

## The Extra Bonus Point Extravaganza!! Build your own electric motor!

In the envelope you will find: 2 magnets, 2 thumbtacks, 2 paper clips, 2 leads (insulated wire), 1 block of wood, and 1 length of insulated copper wire. (You supply a regular 1.5 V battery.)

**Objective:** Construct a working electric motor using only the materials provided (plus the battery). A “working motor” is one that runs unassisted for at least 5 seconds. You may use any tools or manner of fabrication, such as scraping insulation off with a knife or sand paper, but the materials must be from the envelope. Any extra materials such as a piece of tape or glue will, if noticed, disqualify you. Please ensure that your motor is robust; magnets and other parts should be attached to the wood block.

**Extra Credit:** You can earn up to 5 Real Bonus Points (which is equivalent to a half a letter grade). You will earn points as follows: If your motor works, i.e. runs continuously for at least 5 seconds without encouragement, you receive 2 points. Your motor will earn you 1 additional point for every 500 rpm above 500 rpm. For instance, if your motor runs at 1060 rpm you will receive  $2 + 1 = 3$  Bonus Points. If your motor runs faster than 2000 rpm you will earn the maximum of 5 points.<sup>1</sup> These points will be added to you grade directly. The extra credit will improve your grade.

**Contest:** There will be two contests. There will be a prize for the most amusing working motor. And there will be a prize for the highest rpm. The awards will be physics toys (naturally!).

**Due Date and Testing:** Completed motors should be brought to Science G034 on or before **Tuesday, April 21 at 3:30 PM**. *Make sure that your name is written on the wood.* You do not need to supply us with a battery or with wires (clip leads) to connect the battery. Testing will begin at 3:30 PM. You are welcome to join us for testing. Food will be available. . .

**Motor Tune-up:** During the week of April 13, the labs will have an optional a motor tune-up session. Bring your parts, your ideas, and we'll give you helpful suggestions!

**How to get your Motor Back?** You can pick up your motor in lab the following week. We will record the rpm on the wood block so you know how much credit you got.

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<sup>1</sup>At these angular speeds there is more physics and engineering than just e & m in these motors!

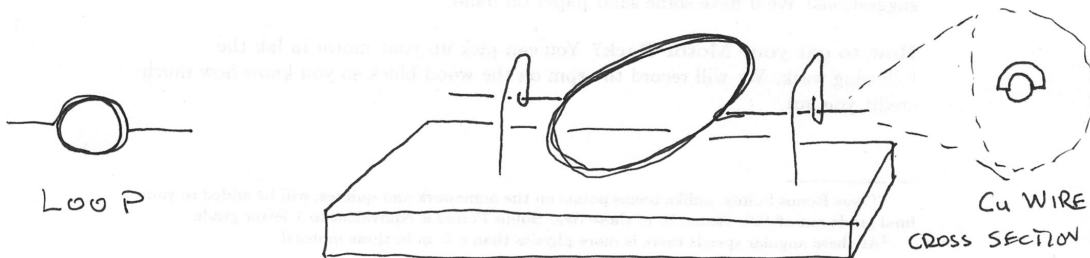
**How to Build a Motor:** To build a working motor requires some understanding of magnetism and a trick, given below. To build a great motor requires ingenuity and care.

- (1) Make a loop of the copper wire with a diameter of about 2 cm (see figure). It is easiest to wrap the wire around a small cylinder such as a liquid paper bottle. The smaller diameter, the more turns you can make but that does not necessarily make a better motor. . .
- (2) To make the windings of the loop stay together, wrap a bit of wire around the coil.
- (3) Decide how to best arrange your magnets to give a large magnetic field. (Hint: Map out your magnets' fields by finding the configurations which repel and attract. Draw a picture of their magnetic fields. How can you make the field the most intense?)
- (4) Make a support for the loop. One way is to use the paper clips as brackets (see figure).
- (5) The hard bit: The insulation on the 2 ends of the copper wire must be removed so that the current will flow. This can be done by scraping or sanding off the clear insulation. But if you remove all the insulation the loop will not continue to rotate! One solution is to remove the insulating material on only one side of the wire. You will have to think through which side must have its insulation removed for your loop and magnetic field configuration.

Another solution is to build a commutator as shown in your book. This would give you a higher torque. Unfortunately, it also gives you more friction.

- (6) Place the magnets under the loop, or where you have decided they ought to go.
- (7) Connect your 1.5 V battery to the paper clips. You may need to give the motor a little push or twist to get it going - but that is ok! Because the loop may spin for some time after a "push," it may be confusing determining whether your motor actually runs; it runs if it spins continuously for minutes on end.

**How to Build the Best Motor:** Your imagination is the only limit; you may want to ignore most, or all, the above advice.



Lots of luck and have fun!