

TO: The Faculty of the College of Engineering

FROM: Elmore Family School of Electrical and Computer Engineering

RE: New Graduate Course, ECE 61220 Advanced VLSI Design

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 61220 Advanced VLSI Design

Sem. 2, Lecture 3, Cr. 3.

Prerequisite: ECE 559 or equivalent

Description: The objective of this course is to train the students with advanced digital circuit design techniques that can be instrumental in achieving higher energy efficiency and resilience to process variations in scaled technologies.

Reason: In the VLSI and Circuit Design research area, there is a basic VLSI design course, ECE 55900, a course on VLSI testing and verification, and a course on VLSI interconnected optimization. This course will complement the other offerings. In addition to digital signal processing algorithms suitable for low-power and high-performance implementation.

The objective of the course is to introduce advanced concepts in high-performance and low-power circuit and system design. Design process, starting from logic synthesis down to layout synthesis will be covered in detail.



Milind Kulkarni,
Associate Head for Teaching and Learning
Elmore Family School of Electrical and Computer Engineering

Course History:

This course has been taught for nearly 20 years. The most recent offerings, Spring 2022 – 21, Spring 2021 – 10, Spring 2020 – 16, Spring 2019 - 26

CRN: ECE 69500 030

CREDIT HOURS: 3

LECTURES: T Th 10:30 am – 11:45 am at Max W & Maileen Brown Hall (EE) 224 and online at <https://purdue-edu.zoom.us/j/3164232249>.

(Some lectures will be held **only** over Zoom at <https://purdue-edu.zoom.us/j/3164232249> as per the announcements)

INSTRUCTOR: **Sumeet Kumar Gupta**

- Office: MSEE 218
- Phone: 765 494 3484
- Email: guptask@purdue.edu

OFFICE HOURS (at <https://purdue-edu.zoom.us/j/3164232249>):

- T 12:00 noon – 1:00 pm, Th 12:00 noon – 12:45 pm, or by appointment
- No office hours during the holidays/breaks.
- The office hours will be held virtually over Zoom.

Important: Please put ‘ECE 695:’ at the beginning of your subject line when you send an email to the instructor.

COURSE WEBSITE: Purdue Brightspace. Login Required.

COURSE MATERIALS:

- Lecture Slides and Videos (To be posted on the website).
- Published Literature

REFERENCE BOOKS

- *Digital Integrated Circuits: A Design Perspective*, 2nd Edition, J.M. Rabaey, A. Chandrakasan, B. Nikolic, Prentice Hall, 2003, ISBN No. 0-13-090996-3.
- *Principles of CMOS VLSI Design: A Systems Perspective*, 2nd Edition, N.H.E. Weste and K. Eshraghian, Prentice Hall, 1993, ISBN No. 0-201-53376-6.
- *CMOS: Circuit Design, Layout, and Simulation*, 3rd Ed., R. Jacob Baker, Wiley-IEEE, 2010.

PREREQUISITES:

- ECE 559 or equivalent. If you have any questions or doubts regarding the pre-requisites, please talk to the instructor.

COMPUTER USAGE

- Cadence, HSPICE, MATLAB and/or Sentaurus to facilitate the analysis and design of digital devices/circuits
- Word processing to prepare the lab reports and the interim and final reports for the project.

COURSE DESCRIPTION AND LEARNING OUTCOMES:

The objective of this course is to train the students with advanced digital circuit design techniques that can be instrumental in achieving higher energy efficiency and resilience to process variations in scaled technologies. After completing the course, the students should have a comprehensive understanding and/or experience in the following:

- Design challenges associated with scaled MOSFETs, including short channel effects, leakage mechanisms, process variations, reliability issues and interconnect parasitics.
- Advantages and disadvantages of emerging technologies and circuit design challenges
- Adaptive design techniques to increase resilience to process variations
- Low power/ultra-low power design in near-threshold/sub-threshold region
- Advanced SRAM design
- Memory design in emerging technologies
- Computing-in-Memory
- Device-Circuit Co-design in Advanced Technologies

COURSE TOPICS AND SCHEDULE (Tentative):

- Week 1: Introduction to digital circuit design metrics and trends, technology scaling, overview of design challenges
- Week 1-2: FinFETs and other advanced transistors: characteristics, advantages and disadvantages
- Week 3: Leakage mechanisms in scaled technologies and circuit design techniques to reduce leakage
- Week 4: Process variations and adaptive circuit design
- Week 5-6: Low Voltage (Near-Threshold) Circuit Design
- Week 7-9: SRAM design: Different variants of SRAMs, failures and design techniques to mitigate them
- Week 10-12: Non-volatile Memories
- Week 13: Computing-in-Memory
- Week 14-15: Student Presentations and other discussion.

GRADING:

- Student Presentations: 25%
- Project: 35%
- Mid Term Exam: 20%
- Final Exam: 20%

The letter grade will be determined after all grading (including the final exam) is completed. This will be done based on cutoff points in the cumulative scores, which will be available only after the final exam is graded.

STUDENT PRESENTATIONS:

- We will have student presentations on a selected theme in the later part of the semester (in April).
- The theme for this year is “Hardware for AI”

- You will need to form groups of two and come up with a focused topic related to the theme. The group will deliver a 30-minute presentation (+ 5 minutes of questions and answers) on their topic.
- The schedule for the presentations will be announced later.
- You must communicate the following to me (details to announced later):
 - Your group (by January 21, 2022)
 - Your topic of presentation (by February 4, 2022)
- The presentations will be graded based on the technical content, quality of slides as well as delivery by the team members.

PROJECTS:

- A major component of this course will be a project on a topic related to “Digital VLSI Design” selected by the team.
- The project will need to be done individually or in groups of two.
- The final 8-page report (following IEEE paper format) will be due on April 30, 2022 (11:59:59 PM).
- You must communicate the following to me (details to announced later):
 - Your group (by January 28, 2022)
 - Your project topic (by February 11, 2022)
- The project topic must be different from the presentation topic.

MID TERM EXAM:

- We will have one mid-term exam on Thursday, March 10, 2022 during the lecture.
- It will be an open-notes exam based on the material that we cover during the lectures.

FINAL EXAM:

- The final exam will be as per University’s schedule during the Final’s week.
- It will be an open-notes exam based on the material that we cover during the lectures.

ACADEMIC DISHONESTY POLICIES:

Every member of the Purdue community is expected to practice honorable and ethical behavior both inside and outside the classroom. Any actions that might unfairly improve a student’s score on homework, or examinations will be considered cheating and will not be tolerated.

Examples of cheating include (but are not limited to):

- Sharing results or other information during an examination.
- Bringing forbidden material or devices to an examination.
- Working on an exam before or after the official time allowed.
- Requesting a re-grade of answers or work that has been altered.
- Submitting homework that is not your own work or engaging in forbidden homework collaborations.

At the instructor’s discretion, cheating on an assignment or examination will result in a reduced score, a zero score, or a failing grade for the course. All occurrences of academic dishonesty will be reported to the Assistant Dean of Students and copied to the ECE Associate Head of Education. If there is any question as to whether a given action might be considered as cheating, please see the instructor or the teaching assistant before you engage in any such action.

NONDISCRIMINATION STATEMENT (From the University Template)

“Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue’s full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.”

ACCESSIBILITY (From the University Template)

“Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.”

ATTENDANCE POLICY DURING COVID-19

The students will be expected to attend the lectures at the time listed above. If for some reason, a student is not able to attend the specific lecture(s), he/she will be expected to go through the video lectures that will be posted on the website. In case of health safety if Purdue decides to go fully online again in the middle of the semester, we may flip the lectures into Zoom lectures and zoom proctored online quiz exams. Everything else should remain the same except you may have to do group work/collaborations over online platforms.

ACADEMIC GUIDANCE IN THE EVENT A STUDENT IS QUARANTINED/ISOLATED

In case a student is quarantined or isolated, he or she should contact the instructor by email to discuss changes, if any, to the course requirements. In addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify the instructor via email. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

OTHER COURSE POLICIES:

- Incomplete grade is only for students who do most of the required work and at the end of the semester due to a **well-documented emergency** cannot finish the course.
- **No make-up exams** will be given.
- **Only in well-documented emergency situations**, we will allow a student to take the exam at a different time, no other excuses are accepted.
- **No late submissions** will be accepted, except in well-documented emergency situations.
- You cannot do extra work after the semester is over to change your grade. **All grades are FINAL once submitted.**
- If you have any issue or difficulty with the course **you need to contact me during the semester and seek help in advance.**

- In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Here are ways to get information about changes in this course.
 - Course webpage
 - Instructor's email
 - Instructor's phone
- Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. (*Source: Purdue DRC Webpage*).

CLASSROOM GUIDANCE REGARDING PROTECT PURDUE (From the university template)

“The [Protect Purdue Plan](#), which includes the [Protect Purdue Pledge](#), is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask [in classrooms and campus buildings](#), at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining appropriate social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the [Office of the Student Rights and Responsibilities](#). See also [Purdue University Bill of Student Rights](#)”.

Related Considerations:

1. *A listing of recommended safe practices for the specific class or laboratory setting (other PPE or safety behavior) can be found at the links below.*
 - [Overarching SOP for Classrooms, Instructional Laboratories, and Experiential Courses](#)
2. *References Supporting Protect Purdue Compliance:*
 - Office of the Dean of Students [Protect Purdue Compliance Plan: Ask, Offer, Leave, Report](#)
 - Office of the Dean of Students [Managing Classroom Behavior and Expectations](#)

MENTAL HEALTH/WELLNESS STATEMENT (From the university template)

“If you find yourself beginning to feel some stress, anxiety, and/or feeling slightly overwhelmed, try [WellTrack](#). Sign in and find information and tools at your fingertips, available to you at any time. If you need support and information about options and resources, please contact or see the [Office of the Dean of Students](#). Call 765-494-1747. The hours of operation are M-F, 8 am- 5 pm. If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a [Purdue Wellness Coach at RecWell](#). Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact [Counseling and Psychological Services \(CAPS\)](#) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.”

ADDITIONAL WELLNESS RESOURCES

TaskHuman offers 1-on-1 live video calls with coaches who help you focus on wellness topics such as anxiety, mindfulness, reducing stress, clean eating, time management, in-home workouts, relationship tensions, and nearly a thousand more topics. You can log on at any time to access experiences as diverse as working through heightened anxiety to a personalized yoga session with carefully vetted providers.

Using this link gets you access to all the perks: <https://taskhuman.com/referral/purdue>.

Learn more here: <https://engineering.purdue.edu/ECE/TaskHuman>.

Don't see a topic you want or have other questions? Contact Brooke Parks, Lead Instructional Specialist in ECE, at brookeparks@purdue.edu.

BASIC NEEDS SECURITY

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the [Critical Needs Fund](#).

EMERGENCY PREPAREDNESS

- For any emergency text or call 911.
- There are more than 300 Emergency Telephones (aka blue lights) throughout campus that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected right away.
- If we hear a fire alarm we will immediately evacuate the building and proceed to Engineering Mall area away from the building.
- Do not use the elevator.
- If we are notified of a Shelter in Place requirement for a tornado warning we will stop classroom or research activities and shelter in the lowest level of this building away from windows and doors. Our preferred location is lowest level possible away from exterior

doors and windows. Seek more information on storm conditions from National Weather Service weather radio or application on mobile device.

- If we are notified of a Shelter in Place requirement for a hazardous materials release we will shelter in our classroom shutting any open doors and windows.
- If we are notified of a Shelter in Place requirement for an active threat such as a shooting we will shelter in a room that is securable preferably without windows.