

# Embedded System Design and Modeling

ECE382N.23, Unique 18090, Fall 2022

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**Lectures:** TTh 11:00-12:30pm, ECJ 1.318

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**Class webpage:** [http://www.ece.utexas.edu/~gerstl/ece382n\\_f22/](http://www.ece.utexas.edu/~gerstl/ece382n_f22/)

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## Background

Embedded computer systems are ubiquitous and deeply integrated into many devices we interact with on a daily basis. They often have to provide strict correctness and real-time guarantees while operating under stringent performance, energy or other resource constraints. Associated challenges demand formal and automated methods for programming and design of such systems. The basis for any formal and automated design process are, however, first and foremost well-defined models that allow predicting system behavior before it is built or deployed.

This course covers theory and practice of system-level design of embedded systems. With an emphasis on the formal modeling foundations and design automation solutions, the course will present methods and techniques for specification, synthesis and performance modeling at the system level. State-of-the-art design languages and design automation methods will be introduced and used in the assignments and project to specify, simulate, analyze, model and synthesize systems based on typical embedded application examples.

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## Catalog Description and Course Topics

Formal methods and design automation techniques for specification, modeling, synthesis, and electronic system-level (ESL) design of embedded systems:

- Models of Computation (MoCs), concurrency and time: finite state machines (FSMs), process networks, dataflow;
  - System-level design languages (SLDLs): discrete event and synchronous reactive simulation semantics;
  - System refinement and modeling, virtual platform prototyping and system simulation: processor and OS modeling, transaction-level modeling (TLM) for communication;
  - System-level synthesis: algorithms for partitioning, scheduling, design space exploration, and embedded hardware and software synthesis;
  - System-level design tools, examples and case studies.
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## Prerequisites

- Fundamentals of embedded & real-time systems and software (EE445L Embedded System Design Lab, or equivalent);
- Working knowledge of C/C++, algorithms and data structures (EE422C Software Design and Implementation, or equivalent);
- Fundamentals of digital hardware design and hardware description languages (EE460M Digital System Design using VHDL, or equivalent).

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**Textbooks**

Recommended (but optional)

1. D. D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, *Embedded System Design: Modeling, Synthesis, Verification*, ISBN 978-1-4419-0503-1, Springer, 2009.
2. P. Marwedel, *Embedded System Design: Embedded Systems, Foundations of Cyber-Physical Systems, and the Internet of Things*, Fourth Edition, ISBN 978-3-030-60912-2, Springer, 2021.
3. E. A. Lee, S. A. Seshia, *Introduction to Embedded Systems: A Cyber-Physical Systems Approach*, Second Edition, ISBN 978-0-262-53381-2, MIT Press, 2017.

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**Grading and Academic Dishonesty Policies**

Homeworks:	30%
Midterm:	20%
Project:	50%

Late submissions will not be accepted. Oral discussion of homework problems is encouraged but make sure to submit your own individual and independent solution. Projects can be done in teams. Collaboration and teamwork on projects is highly encouraged. Copying of any part of a solution without explicit reference to its source is plagiarism and considered cheating.

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**Outline and Schedule (Tentative)**

Week	Dates	Topic
1	Aug 23, 25	Introduction, System-level design methodologies
2	Aug 30, Sep 1	System specification, Models of Computation (MoCs)
3	Sep 6, 8	Process-based, process network & dataflow MoCs and languages
4	Sep 13, 15	State-based, hierarchical & concurrent state machine MoCs
5	Sep 20, 22	System-level design languages
6	Sep 27, 29	System modeling and performance estimation
7	Oct 4, 6	Analytical, profiling and simulation based modeling
8	Oct 11, 13	Machine learning for system modeling
9	Oct 18, 20	System synthesis and hardware/software implementation
10	Oct 25, 27	Partitioning, scheduling, design space exploration
11	Nov 1, 3	Learning-based system design and optimization methods
12	Nov 8, 10	System-level design tools
13	Nov 15, 17	Review, <b>Midterm</b>
14	Nov 22, 24	<i>Fall break</i>
15	Nov 29, Dec 1	<b>Project presentations</b>

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**Sharing of Course Materials**

Sharing of course materials is prohibited. No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online

or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

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**Class Recordings**

Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

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**Electronic Mail Notification Policy**

In this course e-mail will be used as a means of communication with students. You will be responsible for checking your e-mail regularly for class work and announcements. The complete text of the University electronic mail notification policy and instructions for updating your e-mail address are available at <http://cio.utexas.edu/policies/university-electronic-mail-student-notification-policy>.

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**Use of Canvas and Class Web Site**

This course uses the class web page and Canvas to distribute course materials, to communicate and collaborate online, to submit assignments and to post solutions and grades. You will be responsible for checking the class web page and the Canvas course site regularly for class work and announcements. As with all computer systems, there are occasional scheduled downtimes as well as unanticipated disruptions. Notification of disruptions will be posted on the Canvas login page. Scheduled downtimes are not an excuse for late work. However, if there is an unscheduled downtime for a significant period of time, I will make an adjustment if it occurs close to the due date.

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**Students with Disabilities**

The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. Students with disabilities may request appropriate academic accommodations from the Division of Diversity and Community Engagement. For more information, contact Disability and Access (D&A), Student Services Building (SSB), 471-6259, <http://diversity.utexas.edu/disability/>.

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**Religious Holidays**

Religious holy days sometimes conflict with class and examination schedules. If you miss an examination, work assignment, or other project due to the observance of a religious holy day you will be given an opportunity to complete the work missed within a reasonable time after the absence. It is the policy of The University of Texas at Austin that you must notify each of your instructors at least fourteen days prior to the classes scheduled on dates you will be absent to observe a religious holy day.

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## Counseling and Mental Health

Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. The Counseling and Mental Health Center (CMHC) provides counseling, psychiatric, consultation, and prevention services that facilitate students' academic and life goals and enhance their personal growth and well-being: <http://cmhc.utexas.edu/>. You can also talk to the [CARE Counselor in the College of Engineering](#), who can be reached at 512-471-8396 and has drop-in office hours in EER 2.848.

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## Title IX Reporting

Title IX is a federal law that protects against sex and gender-based discrimination, sexual harassment, sexual assault, sexual misconduct, dating/domestic violence and stalking at federally funded educational institutions. UT Austin is committed to fostering a learning and working environment free from discrimination in all its forms where all students, faculty, and staff can learn, work, and thrive. When sexual misconduct occurs in our community, the university can:

1. Intervene to prevent harmful behavior from continuing or escalating.
2. Provide support and remedies to students and employees who have experienced harm or have become involved in a Title IX investigation.
3. Investigate and discipline violations of the university's relevant policies.

Faculty members and certain staff members are considered "Responsible Employees" or "Mandatory Reporters," which means that they are required to report violations of Title IX to the Title IX Coordinator at UT Austin. The instructors (myself and the TAs) are Responsible Employees and must report any Title IX related incidents that are disclosed in writing, discussion, or one-on-one. Before talking with me, the TAs, or any faculty or staff member about a Title IX related incident, be sure to ask whether they are a responsible employee. If you want to speak with someone for support or remedies without making an official report to the university, email [advocate@austin.utexas.edu](mailto:advocate@austin.utexas.edu). For more info about reporting options and resources, visit <https://titleix.utexas.edu/campus-resources> or contact the university's Title IX Office via email at [titleix@austin.utexas.edu](mailto:titleix@austin.utexas.edu).

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## Classroom Evacuation and Emergency Preparedness

All occupants of university buildings are required to evacuate a building when a fire alarm and/ or an official announcement is made indicating a potentially dangerous situation within the building. Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building. If you require assistance in evacuation, inform your instructor in writing during the first week of class. For evacuation in your classroom or building:

1. Follow the instructions of faculty and teaching staff.
2. Exit in an orderly fashion and assemble outside.
3. Do not re-enter a building unless given instructions by emergency personnel.

Emergency evacuation route information and emergency procedures can be found at <http://www.utexas.edu/emergency> and <https://preparedness.utexas.edu>.

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**COVID Guidance**

While we will post information related to the contemporary situation on campus, you are encouraged to stay up-to-date on the latest news as related to the student experience at <https://protect.utexas.edu/>.

To help preserve our in-person learning environment, the university recommends the following to help protect yourself, your friends and family, as well as the community (especially those who can not protect themselves, e.g. children who can not be vaccinated) in Austin in general:

- [Vaccinations are widely available](#), free and not billed to health insurance. The vaccine will help reduce the transmission of the virus to others and reduce serious symptoms in those who are vaccinated.
- Adhere to [university guidances](#) as well as [CDC guidelines](#) and [City of Austin guidelines](#) regarding masking and protecting yourself and others. In particular, properly fitted and high-quality (K)N95 masks can significantly reduce transmission especially indoors and in large crowds (e.g. in class).
- [Proactive Community Testing](#) remains an important part of the university's efforts to protect our community. Tests are fast and free.

To help keep everyone at UT and in our community safe, it is critical that students report COVID-19 symptoms and testing to [University Health Services](#), and faculty and staff report to the [HealthPoint Occupational Health Program](#) (OHP) as soon as possible. To help understand what to do if a fellow student in the class (or the instructor or TA) tests positive for COVID, see this [University Health Services link](#).