**ECE-E 302 Electronic Devices**

**Spring Quarter 2017-18**

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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 biases; 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*.

**Coverage:**

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| --- | --- | --- |
| **Date** | **Topics Covered** | **Study Material** |
| **Week 1**  4/2/2018 | Syllabus, On scale of things, elemental and compound semiconductors, directions and planes, crystal structures, diamond lattices | Sections 1.1-1.4 |
| 4/4/2018 | Review of elements of quantum mechanics; de Broglie wavelength; the uncertainty principle | Section 2.1 |
| 4/6/2018 | Schrodinger’s wave equation, Electrons in free space | Section 2.2, 2.3 |
| **Week 2**  4/9/2018 | **Recitation. HW set 1 is due** | Problems: 1.1, 2, 3, 15; 2.2,3,5, 8 (plots must be computer generated) |
| 4/11/2018 | Potential wells, barriers, one electron atom. Stress is on applications, not derivation. | Section 2.3.4, 2.4.1,2.4.2 |
| 4/13/2018 | E-K relations, energy band gap, drift, effective mass. | Section 3.1.1, 3.2 |
| **Week 3** 4/16/2018 | **Recitation. HW set 2 is due** | Problems: 2.11, 2.12, 2.19, 2.31, 3.13, 3.15, 3.18. |
| 4/18/2018 | Energy band diagram in Si and GaAs, Density of States, Fermi-Dirac Distribution | Section 3.3, 3.4, 3.5 |
| 4/20/2018 | Electron (n0) and Hole (p0) Concentration, carrier concentration and Fermi level (EFi), intrinsic carrier concentration ((ni) | Section 4.1 Eq. 4.11, 4.19 |
| **Week 4**  4/23/2018 | Doping; extrinsic carrier concentration; degenerate and non-degenerate doping, charge neutrality, Fermi level and Carrier concentration | Section 4.2, 4.3 (Eqs 4.39, 4.40), 4.5, 4.6 |
| 4/25/2018 | **Recitation. HW set 3 is due** | Problems: 4.2, 5, 8, 17, 18, 19, 34. |
| 4/27/2018 | Carrier drift, mobility, conductivity, Carrier diffusion. | Sections 5.1,2,3; 5.2 |
| **Week 5**  4/30/2018 | Hall Effect, Continuity Equation, Diffusion Equation | Sections 6.3.2, 6.3.3 |
| 5/2/2018 | **Recitation. HW set 4 is due** | Problems: 4.55, 5.3, 5.12, 5.27, 5.30, 5.32 |
| 5/4/2018 | **Midterm exam 1** |  |
| **Week 6**  5/7/2018 | PN Junctions, built-in potential, electric field, space charge region, junction capacitance | Sections 7.1, 7.2, 7.3 |
| 5/9/2018 | I-V relation of PN Junction diode; current components; | Section 8.1 |
| 5/11/2018 | **HW set 5 is due**  Recitation | Problems TBD |
| **Week 7**  5/14/2018 | I-V relation of PN Junction diodes continued | Sections 8.2.1, 8.2.3, 8.5.1 |
| 5/16/2018 | Small signal model, time response |  |
| 5/18/2018 | **HW set 6 is due**  Recitation | Problems TBD |
| **Week 8**  5/21/2018 | **Midterm Exam 2** |  |
| 5/23/2018 | Bipolar Junction Transistor, Currents; I-V relations Regions of operation | Section 12.1, 12.2, 12.3 |
| 5/25/2018 | BJTs I-V relations, small signal model, time response | Section 12.4,12.5, 12.6 |
| **Week 9**  5/28/2018 | **Memorial Day, University Holiday** |  |
| 5/30/2018 | **HW set 7 is due**  Recitation | Problems TBD |
| 6/1/2018 | Metal oxide semiconductor (MOS) capacitor; regions of operation, threshold voltage; | Sections 10.1,2 |
| **Week 10**  6/4/2018 | MOSFET structure, current voltage relations. | Section 10.3.1, 10.3.2, |
| 6/6/2018 | MOSFET Frequency limitations, cut-off frequency. Ballistic MOSFET | Sections 10.4.1, 2 |
| 6/8/2018 | **HW set 8 is due** | Problems TBD |
| 6/11/2018 | Review, Final Exam Help Session |  |

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