EECE2412— INTRODUCTION TO ELECTRONICS— Spring 2013

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OFFICE HOURS: TBD or by appointment.

These office hours are the two that I have set aside specifically for students in my classes. However, I know your questions will not always follow a schedule. Please feel free to contact me by electronic mail. I normally check my electronic mail frequently throughout the day, from about 9AM until 11PM and at least once a day on weekends. Student questions will be answered as quickly as possible. When I am on travel, I normally read e-mail each evening. Please include the word "ELECTRONICS" as the first word in the suject to get my attention.

TEXT: Hambley, Allan R. *Electronics*, Second Edition, Prentice–Hall

OTHER RESOURCES: For PSPICE, you can download a student version from
http://www.electronics-lab.com/downloads/schematic/013/

There will be some use of Matlab or other software for calculations. I recommend Matlab, but I don't insist on it.

I will put pointers to other resources on the class website.

LOCATION: 35 SL

TIME: Mon, Wed, Thu, 1:35 — 2:40 PM

RECITATION: Tuesdays 11:30am - 1:30pm 325SH, 15 January through 16 April &
Thursdays 3-4pm 325SH, 17 January through 18 April.
James Rooney, tutor.

LAB: As scheduled, in 9HA

EECE2413, Electronics Lab. This lab must be taken simultaneously since the material in the lab supplements the lecture. Note that students from the two lectures sections are intermixed in the labs.

READING: Reading is to be done before the start of the week, to the extent possible. When I lecture, I will assume that you have read the related material.

COURSE DESCRIPTION: In this course you will learn about three types of electronic devices: diodes, bipolar junction transistors (BJTs), and metal-oxide-semiconductor field effect transistors (MOSFETs). You will learn how to design and analyze useful electronic circuits (such as amplifiers) using these components.

GRADING: 20 % on homework (Equal weight on best $n-1$ of n assignments)
55 % on 2 Exams (midterm and final)
25 % on SPICE projects (3 assignments). Highest two of three submitted reports will count 10% each, and lowest will count 5%.

Minimum Performance: Grades will be based on the weighting above, but failure to complete assigned work may reduce the maximum grade you can receive. Starting from an "A," missing more than 2 homework assignments will reduce your grade by one–third letter grade per assignment. Missing a SPICE assignment will reduce it by a full letter grade. For example, if you miss two homeworks and one SPICE assignment, your maximum grade is "C+." Absence from an exam will reduce your possible grade by two letter grades.

HOMEWORK: It is to your advantage not to clutter your work with confusing and unnecessary steps. If I can follow your work clearly, it is easy to give full credit for what you know, and to give partial credit when appropriate.

Working together is acceptable, and even encouraged, on homework, BUT the work that you submit must be your own (no copies of the group's solution!) If you are working with a group, make certain you understand every part of your solution.

If you collaborate with other students, please give appropriate credit to those who helped you, or list the names of students who collaborated. Your grade will not be affected in either direction by collaborating or not collaborating. However, failure to mention it will be treated as academic dishonesty.

Late homework will incur a penalty of 10 points until solutions are posted. After that, late homework will not be graded and will be scored as a zero in the gradebook.

PROJECTS: Collaboration on SPICE projects follows the same rules as on homework, with one exception; I will accept a single report from a group of two or three people. All will, of course, receive the same grade.

Grammar, spelling, and appearance are important. Don't spend great amounts of time and money on fancy artwork, but make everything easy to read. Use a spelling checker. If English is not your first language, (or even if it is) you may want to have someone else read the paper for you.

The report is a text document, similar to a journal article. It is not an oral presentation. Therefore students are encouraged to use word–processors rather than presentation or spreadsheet programs in their preparation.

ETHICAL BEHAVIOR: The following paragraph is specifically modified from the one I usually use, to allow for collaboration on homework as described above.

No collaboration, except as specifically authorized, is allowed under penalty of failure. Plagiarism and cheating will not be tolerated; they will be dealt in accordance with University policies described in the Student Handbook. All engineering majors should be familiar with the Honor Code of our College of Engineering that is included in the freshman course material, and with professional engineering codes of ethics. Although students are encouraged to collaborate on homework assignments to develop a deeper understanding of the topics presented in this course, each student is expected to prepare and submit his/her own, narrative reports, drawings, and other materials. If two students' work is suspiciously similar, a penalty may be assessed to both students. If a situation arises in which you are uncertain if cooperation with another student would constitute cheating or some other violation of the honor code, please ask the instructor for guidance and clarification of these rules. Violators will be referred to the Student Court for review, where penalties may include but are not restricted to: zero credit on the work, student placed on probation, submission of information on judgment in the students' permanent record.

CIVILITY IN THE CLASSROOM: I will treat my students with respect, by being prepared for my lectures, grading your work carefully, answering your questions, and making myself available to you as much as possible. Please treat me, our teaching assistants, and your fellow students with respect, by observing the following rules. (1) Please arrive on time and be seated by the start of the lecture, avoid stepping out during class, or leaving before the class ends. (2) Please avoid unnecessary noise or other disturbance during the class. (3) Please silence all pagers, telephones, and other electronic devices before entering the classroom (This rule applies to the laboratory as well).

SPECIAL NEEDS: The University will make reasonable accommodations for persons with documented disabilities. Students should notify the Disability Resource Center located in 20 Dodge Hall and their instructors of any special needs. Instructors should be notified the first day of classes.

Syllabus

Topic 1 **7,9,10** **14,16 Jan**	**Administrivia.** Introductions, Student lists, Lab Schedule. **Introduction.** Course overview, motivation, circuit models, graphical solutions, approximations, small–signal models, notation. **Op–Amps.** Terminal characteristics, voltage amplifier, transimpedance amplifier, summing junction, gain, impedance, saturation. **Reading:** Chapters 1, 2 (Except 2.7). **Lab:** 1 (Op Amps) Parts 1-2: 22 or 25 Jan. **Lab:** 1 (Op. Amps) Part 3: 29 Jan or 1 Feb.
Topic 2 **17 Jan**	**SPICE.** Getting started with projects.
MLK Holiday — 21 Jan	
Topic 3 **23,24,28,** **30,31 Jan** **4,6 Feb**	**Diodes** Diode Fundamentals. The Ideal Diode, characteristics, circuits, piecewise–continuous functions. Applications. Diode Physics and terminal characteristics. **Reading:** Chapter 3. **Diode Circuits.** Transcendental equations, iteration, graphical analysis, load line, Taylor's series, small–signal model, non–linear behavior. Laser diode example. **Diode Applications** Rectifiers, voltage regulator. Zener voltage regulator, limiters, diode logic, special diodes. **Spice Project:** 1. Diode Circuits (Due 7 Feb). **Lab:** 2a (Diode Circuits): 5 or 8 Feb. **Lab:** 2b (Diode Circuits): 12 or 15 Feb.
Topic 4 **7,11,** **13,14 Feb**	**BJTs.** Physical Concepts, terminal characteristics, Notation, circuit symbols and conventions. Basic DC models. **Reading:** Chapter 4 through 4.6.. Review Day 20 Feb, Exam 21 Feb **Lab:** 3a (BJT): 19 or 22 Feb.

Presidents' Day Holiday 18 Feb
Review Day 20 Feb
Exam 21 Feb

Topic 4+ 25 27,28 Feb	**BJTs.** Physical Concepts, terminal characteristics, Notation, circuit symbols and conventions. Basic DC models. **Reading:** Chapter 4 through 4.6.. **Lab:** 3b (BJT): 26 Feb or 1 Mar.
Spring Break 4–8 Mar	
Topic 5 11,13,14, 18,20 Mar	**BJT Applications.** AMPLIFIERS: Small signal models (Taylor's series again). π and T models. Graphical techniques. Modes of operation, clipping, biasing. Three types of amplifiers, Gain, impedances. OTHER: Cutoff and saturation, BJT Logic. **Reading:** Ch. 4 through 4.8. **Spice Project:** 2. BJT Amplifier (Due 21 Mar). **Lab:** 4a (BJT Amplifier): 12 or 15 Mar. **Lab:** 4b (BJT Amplifier): 19 or 22 Mar.
Topic 6 21,25,27, 28 Mar, 1 Apr	**FET Basics.** Structure and Physics. Terminal characteristics. Saturation and triode regions. Pinch–off. Early Voltage. **Reading:** Chapter 5 through 5.4. **Lab:** 5a (MOS): 26 or 29 Mar. **Lab:** 5b (MOS): 2 or 5 Apr.
Topic 7 3,4,8, 10,11 Apr	**FET Applications.** Graphical solutions, small–signal model, biasing, amplifiers, switches, **Reading:** Chapter 5 through end.
Patriots' Day Holiday 15 Apr	
Topic 8 17 Apr	**CMOS.** logic inverter, analog switch. Current flow and power dissipation in CMOS Logic. **Reading:** Chapter 4, Sec 4.9, and Chapter 6. **Spice Project:** 3. Transistor Amplifier (Due 18 Apr).

Review for Exam 18 Apr
Final Date TBD

Notation

This is the notation used by the text to represent voltages and currents. While I like the choice, I've found it adds some extra confusion for the student. The last column shows a modification I will make in my notes, which I think you will find helpful. I will follow the case selection conventions of the author, but also provide a superscript which is easier to remember. My approach is redundant, and a bit slower to write, but it will make things easier to understand in class, and will still conform to the book.

Table 1

Notation Conventions

Quantity	V or I	Subscript	Voltage Example	
			Text	Notes
Total Instantaneous Signal	lower case	CAPITAL	v_A	v_A
DC Signal	CAPITAL	CAPITAL	V_A	$V_A^{(DC)}$
AC Signal	lower case	lower case	v_a	$v_a^{(ac)}$
Peak of AC	CAPITAL	lower case	V_a	$V_a^{(pk)}$

Thus, any signal is represented by

$$v_A = V_A + v_a \qquad \text{Text}$$

$$v_A = V_A^{(DC)} + v_a^{(ac)} \qquad \text{Notes,}$$

and a sinusoidal signal is represented by

$$v_A = V_A + V_a \, sin \left(\omega t + \phi\right) \qquad \text{Text}$$

$$v_A = V_A^{(DC)} + V_a^{(pk)} \, sin \left(\omega t + \phi\right) \qquad \text{Notes.}$$

Remember that the RMS of an AC signal is $V_a/\sqrt{2}$.

Useful Constants

Table 2

Physical Constants

Speed of Light	c	2.998×10^{8}	meters per second
Planck's Constant	h	6.626×10^{-34}	Joule second
Boltzmann's Constant	k	1.381×10^{-23}	Joules per Kelvin
Electronic Charge	e	1.602×10^{-19}	Coulombs
Thermal Voltage at 273K	kT/e	25.2×10^{-3}	Volts

Decibels

Decibels are a convenient concept to describe gains and losses in electronic systems. The gain of an amplifier is described in terms of the power ratio of output to input, and is expressed in dB. (note lower–case "d," meaning "deci–," and capital "B" for "Bel.") as

$$g = 10\,log\,(p_{OUT}/p_{IN}).$$

If the output and input impedances are the same, then the power gain is the square of the voltage (or current) gain, and

$$g = 10\,log\left(\frac{v_{OUT}}{v_{IN}}\right)^2] = 20\,log\,(v_{OUT}/v_{IN}).$$

Although it is not needed for this course, signals are often expressed in dBm. This is not a measure of gain, but of signal level. It is the ratio of the power to one milliwatt.

$$y = 10\,log\,(p/10^{-3}\mathrm{W}).$$

Typically, this concept is used with 50–Ohm impedances common in RF work, and

$$y = 10\,log\,(v^2/10^{-3}\mathrm{W}/50\mathrm{Ohms}).$$

Multiplier Prefixes

Table 3

Multiplier Prefixes

10^{-18}	atto–	a–	10^{-18} boys = 1 attoboy
10^{-15}	femto–	f–	Your Idea Here
10^{-12}	pico–	p–	10^{-12} boos = 1 picoboo
10^{-9}	nano–	n–	10^{-9} goats = 1 nanogoat
10^{-6}	micro–	μ–	10^{-6} scopes = 1 microscope
10^{-3}	milli–	m–	10^{-3} cents = 1 Millicent
10^{3}	Kilo–	k–	2×10^{3} mockingbirds = 2 kilomockingbirds
10^{6}	Mega–	M–	10^{6} phones = 1 megaphone
10^{9}	Giga–	G–	10^{9} los = 1 gigalo
10^{12}	Tera–	T–	10^{12} bulls = 1 terabull
10^{15}	Peta–	P–	10^{15} lumas = 1 Petaluma
10^{18}	Exo–	E–	10^{18} skeletons = 1 Exoskeleton