ECE 3150: Introduction to Microelectronics

Instructor: Professor Amal El-Ghazaly
308 Phillips Hall
ase63@cornell.edu

Class Schedule:

Lecture: MWF 10:10 am – 11:00 am (Phillips 101)

Weekly Discussion/Lab Sections: *See calendar on last two pages to know which weeks are discussion weeks and which weeks are lab weeks.*

Section	Discussion Time and Location	Lab Time and Location
DIS 201 / LAB 401	Mon. 7:30-8:20pm (Upson 102)	Mon. 7:30-10:30pm (Phillips 237)
DIS 202 / LAB 402	Tues. 1:25-2:15pm (Hollister 368)	Tues. 1:25-4:25pm (Phillips 237)
DIS 203 / LAB 403	Wed. 11:15am-12:05pm (Hollister 206)	Wed. 11:15am-2:15pm (Phillips 237)
DIS 204 / LAB 404	Wed. 7:30-8:20pm (Upson 102)	Wed. 7:30-10:30pm (Phillips 237)
DIS 205 / LAB 405	Fri. 11:15am-12:05pm (Hollister 368)	Fri. 11:15am-2:15pm (Phillips 237)

Office Hours:

Monday	Tuesday	Wednesday	Thursday	Friday
		12:15-1:15 pm, Jacob Tamor, Phillips 237		12:15-1:15 pm, Malek Succar, Phillips 237
3:00-4:00pm, Prof. El-Ghazaly, Phillips 237	2:25-3:25 pm, Yibin Xu, Phillips 237		2:25-3:25 pm, Alice Ho, Phillips 237	3:00-4:00 pm, Kathryn Zhang and Yunnie Kim, Phillips 237
	3:30-4:30pm, Prof. El-Ghazaly, Phillips 237	4:15-5:15pm, Karl Chen and Beth Polito, Phillips 237		
8:30-9:30 pm, Malek Succar, Phillips 237		8:30-9:30 pm, Jacob Tamor, Phillips 237		

Teaching Assistants:

Malek Succar, ms3622@cornell.edu
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Catalog Description:
This course serves as an introduction to the most basic building blocks of modern microelectronics. Discussion builds on students' prior exposure to basic circuit analysis techniques by, first, delving deeper into understanding the operating principles semiconductor devices, then moving to a higher level of abstraction to design circuits using those devices, but with a conscious awareness of their properties, strengths, and limitations. Topics covered include basic semiconductor physics, p-n junctions and diodes, bipolar junction transistors (BJTs), metal-oxide-semiconductor (MOS) capacitors, MOS field effect transistors (FETs), large signal and small signal models of electronic devices, single stage amplifiers, multistage amplifiers, differential amplifiers, analog circuit analysis and design, digital logic design, complimentary MOS (or CMOS) circuits, and the fundamental trade-offs in the various circuit designs. The coursework includes labs and a final project.
Credits: 4
Prerequisites: ECE/ENGRD 2100

Required Textbooks:
Fundamentals of Microelectronics by Behzad Razavi
Semiconductor Device Fundamentals by Robert F. Pierret

Assignments, Quizzes, Lesson, and Project:
- *Homework:* Prior to each lab, a homework assignment will be used to reinforce and solidify concepts taught in class that will be put in practice in the subsequent lab. Homework assignments will include problems where students will be asked to apply course topics to understand, analyze, or design a device or circuit.
- *Labs:* Analytical and design skills will be put to practice in the labs using common electronic instrumentation, including oscilloscopes, source measurement units, and function generators. Labs will include design, construction, and testing of basic semiconductor devices and transistor circuits followed by analysis interpretation of the results. Lab "reports" will be due one week after each lab.
- *Exams:* Intended to inspire students to review and to make mental connections between concepts for deeper understanding, exams will cover material previously covered in the course. Two exams will be given in the course – one midterm exam and one final exam. Exams will include questions probing students' fundamental understanding of the material as well as questions nudging students to apply their skills in device and circuit design. Students will be allowed one 8.5"x11" sheet of notes and a graphing calculator.
- *Participation:* Actively engaging with the subject matter helps students learn it better. Through a combination of activities during lectures and discussion sessions over the course of the semester, students will be asked to engage with the course material. Participation in these activities will count toward the students' final grade.

Grading Scheme:
25% Homework
25% Lab Work
20% Midterm
25% Final Exam
5% Participation

Topics Covered by Week (Tentative)

Week	Topic	Related Book Chapters
Week 1 (January 22)	Basic Circuits Review Diodes and Diode Circuits	Razavi Ch. 1 and 3
Week 2 (January 29)	Basic Semiconductor Physics	Razavi Ch. 2.1 Pierret Ch. 1, 2 and 3
Week 3 (February 5)	pn-junction diodes	Razavi Ch. 2.1 Pierret Ch. 5 and 6
Week 4 (February 12)	Bipolar Junction Transistors (BJTs)	Razavi Ch. 4 Pierret Ch. 10 and 11
Week 5 (February 19)	Small Signal Analysis and Single Stage BJT Amplifiers	Razavi Ch. 4.4.4, 4.6.3 and Razavi Ch. 5
Week 6 (February 26)	Metal-Oxide Semiconductor (MOS) Capacitors	Pierret Ch. 16
Week 7 (March 4)	MOS Field Effect Transistors (MOSFETs)	Razavi Ch. 6 Pierret Ch. 17
Week 8 (March 11)	Review Digital Circuit Design	Razavi Ch. 16
Week 9 (March 18)	Single Stage MOSFET amplifiers	Razavi Ch. 7
Week 10 (March 25)	Multi-Stage Amplifiers	Razavi Ch. 8 and 9
Week 11 (April 1)	*Spring Break – No Class*	
Week 12 (April 8)	Differential Amplifiers	Razavi Ch. 10
Week 13 (April 15)	Frequency Response Review	Razavi Ch. 11
Week 14 (April 22)	Miller Effect Analog Frequency Response	Razavi Ch. 11
Week 15 (April 29)	Additional Topics (optional)	Razavi Ch. 12, and 13, 14, and 15
Week 16 (May 6)	Review	

Student Outcomes:

1. Understand basic semiconductor physics, band diagrams, existence of electrons and holes, and how semiconductors conduct current.
2. Analyze p-n junction diodes and design simple diode circuits.
3. Extend understanding of p-n junctions to reason through bipolar junction transistor operation and tradeoffs.
4. Analyze metal-oxide-semiconductor (MOS) junctions and combine their behavior with p-n junction behavior to reason through MOS field effect transistor operation and tradeoffs.
5. Understand and apply small signal analysis to single and multi-stage amplifier analog circuits.
6. Design and compare building block circuits for both analog and digital circuits.
7. Design and interpret simple complementary MOS circuits for bipolar amplification.

Homework Slip Day:

Each student will be allowed 1 “slip day” throughout the semester, which will allow them to submit their assignment 1 day after the original submission deadline without penalization. Any

submissions delayed beyond that point will be treated according to the Late Homework Policy below for each day late after the slip day extension. Slip days cannot be used to take extensions beyond the late submission window (the 3 days after the original submission date).

Late Homework Policy:

Late assignments will be accepted for 3 days following the original submission deadline. A 5% grade reduction on the assignment will be imposed for each day late.

Regrade Policy:

Regrade requests will be taken into consideration *if and only if* the instructor has made a mistake in the grading *and* when the regrade request is received within 1 week of the date the graded item was handed back to students.

Exam Conflict Policy:

For students having a legitimate conflict with a scheduled exam time, the instructor will schedule *a single make-up exam* in the day or two following the original exam date. If the student also has a legitimate conflict with the make-up exam time, then, in its place, a 15-minute oral exam will be scheduled with the instructor on a separate day, and it will be graded according to the instructor's discretion.

Classroom Etiquette:

PLEASE TAKE NOTES! (I will not be supplying notes/slides.)

Tech Use: please do not use mobile phones, laptops, tablets, etc. during class except to take notes.

Academic Integrity:

As students in engineering and future leaders of the field, students will be held to the utmost standards of Cornell's Code of Academic Integrity. Assignments are intended for students to learn the material. Therefore, students are allowed to discuss with their peers purely to gain a better understanding, but final submissions must be unique. For exams, students will be allowed to use a single sheet of notes compiled from their course notes and course materials. However, they will not be allowed to discuss with other classmates. Labs are a chance for students to interact with circuits hands-on and develop working prototypes of circuits. Students will complete the labs in groups of no more than two. Any failure to abide by the stated academic integrity policies will result in no credit being awarded for the specific homework assignment, lab, or exam.

Any buying or selling of course materials through internet sites is absolutely prohibited. If any of the instructor's course materials or even the students' class notes are sold online without the instructor's prior authorization, the student(s) will be subject to a charge of "Academic Misconduct," and possibly also copyright infringement.

Disability Accommodations:

Equal access to this course is important. If you are registered with Student Disability Services (SDS), *please give me your accommodation letter early in the semester* so that I have adequate time to arrange your approved academic accommodations. If you need an immediate accommodation, please speak with me after class or send an email message to me and/or SDS at sds_cu@cornell.edu. If the need arises for additional accommodations during the semester, please

contact SDS and notify me of any necessary accommodations *at least 7 days prior* to the date of an exam or other scenario when accommodation is necessary. (SDS is located on level 5 of Cornell Health, 110 Ho Plaza, 607-254-4545, sds.cornell.edu)

Testing accommodations: this course is participating in the SDS Alternative Testing Program for the Spring 2023 semester. If you have an approved testing accommodation, you must request it for this course *and* complete an Exam Request Form for each exam in this course via the SDS student portal **by February 8th**. Failure to do so may result in the inability to use your accommodation.

Additionally, be aware that:

- For those with a testing accommodation, evening prelim exams will begin at 6:30 p.m.
- All exam logistics will be communicated to you from SDS (look out for emails from sds@accessiblelearning.mail.cornell.edu). Please note that confirmation about the exact time and room location for your accommodated exam will be communicated to you closer to the exam date (no later than 48 hours prior). Please do not contact me with questions about exam logistics, as I will not be able to answer them. All details are being managed by SDS; therefore, questions should be sent to sds-testing@cornell.edu.
- Coordination of make-up exams (i.e., for students who have been granted prior permission by me to take the exam on a day other than the scheduled date of the main exam) will be handled by me. The SDS Alternative Testing Program will not be involved in the logistics for any make-up exams. If you miss your scheduled accommodated exam, you should notify me, not SDS.

Calendar of Important Dates

Monday	Tuesday	Wednesday	Thursday	Friday
Jan. 22 Lecture (first day of class)	Jan. 23	Jan. 24 Lecture **Homework 1 out**	Jan. 25	Jan. 26 Lecture
Jan. 29 Lecture	Jan. 30	Jan. 31 Lecture	Feb. 1	Feb. 2 Lecture
Feb. 5 Lecture **Lab 1**	Feb. 6 **Lab 1**	Feb. 7 Lecture **Lab 1** **Homework 1 due** **Homework 2 out**	Feb. 8 **Lab 1**	Feb. 9 Lecture **Lab 1**
Feb. 12 Lecture	Feb. 13	Feb. 14 Lecture	Feb. 15	Feb. 16 Lecture **Lab 1 due**
Feb. 19 Lecture **Lab 2**	Feb. 20 **Lab 2**	Feb. 21 Lecture **Lab 2** **Homework 2 due** **Homework 3 out**	Feb. 22 **Lab 2**	Feb. 23 Lecture **Lab 2**
Feb. 26 Fall Break (no classes)	Feb. 27 Fall Break (no classes)	Feb. 28 Lecture	Feb. 29	Mar. 1 Lecture **Lab 2 due**
Mar. 4 Lecture	Mar. 5	Mar. 6 Lecture **Homework 3 due** **Homework 4 out**	Mar. 7	Mar. 8 Lecture
Mar. 11 Lecture	Mar. 12	Mar. 13 Lecture	Mar. 14 **Midterm Exam** **7:30 pm** **Phillips 101**	Mar. 15 Lecture

Monday	Tuesday	Wednesday	Thursday	Friday
Mar. 18 Lecture **Lab 3**	Mar. 19 **Lab 3**	Mar. 20 Lecture **Lab 3** **Homework 4 due** **Homework 5 out**	Mar. 21 **Lab 3**	Mar. 22 Lecture **Lab 3**
Mar. 25 Lecture	Mar. 26	Mar. 27 Lecture	Mar. 28	Mar. 29 Lecture **Lab 3 due**
Apr. 1 Spring Break (no classes)	Apr. 2 Spring Break (no classes)	Apr. 3 Spring Break (no classes)	Apr. 4 Spring Break (no classes)	Apr. 5 Spring Break (no classes)
Apr. 8 Lecture **Lab 4**	Apr. 9 **Lab 4**	Apr. 10 Lecture **Lab 4** **Homework 5 due** **Homework 6 out**	Apr. 11 **Lab 4**	Apr. 12 Lecture **Lab 4**
Apr. 15 Lecture	Apr. 16	Apr. 17 Lecture	Apr. 18	Apr. 19 Lecture **Lab 4 due**
Apr. 22 Lecture **Lab 5**	Apr. 23 **Lab 5**	Apr. 24 Lecture **Lab 5**	Apr. 25 **Lab 5**	Apr. 26 Lecture **Lab 5**
Apr. 29 Lecture	Apr. 30	May 1 Lecture **Homework 6 due**	May 2	May 3 Lecture **Lab 5 due**
May 6 Lecture	May 7 (last day of classes)			May 17 **Final Exam** **7:00 pm** **TBD**