## **Class work/Homework:** To be done at the Fleet Center

**Transformer exhibit**

1. Turn on the current in solenoid 1. Use the compass to draw the magnetic field lines produced by the solenoid. What happens when you turn off the current? Turn off the current in solenoid 1.
2. Pass the magnet in and out of solenoid 2. What does the galvanometer do when you do this? What quantity does a galvanometer measure? Now pass the magnet in and out slowly. Now quickly. Compare the behavior of the galvanometer in the two cases. Explain the difference in behavior in the two cases in terms of changing magnetic fields and the electric currents they induce. In light of this explanation, what do you think will happen if you hold the magnet at rest inside the solenoid? Explain why you think so. Now place the magnet inside the solenoid and hold it still to see if your prediction was correct. Using the same magnet and the same solenoid, think of the most efficient way possible to produce the most electric current. Be creative.
3. Turn on the current in solenoid 1 again. Now move solenoid 2 toward and away from solenoid 1 and record what happens to the galvanometer. How is this action similar to what you did with the magnet? How is it different?

**Eddie currents in disks exhibit**

1. Considering what you learned about Faraday's Law, Lens's Law, and thinking about the eddie current tube you saw in lecture, draw a picture of how you think induced current will flow in the solid metal disk as it falls through the magnetic field (HINT: It may be helpful to imagine the disk as being composed of many concentric circular wire loops of increasing radius as you go out from the center of the disk). Does it matter which way the magnetic field produced by the magnets is oriented (i.e. which way it points)? Next draw the magnetic field that would be produced by that induced current and explain why such a magnetic field causes the disk to fall slowly.
2. Referring to # 1 above, **before** you drop the disks through, predict which will fall the fastest and which will fall the slowest, and explain why you think this. Now drop them through one at a time. Were your predictions correct? If not, try to figure out why.
3. Now imagine that the magnets were much larger, say each was the size of a sheet of plywood. What would happen to the solid metal disk
   a. At the edge of the magnets just after you dropped it?
   b. As it was falling past the center of the magnets?
   c. At the edge of the magnets as it left?

**Generator effect exhibit**

1. Play with the exhibit for a minute or two to get a comfortable grasp of what is going on.
2. Use a magnet to determine the arrangement of the magnets in the exhibit, i.e. which are north poles and which are south. Next draw 2 diagrams of the exhibit, one from a top view and the other from a side view. In both cases indicate the orientation of the magnetic field using flux lines.
3. As you move the rectangular coil back and forth to light up the light bulb, at any time does the magnetic field produced by the magnets change? Considering your answer to that question and Faraday's Law, why is the light bulb lighting up? Is it possible to produce a steady current (DC) with this apparatus? If so, how? If not, does that mean that the light bulb will always flicker on and off and thereby make reading a major nuisance?
4. Suppose the coil were half as long as it is. Would it be possible to make the light bulb light up as brightly? If so, how? If not, why not?
5. Now, instead of the coil being half as long, imagine that one of the pairs magnets were reversed—that the north pole on one side was exchanged with the south pole across from it. Would the light bulb light up more or less brightly as you moved the coil? Explain.
6. And finally, suppose the magnets were situated above and below the coil rather than on either side of it. Could you light up the light bulb? Why, or why not?

**Generator exhibit**

1. Wire coil generator and magnet (the left most apparatus)
    a. Play with the wire coil generator and magnet for a few minutes. Try it with the current off and on and also try placing the magnet in several different orientations with respect to the wire coil motor. It is also necessary to determine the nature of the magnetic field produced by the magnet, i.e. imagine what it would look like if you were to draw it.
    b. If you look closely at the wire coil generator you will notice many closely packed wires inside arranged in bundles of coils, maybe a dozen or so bundles each rotated slightly from its neighbor. When the current is on, do you think it is flowing through all of those wires at the same time? The answer, in fact is no. The apparatus wouldn't function if the current were flowing through all of the bundles simultaneously. Why not? Try to figure out how current is supplied to some bundles and not others. It may be helpful to think about the generator you saw in lecture.
    c. When you reverse the magnet, describe what happens and explain why. You may have also noticed that for a certain orientation of the magnet the coils do not rotate. Explain why you think this is so (HINT: it has to do with the arrangement of the bundles of coils and also with #6 from the Generator effect exhibit above).
2. Two Generators with the light bulb
    a. Again, play around with the exhibit and get a feel for it. In answering the following questions, assume that each hand crank generator is similar to the wire coil generator from #1 above in that the handle is attached to bundles of wire coils and inside the case there is a magnet you cannot see.
    b. With the circuit to the light bulb open, i.e. so it doesn't light when you turn the crank, why does the right generator handle turn when you turn the left generator handle? Actually, the name "generator" is a bit misleading. As you learned, running a generator in reverse transforms it into an "engine". When you turn the left hand crank and the right one also turns, which one is the generator, and which one is the engine? It may be helpful to consider which one transforms mechanical energy into electrical energy and which one transforms electrical energy into mechanical energy. What (or who) is the power source for the generator? Is the wire coil generator from part #1 a generator or an engine and what is its power source?
    c. An important consideration when designing a generator or a motor is its efficiency. How well does it convert one kind of energy into another? With the circuit to the light bulb open, turn the hand crank of one of the generators (does it matter which one you use?) moderately quickly ten times and count how many times the other turns. You should notice that the second hand crank doesn't turn as many times as the one you turned. Why not? What happens to the other crank when you turn one crank very slowly? Why is this so? Come up with a method of calculating the efficiency and explain your reasoning. Define what you used for Ein and Wout.
    d. Now close the circuit so that the light bulb lights when you turn the crank. Why is it more difficult to turn the crank? Again, turn the crank 10 times moderately quickly and count how many times the other crank turns. What does this tell you about the efficiency of your engine with the light bulb in the circuit as opposed to the engine without the light bulb? Why is this so?