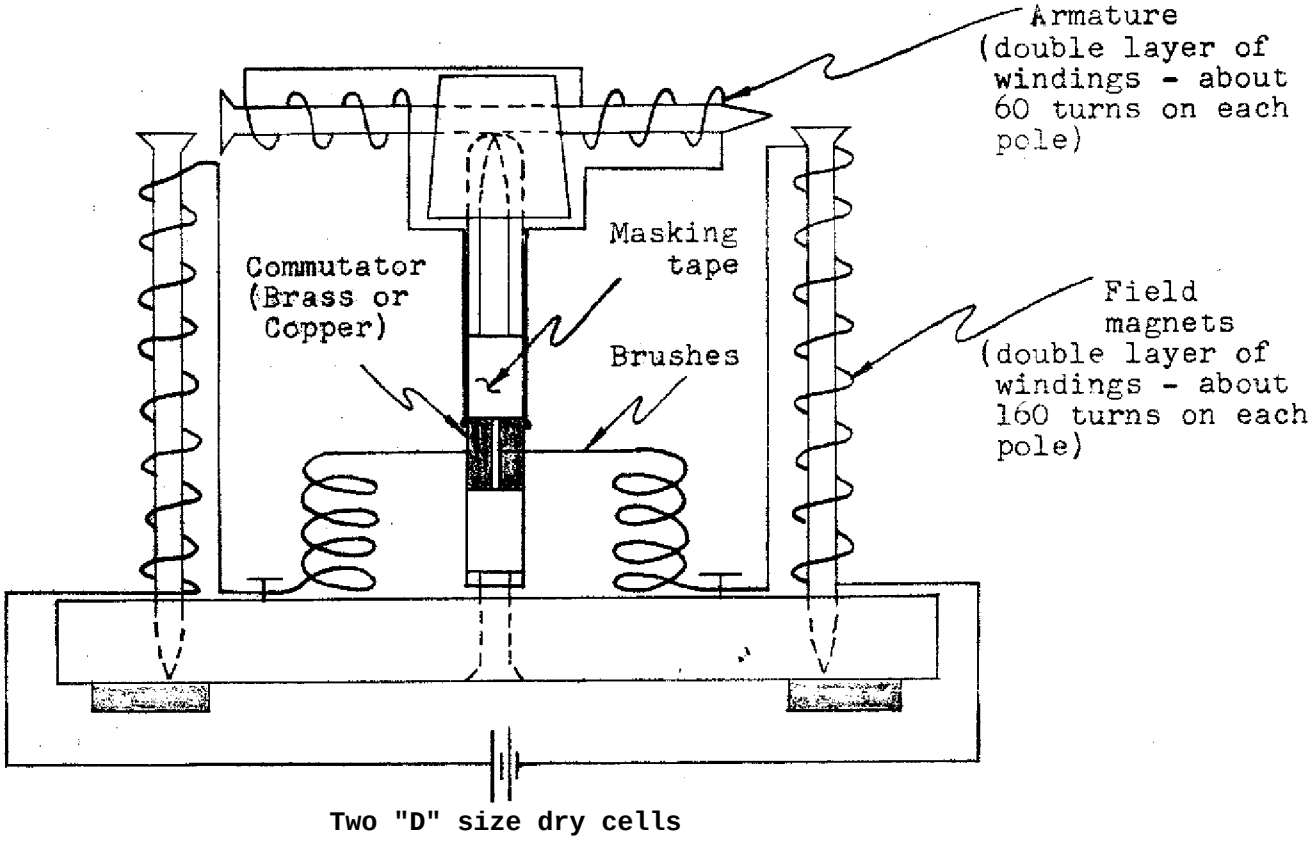
Build an Electric Motor!

Name:_____ **Date:**_____ **Class:**_____



List of Materials

- ☐ about 18 metres of 24 gauge, vinyl-insulated ‘‘hook-up’’ (expensive) or ‘‘cross-connect’’ (cheap) wire
- ☐ four 125mm (5-inch) common spikes (They must be made of steel. Why?)
- ☐ one test tube (13mm x 100mm)
- ☐ one large cork (20mm to 38mm in diameter)
- ☐ one piece of brass shim stock (about 25mm x 50mm)... 0.003-inch thickness recommended
- ☐ four thumb tacks
- ☐ four self-adhesive pads to protect furniture (optional)
- ☐ a plywood base (19mm x 150mm x 200mm) (0.75" x 6" x 8")
- ☐ a small piece of fine emery paper
- ☐ some resin-core solder formulated for electrical work
- ☐ masking tape (either 12mm or 18mm wide)
- ☐ some five-minute epoxy glue

Required Tools

- ☐ hand saw, hacksaw and hammer
- ☐ ruler and pencil
- ☐ hand drill with 3mm (1/8-inch) and 4mm (5/32-inch) drill bits
- ☐ small, sharp pocket knife or cork-borer set
- ☐ scissors
- ☐ wire strippers
- ☐ 25-watt soldering iron
- ☐ file
- ☐ two ‘‘D’’ size dry cells and one six-volt lantern battery

Build an Electric Motor... Instructions

The design of this electric motor is adapted from ideas presented in the *New UNESCO Source Book for Science Teaching*. This is an excellent resource for science teachers at both the elementary and secondary levels and, although published in 1973, it may still be available... either directly from UNESCO or from some of the larger book stores.

This particular electric motor uses current from a battery to excite the field magnets as well as the armature coil. If carefully constructed, it will work *well* with just two dry cells and *vigorously* with a six-volt lantern battery. Except for the direction of the windings, which is critical, the design of this motor is quite ''forgiving'' and allows for some modification, substitution and even a bit of error. A more thorough discussion of design considerations and how this project was used in a classroom can be found at the following website:

http://www.nwconx.net/~gdedemet/motors56/motors1.html

Prepare the base by using a ruler to find its centre. After marking the centre, make two pencil marks in line with and on opposite sides of the centre. Each mark should be 75mm from the centre. Place a piece of scrap wood underneath the base and then drill a 3mm diameter hole through the base at each of the three pencil marks. Ensure that these holes are perpendicular to the large surfaces of the base. Drive two of the 125mm spikes into the base for the field magnets, as shown in the diagram. (Inserting the centre spike, at this time, makes it more difficult to wind the field magnets.) Wind two layers of the insulated wire neatly and tightly onto each of the two field magnet spikes, leaving about 250mm of wire free at the ends. Don't worry about the number of turns; just cover the exposed part of each spike completely with each of the two layers. Thumb tacks can be temporarily used to keep the wire from unwinding, once each field magnet is finished. When the field magnets are finished, arrange two stacks of books or small pieces of wood to support the base appropriately and then drive in the centre spike. On one of the diagonals of the base, at about 38mm on either side of the centre spike, push two thumb tacks part-way into the base. From the appropriate end of each field coil, strip off about 40mm of the insulation and then wind the wire around a pencil three or four times to make a springy coil, as shown in the diagram. Fasten these two ''squiggles'' to the base by means of the thumb tacks and adjust them so that the uninsulated part of each wire touches the central spike. These two ends will serve as the *brushes* of your motor. The other two free ends of the field coils should now be fastened to the base with the remaining thumb tacks. These two ends will eventually be connected to the battery. Care must be taken to wind the field coils in the proper direction. The diagram is a complete plan for the direction of the windings. Unless you have a thorough understanding of the ''right-hand rule'' for the polarity of electromagnets and are able to *correctly* make changes, it is better not to deviate from the diagram.

Your field magnets and brushes, two of the four essential parts of a direct-current electric motor, are now complete. The armature and the commutator remain to be constructed. At right angles to the longitudinal axis of your cork, drill a 4mm diameter hole, about 10mm from the narrow end. Cut the point off the last 125mm spike with a hacksaw and smooth the cut with a file. Then force the spike through the hole in the cork and adjust its position until the assembly balances reasonably well at the centre of the cork. Now, use your pocket knife to neatly gouge out the centre of the cork, at right angles to the spike as shown in the diagram. The hole should be slightly smaller in diameter than your test tube. Mix some five-minute epoxy glue and spread it around the inside of the hole. Then, insert the closed end of the test tube and shim it, if necessary, to make it perfectly perpendicular to the spike. Once the glue has hardened, trim away any excess with your pocket knife and then wind two layers of wire onto each end of the spike, making certain that the direction of the windings is as shown in the diagram. Leave about 200mm of wire free at each end. Masking tape may be used to temporarily hold these free ends in place and keep them from unwinding.

You are now ready to make the commutator. With the scissors, cut two identical pieces of brass shim stock, about 25mm wide and long enough to reach around the test tube with about 2 or 3mm of space between them. Using one strip of masking tape, neatly align and fasten these pieces of brass close to the open end of the test tube, as shown in the diagram. It is very important that the two pieces of brass do not touch each other. Why? Now, cut each of the armature coil's two free ends to the exact length needed. About 5mm of each wire should be in contact with the top of one of the pieces of brass. Strip off about 5mm of the insulation from each of these free ends. Gently clean each piece of brass, with the emery paper, in the area where the armature wire will make contact with it. Bend each armature coil free end so that it makes contact with the brass, without having to be *held* in place, and then *solder* it in place. Soldering small parts, such as these, can be a bit tricky. As a consequence, an adult should give careful instructions and supervise the work. Depending on the age of the youthful motor-builder, it might even be better for an adult to do the actual soldering, with the *assistance* of the youngster. Once the soldering is done, you should finish taping the commutator strips, as shown in the diagram.

Your rotor, consisting of armature and commutator, is now complete. Carefully hold the brushes slightly away from the central spike and very gently (so that the point of the spike doesn't puncture the test tube) lower the rotor into position. Adjust the position of the brushes so that they are parallel to each other, touch the exposed brass of the commutator and change contact from one brass commutator strip to the other just as the armature poles are coming into alignment with the field magnets. Connect two dry cells and give the rotor a slight push. This should set it spinning at a lively speed. If the motor doesn't work right away, don't despair. It may be necessary to adjust the brushes or check the direction of the windings.

This is a very basic motor. What modifications or improvements can you suggest?

*** ''MOTORS56.CHP'', G.M. de Demeter... August 15, 2000. ***