KOÇ UNIVERSITY
ELEC. 313 / PHYS. 313
SEMICONDUCTOR PHYSICS AND DEVICES
FALL 2013

Class Meeting Time and Location: Mon/Wed 15:30–16:45 CAS B35

Instructor: Şükrü Ekin Kocabaş, ENG Z11, (212)338-1776, ekocabas@ku.edu.tr

Office Hours: After lectures or by appointment

Course Website: `http://home.ku.edu.tr/~ekocabas/courses/elec313`

Course Email List: elec313@ku.edu.tr

Number of Credits: 3

ETCS Credits: 5

Prerequisites: Knowledge of electrostatics (i.e. PHYS 102), elementary differential equations and basics of circuits

Course Assistant: Baran Yalçın, byalcin@ku.edu.tr

Course Description: Introduction to semiconductors: crystals, energy bands, charge carriers and doping, the Fermi level, carrier lifetime and mobility, optical properties. Electronic devices: p-n junctions, diodes, transistors; Optoelectronic devices: LED's, diode lasers, detectors.

Course Objectives: This course will provide you with the basic working principles of modern integrated electronics. We will start from a microscopic perspective (atoms & crystals) and arrive at functional components (transistors, LEDs) based on properties of matter which we can control through various mechanisms. Modern clean room fabrication techniques will also be introduced as we move along different topics.

Learning Outcomes: At the end of the course you will have a broad conceptual understanding of how electronic circuits work. You will learn about the principles behind the operation of such devices, how they are made and the history of their development. You will be expected to demonstrate your understanding through homework assignments and examinations.

Teaching Methods: The instructor will lecture. Slides will be used, derivations will be made on the board. There will be times when individual presentations are made, particularly based on readings on the history of the development of integrated circuits.

Assessment Methods
Midterm Exam 1 — %25
Midterm Exam 2 — %25
Final Exam — %35
Weekly problem sets, due one week later — %15

Workload Breakdown

Type	Description	Hours
Lecture	27 lectures, 75 mins each	34
Exams	2 Midterms, 1 Final	21
Homeworks	Around 10 homeworks	30
Other	Short in-class presentations	5
Total		**90**

Tentative Course Contents: This semester we will have 27 lectures.

Date	Topic	Sections
Sept 16	Course overview, Introduction	1.1
Sept 18	Crystal structure, energy-band model	1.2–1.5
Sept 23	Density of states, Fermi function	1.6–1.9
Sept 25	Thermal motion, drift	2.1–2.2
Sept 30	Diffusion, external bias, mobility	2.3–2.5
Oct 2	Recombination, generation, quasi-Fermi levels	2.6–2.8
Oct 7	Introduction to fabrication, oxidation, lithography	3.1–3.3
Oct 9	Etching, doping	3.4–3.6
Oct 14	*No class*	
Oct 16	*No class*	
Oct 21	Deposition, interconnects, testing	3.7–3.9
Oct 23	Introduction to PN Junctions, reverse bias	4.1–4.3
Oct 28	*No class*	
Oct 30	C-V Characteristics, Forward Bias, Continuity Equation	4.4–4.6
Nov 4	Excess carriers, IV Characteristics, Small-signal model	4.7–4.11
Nov 6	Solar cells, LEDs and lighting	4.12–4.13
Nov 11	Lasers and photodiodes, Schottky barriers	4.14–4.16
Nov 13	Thermionic emission, Schottky diodes	4.17–4.20
Nov 18	MOS Capacitor flat-band condition, accumulation, depletion	5.1–5.3
Nov 20	Threshold, inversion, C-V	5.4–5.6
Nov 25	Oxide charge, poly-Si depletion, CCD & CMOS imagers	5.7–5.10
Nov 27	MOSFETs, CMOS technology, surface mobility	6.1–6.3
Dec 2	Threshold voltage, inversion, basic I-V model	6.4–6.6
Dec 4	CMOS Inverter, velocity saturation, extended I-V	6.7–6.9
Dec 9	Parasitic resistances, carrier velocity effects, SRAM, DRAM, Flash	6.10–6.16
Dec 11	Scaling of MOSFETs, subthreshold current, V_t roll-off	7.1–7.3
Dec 16	Tunneling leakage, shallow junctions, trade-offs	7.4–7.7
Dec 18	SOI and multigate MOSFETs, device simulation	7.8–7.11
Dec 23	Bipolar transistors, base and collector current	8.1–8.3
Dec 25	Current gain, base-width modulation, Ebers-Moll Model	8.4–8.6
Jan 2–12	Finals week	

Required Textbook

- C. Hu, *Modern semiconductor devices for integrated circuits*. Upper Saddle River, N.J.: Prentice Hall, 2010, [Online]. Available: `http://www.eecs.berkeley.edu/~hu/Book-Chapters-and-Lecture-Slides-download.html`

Reference Material

- J. W. Orton, *The story of semiconductors*. Oxford; New York: Oxford University Press, 2004, [Online]. Available: `http://libunix.ku.edu.tr/record=b1487534~S9`

- D. A. Neamen, *Semiconductor physics and devices*. New York; London: McGraw-Hill Higher Education ; McGraw-Hill [distributor], 2011,

- R. F. Pierret, *Semiconductor device fundamentals*. Reading, Mass.: Addison-Wesley, 1996,

- B. G. Streetman and S. K. Banerjee, *Solid State Electronic Devices*, 6th ed. London: Prentice-Hall, 2005,

- D. K. Bhattacharya and R. Sharma, *Solid state electronic devices*. New Delhi; New York: Oxford University Press, 2007,

- S. Dimitrijev, *Principles of semiconductor devices*. New York: Oxford University Press, 2011,

Late Homework Policy: You can return one homework late (i.e. return it in on a Monday instead of the default Wednesday deadline). Otherwise late homeworks will not be accepted. Exceptions can be made in case of emergencies—please inform the instructor as soon as possible.

Email Policy: I will try to respond to your emails within 24 hours. If I do not respond after 48 hours, email me again or come to my office.

Academic Integrity: You are encouraged to talk to your classmates about homework assignments and the class in general. For instance, if there is a concept that you need to understand in order to solve a homework problem or if there is a specific technique that you do not know well (i.e. an integration method) feel free to consult your fellow classmates. However, you are expected to do the work yourselves and copying of solutions is not allowed. Make sure you properly reference the work of others as well. Unethical acts regarding the class will be referred to the relevant university committee.

Koç University

Statement on Academic Honesty

with Emphasis on Plagiarism

Koç University expects all its students to perform course-related activities in accordance with the rules set forth in the Student Code of Conduct (http://vpaa.ku.edu.tr/academic/student-code-of-conduct). Actions considered as academic dishonesty at Koç University include but are not limited to cheating, plagiarism, collusion, and impersonating. This statement's goal is to draw attention to cheating and plagiarism related actions deemed unacceptable within the context of Student Code of Conduct:

All individual assignments must be completed by the student himself/herself, and all team assignments must be completed by the members of the team, without the aid of other individuals. If a team member does not contribute to the written documents or participate in the activities of the team, his/her name should not appear on the work submitted for evaluation.

Plagiarism is defined as 'borrowing or using someone else's written statements or ideas without giving written acknowledgement to the author'. Students are encouraged to conduct research beyond the course material, but they must not use any documents prepared by current or previous students, or notes prepared by instructors at Koç University or other universities without properly citing the source. Furthermore, students are expected to adhere to the Classroom Code of Conduct (http://vpaa.ku.edu.tr/academic/classroom-code-of-conduct) and to refrain from all forms of unacceptable behavior during lectures. Failure to adhere to expected behavior may result in disciplinary action.

There are two kinds of plagiarism: Intentional and accidental. Intentional plagiarism (Example: Using a classmate's homework as one's own because the student does not want to spend time working on that homework) is considered intellectual theft, and there is no need to emphasize the wrongfulness of this act. Accidental plagiarism, on the other hand, may be considered as a 'more acceptable' form of plagiarism by some students, which is certainly not how it is perceived by the University administration and faculty. The student is responsible from properly citing a source if he/she is making use of another person's work. For an example on accidental plagiarism, please refer to the document titled "An Example on Accidental Plagiarism".

If you are unsure whether the action you will take would be a violation of Koç University's Student Code of Conduct, please consult with your instructor before taking that action.

An Example on Accidental Plagiarism

This example is taken from a document prepared by the City University of New York.

The following text is taken from Elaine Tyler May's '*Myths and Realities of the American Family*':

"Because women's wages often continue to reflect the fiction that men earn the family wage, single mothers rarely earn enough to support themselves and their children adequately. And because work is still organized around the assumption that mothers stay home with children, even though few mothers can afford to do so, child-care facilities in the United States remain woefully inadequate."

Below, there is an excerpt from a student's homework, who made use of May's original text:

"As Elaine Tyler May points out, "women's wages often continue to reflect the fiction that men earn the family wage" (588). Thus many single mothers cannot support themselves and their children adequately. Furthermore, since work is based on the assumption that mothers stay home with children, facilities for day care in this country are still "woefully inadequate." (May 589)".

You may think that there is no plagiarism here since the student is citing the original author. However, this is an instance of accidental plagiarism. Although the student cites May and uses quotation marks occasionally, the rest of the sentences, more specifically the following section: "Thus many single mothers cannot support themselves and their children adequately. Furthermore, since work is based on the assumption that mothers stay home with children, facilities for day care in this country are still "woefully inadequate." (May 589)" almost exactly duplicates May's original language. So, in order to avoid plagiarism, the student either had to use quotation marks for the rest of the sentences as well, or he/she had to paraphrase May's ideas by using not only his/her own words, but his/her own original ideas as well. You should keep in mind that accidental plagiarism often occurs when the student does not really understand the original text but still tries to make use of it. Understanding the original text and understanding why you agree or disagree with the ideas proposed in that text is crucial both for avoiding plagiarism and for your intellectual development.

Reference(s):

Avoiding and Detecting Plagiarism: A Guide for Graduate Students and Faculty.
The Graduate Center. City University of New York, 2012. Web.
<http://www.gc.cuny.edu/CUNY_GC/media/CUNY-Graduate-Center/PDF/Publications/AvoidingPlagiarism.pdf>