

EEL 4310 Digital Integrated Circuits Design
Class Periods: T, 8-9, 3:00PM-4:55PM; R, 9, 4:05PM-4:55PM
Location: NEB 202
Academic Term: Spring 2020

Instructor:

Name: Dr. Domenic Forte
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Telephone: 352-392-1525
Office Hours: Thursdays, 8:00AM-10:00AM, MAE 226D

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

Please contact through the Canvas website

- Huanyu Wang, huanyuwang@ufl.edu, MAE, office hours TBD
- Muhtadi (Zaki) Choudhury, muhtadichoudhury@ufl.edu, MAE, office hours TBD

Course Description

Fabrication, Layout, Analysis, and Design of Digital Circuits using MOS Transistors. *Lecture. Credits 3.*

Course Pre-Requisites / Co-Requisites

- EEL 3308: Electronic Circuits I
- EEL 3701C: Digital Logic

Course Objectives

Specific Outcomes of Instruction: This course focuses on analysis and design of modern digital circuits. Silicon technology and transistors are introduced and described from a digital point of view, and the performance of various circuits is derived and estimated. CMOS digital circuits will be designed and analyzed. Students will layout and design digital complex circuits using layout software and SPICE and cover advanced topics such as manufacturing variations.

Outcomes are addressed by this course: EE2, a, c, e, I, k

Professional Component (ABET):

This course consists of 2.5 credits of Engineering Design and 0.5 credit of Engineering Science.

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.	Medium
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.	Medium
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	
4. An ability to communicate effectively with a range of audiences	
5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	

6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.	
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty	Medium

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

- i. Introduction to Microelectronic Fabrication
 Author - Richard C. Jaeger
 Publication date and edition - 2nd Edition, Modular Series on Solid State Devices, Volume 5, Prentice Hall
 ISBN Number - 0-201-44494-7
- ii. Digital Integrated Circuits, A Design Perspective
 Author - Jan. M. Rabaey, A. Chandrakasan, and B.Nikolic
 Publication date and edition - 2nd Edition, Prentice Hall
 ISBN Number - 0-13-090996-3, 2003
- iii. Computer and Software required: Workstations with CADENCE Design system on campus, off-campus can use XWindows or X-terminal on a high-speed internet link to UF Campus Computers, or can use equivalent IC design software

Recommended Materials

- i. CMOS: Circuit Design, Layout, and Simulation
 Author: R. Jacob Baker
 Publication date and edition - 4th Edition, Wiley-IEEE Press
 ISBN Number - 978-1119481515, 2019

Topics to be covered

Wk	Date	Tentative Topics
1	1/6-1/12	Syllabus, Design/Fabrication Flow, Moore's Law, and Transistor Layout
2	1/13-1/19	Fabrication Steps and Design Rules; Alignment Errors
3	1/20-1/26	MOSFET Operation, Current Models, and Body Bias
4	1/27-2/2	Parasitic Capacitance; CMOS Inverter and Voltage Transfer Curve;
5	2/3-2/9	Intro to Semiconductor Memories;
6	2/10-2/16	SRAM Operation, Design, and Layout; Decoders and Sense Amps
7	2/17-2/23	DRAM, Flash, and ROM
8	2/24-3/1	CMOS Inverter Delay and Power
9	3/2-3/8	----- SPRING BREAK -----
10	3/9-3/15	CMOS Logic Gates, Stick Diagrams and Layout; CMOS Gate Delay and Sizing
11	3/16-3/22	Intro to Sequential Logic; Basic Latch and Register Designs
12	3/23-3/29	Latch/Register cont.; Setup/Hold Time Constraints; Advanced Latch and Register Design
13	3/30-4/5	Advanced MOS Process Integration, Dennard Scaling
14	4/6-4/12	Advanced Contacts, Metallization, Spacers, Local Interconnects, and FinFETs
15	4/13-4/19	Classical and Advanced Packaging
16	4/20-4-22	Review

Assignments, Projects, and Exams Tentative Schedule

Wk	Date	Tentative Deadlines
1	1/6-1/12	Homework #1 and Cadence Tutorial 1 Assigned;
2	1/13-1/19	Cadence Tutorial 1 due (1/14); Tutorial 2 Assigned;
3	1/20-1/26	Cadence Tutorial 2 due (1/21); Tutorial 3 Assigned;
4	1/27-2/2	Homework #1 due (1/28); Quiz #1 (1/30) ; Homework #2 Assigned
5	2/3-2/9	Cadence Tutorial 3 Due (2/6); Cadence Project 1 Assigned;
6	2/10-2/16	
7	2/17-2/23	Homework #2 Due (2/20)
8	2/24-3/1	Exam #1 (2/24); Cadence Project 1 Due (2/27); Homework #3 Assigned;
9	3/2-3/8	SPRING BREAK
10	3/9-3/15	Final Cadence Project Assigned;
11	3/16-3/22	Homework #3 Due (3/17); Homework #4 Assigned;
12	3/23-3/29	Homework #4 Due (3/26)
13	3/30-4/5	Exam #2 (3/31); Homework #5 Assigned
14	4/6-4/12	
15	4/13-4/19	Final Cadence Project Due (4/18)
16	4/20-4-22	Homework #5 Due (4/21)
17	TBD	Final Exam

Attendance Policy, Class Expectations, and Make-Up Policy

- Due to quantity and of material, it is important to make every attempt to attend class. Slides will be posted but not annotated materials and work on blackboard (except under extenuating circumstances).
- No exam make-up unless a valid excuse is presented beforehand. All valid excuses must be approved by the Professor. Excused absences must be in compliance with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations/>) and require appropriate documentation.
- All homework assignments must be submitted in class or online before the deadline (no exceptions) since solutions are posted after lecture.
- All projects must be handed in on time or credit will be deducted (10% each day).

Format of Homework

- All homework must be written legibly so that it can be graded. Illegible solutions will be given zero credit.
- Homework can be submitted on Canvas or in class. If submitted in class, the homework must contain a cover sheet with the student's name, UFID, homework assignment number, and due date. Any homework without this information will receive zero credit. If submitted in class, the homework must be stapled. Any homework that is not stapled will receive zero credit.

Projects

- Three Cadence tutorials and two layout/simulation projects will be assigned throughout the semester. All are completed individually except for the final project which is completed in groups.
- All project materials will be checked for plagiarism using Turnitin software feature in Canvas. See University Honesty Policy below.

Evaluation of Grades

- Class Examination 60%
 - (Quiz #1) (10%)
 - (Exam #1) (15%)
 - (Exam#2) (15%)
 - (Comprehensive Final Exam) (20%)
- Homework 10%
- Cadence 30%
 - (Tutorial #1) (1.25%)
 - (Tutorial #2) (1.25%)
 - (Tutorial #3) (2.5%)
 - (SRAM Assignment) (10%)
 - (Final Project) (15%)

Grading Policy

Percent	Grade	Grade Points
90.0 - 100	A	4.00
86.7 - 89.9	A-	3.67
83.4 - 86.6	B+	3.33
80.0 - 83.3	B	3.00
76.7 - 79.9	B-	2.67
73.4 - 76.6	C +	2.33
70.0 - 73.3	C	2.00
66.7 - 69.9	C-	1.67
63.4 - 66.6	D+	1.33
60.0 - 63.3	D	1.00
56.8 - 59.0	D-	0.67
0 - 56.7	E	0.00

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluer.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.ua.ufl.edu/public-results/>.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor

Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://care.dso.ufl.edu>

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.