SYLLABUS (COURSE INFORMATION)

Instructor:

Professor Clark Nguyen, 574 Cory Hall
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Office Hours: M 3:00-4:00 p.m. via Zoom
W 11:30 a.m. - 12:30 p.m. via Zoom

Teaching Assistants (TA's):

Mr. Kieran Peleaux, 373 Cory Hall
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Office Hours: M 11 a.m. - 12 noon, via Zoom
Th 2:30-3:30 p.m., via Zoom

Ms. Qiutong Jin, 373 Cory Hall
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Office Hours: W 1-2 p.m., via Zoom
Th 11 a.m. - 12 noon, via Zoom

Lecture: Monday, Wednesday, Friday 2-3 p.m. via Zoom

Discussion Sections:

Section 201: Wednesday, 4-5 p.m. via Zoom
Section 202: Monday, 1-2 p.m. via Zoom

Laboratory Sections:

Section 101: Monday, 5 p.m. - 8 p.m. via Zoom
Section 102: Tuesday, 11 a.m. - 2 p.m. via Zoom

Course Website:

https://inst.eecs.berkeley.edu/~ee105/fa20/

Office Hours:

Office hours are the primary mechanism for individual contact with Professor Nguyen and the TA's. All students are strongly encouraged to make use of office hours. The Zoom links for office hours will be sent as calendar invites to all students in the class.

Course Description:

In this age of instant information and interconnectivity, few (if any) devices have had a larger impact than the transistor. Indeed, electronic circuits made using transistors have enabled the vast majority of technological advances over the past decade, from smartphones, to smart homes, to the ultrafast computers and networks that make the internet possible. Over the years, both analog and digital transistor circuits have contributed to this technological revolution. Analog circuits, which represent information in a continuous fashion (much like our own human perception of the world), have found use as amplifiers for a myriad of applications, from music to radio transmitters. Digital circuits, which represent information in a discrete encoded fashion, are now widely used in applications ranging from digital modelers to the most sophisticated supercomputers. Many of today's most important circuits, such as those used for wireless communications, utilize a combination of analog and digital circuits—termed "mixed signal circuits"—to enable interference free information transfer, global positioning (GPS) receivers, and commercial satellite links. All of this, again, made possible via the amplifying and switching capabilities of a tiny, nonlinear device—the integrated circuit transistor.

EE 105 is the leader course for the Physical Electronics, MEMS, and Integrated Circuits programs in the EECS Department that aims to teach the basics of semiconductor device physics, modeling, and transistor-level circuit design—both analog and digital—and thereby prepare students for more advanced courses in these areas. The course will cover circuit modeling and operation of field-effect and bipolar junction transistors; properties of nonlinear elements; small-signal and piecewise analysis of nonlinear circuits; analysis and design of basic single- and multi-stage transistor amplifiers; biasing, gain, and frequency response of analog circuits; and digital oscillators, with emphasis on propagation delay and power dissipation.

There will be three lectures, a discussion, and approximately one laboratory session per week. Towards the end of the course, several blocks of laboratory sessions will focus on larger design projects, lasting two to four weeks each. Design projects will entail both design, simulation, and construction/demonstration in the laboratory. Reading assignments (indicated on the COURSE SCHEDULE), problem sets (approximately one per week), two midterm exams, and a final exam will supplement the lectures. SPICE will serve extensively as the principal circuit simulator for assignments and design projects. Although the material covered in the lectures and in the text is fundamentally the same, the perspectives differ, and you are all strongly encouraged to attend both the lecture and complete your reading assignments. Furthermore, there will be occasional announcements in lectures that will affect your laboratory, problem sets, and exams. THEREFORE, COME TO LECTURES.

Lectures, discussion, and laboratory, 4 units.

Prerequisites:

The prerequisites for this course are currently EE 16A and 16B. It is assumed that you are familiar with the following topics:

- Basic network theory: *RLC* circuits, analysis methods, step/frequency response, poles and zeros, complex impedance, transient response analysis
- Ideal operational amplifier circuit design and analysis
- Some exposure to digital logic circuits, e.g., inverter operation
- Basic electromagnetics: fields and waves, potential, Gauss's law

Texts:

Required: A.S. Sedra, K.G. Smith, *Microelectronic Circuits,* 7th Edition. New York: Oxford University Press, 2014.

Various supplementary material released throughout the course.

Supplementary: Tuinenga, *SPICE: A Guide to Circuit Simulation & Analysis Using PSpice*

References: R. C. Jaegar, *Microelectronic Circuit Design,* 5th Edition. New York: McGraw-Hill, 2015.

Savant, Roden, Carpenter, *Electronic Design*, 2nd Ed., Benjamin Cummings

Horenstein, Microelectronic *Circuits and Devices*, Prentice Hall

These texts could be helpful as supplementary material in the event you need an alternative explanation from Sedra & Smith's.

Reading Assignments:

Reading assignments include sections of the required textbook, laboratory readings, distributed readings, and supplementary notes handed out in lecture. The COURSE SCHEDULE indicates reading assignments. Problem assignments might also specify reading assignments where appropriate. Distributed notes will supplement topics for which lecture coverage is substantially different from the textbook. Students are responsible for all material in the reading. In particular, the scope of coverage for problem sets, the midterms, the lab projects, and the final examination includes the reading assignments as well as lecture material.

Problem Sets:

There will be several homework sets over the course of the semester, assigned approximately once per week. Each new problem set will normally post on the course website on a Friday and be due the next Friday. Turn in problem sets via Gradescope by 12 noon on the due date. Solutions will post on the web early the next week.

Late Homework Policy: A late homework will lose 10% per day, i.e., the final graded homework score will reduce by 10% per day. For example, once a homework is late, it has lost 10%. If it late by more than a day, then it loses 20%, and so on.

Laboratory:

In the interest of staying resilient during the current pandemic, we will attempt to preserve at least some of the hands-on physical EE105 laboratory. To do this, we will mail lab kits to all enrolled students. We ask only that you mail them back to us by the end of the semester so they can be available for the next offering of this course. The lab kits contain components and instruments needed for the physical labs, including the Analog Discovery 2 combined oscilloscope/waveform generator/network analyzer that together with a USB-equipped computer makes possible many measurements. Unfortunately, there is no cost-effective way to send instruments equivalent to the Semiconductor Parameter Analyzers that sit in the physical EE105 laboratory and get fairly heavy use in the ground version of EE105. On the bright side, the labs that we adjusted for remote delivery this semester will teach you how to make the same measurements without a semiconductor parameter analyzer, and this might in fact be the more important thing to learn.

Laboratories 1-4 will be online in the "Labs" page on the course website. Labs 5 and 6 are design projects that will post to the website during the latter half of the semester. The laboratory exercises aim to reinforce the material covered in lecture and in problem sets. Virtual laboratory sessions will meet weekly during which your lab TA will be available via Zoom to help you build, measure, and debug your circuits. We will see how this goes. It is already very difficult to help someone debug a circuit in-person. Debugging via Zoom will probably be considerably more difficult. But we will try.

In previous in-person renditions of this course, students worked in pairs. Unfortunately, the remote nature of the labs this semester will not allow this. Inevitably, you will need to do your lab work by yourself this semester. The topics covered in the labs are coordinated with the lectures but will lag somewhat.

Laboratory assignments will typically consist of three sections:

Preliminary Discussions and Problems: intended to familiarize you with the laboratory topic, and in some cases, perform some design tasks

Laboratory Procedure: usually a series of measurements to illustrate specific circuit topologies and characteristics

General Questions: intended to encourage you to generalize and apply your laboratory experiences

It is vital that you read the entire laboratory and, where appropriate, do the preliminary problems prior to their laboratory sessions! Failure to do so will make it difficult to complete the assignment in the period when your TA is available to help you. *Pre-lab problems are due at the beginning of the corresponding lab session.*

Each laboratory has Result Sheets to simplify the grading process. In most cases, the remainder of the material should be included in a laboratory report, attached to the Result Sheets. Each student must turn in his/her own report. Laboratory reports will be due in the subsequent laboratory session. Your lab TA will provide you with more information.

One of the main purposes of the course is to convey trade-offs involved in analog and digital circuit design (e.g., gain vs. bandwidth, speed vs. power). For this reason, the last two laboratory assignments will take the form of open-ended design problems. In general, these labs will provide a set of specifications. You will be required to select a circuit topology, do a paper design "by hand" to determine the validity of the topology and any relevant parameters (operating points, component values, etc.), perform computer simulations to validate the paper design, and physically implement the design to demonstrate that it meets the specifications. Note that these design problems require a considerable amount of time to complete and take the place of two or more regular assignments. They also receive a grading weight roughly in proportion to the time allotted for completion. You are *strongly* encouraged to start on these labs as soon as they become available.

The grading policy for the laboratory assignments are as follows:

Technical Content: 90%   Document Quality: 10%

The "document quality" category aims to encourage you to prepare your reports in a manner that makes them readable and easy to evaluate.

For the first four labs (not the design projects), the "technical content" is broken down as follows:

Prelab: 30%   Report: 60%

The overall point totals assigned to the laboratories for grading purposes are as follows:

Assignment	**Points**
Lab 1: Laboratory Introduction—Review of Passive Networks	100
Lab 2: Characterization of the 741 Op-Amp	100
Lab 3: Configurable Amplifiers Using Small-Signal MOS Resistors	100
Lab 4: Biasing of Bipolar Transistors	100
Lab 5: Design Problem 1 — Common Emitter Amplifier	200
Lab 6: Design Problem 2 — to be assigned	400
TOTAL	1000

Midterms:

Your COURSE SCHEDULE indicates the tentative date for the midterm exam in this course. We will try to adhere to this date so much as possible. Exam policy for Fall semester is somewhat of a moving target at present, so it is unclear whether this midterm can be proctored (via Zoom). If so, and if we choose this route, then it will likely be closed book. If not, then it will be open book, and we will just release it for a set time interval (of your choice) on a given day. Keep in mind that open book exams are often harder than closed book.

Final Exam:

The final exam will be comprehensive, covering all the material in the course. This includes everything covered in problem sets, lectures, and readings. For now, keep the official scheduled exam time for this course (indicated in your COURSE SCHEDULE document) clear with the assumption that we will use it for the final exam.

Computer Accounts/CAD Tools:

To get a computer account for this course, go to http://inst.eecs.berkeley.edu/webacct. You can login using CalNet and get your account immediately. You can return to this link if you forget your login name or password. This procedure will work for all enrolled, waitlisted, and cross-listed students. If you are unable to login, please notify an instructor.

The supplementary text, *SPICE: A Guide to Circuit Simulation & Analysis Using PSpice* by Tuinenga, is a useful aid to those students seeking more information on SPICE. SPICE is the most widely used circuit simulator in the field.

Cardkey Access:

Given that this course is all remote, there is no need to access the physical laboratory, so no need for card key access.

Grading Policy:

Course grades will use the following tentative grading formula.

Problem Sets:	15%
Laboratory/Projects:	35%
Midterm Exam:	20%
Final Exam:	30%