

AE 8803: Intelligent Cyber-Physical Systems

Course Syllabus

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Time & Location: TThu 8:00am-9:15am J. Erskine Love Manufacturing 184

Office Hours: TThu 11:00am-12:30pm

These are the “formal” office hours. However, you are more than welcome to stop by my office any time, should you have any questions regarding the course material. Additionally, appointments can be arranged to discuss any questions regarding the course material. The easiest way to reach me is, however, via e-mail.

Course Web Page: All relevant information on the class will be disseminated electronically at canvas.

Required Texts: There is no required text. The instructor will provide notes and research papers.

Prerequisites: Undergraduate linear algebra, probability and signal processing, understanding of modern (state space) control theory

Required Software: Student Edition of MATLAB

Course Description and Topics: In this course, we will review several recent advancements in cyber-physical systems and intelligent control. Topics will include core principles of CPS, differential equations to model physical processes, graph theory and CPS communication structures, control loops in CPS, intelligent control, game theoretic frameworks for secure control, control and estimation over lossy and attacked networks, intrusion and fault detection in CPS, differential and temporal logic for safety of execution, machine learning in CPS.

Course Topics:

- I. Introductory Topics
- II. CPS Communication Structures
- III. Cooperative Control Loops and Importance of Control and Actuation in CPS
- IV. Intelligent Hybrid Control
- VI. Secure Control
- VII. Control and Estimation over Lossy and Attacked Networks
- VIII. Intrusion Detection and Fault Detection in Cyber-Physical Systems
- IX. Differential and Temporal Logic
- X. Topics on Machine Learning and CPS

Tentative Grading Policy

Tentative Grading: Homework and Paper Presentations 25%-Midterm Project 35%-Final Project 40%

Student Learning Outcomes:

1. Understand control and shared resources in cyber-physical systems.

Assessment- homework design projects.

2. Understand the basic different types of graphs that dictate the flow of information.

Assessment- homework design projects and examinations.

3. Ability to perform designs with various tools using MATLAB.

Assessment- design and simulation projects assigned in homework.

4. Understand control over adversarial and “lossy” networks.

Assessment- design and simulation projects in homework.

5. Understand intrusion detection and identification.

Assessment- design and simulation projects in homework, exams.

6. Learn to perform a literature search and prepare a research paper with a unified presentation and exposition on a selected topic.

Assessment- Final Project Report.

Homework Assignments:

- Due at the beginning of the class on the due date. Solutions to the homework will be posted on the web at the time that they are due. Therefore, **NO LATE HOMEWORK** will be accepted.
- Electronic submissions will be accepted before the class starts.
- Late homework will not be accepted without formal documentation of extenuating circumstances (e.g., a note from a Dean, a physician, etc.).

Course Policies: 1. **NO CELL PHONES** are allowed during lecture. 2. Be on time to class. Tardy is discouraged. 3. No make-up exams/quizzes. If you miss the exam, a zero score will be assigned to the missed exam/quiz. 4. If you miss a class due to personal emergency or medical reasons, please be sure to inform the instructor by e-mail. 5. Homework assignments are to be submitted by the due date. You may discuss homework problems with your classmates, but you are responsible for your own works. 6. After an assignment grade has been posted online, students must see the instructor within one week if they wish to discuss the assignment and their work.

Principles of Community: Students are expected to be polite and professional when interacting with one another and with the instructor. Abusive or insensitive behavior will not be tolerated.

Academic Support: The instructor will provide assistance through normal protocols, such as office hours, but cannot serve as a private tutor.

Special Accommodations: Special accommodations can be made for students with disabilities. Please bring any such issues to the instructor's attention *no later than the second week of class*.

Georgia Tech School of Aerospace Engineering Values



Integrity

I achieve excellence by embodying the highest ethical standards and communicating openly, authentically, and with humility.



Respect

I extend courtesy to everyone and promote a culture of inclusion, fairness, and equity.



Community

I am a global citizen and celebrate our collective achievements and contributions to the world around us.



Accountability

I take ownership of my actions and value the responsibility to honor public trust.



Adaptability

I embrace change as a path to progress, success, and innovation.

Discussion Points

1. **Honesty:** The School of Aerospace Engineering values honesty and integrity of all members of our community. An important element of this value is the academic honor code.

Georgia Tech Honor Challenge Statement: I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community.

Honor Code: http://policylibrary.gatech.edu/student-affairs/academic-honor-code#Article_I:Honor_Agreement

2. **Well Being:** The School of Aerospace Engineering values the complete well-being of all members of its community, which includes professional, physical, spiritual, emotional, and social dimensions. There are numerous resources to support the health and well-being of all members of our community: <https://gatech.instructure.com/courses/108574>

Mental Health Resources:

Emergencies: Can either Call 911 or call Campus Police at 404.894.2500
<http://www.police.gatech.edu/>

Center for Assessment, Referral, & Ed. (CARE): <https://care.gatech.edu/> 404.894.3498
(Counselor On-Call)

Counseling Center: <https://counseling.gatech.edu/> 404.894.2575

Stamps Health Services: <https://health.gatech.edu/> 404.894.1420

Student Life and Dean of Students: <https://studentlife.gatech.edu/content/get-help-now>
404.894.6367

Victim-Survivor Support (VOICE): <https://healthinitiatives.gatech.edu/well-being/voice>
404-385-4464/(or 4451)

National Suicide Prevention Lifeline: 1.800.273.TALK (8255)

Georgia Crisis and Access Line: 1.800.715.4225

COVID-19 Safety

GT Safety Guidelines: <https://health.gatech.edu/tech-moving-forward>

Current guidance is summarized at the site above and please continue to follow the site above and other Institute communications in case changes occur:

3. **Social Justice:** The School of Aerospace Engineering values social justice for all members of the Georgia Tech community and the larger society. Social justice means that everyone's human rights are respected and protected. We stand committed in the fight against racism, discrimination, racial bias, and racial injustice. Our shared vision is one of social justice, opportunity, community, and equity. We believe that the diversity and contributions from all of our members are essential and make us who we are. We believe that our impact must reach beyond the classroom, research labs, our campus, and the technology we create, but must also improve the human condition where injustice lives. We will continue to work to understand, value, and celebrate all people and create an inclusive educational and work environment that welcomes all.

As a matter of policy, Georgia Tech is committed to equal opportunity, a culture of inclusion, and an environment free from discrimination and harassment in its educational programs and employment. Georgia Tech prohibits discrimination, including discriminatory harassment, on the basis of race, ethnicity, ancestry, color, religion, sex (including pregnancy), sexual orientation, gender identity, national origin, age, disability, genetics, or veteran status in its programs, activities, employment, and admissions.

<http://policylibrary.gatech.edu/equal-opportunity-nondiscrimination-and-anti-harassment-policy>

Tentative Roadmap		Spring 2023 (AE 8803)		
Number of Lecture	date	day	Topic	Reading Assignments
1	10-Jan	tue	Introduction to CPS	-
2	12-Jan	thurs	Differential Equations as Models of Physical Processes (Physical Part)	-
3	17-Jan	tue	Graph Theory and Communication Structure in CPS (Cyber Part)	-
4	19-Jan	thurs	Graph Theory and Communication Structure in CPS (Cyber Part)	-
5	24-Jan	tue	Graph Theory and Communication Structure in CPS (Cyber Part)	Provided Research Papers
6	26-Jan	thurs	Graph Theory and Communication Structure in CPS (Cyber Part)	Provided Research Papers
7	31-Jan	tue	Control Loops and Importance of Control and Actuation in CPS	-
8	2-Feb	thurs	Control Loops and Importance of Control and Actuation in CPS	Provided Research Papers
9	7-Feb	tue	Control Loops and Importance of Control and Actuation in CPS	Provided Research Papers
10	9-Feb	thurs	Invariant Synthesis	-
11	14-Feb	tue	Invariant Synthesis	Provided Research Papers
12	16-Feb	thurs	Invariant Synthesis	-
13	21-Feb	tue	Validation	Provided Research Papers
14	23-Feb	thurs	Secure Cooperative Control	Provided Research Papers
15	28-Feb	tue	Secure Cooperative Control	Provided Research Papers
16	2-Mar	thurs	Control and Estimation over Lossy and Attacked Networks	Provided Research Papers
17	7-Mar	tue	Control and Estimation over Lossy and Attacked Networks	Provided Research Papers
18	9-Mar	thurs	Intrusion Detection and Fault Detection in CPS	Provided Research Papers
19	14-Mar	tue	Intrusion Detection and Fault Detection in CPS	Provided Research Papers
20	16-Mar	thurs	Differential and Temporal Logic for Safety of Execution of CPS	Provided Research Papers
21	21-Mar	tue	Spring Break (No class)	-
22	23-Mar	thurs	Spring Break (No class)	-
23	28-Mar	tue	Differential and Temporal Logic for Safety of Execution of CPS	-
24	30-Mar	thurs	Differential and Temporal Logic for Safety of Execution of CPS	-
25	4-Apr	tue	Differential and Temporal Logic for Safety of Execution of CPS	Provided Research Papers
26	6-Apr	thurs	Differential and Temporal Logic for Safety of Execution of CPS	Provided Research Papers
27	11-Apr	tue	Topics on Machine Learning and CPS	Provided Research Papers
28	13-Apr	thurs	Topics on Machine Learning and CPS	Provided Research Papers
29	18-Apr	tue	Topics on Machine Learning and CPS	Provided Research Papers
30	20-Apr	thurs	Project Presentations	-
31	25-Apr	thurs	Project Presentations	-