ECE558/658 – Intro VLSI Design/VLSI Design Principles

• **Number of Credits:**	4
• **Lecture:**	TuTh 11:30-12:45 Marston 132
• **Office hours:**	To be determined
• **Professor:**	Daniel Holcomb, 309H KEB, holcomb@engin.umass.edu
• **Teaching Assistants:**	Siva Nishok Dhanuskodi, sdhanusk@umass.edu Shahrzad Keshavarz, skeshavarz@umass.edu
• **Required Textbook:**	Neil Weste and David Harris, CMOS VLSI Design: A Circuits and Systems Perspective, 4th Edition, 2011.
• **Further Reading:**	Jan Rabaey, Anantha Chandrakasan and Borivoje Nikolic, Digital Integrated Circuits, 2nd Edition, 2003.

Description

This mezzanine/grad course provides an introduction to the fascinating world of computer chip design. VLSI (Very Large Scale Integration) is the engineering discipline that organizes huge numbers of transistors and wires into massively complex systems that are functional and manufacturable, while meeting cost, power, reliability and other constraints. The defining characteristic of VLSI is its use of design abstractions to enable automation and manage complexity. The subject is challenging, but can be highly rewarding. The course will use Moodle for communicating information, and includes lab assignments using industry-standard design tools.

Your instructor and TAs work at the intersection of hardware design and security, which is an area with a number of exciting research topics. These topics include power side channels for exfiltrating cryptographic keys, physical unclonable functions that use process variations to authenticate chips, split manufacturing to have trusted chips fabricated by untrusted foundries, fault injections that cause chips to reveal secrets, the risk of hardware Trojans, reverse engineering, etc.

ECE558 and ECE658 meet together. ECE558 does not assume VLSI background. ECE658 is a graduate VLSI course and a PhD core course, appropriate for students that want to pursue a career or research in VLSI. ECE658 assumes basic knowledge of VLSI and experience/ability to work with Unix and scripted commercial CAD tools. ECE658 students will have additional problems on labs and exams.

Major Course Topics (subject to change)

- Overview, History and Trends
- Devices – Basic MOSFET, Variations, Leakage, FinFETs, Post-CMOS
- Inverter and Gates – Models for DC and Timing Analysis
- Wires – RC models, Repeaters, Buffers, Networks on Chip
- Synthesis – Verilog, Cell Libraries, Place and Route
- Memories – SRAM, DRAM, Non-Volatile memories
- Variations – Impact on Timing and Other Failures
- Power and Energy – Dynamic and Static, Thermal Issues
- FPGAs and other Programmable Components
- Reliability and Test
- Manufacturing – Process basics, Yield, FinFET issues, etc.
- Semiconductor Business – Top 20 companies, Fabless model, IP re-use, CAD

Grading Policy (Subject to change)

The grades for the course are based on exams, lab assignments, and quizzes, according to the weighting shown. The quizzes are unannounced, and designed to provide incentive to stay engaged with course material. Lowest quiz

score will be dropped. Problems from the book may be suggested, but will not be turned in or graded. Cutoffs for letter grades will be determined at the end of semester.

Grade Component	Weight
Mid-term Exam	30%
Final Exam	30%
Labs	30%
Unannounced In-class Quizzes	10%

Lab Assignments

Lab assignments are completed using industry-standard CAD tools running on ECE department servers. Students taking ECE558 will work on vlsicad1.ecs.umass.edu, and students in ECE658 will work on vlsicad2.ecs.umass.edu. Learning to navigate the tools and complete the assignments requires an investment of time, but provides a valuable skill.

Motivated students that are performing well in the course can propose research-oriented group projects to replace labs 3 and 4. This option is intended for students considering graduate research in VLSI, as it can lead to a research paper or thesis. More details will be announced in October.

- Lab 0: Setting up tools and accounts (2 pts)
- Lab 1: Design, Layout, Extraction, Analysis of combinational CMOS Multiplexer (7 pts)
- Lab 2: Design and analysis of sequential 1-bit accumulator (7 pts)
- Lab 3: Synthesis and Place-and-Route of two designs (7 pts)
- Lab 4: Implement Network-on-Chip (7 pts)

Academic Honesty Policy Statement

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Dishonesty in the course will at minimum result in a grade of F for the assignment, and a further 10 point penalty to overall course grade.

Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. The procedures outlined below are intended to provide an efficient and orderly process by which action may be taken if it appears that academic dishonesty has occurred and by which students may appeal such actions.

Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent. For more information about what constitutes academic dishonesty, please see the Dean of Students' website: `http://umass.edu/dean_students/codeofconduct/acadhonesty/`

Disability Statement

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), Learning Disabilities Support Services (LDSS), or Psychological Disabilities Services (PDS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements.