Engin 1760: Design of Space Systems

Video course description; https://youtu.be/CYVsHzMQ9dY

After years specializing deeply into a niche within thermodynamics, it was a big adjustment when I went to work (first at Jet Propulsion Lab and then Martin Marietta) and was doing anything but thermo - droplet formation in nozzles, space mission propulsion systems, fluorine-hydrogen chemical lasers, forest fire propagation and eventually microsatellite systems design and then running a company building miniature spacecraft, none of which I knew anything about. For most engineers, what we are really prepared for is to jump into whatever the problem is that faces us, to get up to speed and to eventually create something which never existed before - a wind tunnel or a spacecraft, tires made of recycled materials or a PC chassis.

That is engin 176 - jumping into a field you may know nothing about, space engineering, a focus on design of a device and the system it lives in, and a quick dive into all the technologies relevant to space systems design, problems which come up in many other devices including PCs, smartphones, robots and kitchen appliances:

- handling batteries and power management
- wireless communications
- survival in tough environments (particularly humans mishandling their stuff)
- autonomy and automatic control
- structural design
- thermal statics and dynamics
- organizing the program to get it all done
- reliability
- cost estimation.

Finally you put all of the elements together into the simplest, most effective, system and device design. In 176 the design groups also prototype elements of their design to demonstrate physically their operation and feasibility.

Students in 176 have designed a space solar power station for power beaming to earth with no pollution or climate down-sides, ultra low cost earth orbiting telescopes for student and amateur astronomy, lighting at night from orbit for search and rescue, robots to shape zen gardens on the surface of the moon big enough to see from earth, orbital debris cleanup, asteroid defense and space greenhouses to move toward a fully autonomous space colony, which was also studied - the international lunar city of 3500 inhabitants. Brown's equisat, launched by NASA in May of 2018 and still operational in space controlled from our own Ground Station at Ladd observatory (soon to be on the roof of the ERC) began as a project in 176.

176 has a few prerequisites but they are often waived depending on the individual so don't be discouraged if you don't have them. Students with many backgrounds besides engineering, RISD students, physics and geology students, political scientists, 2nd, 3rd, 4th year and graduate students have all done well in 176. Design is a big word and it benefits from a diversity of points of view.

One intangible of 176 is that I myself took 176 as a senior in 1976, and then spent 40+ years in space engineering. The course goes beyond the technical. Students learn what it's like to work in your specialty, grow in it and ultimately try to make forward progress with innovative designs - not always welcomed by the *status quo*. I hope you'll consider 176 in Spring Semester. Any questions please email me directly:
rick_fleeter@brown.edu

See you in space?

- Rick Fleeter

EN1760 – Design of Space Systems

Instructor: Professor Rick Fleeter

Course Description:
Application of engineering techniques developed in previous coursework to the specific demands of space mission and systems design. With the ultimate goal of producing a feasible, defendable mission, system and spacecraft design, engineering analysis will be undertaken including finite element thermal and structural design, materials strength and selection, analog and digital electronics systems including RF / communications and power systems, dynamics, stability and control and specific requirements for success in the space environment, including radiation, reliability and autonomy.

Prerequisite: No previous experience in space systems engineering is required.
Prerequistes listed on CAB applicable only for students taking 1760 for senior capstone design course credit in the BSc program in engineering.

Texts: Lecture slides and audio MP3 files are available at course website on Canvas. Space Mission Engineering (James Wertz, Editor) and The Logic of Microspace (Rick Fleeter) both published by Kluwer Scientific Press.

Class Schedule: 3 x 50 min lectures each week (MWF 1 - 1.50 pm)

Topics Covered

1. Introduction
2. The Space Environment
3. Propulsion systems
4. Navigation Systems; Design Tools
5. Orbits and Orbital Calculations
6. Launch Vehicles
7. Power and Mechanisms
8. Radio and Communications
9. Thermal/Mechanical Design; Finite Element Analysis
10. Reliability
11. Digital electronics and software
12. Project Management
13. Economic Considerations

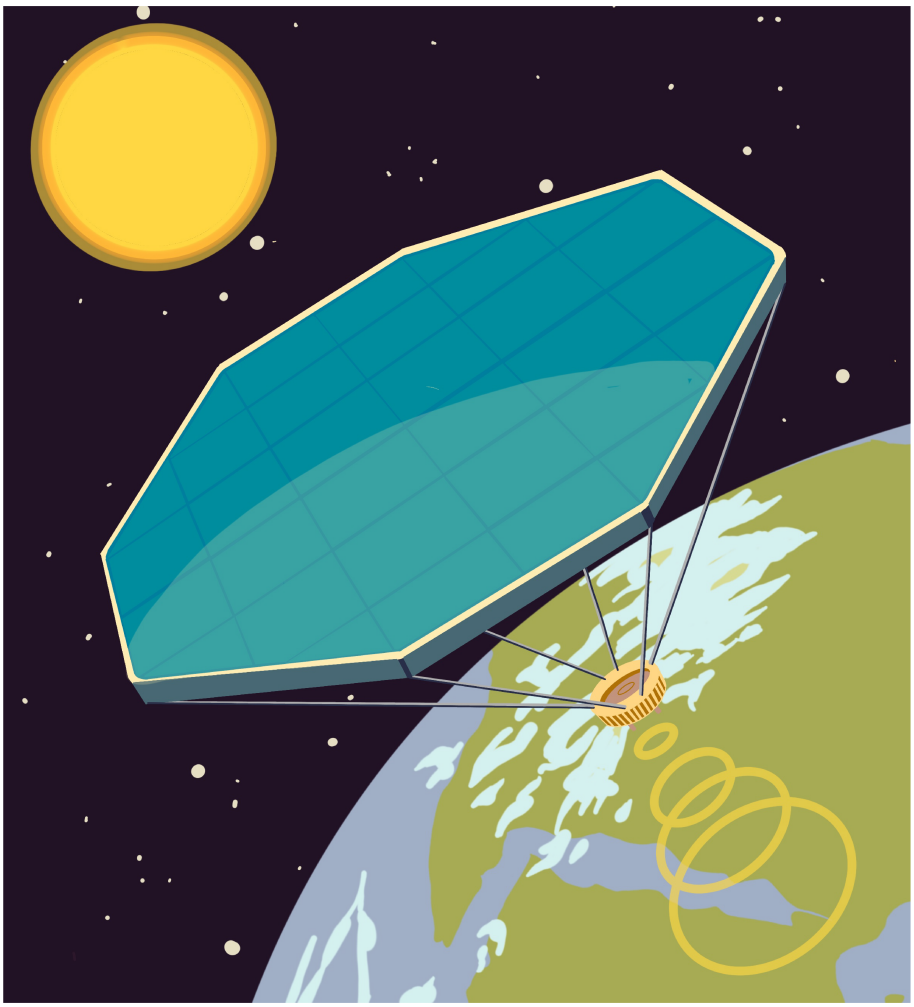
Laboratory: Students work in design groups. Each group, with guidance from Prof. Fleeter and the TAs, will decide on a desired space activity and then architect the system which would realize that capability. That design study is ongoing throughout the semester culminating in a final presentation the last week of class made by the entire group. The team will also produce a working prototype of a critical element of their design, also presented during the last week of class. These two presentations are instead of a formal written final exam. There is also a brief one on one oral exam of about 15 minutes duration per student to talk about the student's contribution to the design project and the demonstration project and related topics from the course itself.

Design Project: Major team design project
The class members group themselves into teams of no less than 3 and no more than 5 members. Each team is responsible to synthesize a mission which must be an innovative space application which will stress one or more current technology boundaries. Over the course of the semester teams present their missions and engineering work at the conceptual, preliminary, and detailed design level to the class, instructor, TA and outside experts, and defend the design approach and feasibility, including business and legal, as well as engineering aspects. After satisfactory development of the mission statement, each team must create and present both orally and in report form, a design package incorporating all of the engineering disciplines and tools listed in the course description. In addition, one specific technology element of the system becomes the subject of a hardware design and development project, to demonstrate the viability of that particular aspect of the mission.

Course Goals
- understand the be able to apply the 13 topical areas to the creation of a mission concept and to the design of an integrated solution incorporating space, ground. launch and infrastructural elements

- **defend design decisions through the use of trade-studies and performance estimation**
- **communicate the design and development plan orally and in writingù**
- **construction of a hardware demonstration of a key technology or subsystem**

Professionalism Component:
Elements of course simulate professional project management, evolution and design processes. The course provides close interaction with engineers currently working in the aerospace industry. These individuals are available for consultation and sometimes attend design presentations.



ENGN 1760
Designing Space Systems

Professor: rick_fleeter@brown.edu

Spring 2020

Design for the near or far future of space exploration.

Above: Illustration of Solar Power Plant designed by students in 176