

16/18-873: Spacecraft Design-Build-Fly Lab

Fall 2024 – Spring 2025

Course Description

Spacecraft design is a truly interdisciplinary subject that draws from every branch of engineering. This capstone design class brings together the material from prior classes in a way that emphasizes the interactions between disciplines and demonstrates how some of the more theoretical topics are synthesized in the practical design of a spacecraft. The class will design, build, and test a small satellite that addresses objectives and requirements posed at the beginning of the course sequence. Students will work in subsystem teams, each focusing on some aspect of the spacecraft, but exposed to many different disciplines and challenges. Practical, hands-on engineering skills will be emphasized, along with fabrication and testing of physical hardware and the creation of thorough documentation.

Instructors

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| Prof. Zac Manchester | Email: zacm@cmu.edu |
| Prof. Brandon Lucia | Email: blucia@cmu.edu |
| TA: Neil Khera | Email: nkhera@andrew.cmu.edu |
| TA: Kyle McCleary | Email: kmcclear@andrew.cmu.edu |
| TA: Ibrahima Sow | Email: isow@andrew.cmu.edu |

Learning Objectives

The goal of this course is to give students hands-on experience designing and building small spacecraft subsystems and integrating them into a CubeSat. Throughout this course, students will:

1. Understand how the design and integration of a system whose performance depends on the success of many interacting subsystems.
2. Work within a small team to fabricate, and test hardware and software through rapid design iteration.
3. Coordinate with other teams to integrate subsystems into a complete spacecraft.
4. Gain exposure to the complete life cycle of a small satellite mission.

Logistics

The course will involve designing and building hardware in small teams. Class time will be used primarily for weekly team meetings and consulting time to meet with the instructors.

- Lectures on selected topics will be held at 3:30 on Mondays, followed by consulting hours.
- All-hands meetings will be held at 3:30 on Wednesdays, followed by consulting hours.
- Sub team meetings will be held once per week at times coordinated with the instructors.
- Attendance of weekly team meetings is mandatory.
- Slack will be used for coordination between teams and instructors. All students will be added to the “SpacecraftDesignBuildFlyLab” slack channel.
- GitHub will be used to manage project files for all teams.

Assignments and Exams

There will be no exams in this course. Evaluation will be based on participation, contribution to design and fabrication work, and final documentation from each team.

Grading

Grading will be based on:

- 25% Participation and attendance of team meetings
- 25% Individual technical contributions quantified by git commit history and peer surveys
- 25% Completeness and quality of team documentation
- 25% Outcome of design review

Learning Resources

There is no textbook required for this course. Video recordings of lectures and lecture notes will be posted online. Additional references for further reading will be provided with each lecture.

Course Policies

Attendance: This is a team-based course. In order to coordinate work among teams, participation in weekly meetings is required. If you are unable to be present at a meeting, you must notify the instructors and ensure that your teammates are prepared to present your work.

Accommodations for Students with Disabilities: If you have a disability and are registered with the Office of Disability Resources, I encourage you to use their online system to notify me of your accommodations and discuss your needs with me as early in the semester as possible. I will work with you to ensure that accommodations are 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.

Statement of Support for Students’ Health & Well-Being: Take care of yourself. 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.

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. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit <http://www.cmu.edu/counseling>. Consider reaching out to a friend, faculty, or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

CaPS: 412-268-2922

Re:solve Crisis Network: 888-796-8226

If the situation is life threatening, call the police:

On campus: CMU Police: 412-268-2323

Off campus: 911

Tentative Fall 2024 Schedule

| Week | Dates | Topics |
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| 1 | Aug 26 Aug 28 | Course Overview & Logistics Team Selections |
| 2 | Sep 2 Sep 4 | No Class (Labor Day) Mission Objectives and Requirements (Z+B) |
| 3 | Sep 9 Sep 11 | Lab Intro (TAs) All-Hands Meeting (Requirements Discussion) |
| 4 | Sep 16 Sep 18 | Spacecraft Dynamics and Simulation (Z) All-Hands Meeting |
| 5 | Sep 23 Sep 25 | Orbit Determination & Spacecraft Navigation (Z) All-Hands Meeting and Project Management (B) |
| 6 | Sep 30 Oct 2 | Orbital Edge Computing (B) All-Hands Meeting |
| 7 | Oct 7 Oct 9 | Machine Vision in Space (Kyle) All-Hands Meeting (TAs) |
| 8 | Oct 14 Oct 16 | No Class (Fall Break) No Class (Fall Break) |
| 9 | Oct 21 Oct 23 | Attitude Determination and Control (Z) All-Hands Meeting |
| 10 | Oct 28 Oct 30 | Spacecraft Communication (Z) All-Hands Meeting |
| 11 | Nov 4 Nov 6 | Case Studies: V-R3x and PY4 (Z) All-Hands Meeting |
| 12 | Nov 11 Nov 13 | Case Study: Guest Lecture All-Hands Meeting |
| 13 | Nov 18 Nov 20 | Case Study: Guest Lecture All-Hands Meeting |
| 14 | Nov 25 Nov 28 | TBD No Class (Thanksgiving Break) |
| 14 | Dec 2 Dec 4 | Design Review Design Review |