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 by approximately 50%, a trend mirrored at VMI. Although this is good news for us (our department's 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 (for example, Massachusetts has started this program). You are invited as a VMI Electrical Engineering student, known for your ability to describe abstract electrical concepts in concrete terms, to provide a combined lecture/hands-on lab to high school students in support of this program to convince more young men and women to become engineers.

In this lab you will create a written lesson plan for a short lecture and lab, and present it to 12th grade students. The entire class will be conducted in the Engineering Library, two or three cadets per table of two high school students. You will have 10 minutes at the start of the class to present theory, and the remaining time to run a hands-on lab at your table. During the theory portion you must explain how to design a working 555 timer circuit that blinks an LED. During the laboratory portion you will assist student lab teams as they build their own circuit on a small solderless breadboard to flash an LED from a 9V battery (including current-limiting resistor). Each lab team will be pre-identified; you will have a list of your table's two 12th grade students' names in advance. I will provide solderless breadboards, spools of uncut/unstripped wire, and a selection of LEDs, 9V batteries and clips, 555 timers, resistors, and 10 μF capacitors in kits for each lab team on our first lab meeting. Check all items to make sure they work.

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 your table cleans its area, and collect all the components except the used wire and resistors in the containers you were originally issued, throw out the resistors, batteries, and used wire, and return control of your table to the 12th grade teachers. The following period I will collect the lab kits – make sure yours are in the same condition you received them (neatly-arranged components, empty protoboards, etc.).

Timetable

30 Oct	Meet with instructor and discuss approaches. Divide into teams.
6 Nov	Prepare lesson plans. Request any additional materials.
13 Nov	**Turn in written lesson plans**. Prepare for lesson.
4 Dec	Teach 12th grade students
11 Dec	Clean lab, return materials

Agenda of cadet/high-school student day at VMI

0945	arrive at VMI
1000 – 1045	visit Chem, COL Smith
1045 – 1100	move to Bio
1100 – 1145	visit Bio, MAJ Smythe
1045 – 1100	move to Physics
1200 – 1245	visit Physics, COL Brooke
1300 – 1345	lunch at Crozet, COL Squire & cadet volunteers (please let me know if interested!)
1345 – 1400	move to Nichols
1400 – 1600	ECE lab/class by ECE cadets
1615	Parade
1700	Depart VMI

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 they will have some limited exposure to topics of current, voltage, and resistance, but nothing else. 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 would not 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:

- How will you teach the topics of timer design (that you described in Section I) 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.
- 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? (you will need to prestrip them because we cannot leave any clippings in the subsmess). 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? (Keep in mind most have only learned basic math in the past three years, and none will know algebra).
- 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.

One Piece of 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 the high 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; package anything not absolutely necessary for use if the students finish too quickly, and strip the class down to the essential core of one short “design” task and leave all the rest of the time to “building”. High school seniors have a listening attention span of only about 30 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 the greatest confidence in your abilities as a VMI cadet.

Kit Supplies

For 8 teams (i.e. 8 12th grade student teams of 2, corresponding to 8 VMI ECE cadet teams of 3 teams of 3 and 5 teams of 2)

1	plastic carrying case (Plano 3860)
1	wire cutter
1	resistor color-code reader card
2	1" diameter mini speakers
2	CdS cells
3	hand-rolled 5' rolls of 22AWG solid core wire (red, black, white), held together with twist tie
N	9V batteries
N	9V battery clips
N	solderless breadboards
N	555 timers
N	LEDs
N	10uF capacitors

Notes: remind students that lab kits should be in same condition when returned as when issued: protoboards should be bare. No pieces of used wire floating around. Items neatly organized.

Team 1
Cadets: Jared Anter, Noah Breeding
Students: Nick Adams, Scott Borah

Team 2
Cadets: Garner Fleming, Hayden Grimmett, Jackson Jennings
Students: Logan Duncan, Derek Hackenbracht

Team 3
Cadets: Walter Kitson, Brahn Kush
Students: Maryah Haley, Chloe Ingersoll

Team 4
Cadets: Bradley Lythgoe, John Matzeder, Eric Munro
Students: Anna Claire Kittrell, Hannah Murphy

Team 5
Cadets: William Nicholson, Roboert Peterson
Students: Claire Owens, Juette Renalds

Team 6
Cadets: Nate Porterfield, Ben Smith
Students: Parks Robinson, Nick Toone

Team 7
Cadets: Josh Thomas, Kevin Yang
Students: Grace Walker, Brandon Wilson