own.

95 Botsford Place, Buffalo, N.Y. 14216 U.S.A.
716-874-0133 • 800-875-3214 • FAX 716-874-9853 • info@sciencefirst.com • www.sciencefirst.com

10-135 Kit contains:

26-9123	Wire, 200 cm long	2
51-1352	Field Pole	1
51-1358	Mounting Bracket	1
51-1350	Armature Half	2
26-9214	Insulating Tubing piece, about 4.5 cm	1
31-0135	Motor Shaft	1
57-1005	Commutator Insulators	2
33-0135	Bronze Wire Brushes	2
51-1355	Shaft Supports	2
29-1038	Paper Fasteners	2
26-1040	Battery Clips	2
20-1101	Screws	2
20-2102	Hex Nuts	2
57-0135	Plastic Base	1
24-0135	Instructions	1

Warranty and Parts:

We replace all defective or missing parts free of charge. Our products are warranted to be free from defect for 90 days. While we will gladly send missing parts promptly, we do not sell replacement parts singly. If you need extra parts, please check out our cost-saving bulk packs on page 4.

Tools Needed:

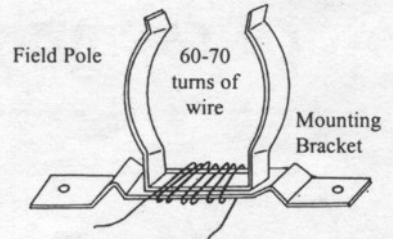
- Sandpaper
- Sharp knife, scissors, razor blade or wire cutters for cutting/scraping.
- Small regular screwdriver
- Pair of needlenose pliers

You need 1 AA battery, not included.

Toy Motor Assembly:

A. Field Coil

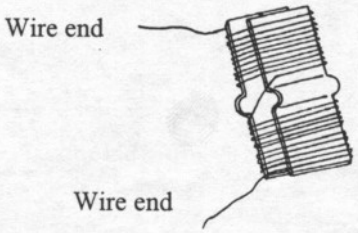
1. Unroll one of the rolls of wire. It's best to do this by unwrapping the end of the coil, putting the coil on your finger and unrolling it like a spool.
2. Cut off a piece of wire about 6" long. Keep the piece because you will need it as a lead to the batter.
3. Clean the insulation off about 1" of each end of the long wire.
4. Hold the two pieces of the field together and wrap about 60 - 70 neat, tight coils around the two field pieces. Keep a piece at least 2" long on one end of the coil, and keep a piece 6" free on the other end. Wrap as much as possible on the bottom of the filed coil. If you go up the sides too much, wire may interfere with the armature.



Wire wound around field pole and mounting bracket

B. Armature

1. Put the two halves of the armature together with the shaft between them.
2. Using the second long piece of wire, start at one end leaving 2" free. Wrap 8 turns on one side then cross over the middle and wrap 8 turns on this side. Be sure you start at the end and wrap toward the middle Then bring the wire back to the first side and start over. **Be careful to have the windings always go in the same direction and that you have about the same number of windings on each side.** Continue to do this until the wire has all been wrapped, except for about 2".
3. Strip the insulation off each end of the wire, to about 1/2" from the armature coil.

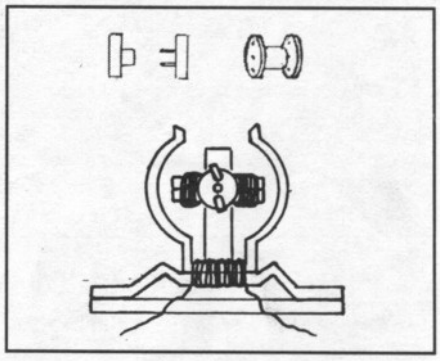


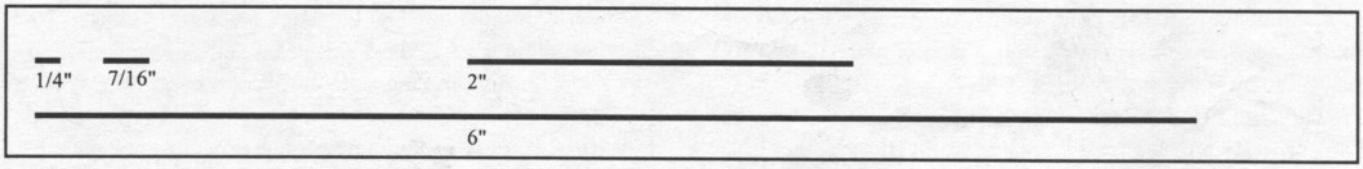
C. Commutator

1. Cut about 1/4" off the black insulator tubing and slip it on to the long end of the wire armature shaft.
2. Put a round, black plastic commutator insulator on the shaft. Push the two wires from the armature coil through the two smallest holes in the commutator insulator and the armature rod through the larger hole in the center.
3. Cut a second piece of black tubing insulator about 7/16" long and put it on the armature shaft next to the commutator insulator.
4. Put another black commutator insulator on the shaft next to the shaft insulator.
5. Put the two wires through the insulator, then bend the wires out, but **do not cut those wires off yet!**
6. Turn the commutator (two black pieces with the shaft insulator between them) until the wires are half way around the rod from the armature coil (the big coil of wire you just wound.) Snap commutators together. (*See Diagram*).

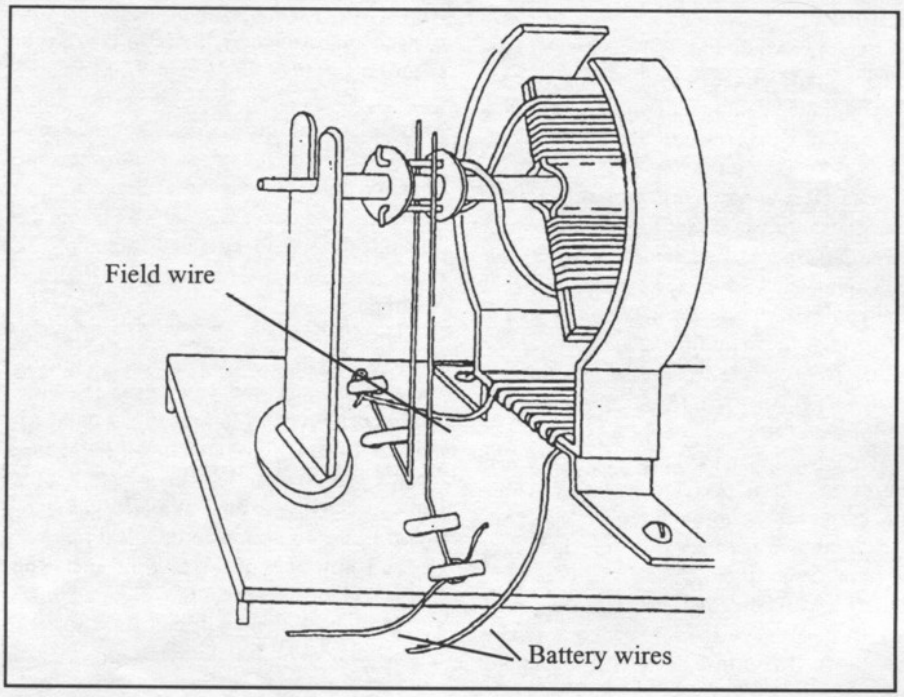
Important! Both commutator insulators must be at right angles to the armature. The holes should be in a vertical position when armature is horizontal. Alignment is very important! Your motor won't run well if the commutators are not turned to the correct angle.

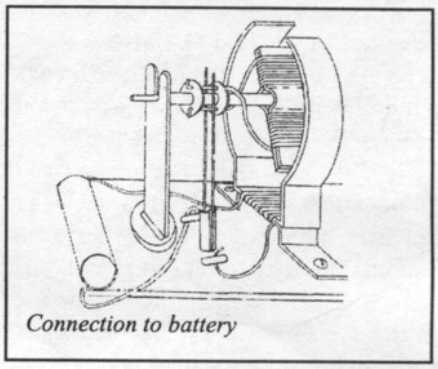
7. Cut off the excess commutator wire.





95 Botsford Place, Buffalo, N.Y. 14216 U.S.A.
716-874-0133 • 800-875-3214 • FAX 716-874-9853 • info@sciencefirst.com • www.sciencefirst.com




Connection to battery

D. Assembling the Motor

1. Fasten the field coil to the board with 2 little nuts and bolts with the wire toward the middle of the board.
2. Fasten the shaft support nearest to the field coil firmly to the base. The tab on the upright should point out.
3. Place the brush so that the hole at the end of the brush is over the outside hole on the board and it crosses the inside hole.
4. Bend the brush up, just inside the hole. Make the bend as square as possible.
5. Bend the second brush similarly
6. When completed, each brush should be bent so the hole at the end of the brush is over the outside hole on the board and crosses over the inside hole.
7. Connect the wire from the field coil to one of the brushes. This can be done by inserting the wire from the field coil through the little triangular hole at the top of the clip. Now put the clip through the brush and the outside hole in the base and spread it out under the base. Put a second clip on the brush and attach it to the base in the same way.
8. Take the 6" piece of wire that you cut off the first day and strip about an inch off each end. Connect one end of it to the other brush like you did the wire from the field coil.
9. Install the second shaft support.
10. Lay the armature on the two shaft supports. With the coil centered between the field coil uprights, estimate the distance between the commutator and the upright. Then cut a piece of black insulator tubing to go between the armature and the shaft supports. The length of the insulator will be determined by the distance between the armature and the shaft support. It is better to have it a little too short than a too long.
11. The armature **must** go very close to, but not touch the field. The armature and field pole are connected in series. You may need to use some Needle Nose Pliers to bend the uprights of the field coil so the armature turns freely bus is not too far from the field coil uprights.

E. Connect Motor To Battery

1. Scrape the remaining ends of the field and battery wires, if not done earlier. Snap 2 battery clips into holes on the base. Terminals on clips point away from each other.
2. Connect 2 wire ends to battery. Spin motor shaft by hand to get started.

Experiments:

1. Put the battery in the other way. What does the motor do? Will it spin the same or the opposite way? Try to answer this *before* you do the experiment.

2. What happens to the direction of shaft rotation if you turn the commutator 180°? Answer this *before* doing the experiment.

3. Put the commutator in the same plane as the armature and try to run the motor. How important is the plane of the commutator relative to the plane of the armature for operation of the motor?

4. Handle the motor shaft with your fingers as it rotates at low speeds. Note how the twisting force (**torque**) is not constant as the shaft rotates through one revolution. Plot out the graph of torque against angular position. Define a 0° starting point for the armature, then feel the torque as you rotate the shaft through 360°. Explain your graph.

5. Short out the commutator with fine wire. Attach two wires from each brush to an armature wire. What is the resting, stable position of the armature when the power is connected? (Connect the voltage in short, quick connections since the armature will heat up.)

6. Note how the field pole extends up and around the armature but has no wire winding around it. Do you need this component in the motor? Could you eliminate it and wind the wire around the midportion of the mounting bracket? Unwind the field coil and remove it. Now wind the coil of wire back again and connect up the motor. Does removal of the field pole reduce the efficiency of the motor? Explain.

95 Botsford Place, Buffalo, N.Y. 14216 U.S.A.
716-874-0133 • 800-875-3214 • FAX 716-874-9853 • info@sciencefirst.com • www.sciencefirst.com

7. Connect higher voltage batteries to the motor. (See **10-171 Battery Kit**). Or connect a power supply of 6 or 9 volts or more. What happens? How would you redesign the motor to run on 15v? Note the blackening around the brushes and commutator. Why does this happen? Leave the motor going with 9v attached and run it to destruction. What part fails first? What part do you think would have failed next? Fix the failure if you can and run it again until something fails. This is called destructive testing. What do you learn from destructive testing?

8. Try connecting an AC voltage source such as a 6-12 volt AC wall transformer in place of the battery. (*Do not use the 110 volt line outlet directly as this is dangerous and will instantly destroy your motor!*) Does the motor run? Why? Think back to the results in Experiment 1 when you reversed the battery. **Hint:** This kind of motor is known as a *universal* motor. Explain.

What to do if your motor doesn't work:

1. Check all electrical connections. Are they scraped free of insulation? (Places to check: both wires from the armature which are threaded through the commutators - one to the battery, one to the brushes; both ends of wire leading from the battery to the brushes.)
2. Can the shaft spin freely by hand? If not, you may have to trim your tubing. (If the field pole interferes with armature rotation, gently bend it out of the way.)
3. Make sure holes in both commutators are at right angles to the armature.
4. Is your battery fresh?
5. Do both brushes contact the commutator lightly? You may have to adjust these by trial and error.
6. Use an occasional drop of oil at both ends of the motor shaft where it meets the shaft supports.
7. The "bright" surfaces of the bronze wires may oxidize eventually. This may lead to poor contact between brushes and commutators. To prevent this, coat the "bright" surfaces with solder by "tinning" the surfaces using an electric solder iron.
8. To keep the armature and commutators at right angles to each other, you can apply some "**super glue**" to make a permanent bond at the contact points.

Theory:

The Toy Motor illustrates on a small scale the essential features of an electric motor. By assembling it, getting it to run and observing its motion, you can study basic components of all electric motors.

An electric motor uses the principle of magnetism to cause motion and does so by an arrangement of stationary and movable electromagnets. The three basic parts are the **field poles,** *which produce a stationary magnetic field;* the **armature**, *which produces a movable or reversing one; and* a **switch,** *which is formed by the arrangement of brushes and commutators.*

An electromagnet is a soft iron core with insulated wire wrapped around it. As an electric current flows through the wire, it create what is known as **Lines of Force** which flow at right angles to the wire. The iron absorbs these Lines of Force and becomes magnetized.

Every magnet has 2 poles - a **north**, or *positive*, and a **south** or *negative*. "Like" poles of a magnet repel each other; "unlike" poles attract. One North pole repels another North pole, but it attracts a South pole.

The attracting and repelling of the magnets causes the motor to run. The field poles become an electromagnet when an electric current flows through the wire coil wound around them. The armature also becomes an electromagnet when an electric current passes through its wire coil. The armature, however, produces a reversing magnetic field while the magnetic field produced by the field poles remains stationary.

The North pole of the field pole attracts the South pole of the armature, which turns in response to this magnetic attraction. But in order to keep the armature turning, you must break the current and change the polarity of the armature magnet. Otherwise the armature would remain permanently fixed in one position for as long as electric current was flowing and nothing would move.

Breaking the electric current through the armature and reversing its direction is done by a switch consisting of the brushes and commutators. These components are arranged in the following way. The commutators are attached directly to the motor by means of their location on the motor shaft and are connected to the armature by means of the armature wires threaded through them. The brushes rest lightly against the wires connecting the commutators to the armature. The brushes complete the electric circuit and enable the electric current to flow into the armature wires.

If the electricity always flowed in the same direction, the field magnet would pull the armature in the same position. It would remain frozen in this position and there would be no motion. However, just at the very height of the attraction of field magnet for armature magnet, when the armature magnet has turned halfway around, the brush strikes the armature wires on the motor shaft tot reverse the direction of the current For example, instead of flowing from what was the left wing of the armature through to the right, it now flows in the opposite direction reversing the North and South poles.

The arrangement of wires from armature through commutators is what causes this reversal. Remember that you twisted the wires 90° to position them at right angles to the armature. Due to this orientation, the armature magnet reverses itself as the armature turns halfway, and the armature completes its revolution as what is now a North pole is repelled by the North pole of the field magnet. The South pole of the armature will be continually turning in a series of half turns to seek the stationary North field pole.

The reason the armature revolves in a complete circle of 360 ° rather than flipping back and forth in half circles is because the momentum of the motor will carry the attraction of North and South a little past the point of peak attraction; as polarity changes, the armature completes its revolution in an attempt to "catch up" with the change in location of the poles.

Did you know?
Toy Motor is also available in cost-saving bulk packs

Related Products:

10-171 Battery Kit - Power your motor kit with this variable DC power supply.

10-138 - Bulk Pack - Enough parts for 48 students at a discounted price, with spares. Your best value. *Contact us for more information.*

10-135 Class Pack - Enough parts for 30 students, with spares. *Contact us for more information.*

P/N 24-0135

95 Botsford Place, Buffalo, N.Y. 14216 U.S.A.
716-874-0133 • 800-875-3214 • FAX 716-874-9853 • info@sciencefirst.com • www.sciencefirst.com