

Carnegie Mellon University Master of Software Engineering

17-648: Sensor Based Systems

T, R 11:00pm – 12:20pm In Person Expectation (IPE) A4, Spring 2025, 6 Units Expected Weekly Effort – 12 hours

Instructor Prof. Scott Pavetti

Email <u>spavetti@cmu.edu</u>

Office Location & Hours By Appointment

Course Description. This hands-on course takes you through the sensor based IoT world, from basic sensor technologies all the way up to large-scale IoT systems and AI use cases. You'll start by getting comfortable with individual sensors and processing sensor signals, then move on to scenarios that involve control and data acquisition. Next, you'll learn about wireless protocols, network setups, and data collection techniques that connect everything together. As the course progresses, you'll pick up skills in IoT security, cloud integration, and making sense of all that data. We will finish with learning design paradigms for full-scale IoT systems. We focus on practical learning with real projects, showing you how to tackle scaling challenges from managing lots of devices to deploying globally. By the end of this course, you'll know how to build IoT solutions that can grow from a simple prototype to a production system.

Prior Knowledge. Students taking this course should have some prior experience with IoT or embedded devices, but it isn't a hard prerequisite. The course has significant programming components, requiring writing C code compiled on the gcc compiler. The class will require proficiency with C/C++, python, Linux command line, and Docker to succeed. Additional knowledge is required for containerization and Linux. No prior knowledge of sensors or wireless systems is necessary.

Technologies. Docker, MQTT, Grafana, Prometheus, C/C++, Python, Linux, GCC toolchain

Learning Objectives. After completing this course, you will be able to:

- Code (in C) selected design subcomponents of sensor based embedded systems.
- Evaluate the effectiveness of software designs in guiding software implementations.
- Prototype and evaluate sensor-based systems spanning from the device to visualization on backend systems.

Learning Resources:

All readings will be provided via Canvas, no textbook is required for this course.

Use of Zoom in the Class:

In our class, we will not be using Zoom unless circumstances change.

Assessments.

- Quizzes: Testing your knowledge of the fundamentals.
- **Programming Assignments**: Programming the designed parts of a system done in C.
- **Project Milestones:** Prototyping a system of remote sensors integrated with a vehicle, a gateway, and a backend monitoring and storage solution.
- **Class participation**, to enrich the discussion with your insight, relevant experience, critical questions, and analysis of the material. The quality of contribution is more important than the quantity.

Assessment	Final Grade %	Grade	Percentage Interval
Programming Assignments	30%	A+, A, A-	98-100%, 92-98%, 90-92%
Project Milestones	40%	B+, B, B-	88-90%, 82-88%, 80-82%
Participation	10%	С	70-80%
Quizzes	20%	D	60-70%
		R (F)	Below 60%

End of Semester Grade Increase Policy

We all know the frustration of being just a percentage point away from the next highest grade. This course has a grade bump policy that lets students have a chance to overcome this problem. Below are the criteria you can use to attempt the next highest grade.

If your final percentage is within 0.5% of the next grade increment, email the instructor and ask for a grade increase. The instructor will reply with a question that you must answer about the course. If the answer is accepted, you will receive the next highest grade.

If your final percentage is between 1% and 0.5% it is the instructor's discretion, which you may be declined or asked *two* bonus questions. The choice depends on factors, but mostly

timeliness in assignments, and course engagement. To make it more likely to get the grade bump questions you should have attended and participated in class and have been timely with submissions.

All responses to bonus questions must be within 24 hours of the instructor's question email to receive credit. In addition to this stipulation, all bump requests must be made no less than 3 days prior to the end of semester grading deadline.

Programming Assignments

Programming is a significant component of Sensor Based Systems. Programming assignments will be implementations of specific topics covered by in-class lectures. Assignments vary from year to year, but here are some titles of assignments to give you an idea of what to expect.

- 1. C Programming Integrity checks
- 2. C Programming Transfer Functions
- 3. Python Lidar Data Interpretation
- 4. C Programming Serial Command Interfaces

IoT Project

This course features a prototype project that navigates the space of 'full stack' Sensor Based IoT systems. Students will develop a working system based on tools such as docker, MQTT, Prometheus, and Grafana. There are several milestones associated with the project, each one building the system up incrementally. Assessments are a combination of demonstrations, reports, and technical evaluation by the instructor. See the project description on Canvas for details.

Quizzes

There are a small number of quizzes in this course and will typically be a combination of quantitative and qualitative questions on recent topics from class. There are no exams in this class. Quizzes are intended to reinforce domain knowledge of sensor-based systems and will include material up to the quizzes and aren't cumulative across quizzes.

Participation

There is a combination of several things used to assess class participation. Not surprisingly, participation is appreciated by coming to all classes, interacting with the instructor and other students on discussions, and the activity done in collaborating and maintaining a coding standard document.

Course and Grading Policies

• Late-work policy: All work is expected to be handed in at the indicated due date and time. Every assignment has a one-day grace period Work that is turned in after the grace period may be assessed a daily penalty up to 5 days then the assignment will be assessed at a zero. In the first week of classes, a course schedule is available on Canvas for each assignment, assignment; please use them to plan. Any request for an assignment regrade must be made within 5 days of the grade release for that assignment.

You should notify the course TA(s) and instructor <u>before</u> the submission deadline that you will submit late. Late work must be submitted as soon as circumstances allow, ordinarily within 24 hours of the grace period. If you have any questions, you should raise them immediately rather than waiting for conflicts to arise.

• **Participation policy**. Class participation will be graded by in-class engagement, including asking relevant questions based on a critical review of required readings, lectures, and comments made by your peers. The lack of attendance, and the use of mobile devices, including phones and laptops, will count against your participation grade.

This semester involves regular use of technology during class — both for in-person and remote students. Research has shown that divided attention is detrimental to learning, so I encourage you to close any windows not directly related to what we are doing while you are in class. Please turn off your phone notifications and limit other likely sources of technology disruption, so that you can fully engage with the material, each other, and me. This will create a better learning environment for everyone.

Recording of Class Sessions. This course is not scheduled to be recorded, but if circumstances change, the class will be recorded via Panopto and shared on Canvas.

Course Schedule. The following schedule provides a general overview of topics and assignments. Please refer to the syllabus online in Canvas for specific lecture topics, reading assignments and due dates.

Schedule by Lecture Topic

Class	Торіс
1	Introduction
2	Sensor Fundamentals
3	Transfer Functions

Class	Торіс
4	Sensor Noise and Filtering
5	Control – On/Off, PID, and FLC
5	Datalogging
6	Sensor Dive - Lidar
-	No Classes - Carnival
8	Messaging and Gateways
9	Wireless Sensor Nodes
10	Data Protocols, Databases, and IoT Workloads
11	Large Scale IoT Design
12	IoT Security and Privacy
13	Al, Analytics, and Visualization

Accommodations for Students Disabilities. If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodation and needs with me as early in the semester as possible. I will work with you to ensure that accommodation is provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at access@andrew.cmu.edu.

Academic Integrity. Honesty and transparency are important to good academic scholarship. Plagiarism and cheating, however, are serious academic offenses with serious consequences. If you are discovered engaging in either behavior in this course, you will earn a failing grade on the assignment in question, and further disciplinary action may be taken.

Academic integrity and collaboration: Honesty and transparency are important to good scholarship. Plagiarism and cheating, however, are serious academic offenses with serious consequences. If you are discovered engaging in either behavior in this course, you will earn a failing grade on the assignment in question (via the assessment of negative points on said assignment), and further disciplinary action may be taken. Additionally, and for the avoidance of doubt, the use of ChatGPT and similar LLM/AI models is *expressly prohibited* in this course; use of such tools will result in an automatic penalty of course failure in addition to a referral for potential further disciplinary action.

For a clear description of what counts as plagiarism, cheating, and/or the use of unauthorized sources, please see the University's Policy on Academic Integrity here: <u>https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html</u>. If you have any questions regarding plagiarism or cheating, please ask me as soon as possible to avoid any misunderstandings. For more information about Carnegie Mellon's standards with respect to academic integrity, you can also check out the Office of Community Standards & Integrity website: <u>https://www.cmu.edu/student-and-students/avoiding/index.html.</u>

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Student Wellness. As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, increased anxiety, substance use, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. CMU services are available, and treatment does work. You can learn more about confidential mental health services available on campus at the <u>Counseling and Psychological Services</u> website. Support is always available (24/7) from Counseling and Psychological Services: 412-268-2922.

This semester is unlike any other. We are all under a lot of stress and uncertainty at this time. Attending Zoom classes all day can take its toll on our mental health. Make sure to move regularly, eat well, and reach out to your support system or me **spavetti@cmu.edu** if you need to. We can all benefit from support in times of stress, and this semester is no exception.

Respect for Diversity. It is my intent that students from all diverse backgrounds and perspective be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength, and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know if any of our class meetings conflict with your religious observations so that I can make alternate arrangements for you.