ECE 415/515 - Fundamentals of Semiconductor Devices – Fall 2012

Class time:	Tuesday, Thursday 12:00-13:50 SB1-107, CRN 415: 11143 CRN 515: 15329 Lectures posted at http://web.cecs.pdx.edu/~jmorris/ECE 415 & 515 Semiconductor Devices/
Prerequisite:	PH319, ECE322 A strong background in solid state physics is expected.
Course Objectives:	Students will attain solid physical understanding of operation of basic semiconductor devices and will be able to apply this knowledge in the areas of device characterization, modeling and device design. Students will be able to do independent study of relatively simple existing or novel devices or novel modes of operation.
Main Topics:	Semiconductors & Energy Bands, Carrier Transport, Modeling, P-N Junctions, MOS Capacitor, Field Effect Transistors (JFET, MOSFET), Photovoltaics, Bipolar Junction Transistors, Power devices.
Course outcomes:	Ability to: 1. Understand and analyze performance of intrinsic and extrinsic semiconductors 2. Understand and analyze operation of p-n junction 3. Understand and analyze performance of MOS capacitor, FET and MOS transistor 4. Model semiconductor devices and to examine accuracy and limits of models 5. Trade-off device design parameters based on understanding of device operation and design goals 6. Understand and analyze bipolar transistors for dc and ac operation 7. Understand and analyze performance of MOS devices fabricated in sub-micron technology 8. Write succinct, accurate and complete technical reports
Instructor:	James E. Morris, FAB 160-13. E-mail: jmorris@cecs.pdx.edu . Please put "ECE 415/515" in subject line so that I can automatically sort your e-mail questions.
Office Hours:	Tuesday 9 – 10 am and Thursday 4 – 5 pm, or by appointment (request by e-mail.)
Textbook:	Donald A. Neaman, *Semiconductor Physics and Devices: Basic Principles*, 4th edition, McGraw-Hill, 2012 (ISBN: 978-0-07-352958-5)
Reference Books:	Sima Dimitrijev, *Principles of Semiconductor Devices*, 2nd edition, Oxford University Press, 2012 Streetman, B.G. & Banerjee, S.K., *Solid State Electronic Devices*, Pearson/Prentice Hall, 6th edition, 2006 Edward S. Yang, *Microelectronic Devices*, McGraw-Hill, 1988. Kanaan Kano, *Semiconductor Devices*, Prentice-Hall, 1998. Sze, S.M. *Physics of Semiconductor Devices*. New York: Wiley, 1985 *Modular Series on Solid-State Devices, Volumes I-IV*. Reading, MA: Addison-Wesley.
Reference Journals:	IEEE Transactions on Electron Devices and IEEE Electron Device Letters.
Assignments and Grading:	1. 20% Homework (10 homeworks) + 3% "bonus" 2. 20% Two Device Characterization Projects ("on-line lab") 3. 30% Midterm (25% for graduate students) 4. 30% Final (25% for graduate students) 5. 10% literature review project (for graduate students only) Final grades are "curved". Median score is expected to correspond to a letter grade around B, depending on the overall success of class. Sample grading A 92.0 - 100 A- 88.0 - 92 B+ 84.0 – 88 B 80.0 - 84 B- 76.0 - 80 C+ 72.0 - 76 C 68.0 - 72 C- 64.0 - 68 D+ 60.0 - 64 D 56.0 - 60 D- 50.0 - 56
Homework:	Homework is due within a week after the topics are covered. Examine the problems when the lecture is posted so you can ask questions in office hours. Solutions will be posted on the website above to check against your own work. Late homework earns zero grade.
Projects	We will characterize real PN diodes and MOSFETs using the MIT Microelectronics WebLab, an online characterization test station. ilab.mit.edu. A manual can be downloaded from the WebLab homepage. Projects should be started early.
Research Presentation:	Students receiving graduate credit will present a written paper to the class on the results of their literature review of a current topic in semiconductor device physics.
Links of interest:	On-line textbook: http://ecee.colorado.edu/~bart/book/start.htm International Technology Roadmap for Semiconductors web site: http://public.itrs.net/ , Chip Shots Gallery: http://micro.magnet.fsu.edu/chipshots/index.html
Disability:	If you have a recognized disability and are in need of academic accommodations, please notify me (the instructor) immediately to arrange needed support. For more information about the Disability Resource Center, see http://www.drc.pdx.edu/ .
Class Etiquette:	Students are expected to complete the chapter reading prior to class, attend regularly, participate, and complete all assigned work. Turn off all cell phones. Respect for others includes not talking in class (or texting.)
Collaboration:	Students are encouraged to work together on homework. Collaboration can involve giving or receiving suggestions, explaining topics, and checking work. It does not include copying solutions line by line, using model answers (on-line or otherwise,) or plagiarism (using another's words.) Any of these will result in zero credit and all cases will be reported as student code of conduct violations. See http://www.pdx.edu/dos/codeofconduct .

ECE 415/515 Schedule: Fall 2012 J.E. Morris (for planning purposes)

	Day	Date	Reading	Topics or Tests	Homework & projects due
1	Tues	9/25	Ch 1 & 2	Course introduction; history of semiconductors; review Ch 1 (crystals) & Ch 2 (quantum mech)	
	Thur	9/27	Ch 3.1 - 3	Semiconductors: Energy Bands	
2	Tues	10/2	Ch 3.4 – 5 Ch 4.1 - 2	Semiconductors: Density of states, Fermi levels	HW1 (Ch 1, 2, 3.1-3.3) (2pts)
	Thur	10/4	Ch 4.3 - 6	Semiconductors: Extrinsic semiconductors	
3	Tues	10/9	Ch 5	Semiconductors: Transport phenomena	HW2 (Ch 3.4-3.5, 4.1-4.6) (2pts)
	Thur	10/11	Ch 6	Semiconductors: Non-equilibrium (excess carriers)	
4	Tues	10/16	Ch 7	P-N Junctions: Equilibrium, bias	HW3 (Ch 5 & 6) (2pts)
	Thur	10/18	Ch 8	P-N Junctions: Currents, breakdown, transients & ac (project)	
5	Tues	10/23*	Ch 9	P-N Junctions: Metal-semiconductor/hetero-junctions	HW4 (Ch 7 & 8) (2pts)
	Thur	10/25*	Ch 10.1 - 2	MOSFET: MOS capacitor	**PN diode project #1 due**
6	Tues	10/30	Ch 10.3	MOSFET: MOSFET operation & characteristics	HW5 (Ch 9 & 10.1-10.2) (2pts)
	Thur	11/1*	Ch 10.4 Ch 11.1	MOSFET: Frequency limits, (project), non-ideal, sub-threshold	
7	Tues	11/6	Ch 11.2 - 5	MOSFETs: Substrate bias, scaling, short channel, etc	HW6 (Ch 10.3-10.4, 11.1) (2pts)
	Thur	11/8		**MID-TERM EXAM: Chapters 1 - 9.**	
8	Tues	11/13	Ch 12.1 - 3	BJTs: Operation, minority carrier, CB	HW7 (Ch 11.2-11.5) (1 pt)
	Thur	11/15	Ch 12.4 - 8	BJTs: Non-ideal, models, switching	**MOSFET project #2 due**
9	Tues	11/20	Ch 15.4 - 6	Power:, BJT, MOSFET, 4-layer devices	HW8 (Ch 12) (2 pts)
	Thur	11/22		**Thanksgiving Holiday**	
10	Tues	11/27	Ch 14.1 - 5	Optical: Solar cells, detectors, luminescence, LEDs	HW9 (Ch 15) (1 pt)
	Thur	11/29		Graduate Project reports (oral with ppt slides)	HW10 (Ch 14) (1 pt)
	Thu	**12/6**		**FINAL EXAM: 10:15-12:05** MOSFETS, BJTS (Ch. 10-127) ETC (14.1-5, 15.5-6)	**ECE515 graduate literature project due 5 pm Friday 11/30**

All course components must be completed satisfactorily, even if late. (Bonus 3 pts if all 10 HW's submitted and non-zero)

* Lectures given by Prof C_W Nam.