ECE 465 — Digital Systems
Fall 2018, T/Th 3:30-4:45 pm

Teaching Staff
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Office Hours: T/Th 5-6 pm.
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Important: Description and Philosophy
This course will discuss techniques and theories of the art and science of designing and optimizing semi-complex to complex combinational and sequential circuits, and for testing the correctness of implemented circuits (whatever the implementation platform be: PCBs with discrete components or IC chips). The course will stress analytical and critical thinking, and creativity as opposed to rote or recipe-based learning (the latter skills will not be helpful at all in this course). These are the skills and temperament that are highly desired in the current technology and innovation-hungry industry. The types of designs, problem-solving and formal proofs that will be asked many times in homeworks, projects and exams will require good analytical and in-depth thinking.

To recap, the course will teach and require:

1. Analytical Rigor: Mathematical knowledge and using it for in-depth analysis of circuits (e.g., hardware cost and delay analysis) and design techniques (e.g., optimality or correctness proofs of techniques).
2. Creativity: In-depth thinking, creativity and ingenuity in solving semi-complex problems.
3. Motivation to learn and do well.
4. Integrity.

It is hoped that those who take this course buy in enthusiastically to the aforementioned learning philosophy, and are willing to execute it.

Course Material
Lecture Notes: Almost all will be put online on the course web page: www.ece.uic.edu/~dutt/courses/ece465/ece465.html
Homeworks, Projects and Quizes

Homework: About four homeworks (HWs) will be assigned. Homeworks are to be submitted ONLY in class on the due date. Late HWs will not be accepted.

Projects: There will be 1-2 projects (depending on resources available) using the Quartus software. Projects are to be submitted as electronic copies of three main items (some other items may be requested based on the project): (a) the project report, (b) the design or code, as the case may be, and (c) the simulation results, by 11:59 pm on the due date on blackboard (BB).

Honour policy (see details later) of doing the above assignments on your own (or within a team) with no help from any source including any person is to be strictly followed, and if you do not, your unethical actions will be detected as so many others have been in past semesters, and penalized as either a zero in that assignment or lowering of your obtained final letter grade by one grade point for each violation or failing the course, depending on the egregiousness of the unethical action. For HWs (but not for projects), you are free to discuss broad solution approaches with other students, but the final solution in its details need to be your own.

Quizes: There will be 1 quiz that will mainly be given to test your preparation of background material that are extremely important for understanding the course material. You will be told about the background material needed for the course material from time to time (a list is also given later in this syllabus) and will be informed of the corresponding quiz.

Honour policy for quizzes will be the same as for exams; see below.

Examination Schedule

It is possible that the exams will be made take-home requiring electronic submission using text-processing and figure-drawing s/w such as MS Word and Powerpoint (with final conversion to a pdf document).

Honour policy of doing the exam work on your own with no help from any source including any person is to be strictly followed, and if you do not, your unethical actions will be detected as so many others have been in past semesters, and penalized as either a zero in that exam or lowering of your obtained final letter grade by one grade point for each violation or failing the course, depending on the egregiousness of the unethical action(s).

Midterm Exam: In the 8’th or 9’th week of the semseter.

Final Exam: Either in the weekend after last class (assuming a take-home exam) or during finals week, but not necessarily as scheduled by the official system if it is a take-home exam.

Grade Distribution—tentative

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<td>Homeworks</td>
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<td>Quizes</td>
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<td>Projects</td>
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<td>Midterm Exam</td>
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<td>Final Exam</td>
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Honor Code

The following Honor Code policy shall be in effect in this course:

- Not to seek unfair advantage over other students, including, but not limited to: (a) giving or receiving unauthorized aid (i.e., outside of your official project work team) during completion of academic requirements (this includes lab work, homeworks and exams); (b) obtaining past semesters’ project and homework solutions and creating your project/homework from them. (c) Not to obtain solutions to HWs/exams/projects from any source including the internet. All work is to be performed on your own and you can only collaborate on this with your teammate(s) for projects

For your information, we have electronic copies of past student projects and can verify if your project’s design/code has any similarity with that of past projects (even if you change entity names and or some parts of a past project). Past students have also been told not to give anyone their projects or homework solutions, and to report if anyone asks for them. So, please do not even think of asking for these, if you value honesty, fairness, and your status as a student in good standing at UIC.

- To represent fact and self truthfully at all times.

- Not to pass on your project work or homework solutions to anyone else ever, either in this seeseter, or at any future time including after you graduate.

Violations of the Honor Code are just causes for discipline under the University of Illinois at Chicago Student Disciplinary Procedure, and all allegations of Honor Code violations shall be handled pursuant to that Procedure. The course penalty for any honor code violation will range from a zero in the assignment in which the violation is detected to lowering of your obtained final letter grade by one grade point for each violation to failing the course, depending on the egregiousness of the unethical action(s).

Course Outline

Note: The sections of the text listed below in square brackets for the various topics may not always cover all subtopics discussed in class or may cover more subtopics than discussed in class, as the book will not be followed 100%. Handouts will be given on some occasions. But mainly it is important to attend all lectures in order to learn all the material and do well in the course. Lecture #s corresponds to 1 hr 15 min lectures.

1. Introduction (1.5 lecture) (Sec. 0.2).

2. Self-Review of Basics for the quiz
   Boolean algebra, fundamental definitions (implicants, prime implicants, implicates, prime implicates, etc.), minimization using Boolean algebra, minimization using K-maps, hazards in combinational circuits and their solutions, synthesis using NAND/NOR gates [1.1, 1.3-1.4, 2.1-2.2, 2.5, 3.1-3.8]

3. High-Level Design Approaches including Divide-&-Conquer (5.5 lectures)

4. Advanced Two-level Combinational Circuit Minimization (4 lectures)
   Quine-McCluskey method (single and multiple functions), Petrick’s algorithm [3.9-3.10]

5. Component-Based Combinational Circuit Synthesis (MUXes, PLAs, PALs) (4 lectures) [4.2, 4.4, 5.1-5.5]
6. **Synchronous Sequential Circuits (9 lectures)**
   finite state machine (FSM) synthesis (Moore, Mealy), synthesis of synchronous sequential circuits, clocking methods, state minimization and state assignment techniques, one-hot design style [8.1-8.4, 9.1-9.4]

7. Either:
   (a) **Testing of Combinational and Sequential Circuits (3 lectures)** [12.1-12.4]
   OR
   (b) **Asynchronous Sequential Circuits (3 lectures)**
   Synthesis (pulse & fundamental modes), races and hazards [10.1-10.6]

### Background Review Material

*(a) Logic Design Background :* Please carefully review the following background material from ECE 265 for you to understand the lectures in ECE 465 and do well in the quizzes. The secs. in text where these material are available are listed in square brackets. *The week # given is the week in which these material have to be reviewed by you.*

1. **Introduction:** [0.1-0.2] – week 1
2. **Number Systems and Codes:** [1.1-1.2] – week 1
3. **Boolean Algebra:** [2.1-2.2] – week 1
4. **K-maps:** [3.1-3.7] – weeks 1 and 2
5. **Logic gates, synthesis of logic circuits using NAND/NOR gates:** [2.3-2.4.1, 2.5-2.6] – week 2
   Topics in items 4 and 5 also available at: http://www.ece.uic.edu/~dutt/courses/ece465/lect-notes/lect2-new-465.ppt
6. **Latches and FFs:** [6.1-6.4.2 except the discussion on 74LS75 and 74116 D-latches] – week 7

*(b) Discrete Math Background :* While CS 201 is not a formal pre-requisite for this course, nevertheless the following discrete math background is needed for this course (and is standard requirement at all strong schools). While an attempt will be made to provide pointers to these topics as and when required, it will be much better for you to review these topics thoroughly from either the CS 201 textbook or by googling these topics (wikipedia and math.com are good sources) in the initial 2 weeks of this course.

1. **Sets and set theory** (mild requirement; only simple and intuitive set theory concepts like disjointness, intersection, union will be needed) – week 2
2. **Sequences and series** (arithmetic and geometric series in particular) – week 2
3. **Permutations and Combinations** – week 2
4. **Complexity order notations** (big Oh, big Theta, and big Omega notations) – week 3
5. **Elementary probability theory** (especially the average of a metric with a given probability distribution) – week 3
6. **Proof techniques** (e.g., proof by induction, proof by contradiction) – week 4
Things You Need to Do Besides Assignments and Exams

1. Need to review the material according to the schedule given above. You will be asked Qs about it next class, and this will also be needed to understand the material in the next class.

2. Need to study the material covered in class before the next class so that you have a good handle on it for the next set of topics. Again, Qs will be asked in the next class about material covered previously.

3. At least a 80% attendance to pass the class (will not take attendance, but I will be able to detect who is absent in a particular class). Students being absent a lot generally have got C’s or D’s, not because I’ve penalized them (I did not), but because they did not understand many of the intricacies of a topic just be reading the slides and text. So it will be best for you to get close to a 100% attendance.