ECE 3040 Dr. Alan Doolittle

I have thoroughly enjoyed meeting each of you and hope that I have had a positive influence on your carriers. Please feel free to consult with me in your future work. If I can help you in any way, please come by and talk.

Also, if you have not already completed the online computer evaluation, please do so. I am very interested in your comments on my performance, and the class in general. The evaluation is available at:

http://www.coursesurvey.gatech.edu

Use the following as a final exam study *GUIDE*. It by no means is meant to be 100% complete. All material covered in this course is fair game for the exam.

<table>
<tr><td>1</td><td>Class introduction and policies</td><td>Handout</td></tr>
<tr><td>2</td><td>Semiconductor materials
Crystal structures
Semiconductor materials
Classifications of materials (metals, insulators,semiconductors, etc...)
Classifications of semiconductors (elemental, compound, binary,ternary, etc...)
Classifications and descriptive techniques of crystals and crystal structure (polycrystalline, crystalline, unit cells, Miller indexes, etc...)
Energy bandgap (what they are and where do they come from), ENERGY BAND DIAGRAMS, electron and hole generation</td><td>Pierret 1.1,
1.2, 1.4,
2.1, and 2.2</td></tr>
<tr><td>3</td><td>Carrier Properties
State and Carrier Distributions
Equilibrium carrier concentrations
Effective mass, intrinsic carrier concentration, extrinsic materials (doped), doping types (p or n), fermi-level movement with doping, fermi-probability distributions (meaning and be able to apply), density of states, calculations of electron and hole concentrations based on doping (total ionization only), fermi-level etc..., LAW OF MASS ACTION, charge neutrality, carrier freeze out, etc...</td><td>Pierret 2.3
2.4,
2.5, 2.6</td></tr>
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4	Drift Diffusion Generation/Recombination Equations of State • Drift velocity, mobility, Einstein relationship, resistivity, {relationships between electric fields-energy band diagrams-potential energy-electron and hole motion}, current continuity equations, electron and hole total currents (drift + diffusion), processes of generation and recombination and under what conditions do they occur, direct verses indirect bandgaps, absorption coefficients and absorption, excess carrier concentrations, electron/hole continuity equations, minority carrier diffusion equations (I would give you the general solution format if it were more complicated than simple calculus), diffusion length, quasi fermi levels (concept and calculation, ***LAW OF THE JUNCTION*** (relates np to quasi-fermi levels and applied voltage	Pierret 3.1 3.2 3.3, 3.4
6	p-n Junction Electrostatics Ideal Diode • Poisson equation, charge neutrality, ENERGY BAND DIAGRAMS UNDER BIAS, built in potential, step junction solution results only (including depletion widths, capacitances, and electric fields), understand how it works! • Electron and hole motion across the diode (drift vs. diffusion components), IV-curve and IV-equations, saturation current density as a function of diode design, reverse bias break down mechanisms	Pierret 5.1, 5.2 6.1

7	p-n Junction Small Signal Model p-n Junction Large Signal Model ~~Diode SPICE Model~~ Diode Circuit Analysis and Applications • Rectifiers, tuning elements, high frequency switches, photo-diodes, photo-detectors, etc...	Jaeger 3.4-3.14, 13.4 Pierret 9.2, Notes
8	Introduction to Bipolar Junction Transistors BJT Physics Ebers-Moll Model (FULL model not included on the final, but the simplified form used for Forward active may be) • HOW it WORKS! • Regions of operation, IV-curves, IV-equations, ENERGY BAND DIAGRAMS, electron and hole energy motion under various bias, performance characterization parameters (base transport factor, emitter efficiency, various DC current gains, transit times, etc...)	Pierret 10.1- 10.6 11.1 11.1
9	BJT Small Signal Model ~~BJT SPICE Model~~ BJT Circuits • DC analysis, small signal conversion and AC analysis	Jaeger 13.5-13.6 Notes
10	Metal Oxide Semiconductor Capacitor MOSFET Basics MOSFET Device Physics MOSFET Small Signal Model • How they work! • Energy band diagrams under bias, surface potentials, cross sectional views for different bias conditions, threshold voltages, IV-curves and IV equations under various bias, body-source voltage effect. • Conversion to, calculation of and use of small signal models	Pierret 16.2, 16.3 Pierret 17.1-17.2 Jaeger 4.1-4.11, Notes Jaeger 13.7

11	~~MOSFET SPICE Model~~ Common Emitter Amplifier Common Source Amplifier Common Collector/Drain Amplifier Common Base/Gate Amplifier Differential Amplifier • How they work only. No analysis. Single and Multi Stage Amplifiers • Amplifier configurations and Design Goals (current, voltage, etc... and high/low input and output resistances), transistor amplifier configurations (CC, CD, etc...), Gain, Input and output resistances • ***Know DC solutions, conversion to small signal circuit and AC analysis of the small signal circuit***	Notes Notes Notes Jaeger 13.6, 13.10, 13.11 13.9, 13.10, 13.11 14.1, 14.3 Jaeger 14.1, 14.4 15.1-15.3
14	Operational Amplifier 1st order Op Amp Circuits Non-ideal Op Amps and Op Amp circuits Op Amp Frequency Response and filters • Know the basic gain expressions for the different "op-amp building blocks" (inverting, non-inverting, unity gain, summing, etc...), understand gain-bandwidth product limitations on frequency response "Fairchild" 741 Op Amp • Be able to describe (ONLY DESCRIBE) the function of various sections of the 741 op-amp	Jaeger 12.1, 12.2 12.3-12.4 12.5 Jaeger 12.6 and notes 16.7

16	Logic Gates and Levels Dynamic Response Boolean Algebra NMOS Inverter, and **ALL** Gates discussed CMOS Inverter, and **ALL** Gates discussed VOL, VOH, VIL, VIH and noise margin calculations or determination from the VTC, time response and characterization parameters (delays etc...) Summer Students: I will not ask you to analyze the saturated enhancement load or the depletion load inverter. (This should help!).	Jaeger 6.1, 6.2 6.3 6.4 7.1, 7.2, 7.3, 7.4 8.1, 8.2, 8.3, 8.4, 8.5