EE223 Laboratory
Teaching Lab

Objectives
1) Create enthusiasm about ECE as a career in high school students
2) Practice engineering written and oral communication skills
3) Practice teaching and presentation skills
4) Review basic circuit quantities and analysis methods

Problem
Engineers of all varieties are in critically short national supply, and electrical engineers especially so. Despite a projected growth need of EE's of nearly 100% in the next decade, B.S. degrees in EE have declined nationally. Although this is good news for us (our graduates consistently have the highest average starting salaries of any other department), some states have become sufficiently concerned to create mandatory engineering courses in public schools (e.g., Massachusetts). As a VMI Electrical Engineering student, known for your ability to describe abstract electrical concepts in concrete terms, you will provide a combined lecture/hands-on lab to inspire more young men and women to become electrical engineers.

Your Lab
Create a written lesson plan for a short lecture and lab, and present it to 6th grade students. The entire class will be conducted in the Engineering Library, with two cadets per team teaching roughly 6-8 pre-identified middle school students. You will know your students' names in advance. I will provide equipment kits at our first lab meeting- check all items to make sure they work. You will have three required tasks:

1) Theory portion: No more than 10 minutes maximum. You decide what you want to cover, but must include what current and voltage are, that batteries store electric energy chemically, and that one can change kinetic energy into electrical energy by moving a magnet across wire loops. Also, instead of magnetic motion across a loop wire making electricity, run it in reverse: electricity through a wire loop makes an electromagnet. Have fun with this –add whatever theory/demos/stories you think interesting.

2) Building portion #1: Have them build a simple circuit of a wire coil (a 100mH inductor in which you have already stripped off the rubber insulation so they see it is just a wire coil) and LED in a protoboard. Have them move a magnet over a coil of wire to make enough electricity to light the LED. Explain why this occurs, and how it is used in power plants to generate the electricity that powers our homes. Then place the battery across the inductor coil to make an electromagnet that can pick up a metal washer.

3) Building portion #2: Help them build a 555 timer circuit that blinks an LED on a small solderless breadboard. It will be powered by a 9V battery. Include a current-limiting resistor.

The written lesson plan is worth one lab grade, and your class itself another two. I will walk around and observe each of you and your tables during your class. I'll be looking for your enthusiasm, your ability to keep your class orderly, and your ability to help your teams complete the lab on time. At the end of the period, ensure you clean your area, and collect all the components except the used wire and resistors in the containers you were originally issued, throw out the resistors, batteries, broken components, and used wire, and return control of your table to the Lylburn Downing teachers. The following period I will collect the lab kits, so make sure yours are in the same condition you received them (neatly-arranged components, empty protoboards, etc.) minus the resistors, battery, and wire.

2022 Timetable
9 Nov	Meet with instructor and discuss approaches.
15 Nov	Prepare lesson plans. Request any additional materials.
29 Nov	**Turn in written lesson plans**. Prepare for lesson.
6 Dec	Teach students
13 Dec	Clean lab, return materials

Written Lesson Plan

The lesson plan should have three parts:

I. **Objectives**. ("By the end of the lesson, students will be able to …"). The objectives should be testable, even if you choose not to test, and should cover both the short lecture and laboratory component. For example, if teaching about the nodal method, a poor objective would be "students will be able to explain how to solve problems using the nodal method". A good one would be "students will be able to optimally choose which node to make a ground so that the complexity of the resulting KCL equations are minimized". There will be many objectives associated with this assignment. As you create the objectives, keep in mind that most students will not know anything about current or voltage. They won't be able to read schematic diagrams, won't know Ohm's Law, won't know what a resistor looks like, and if given V=IR, won't be able to solve for R. Keep things simple and fun.

II. **Plan**. This is the meat of the lesson plan. In it describe what you plan to do first, how long it will take, what you plan to do next, etc. Here are some of the things you will need to consider in your plan:

- Logistically, what tables will you use? How will you arrange seating? Where will you sit? How will you work with your cadet partner to teach all the student pairs?
- How will you teach the objectives of electricity generation, electromagnet and timer design in the lecture portion? Will you use handouts? Brief using a butcher-paper board (and if so, where will you obtain one?) Use pre-made posters? Portable whiteboards? Will you use any demonstrations? If so, what are their schematics, and how will you power them? Ten minutes is very short, and I'll announce when the time is over. I don't recommend trying to teach more than either how to work the design equations OR how to read a schematic OR how to read resistor color codes; decide how to simplify the other parts you don't choose to teach.
- You must prebuild both parts (the electrical generator and LED blinker) yourself first to use as a demo. You must also pre-strip the rubber outer covering of the 100mH inductors so that the students see they are just wire coils. There's probably other prep work you will want to do.
- For the lab portion, how will you explain how to make connections using a solderless breadboard? Or will you sidestep the issue entirely by providing them a picture of the circuit built upon the solderless breadboard (e.g. using a picture of the 9V battery instead of the voltage source symbol)? How many precut/prestripped wires will you need to make? Will you make an "approved solution" for them to copy? How will you have them design the oscillator – will you tell them what resistors are required for different frequencies? Give them a graphic table? Have them set R1=R2 and solve the equations themselves (keep in mind they won't understand how 5, 5k, and 5M resistors are different)? Will you need to provide paper and pencils for them to work scratch problems? How will you help them know which resistors in their kits are which (e.g. simplified color chart)?
- How will you handle the needs of slower student teams that have trouble keeping up in the lab? The lab groups that have trouble with basic math?
- How will you handle the needs of faster student teams that finish early? (e.g. you could have them experiment with making their circuit blink more slowly or quickly, or replace some of the resistors with CdS cells (light-dependent resistors). You could bring a small speaker and have them change the oscillation speed from a couple of Hz blinking the LED to a couple of kHz to drive the speaker. What will you do in the highly unlikely event that your whole table finishes quickly; will you have any canned post-lab lecture topics that you can pull out?
- How do you plan to sum up the lab at the end of class, so everything is cleaned up? Ideally, most students will have just finished construction and will be noodling with changing values of their circuit, but some will have only half-built their circuit. The components must be disassembled and returned by the end of class. You can save yourself some work by having the students disassemble their boards, rather than you.

III. **Handouts.** Include lab sheets, board/desk problems, notes, circuit diagrams/pictures, and any other handouts you wish to use.

Unsolicited Advice

Try your plan out on a non-science or engineering friend. If they sail through in a fraction of the time you've allotted, your plan will work well. If they have trouble with any aspect of it, fix it before you try it with middle school students.

Final Thoughts

The most common problem cadets have with this class is that they try to cover too much or move too fast for their students. If you think you may be covering too much material, you almost certainly are. Consider putting any components not needed for the core projects (speaker, CdS cell, extra resistor) in a bag in case the students finish too quickly. Strip the class down to the essential core of one short "design" task and leave all the rest of the time to "building". Middle school students have a listening attention span of only about 20 minutes (how often do you as adults start to daydream in a 50-minute class?). Have fun with this assignment. The students will look up to you, both as college-age adults and as VMI cadets, and they will respond well if they see you enjoying yourself and engineering. Whether you decide to go into industry, government, academia, or the military, your ability to teach others will profoundly affect your success, and I have great confidence in your abilities as a VMI cadet.

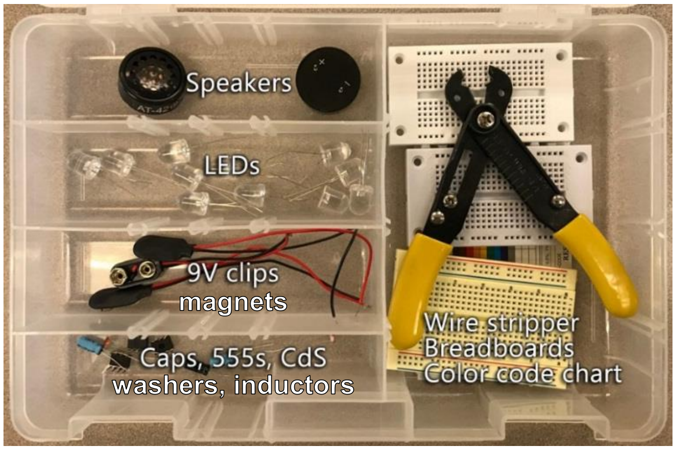
Kit Supplies

N is the number of blinker sets. I suggest one set for the cadet leaders as an example, 1 per student pair, 1 extra for breakage except the LED for which I suggest 3 extra. So cadets teaching 6 students teamed in pairs would want 1 set as a demo + 3 sets for the team pairs = 4 sets + spare LEDs.

1	plastic carrying case (Plano 3860)
1	wire cutter
1	resistor color-code reader card
3	hand-rolled 1' rolls of 22AWG solid core wire
N	100mH inductors
N	Magnets
N	1" diameter mini speakers
N	CdS cells
N	9V batteries
N	9V battery clips
N	solderless breadboards
N	555 timers
N	LEDs
N	10uF capacitors
N	#8 washers

Returning Kits

- Remove wires & components from breadboards
- Throw away resistors and wires
- If there's anything broken, throw that away too <u>and replace it</u>
- Restore the boxes as shown to the right



2022 LDMS Students (44)

Team	Cadets	Pair	LDMS Students
1	Tim Mackey, Laini Morgan NEB 427	1 2 3	Micha Patterson, Anika McKeever Allison Taylor, Charlotte O'Byrne Kelly Fu, Gabby Bushnell
2	Caleb Fender, Liam Noonan NEB 427	1 2 3	Alden Schultz, Sammy Davis Braiden Hemmings, Evan Lanier Joe Vargas, Calvin Lambert
3	Cole Bowyer, Ben Wallace NEB 427	1 2 3	Josie King-Bond, Liesl Niebur Hudson Saunders, Sam Wollner Grant Swenty, Leif Guse
4	KC Etienne, Rubén Medina NEB 428	1 2 3	Jude Braman, June Wilson Madison Mangione, Kyra Strowbridge Elliott Allen, Ru Bucy
5	Grant Martin, Brian Tavenner NEB 428	1 2 3	Summer Canter, Audra Roney Rowe Carter, Fisher Newhall EJ Clemment, Sarah Edgar, Allison Licona-Asto
6	Ben Schreher, DJ Thompson NEB 428	1 2 3	Alex Driver, Caden Sheets Kayden Jones, Luke Eichholz Kevin Kimbler, Emil Heirman
7	Josh Tuell, Sudarshana Raj NEB 428	1 2 3	Maddie Smith, Maeve McGrath Avery Diette, Shanta Dates Graham Shester, Jayden Salvador, Bella Watkins