SIE 452/552: Space Systems Engineering, Spring 2025
Syllabus

Course Instructor
Instructor: Prof. Fabio Curti, Department of Systems, and Industrial Engineering (SIE)
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Office Hours: Fri 2:00 – 3:00 pm (tentative) or by Appointment
Co-instructors: Dr. Andrea D'Ambrosio (email: dambrosio@arizona.edu)
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Course Meetings
01/15/2025 – 05/07/2025 Mon-Wed-Fri, 11:00-11:50 am, C E Chavez Bldg., Room 304. The lectures will be videorecorded and posted on d2l.arizona.edu.

Course Objectives and Expected Learning Outcomes
The main objective of the course is to introduce the fundamentals of space systems engineering to senior undergraduate and graduate science and engineering students. Designing a system for a space mission (e.g. spacecraft, smallsat, cubesat) is a complex endeavor that requires the understanding of a variety of specialized subjects: orbital mechanics, attitude determination and control, space communications, thermal control, propulsion, power systems, structure and mechanisms. The course structure is conceived to provide the students with the skills and methodologies that are required to complete a preliminary design of a space system at both system and subsystem levels. Fundamentals of spacecraft subsystem design are introduced and embedded in a model-based system engineering process that will drive the preliminary design of a full-scale space system. The lectures will provide the technical content that drives the system and subsystem design that will be accomplished throughout the semester.

By taking this course, the **undergraduate** and **graduate** students are expected to:
1. master the system engineering process required to design a space mission.
2. have a solid understanding of the principles behind spacecraft subsystem design.
3. be able to analyze each spacecraft subsystem.
4. be able to perform a preliminary sizing of the full space system.

In addition, the **graduate students** will possess the capability to:
1. perform a preliminary design of a space system.
2. specify the requirements for a space mission performing a specified task.
3. critically evaluate choices of design and architecture.

Semester assignments and final project
The students are required to prepare a design workbook that will be updated with multiple assignments over the course of the semester. The final grade will be computed by evaluating a set of assignments that will be submitted during the semester plus a final report. All Assignments will be submitted to D2L before the due date and time.

The project for the **undergraduate students** will be on the basic principles of a space system. The project for **graduate** students will concern the design of a space mission.

Course Breakdown

Weeks	Topics	Assignments
1	***Introduction to Space Systems*** ▪ Space systems, Reference Systems in Astrodynamics, Time in Astrodynamics	Assignment 1
1-2	***Fundamentals of Astrodynamics*** ▪ Keplerian Motion, Classical Orbital Elements ▪ Time Equation, Orbit Propagation (Matlab) ▪ Tsiolkovsky Equation, Impulsive Maneuvers ▪ Launch Vehicles: Launch Site, Dynamics, Examples	
3-4	***Interplanetary Missions*** ▪ Lambert Problem, Lambert Solver, Pork Chop Plots, and SPICE (Matlab) ▪ Solar System, Intercept Problem, Hyperbolic Trajectory ▪ Planetary Departure and Capture ▪ Planetary Flyby	Assignment 2
4-6	***Earth Missions*** ▪ Earth Space Environment ▪ Orbit Perturbations, TLE ▪ Ground Track Analysis ▪ LEO: Ground Track, Visibility and Coverage. ▪ GEO: GEO Maneuvers, GEO Station-keeping ▪ Ground Station Accesses (Matlab) ▪ Satellite Constellations/Periodic orbit	Assignment 3
6-8	***Attitude control*** ▪ Attitude Kinematics ▪ Attitude Dynamics and Stability ▪ Attitude Control Architecture ▪ Momentum Bias ▪ Reaction Wheels ▪ Active Magnetic Control	Assignment 4
8	***Attitude determination*** ▪ Attitude sensors ▪ Attitude estimation	
9-10	***Power & Thermal Subsystems*** ▪ Primary & Secondary Power Subsystems ▪ Power Subsystem Design ▪ Thermal Environment ▪ Thermal Control	Assignment 5

10-11	***Propulsion Subsystem*** ▪ Theoretical Rocket Performance ▪ Propellant Storage and Feeding Systems ▪ Chemical Propulsion (Cold Gas, Mono/Bi-Propellant) ▪ Electric Propulsion	Assignment 6
12-13	***Space Communication, Data Handling, &Ground Station*** ▪ Space Radio Link ▪ Link Budget ▪ Space Link Design, Examples (Matlab) ▪ Telemetry, Telecommand & Coding ▪ Ground Station	Assignment 7
14-16	***Systems Engineering Process & Final Project*** ▪ Space Project Life Cycle, TRL ▪ System Requirements, Examples ▪ **Final Project**	

Course Prerequisites

Advanced standing is required for **undergraduate** students. Please visit the webpage for more information on the advanced standing:
https://engineering.arizona.edu/academic-policies/advanced-standing.

For **graduate** students, knowledge of a programming language is required (e.g., MatLab, Python). Introductory knowledge of linear algebra, differential equations and mechanics is recommended, but it is not required because the above topics will be reviewed in class.

Reading Materials

Lecture notes, provided and can be downloaded from D2L course website
Reference books:

1. Charles D. Brown, ***Elements of Spacecraft Design***, 2nd edition, AIAA Educational Series, Reston, VA, American Institute of Aeronautics and Astronautics, Inc., ©2002. ISBN-13-978-1563472626 (Required). UoA library online
2. Howard D. Curtis, ***Orbital Mechanics for Engineering Students***, 3rd edition Elsevier. ISBN-13 -978-0080977478 (Recommended). UoA library online.
3. P. Fortescue, G. Swinerd, J. Stark, ***Spacecraft Systems Engineering,*** 4th edition, Wiley 2011, ISBN-13-978-0470750124 (Recommended). UoA library online
4. ***NASA Systems Engineering Handbook***, NASA SP-2016-6105 Rev2 (Recommended). UoA library online.

Grading Scale and Grade Policy

The grading scheme will follow the distribution below. University policy regarding grades and grading systems is available at http://catalog.arizona.edu/policy/grades-and-grading-system

Points	Percentage	Letter Grade
90-100	90%-100%	**A**
80-89	80%-89%	**B**
70-79	70%-79%	**C**
60-69	60%-69%	**D**
<60	<60%	**E**

Course grades for **undergraduate** section will be determined based on the following criteria:
5 Assignments (max 16 points each): 80
Final project max 20 points: : 20

Course grades for **graduate** section will be determined based on the following criteria:
5 Assignments (max 14 points each): 70
Final project max 30 points: : 30

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Subject to Change Statement

The information contained in the course syllabus, may be subject to change, as deemed appropriate by the instructor, see http://policy.arizona.edu/faculty-affairs-and-academics/course-syllabus-policy-undergraduate-template.