Electromagnetic Dissection ~ Project Instructions
(Do NOT Submit Pages 1-5)

Inquiry Question
What is meant by "reverse engineering"? Have you ever taken apart something electronic to see how it works? Can you make it better with a few modifications?

The ability to repair basic electronic devices is not only environmentally friendly, but also might save you lots of money. Reverse engineering takes patience and thought. You need to be methodical when you take something apart, documenting your work, so that you are able to completely understand how it operates. Only then can you make it better!

Instructions
Using a pencil, answer the following questions. The lab is marked based on clarity of responses, completeness, neatness, and accuracy. Do your best! Please ensure that any data measured (or recorded) includes the appropriate number of significant digits (only one uncertain digit).
This activity is divided into three sections: • **Core** – this first section explores only the basic "core" ideas involved in understanding. Students must demonstrate a sound understand with all of their answers in this section BEFORE attempting the next section. • **Mastery** – Your instructor will NOT review this section if the Core section above shows any misconceptions. In this section students will make predictions and apply the concepts and ideas learned above. For complete mastery it is expected that data collection and scientific procedures will be as accurate as possible. All work shown should be clear with any units included. Answers should be rounded off to the correct number of significant figures based on the data collected. • **Ace** – Once again, your instructor will only look at this section provided he/she is confident that the above Mastery criteria has been met. In this section students will demonstrate a deeper understanding of the concepts through error analysis, experimental design etc. Physics concepts from other units already covered will often be required here.
This Project will be graded according to this Marking Rubric (link).

Reverse Engineering - A "Dissection" of a Simple Electromagnetic Device

The overall objectives of this exercise are to see first-hand the:

- Connections between science and engineering.
- Impact that engineers (the creators) have on the lives of people (the customers/users).

This activity is designed to give you an opportunity to take a machine or device apart; this is referred to as "dissection". We often take for granted how machines affect our lives, and seldom consider the inner workings of these devices. Many of these devices employ simple concepts found in any high school physics course. Their simplicity can be ingenious.

Materials:

- Machine or device for dissection (see notes below)
- Disassembly kit (tools needed for taking the device apart, any written instructions necessary for disassembly plus several sheets of paper for note-taking)
- The specifics of the kit will depend upon the device that you choose to use, but keep the tool set simple (e.g., a single screw driver)
- A digital camera for documenting the dissection

Recommended prerequisites for device selection are that it:

- Can be taken apart with simple tools (e.g., screwdrivers, snap fits).
- Is of a size that is easy to see (not so small that one needs a magnifying glass to or so large and heavy that it is difficult to move and hold).
- Has a number (e.g., at least 4, but not more than 30) of mechanical components (e.g., springs, gears, bearings) inside.
- Has an electrical aspect to it that is battery powered. This prerequisite is desirable but not necessary as some devices generate their own electricity. The DC battery will ensure a reasonable level of safety.
- Costs less than $10/device. The reasons for this prerequisite are twofold: to keep overall cost of the exercise down AND to allow you to see the large amount of engineering involved even in relatively inexpensive devices.
- Works. A very important part of the exercise is for you to see how the external function of the device is achieved internally.
- Does not require detailed disassembly instructions. It should be obvious how it comes apart.
- Must be able to put it back together in working order. In other words, your dissection should not harm the parts

Items that typically cost less than $10 each:

- Electric pencil sharpener
- Power transformer converting AC to DC voltage
- Electric doorbell
- Remote Control Toy Car (Battery Powered)
- Talking Doll
- Battery powered fan

Other suggested devices/machines:

- Cordless Power drill (battery powered)
- Electric toothbrush
- Mechanical generator (one that powers a light for your bicycle using your energy is perfect)
- Microphone (large enough to see the inner components easily)

Other suggested devices/machines that utilize AC power:

The devices below would be appropriate but considerably more dangerous to dissect. For AC devices keep them UNPLUGGED at all times and DO NOT plug them back in upon reassembly. Consider these devices as "junk" once the dissection is complete

- Hair dryer
- Tape recorder
- Electric razor
- Blender
- Food Processor
- Vacuum
- Electric Stapler or Nailer
- Speakers (tough to put back together – be careful)
- Electric Fan

Where to find devices (and other ideas):

- Hardware stores
- Target stores
- Drug stores
- Toy stores (e.g., Toys 'R Us)
- K-Mart
- Salvage yard/Junk Drawer/Basement/Closet

Safety:

Make sure that your chosen device is **NOT CONNECTED TO POWER** when dissecting. Devices that utilize AC power (plug into the wall) are considerably more dangerous. We recommend NOT putting these devices back together after the dissection as they could become a fire hazard. Consider them to be junk.

ANY device that you dissect that is not found on the list above needs to be APPROVED by your teacher BEFORE dissecting (eg. Old TVs are extremely dangerous as they often contain high-voltage capacitors that maintain their charge).

Basic Guidelines:

You need to become the "expert" with the device. Take it apart and put it back together enough times so that you have a good feel for the difficulties involved. If there is some aspect of the disassembly or reassembly that is particularly tricky, consider creating a simple handout on the procedure. Discussing the exercise with the teacher will help you:

Take some time to "play" with your device (e.g., push buttons, turn it on). Now begin the dissection. You should spend no more than 20 to 25 minutes taking the device apart AND putting it back together. Make sure you have the tools necessary to disassemble the device (e.g., screwdriver, magnet for collecting screws).

Document your dissection using your digital camera. Each major “phase” of the dissection should be photographed. Some stages may require multiple photos to display all of the parts involved.

Hand in the final draft according to the Student Handout template provided. Be sure to answer the following questions on some scrape paper as you go:

a) What does the device do and how does it do it?
b) How many parts are inside?
c) What science/scientific principles were used in this machine? (e.g., chemistry in batteries and materials, physics in electromagnetism and load transfer, biology in human factors)?
d) How many engineers do you think were involved in making this type of machine? What types of engineers are involved?
e) What other machines would you expect to find similar components in?
f) How do you think it was assembled? How much do you think it cost to build?
g) Rank the parts of the device that might fail in order of probability (the most likely to fail part first, down to the least likely)
h) Justify your rankings with a brief explanation for each choice.

Electromagnetic Dissection ~ *Project* Name: _____

Potential Credits: /25

Using a pencil, answer the following questions/report. The lab is marked based on clarity of responses, completeness, neatness, and accuracy. Do your best! Please ensure that any data measured (or recorded) includes the appropriate number of significant digits (only one uncertain digit).

Instructions:

Choose a simple device that utilizes the principles of electromagnetic induction and "dissect" it methodically. Document your dissection as you go with a digital camera. Import the pictures into the appropriate tables provided.

Please set you camera's "Image Recording Size" to a small setting to alleviate any issues with uploading your final document (ie set to use fewer megapixels)

Part 1: Core

Device Description

Insert a photo or two of your device, then describe what it does and discuss the energy transformations involved:

Photo(s) of Device	Description (name and what it does)	Energy Transformations Involved

Dissection

Provide a list of the tools required to take apart and put together your device

Materials and Tools Required for Dissection:

Document Dissection "Stages"

Take photos (or create a video) to document the stages of the dissection so that all of the major parts can be viewed. Name and label the parts associated with each photo. You will be referring back to these names later. You may simply label the parts with letters on a piece of tape (before you take the photo), then describe the labels in the right hand column, or you can take the photo, attach it to the table, and label the photo directly with appropriate software.

Dissection "Stage" – photo of dissection	***Names of labelled parts***
	…cont next page

Dissection "Stage" – photo of dissection	***Names of labelled parts***

The Physics and Engineering Behind Your Device:

For each of the parts listed above describe its function and explain the physics concept involved. For Electricity and Magnetism you may wish to discuss the Physics principle(s) such as Faraday's Law, Lenz's Law, Back Emf, Ohm's Law, flux, induced Emf etc. If it is a mechanical component (such as an axel, gear, pulley, bearing etc.) discuss how it utilizes the classical mechanics that you have learned. Does it take advantage of torques or lever arms? Does it make the device more efficient? Is it an example of one of Newton's Laws?

Part	***Diagram (may not be necessary)***	***Function and Physics***
		…cont next page

Part	***Diagram (may not be necessary)***	***Function and Physics***

Part 2: Mastery

Troubleshooting Your Device

Rank the parts of the device that **might fail** in order of probability (the most likely to fail part first, down to the least likely). Justify your rankings with a brief explanation for each choice.

Part that could fail ***(most likely to least likely)***	***Justification***

Part 3: Ace

For this part of the task you have three choices. All involve modifying your device.

Choice 1: Modify your device to perform a completely different electrical function than what it was originally intended for. It must still use electricity as its energy source.

Choice 2: Modify or alter your device so that it operates better. You must make at least two modifications and demonstrate that each one improves the performance of your device.

Choice 3: Modify your device so that it is more efficient. You must make at least two modifications and demonstrate that each one improves the efficiency of your device.

Video your new device and ***demonstrate*** how it works, what the improvements are, and how you know that it works as it should.

Have fun! Be creative and think outside the box.