Georgia Institute of Technology

School of Electrical and Computer Engineering

ECE3080: Semiconductor Devices

Syllabus Spring 2011

Introduction:

Understanding semiconductor devices is critical in designing and improving many types of systems. ECE3080 will give you an understanding of how devices work, the critical issues and the key design tradeoffs in the devices. ECE 3040 is a prerequisite for the class, and it is assumed that you are already familiar to some degree with the material up to and including pn junctions. After the addition of some more advanced material in the semiconductor background area, the course will focus heavily on optoelectronic devices, followed by BJT, HBT and MOSFET structures.

Instructor: Professor: Dr. Alan Doolittle
Office: Pettite 208 (note this is erroneously listed in some ECE websites)

Work: 404 894-9884 **Home**: 770-707-1302 (before 9 PM unless an emergency)
Email: alan.doolittle@ece.gatech.edu (by far, the best way to communicate with me).

Textbooks

The two textbooks are:

- Betty Lise Anderson and Richard L. Anderson, "Fundamentals of Semiconductor Devices", McGraw-Hill

Web Resources:
Official Class Web site: http://users.ece.gatech.edu/~alan/index.html

Office Hours: Officially: Mondays 2:30-3:30. Most weeks I hold "open office hours" on Mondays where you can come by for help anytime that is pre-arranged (strongly recommended to insure I am there, preferably by email) or drop by unplanned (no guarantee I will be in my office but most times I will). ***All students are strongly encouraged to consult me with any problem, academic, personal or professional!***

Grading Schedule:
Grades will be based on a 100 point scale (see note on the final exam below), but bonus points will frequently be awarded. Exams will fall approximately every 5 weeks.

		Approximate Date
Exam 1	20%	~February 21st (Monday)
Exam 2	20%	~March 18th (Friday)
Presentation	20%	~Beginning March 28th
Homework	2% each ~5 per term	~Every 1-1.5 Weeks
Final Exam*	30%	Week of May 2nd
Pop Quizzes	0.5% Bonus	As needed to insure attendance

Final Exam is currently planned for 11:30 AM - 2:20 PM, May 4, 2011

Each homework is ***ungraded*** and adds a fixed 2 % (or 0%) if ***ALL*** (or some) assignments are attempted. Homework will be representative of test problems (see later statistics for proof). Previous analysis has shown a relationship of (Increased Test Score) ~ =26 x (Percentage of Homework Attempted)! If more than 5 homework assignments are made, all those above 5 will be counted as bonus points (a good way to raise your grade a couple of points). If less than 5 are assigned, bonus points will be awarded to all to raise the homework contribution to 10%.

*Final exams often have many bonus points, thus accounting for as much as 35-40% of your overall grade ***IF*** all bonus points are attempted. This is all the curve given, in a since, an earned curve. Those that get the exam bonus points will get the benefit of the curve.

The declared value of the final exam is $6000 (but of course is not for sale). As such participation in the attempted theft of the exam constitutes felony theft. Receipt of any information about the exam constitutes felony theft by receiving.

Exam Design and Grading:
Exams will cover all material assigned as reading, homework and discussed in class.
Each exam will be designed with the following approach:

1.) The first ~33% of points will be easily obtained by students that attended class. Everyone is expected to get an "A" on these problems.
2.) The second ~33% of points will be obtained by students who understood all text, class work and homework, but will require deeper thought. Most classes will average a "B- or C" on these problems.
3.) The remaining points will challenge all students in the class. Most classes will average a "C-D" on these problems.
The overall average for most classes will be a "C to A".
Important: I do not curve in the traditional GT way. Bonus points are added to the final exam to allow you to receive an "earned curve". If you do not learn the material, you can not get the benefit of a curve.

What is Expected of Students
All students are required to follow the academic honor codes established by Georgia Tech.
All students are expected to be respectful of other students.
All students are responsible for materials covered in and/or assigned in class REGARDLESS of whether they attended class.
I strongly prefer an interactive class. Let me know if you do or do not understand what is being lectured. Ask questions!

Instructor Commitment to the Student.
While statistics always result in some students who will perform poorly in this class, no student will perform poorly due to lack of access to the instructor. To that end, I will make every reasonable provision possible to insure your success in this class. Students are strongly encouraged to seek help from this instructor with any problem, academic, personal or otherwise. Students are also strongly encouraged to supply the instructor with constructive criticism regarding all aspects of class activity. Such criticism (even/especially that considered negative) will be greatly appreciated.

Approximate Topical List and Order

The following is an anticipated schedule of topics. However, as this is a course under development, topical coverage is at best suggested. For now, ignore the week numbering as this is likely to change.

Order (not week)	Topic	Reading Material
1	Class introduction and policies	See Lecture Slides for reading assignments
2	Semiconductor materials Crystal structures Semiconductor materials Quantum Mechanics and Band Theory	See Lecture Slides for reading assignments
3	Carrier Properties State and Carrier Distributions Equilibrium carrier concentrations	See Lecture Slides for reading assignments
4	Drift Diffusion Generation/Recombination	See Lecture Slides for reading assignments
5	Generation/Recombination Equations of State Minority Carrier Diffusion Equation Introduction to p-n junctions	See Lecture Slides for reading assignments
6	p-n Junction Electrostatics Ideal Diode	See Lecture Slides for reading assignments
7	p-n Junction Small Signal Model p-n Junction Large Signal Model and distortion Diode Applications Non-Idealities in pn Junctions AC & Transients in pn Junctions Heterojunctions Compound Semiconductor Diodes Schottky barrier diodes Metal-Semiconductor Contacts Semiconductor Fabrication LEDs: Basic Operation LEDs: Key Design Parameters LEDs: Device Structures Lasers: Basic Operation Lasers: Basic Operation Lasers: Key Design Parameters	See Lecture Slides for reading assignments

Order (not week)	Topic	Reading Material
	Lasers: Laser Structures Solar Cells: Basic Operation Solar Cells: Design Photodetectors: Basic Operation Photodetectors: Devices and Uses	
8	Introduction to Bipolar Junction Transistors BJT Physics HBT Physics and applications	See Lecture Slides for reading assignments
9	Metal Oxide Semiconductor Capacitor	See Lecture Slides for reading assignments
10	MOSFET Basics MOSFET Device Physics	See Lecture Slides for reading assignments
11	MESFET JFET	See Lecture Slides for reading assignments
12	Polarization Based Devices (III-Nitrides and Ferroelectrics)	Notes
13	Advanced Transistor Structures	Notes
14 15 16	Other Devices: CCD, Microwave transistors, Gunn Diodes, Impatt Diodes, power transistors, organic semiconductors, MEMS, Floating gate memory components (flash etc…), Future devices such as memristors and neuromorphic computing	Notes
17	Final Exams	Final Exams

Presentation Details:

It is my desire to make your presentation topic as interesting and as useful to you as possible. All topics must be unique. No topic can be shared by another student. Papers regarding topics partially covered in class should provide much more detail than what was covered in our text and class discussions. If chosen carefully, the paper can be a benefit to you instead of a time liability.

Some suggested topics include, but are not limited to:

Topics could include (many others exist):
Deep-submicron CMOS transistors, FinFETs, (HFET/MESFET/MODFET/HEMT/HBT/BJT) devices in (silicon / silicon-germanium / antimony / arsenic / phosphide / nitride / carbide) material systems, Si or SiC power devices (FET, BJT, SIT, Thyristors, Diodes), Si DRAMs, SRAMs, MEMs, memristors, neuromorphic computing, Oxide characterization via (corona discharge, CV, thermal stress) measurements, semiconductor laser/LEDs/modulators/optoelectronic integrated circuits, photodiodes, solar cells (Si, GaAs, InP, CdTe, CIS, Nitride), power switches, non-linear optical devices, optical bandgap devices/materials, yield, reliability, etc...

<u>I WANT TO SEE DETAIL!!!! TELL ME WHAT YOU LEARNED!</u> Ideally, I would like you to tell me something I do not already know. In the absence of this, (because I will likely be familiar with most topics) it should answer a "yes" to the question; "If I heard this topic from you for the first time, would I understand the topic well?"

Presentation specifications:

Length dependent on class size: Generally 10 minutes with a 2-5 minute question and answer time with details to come later. Presentations are to be given in PowerPoint with both hard and electronic copies supplied to the instructor prior to your scheduled presentation. Presentation topics scheduled by order of topic submission (first come, first time slot selection). Presentations are due the day of exam 2 so that everyone has the same deadline regardless of assigned time slot.

Presentations will be graded based on mastery of the subject matter.

Grading Breakdown:

Meeting Assignment Requirements	**25%**
This includes 10% for having a preloaded and verified operational PowerPoint presentation.	
Presentation (organization/clarity etc...)	25%
Content (detail, detail, detail...)	50%

Your final WILL have 1-2 questions from each presentation on the final exam. Thus, everyone is required to attend the presentations.