ECE-E 302 Electronic Devices
Spring Quarter 2015/16

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Textbook: 1. D.A. Neamen "Semiconductor Physics and Devices: Basic Principles " 4th Ed. McGraw-Hill, 2012.
2. "Principles of Semiconductor Devices" B. Van Zeghbroeck, Free Access E-book available at http://ecee.colorado.edu/~bart/book/book/index.html

Other useful, higher level, texts:
1. "Physics of Semiconductor Devices," S. M. Sze and Kwok K. Ng, J. 3rd Edition, John Wiley, 2007.
2. "Fundamental of Semiconductor Theory and Device Physics," S. Wang, Prentice Hall, 1989.

Purpose and Contents:

This is a general introductory course on the physics of semiconductor devices. Important topics from solid-state physics are followed by description of operation of a number of semiconductor devices. The student will develop insight into device operation and learns mathematical techniques that allow its precise description which, in turn, will help further understand device behavior. Sample topics include: Definition of a semiconductor; energy band diagram; electrons and holes; Fermi-Dirac distributions; Fermi level; carrier

concentration calculations; mobility; conductivity; drift; diffusion; recombination and generation; Continuity equation; basic theory of PN junctions; forward and reverse bias es; I-V relation; switching behavior; ac operation; capacitance of a PN junction; applications of PN junctions to solar cells, rectifiers, and photodetectors; basic operation of a BJT; regions of operation, calculation of I-V relations; switching behavior, small signal models; basic operation of metal oxide semiconductor (MOS); operation of MOSFETs and JFETS.

Laboratory:

Laboratory is an integral part of this course. Each lab will start with a brief description by the TA. The students should download and read the labs prior to their session. Lab reports are due one week after the experiment. The following experiments will be performed.

Experiment 1: Operation of light emitting diodes
Experiment 2: Operation of a photo-diode, a photo-cell, and solar cell
Experiment 3: Hall measurement
Experiment 4: Operation of a PN junction
Experiment 5: Capacitance and switching behavior of a PN junction
Experiment 6: CV behavior of a MOS
Experiment 7: Operation of JFETS and MOSFETs
Experiment 8: Operation of BJTs

Grading policy:

Homework and quizzes 10%
Homework may be attempted in groups, but each student should separately hand in his/her work. Pop quizzes will be given during recitation sections based on homework problems due that day.
Labs 15%
See grading rubric of each project
Midterms 45%
Final Exam 30%
No make up exam will be given unless for *documented emergencies*.
All students must comply with Drexel University academic code of conduct available at http://www.drexel.edu/provost/policies/academic_dishonesty.asp

Coverage:

Date	Topics Covered	Study Material
Week 1 9/19/2016	Review of syllabus, elemental and compound semiconductors, directions and planes, crystal structures, diamond lattices	Sections 1.1-1.4
9/21/2016	Review of elements of quantum mechanics; de Broglie wavelength; the uncertainty principle	Section 2.1
9/23/2016	Schrödinger's wave equation, Electrons in free space	Section 2.2, 2.3

Week 2 9/26/2016	**Recitation. HW set 1 is due**	Problems: 1.3, 7, 21; 2.1, 6, 18, 22 (plots must be computer generated)
9/28/2016	Potential wells, barriers, one electron atom. Stress is on applications, not derivation.	Section 2.3.4, 2.4.1,2.4.2
10/30/2016	E-K relations, energy band gap, drift, effective mass.	Section 3.1.1, 3.2
Week 3 10/03/2016	**Recitation. HW set 2 is due**	Problems: 2.26; 2.31, 3.13, 17, 28, 30, 32 (plots must be computer generated)
10/05/2016	Energy band diagram in Si and GaAs, Density of States, Fermi-Dirac Distribution	Section 3.3, 3.4, 3.5
10/07/2016	Electron (n_0) and Hole (p_0) Concentration, carrier concentration and Fermi level (E_{Fi}), intrinsic carrier concentration ((n_i)	Section 4.1 Eq. 4.11, 4.19
Week 4 10/10/2016	**Columbus Day, University Holiday**	
10/12/2016	Doping; extrinsic carrier concentration; degenerate and non-degenerate doping, charge neutrality, Fermi level and Carrier concentration **Recitation.** **HW set 3 is due**	Section 4.2, 4.3 (Eqs 4.39, 4.40), 4.5, 4.6 Problems: 4.2, 8, 17, 18, 23, 34.
10/14/2016	Carrier drift, mobility, conductivity, Carrier diffusion, Hall effect	Sections 5.1,2,3; 5.2
Week 5 10/17/2016	Continuity Equation, Diffusion Equation	Sections 6.3.2, 6.3.3
10/19/2016	**Recitation. HW set 4 is due**	Problems: 5.1, 2, 23, 30, 32,33
10/21/2016	**Midterm Exam 1**	
Week 6 10/24/2016	PN Junctions, built-in potential, electric field, space charge region, junction capacitance	Sections 7.1, 7.2, 7.3
10/26/2016	I-V relation of PN Junction diode; current components;	8.1
10/28/2016	Recitation I-V relation of PN Junction diodes continued	8.2.1, 8.2.3, 8.5.1
Week 7 10/31/2016	**HW set 5 is due**	Problems 6.10, 6.20, 7.2, 7.5, 7.17

11/02/2016	Small signal model, time response	
11/04/2016	**HW set 6 is due**	Problems 8.5, 15, 16, and 24
Week 8 11/07/2016	Bipolar Junction Transistor, Currents; I-V relations Regions of operation	
11/09/2016	**Midterm Exam 2**	Section 12.1, 12.2, 12.3
11/11/2016	BJTs I-V relations, small signal model, time response	Section 12.4,12.5, 12.6
Week 9 11/14/2016	**HW set 7 is due** Recitation	Problems 12.1, 7, 9, 21
11/16/2016	Metal oxide semiconductor (MOS) capacitor; regions of operation, threshold voltage;	Sections 10.1,2
11/18/2016	MOSFET structure, current voltage relations.	Section 10.3.1, 10.3.2,
Week 10 11/21/2016	MOSFET Frequency limitations, cut-off frequency.	Sections 10.4.1, 2
11/23/2016	JFETs and MESFETS	
11/25/2016	MODFETs	
11/28/2016	**HW set 8 is due**	Problems 10.1, 10.10, 10.33, 10.37.