CPS1: Testbeds, Applications, and Policy
Credits: 3
Course Number: ENGR 6599
Instructors: Tolu Odumosu and Brad Campbell

Abbreviated Course Description

This is a core Cyber-Physical Systems (CPS) class. This course is designed to develop cross-competency in the technical, analytical and professional capabilities necessary for the emerging field of Cyber-Physical Systems (CPS). It provides convergence learning activities that are based around developing CPS test-beds and exploring the ethical, social and policy dimensions of CPS work. The course also introduces and emphasizes the importance of communication as a necessary skill.

Overview
CPS as a discipline integrates the cyber, physical and social worlds. The responsibilities of CPS professionals are then to sense, analyze and actuate upon the world with efficient, safe, secure and efficacious engineered systems. To do this effectively, CPS professionals need to develop cross-competency in technical, analytical and professional capabilities that are necessary for the efficacious and safe functioning of CPS systems. CPS is an inherently interdisciplinary discipline and practicing engineers must build systems and create knowledge at the inter-section of multiple knowledge domains. The best way to learn to do this is by participating in convergence learning activities that integrate an interdisciplinary CPS perspective from the onset.

Test-Beds are an important and useful tool for the CPS engineer. They allow for the simulation of real-world conditions and enable engineers to carefully observe the impact of their designs, changes and interventions in a controlled environment. CPS engineers must understand how test-beds are utilized, deployed and maintained. Test-Beds allow for rigorous testing and certification before changes are deployed on live systems. They allow for validation of data collection and are a great avenue to think critically about all aspects of the system’s design.

CPS engineers also need to understand the role policy plays in shaping the possibilities of CPS systems and how technical standards can be utilized in achieving societally desirable goals of safety and resiliency. They must be able to perform critical analyses of systems with an eye towards, safety, ethics, compliance and human welfare. As all engineered systems reconfigure social relationships and hierarchies in ways that can have profound and important long-term societal implications. CPS engineers must have the analytical skills to describe and understand the interaction of their design on various human agents including users, regulators, non-users and various publics.

CPS as a discipline is at the fore-front of engineering new cyber-physical capabilities that could have significant effects on entire industries and job categories and engineers need to be prepared to participate in debates about the future that they are shaping from an informed and ethical perspective.

This course is designed to teach these necessary competencies.
Course Objectives

At the end of this course, you will be able to do the following:

1. Hands on work with test-beds, understanding sensors, actuators, programming, wireless communications, and apps. How to collect, test and build models of CPS systems with test-bed data.
2. Describe and critically comment on social and policy debates surrounding the field of CPS.
3. Understand the principles of user centered design design and how users and non-users are implicated in design.
4. Understand the IEEE Ethically Aligned Design Framework and how to utilize it to design cyber-physical systems.
5. Participate in ethical case studies and discussions of different cyber-physical systems.
6. Develop competencies in teamwork and communication in an engineering context, including the ability to communicate clearly and persuasively in verbal, visual, and written formats to colleagues and relevant stakeholders.

Assessments

Your progress in the course will be assessed on all the dimensions described in the course objectives above. We will release detailed instructions for each assessment on Collab as we progress throughout the semester.

A. CPS Case Study: Over the course of the semester, you will write a develop a fully-fledged case study of a CPS System. Your case study will examine the CPS system from multiple perspectives. Describing the sensors, actuators, software and control systems and then undertake a user-oriented analysis of the system, analyze the system using the IEEE Ethically Aligned Design framework, and discuss policy and standards as they apply to the case. Possible examples include da Vinci minimally invasive robots, Boeing MCAS 737 Max 8.

B. Test-Bed Seminar: Over the course of the semester you will participate in a test-bed seminar where you will study and gain hands on experience using at least two test-beds in the Link Lab. Potential Test beds include Living Link Lab, Smart City Test-Bed, Smart Health Test-Bed

C. Presentation & Communication Evaluation: We will collectively define the criteria for effective presentations and take develop an evaluative framework for presentations. You will need to gather feedback on your presentation mechanics over the course of the semester using the model we develop together.

D. Writing in Context: CPS engineers need to be able to undertake different kinds and styles of writing. From academic papers to patent applications to internal memos to policy reviews. This assessment requires you to focus on one element of engineering writing and prepare a writing sample-in-context.
E. **Idea Pitch**: CPS Engineers are often times entrepreneurs and need to develop entrepreneurial insights and perspectives. This ideas can be utilized both inside firms, and in starting one’s own firm. This assessment requires you to work in groups to develop a pitch for a new CPS system.

F. **Participation & Leadership**: This course can be truly transformational in your course of study here at SEAS. However, the level of benefit you will receive is directly proportional to your level of engagement and effort. Active participation is therefore essential to getting the most out of the course. As CPS engineers work in groups, you will need to apply all that we will teach you about group work to ensure that your groups are high-functioning groups. Over the course of the semester, you will have the opportunity to lead your group and will submit a self-evaluation and be evaluated by your peers on your participation and leadership in the group.

Here is a breakdown of grading weights for each assessment in the class.

- Assessment A 15%
- Assessment B 40%
- Assessment C 10%
- Assessment D 15%
- Assessment E 10%
- Assessment F 10%

**Total** 100%

Final grades are determined by the schedule below:

- **A+** 97-100
- **A** 93-96
- **A-** 90-92
- **B+** 87-89
- **B** 83-86
- **B-** 80-82
- **C+** 77-79
- **C** 73-76
- **C-** 70-72
- **D+** 67-69
- **D** 63-66
- **D-** 60-62
- **F** below 60
**Class Schedule**

**When do we meet?**
Lecture: meets Tuesday in Rice 032 - 9:30am – 10:45am
Lab: meets Thursdays in Rice 032 - 9:30am – 10:45am

**How should we meet?**
Prepared, excited, and ready to learn and contribute each and every day.

Below is the class schedule. Please consult the schedule regularly for reading assignments, assessment due dates, and other relevant information. Please check the class schedule frequently as we may make changes and updates as the semester progresses.

<table>
<thead>
<tr>
<th>Week</th>
<th>Critical Analysis, Communication, Policy &amp; Ethics</th>
<th>Sensing at Scale</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lecture &amp; Lab: Course Introduction – what is CPS; overview of the Link Lab testbed; goals; teams; hands-on</td>
<td>Applications (Outdoors) – why CPS – special problems at intersection of cyber and physical</td>
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<td>2.</td>
<td>Issues in CPS Ethics 1</td>
<td>Applications (Indoors) – why CPS and different than outdoors</td>
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<td></td>
<td>LAB: Test Bed Seminar</td>
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<td>3.</td>
<td>CPS Design &amp; STS: Case Study 1: What do engineers actually do when they design systems?</td>
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<td></td>
<td>LAB: Test Bed Seminar</td>
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<td>4.</td>
<td>Users and Non-Users:</td>
<td>Sensing Basics Embedded - Gateway – Cloud</td>
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<td>LAB: Test Bed Seminar</td>
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<td>5.</td>
<td>CPS Ethics Conversation 1: Standards and the Consequences of Classification</td>
<td>Sensor Nodes What can we measure? Examples from our testbed</td>
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<td>LAB: Test Bed Seminar</td>
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<td>6.</td>
<td><strong>Real, Imagined and Constituted Users</strong></td>
<td>Teams and testbed projects</td>
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<td>7.</td>
<td><strong>Writing in Context 1</strong></td>
<td>The Macroscope: Wireless Sensor Networks</td>
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<td>8.</td>
<td><strong>Writing in Context 2</strong></td>
<td>Long Range Communication – wireless protocols ; MAC layer</td>
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<td>9.</td>
<td><strong>Entrepreneurship &amp; CPS</strong></td>
<td>Routing</td>
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<td>10.</td>
<td><strong>CPS Case Study 1</strong></td>
<td>WSN Services: Time and Location</td>
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<tr>
<td>11.</td>
<td><strong>CPS Case Study 2</strong></td>
<td>Power: Mains vs. Batteries vs. Energy-Harvesting</td>
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<td>12.</td>
<td><strong>On Presentations and Communication</strong></td>
<td>The Edge/FOG: Processing near the sensors</td>
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<td>13.</td>
<td>Presentations</td>
<td>The Cloud: Processing at scale</td>
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<td>14.</td>
<td>Presentations</td>
<td>The Living Link Lab: A UVA Testbed Project demos</td>
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<tr>
<td>15.</td>
<td><strong>Idea Pitch</strong></td>
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General Course FAQs

How will we communicate in this course?
We will make extensive use of the course website, Collab and e-mail. You are expected to be courteous, respectful and professional in your e-mail. To distinguish between course matters and everyday business, please begin each e-mail you write with “CPS5100” in the subject line. As a professional we expect that you will pay close attention to all e-mail from the all instructors.

What texts and supplies do I need for the course?
You do not need to purchase any books for this course. We will read a number of book chapters and articles, all of which will be available under the Resources tab on Collab.

How should I submit my written work?
To facilitate accurate and speedy responses, please submit assignments electronically as PDF files to the appropriate folder in Collab. We are unable to process any other file type (e.g. doc or .docx). Late or missing work will lose points. To protect yourself from computer crashes, always make and keep a hard copy of each assignment. Remember that we grade the document as it appears on Collab. Please make sure to turn in your work correctly (i.e. not a Word doc. or a rough draft) and on time by the deadline and to check Collab to verify that it was submitted. Any late or missing work will lose significant points regardless of the reason (and even if you can produce an electronic time-stamped document that shows you haven’t made any changes since before the deadline). It is your responsibility to make sure your work is turned in correctly and on time.

What practices can hinder my performance in the course?
While we anticipate that all students will pass this course, previous unpleasant experiences require that we explain in advance the ways in which it is possible to fail the course. First, you can fail the course if you do not turn in all of the assignments and/or the quality of your work is below what we deem as the acceptable minimum. Second, we have the option to fail you if you do not submit any or all of the assignments on the due dates. And third, you can fail if you have an inordinate number of class absences, excused or unexcused.

What accommodations are there for students with learning needs?
Should you have learning needs that require accommodation, please provide the appropriate documentation from the SDAC to your Lab Heads at least two weeks before the mid-term exam. We are not necessarily able to provide accommodation once an assignment or exam is underway.

What is the Attendance Policy?
Attendance is required for all classes and is considered part of your practice of professionalism.

To whom do I go if I have a question that has not been addressed by this FAQ?
It depends. If it is a question about material discussed in lecture, please email the faculty member who gave the lecture. If it is any other question about policies or assignment or other kinds of material needs, please email Prof. Odumosu.
Statement on Safety and Wellbeing

The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that we and the University hold as critically important:

1. Power-based personal violence will not be tolerated.
2. Everyone has a responsibility to do their part to maintain a safe community on Grounds.

As a result, the School of Engineering and Applied Science proudly serves as a safe space for its students and aims to promote their safety and wellbeing. If you are feeling overwhelmed, stressed, or isolated, there are many individuals here who are ready and wanting to help. If you wish, you can make an appointment with any of your SEAS faculty, and go to their office to talk in private.

As your professors, know that we care about you and your well-being and stand ready to provide support and resources as we can. You should also be aware that as faculty members, we are responsible employees, which means that we are required by University policy and federal law to report what you tell us to the University’s Title IX Coordinator.

The Title IX Coordinator’s job is to ensure that reporting students receive the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community. If you would rather keep this information confidential, there are Confidential Employees you can talk to on Grounds (http://www.virginia.edu/justreportit/confidential_resources.pdf). The worst possible situation would be for you or your friend to remain silent when there are so many here willing and able to help.

If you or someone you know is struggling with gender, sexual, or domestic violence, there are many community and University of Virginia resources available. The Office of the Dean of Students, Sexual Assault Resource Agency (SARA), Shelter for Help in Emergency (SHE), and UVA Women’s Center are ready and eager to help. Contact the Director of Sexual and Domestic Violence Services at 434-982-2774 as necessary.

Alternatively, there are also other University of Virginia resources available. The Student Health Center offers Counseling and Psychological Services (CAPS) for its students. Call 434-243-5150 (or 434-972-7004 for after hours and weekend crisis assistance) to get started and schedule an appointment. If you prefer to speak anonymously and confidentially over the phone, call Madison House’s HELP Line at any hour of any day: 434-295-8255.