



Department of Astronautical Engineering

ASTE 330 Fall 2018: Introduction to Spacecraft Systems and the Space Environment

3 units

Lecture Tuesdays and Thursdays 9:30-10:50 AM, VKC 260

Instructor:

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Office Hours: By appointment.

NOTE: For the second time, ASTE 330 is being offered as a two-semester course. Eventually it will be ASTE 330ab, but this time, ASTE 330 Fall 2018 will be the first semester and the second semester will be ASTE 499 in Spring 2019. The second semester will be about space systems engineering and about the design process; there will be a spacecraft design project done in teams.

Text:

There are two required textbooks:

1. Vincent L. Pisacane, *Fundamentals of Space Systems*, 2nd ed. Oxford, 2005. ISBN 978-0195162059.
2. *Space Mission Engineering: The New SMAD*, James R. Wertz, David F. Everett and Jeffery J. Puschell, eds. Microcosm, 2011. ISBN 978-1881883159.

Pisacane is a true textbook and explains things starting from first principles. SMAD is more of a reference; its explanations are quite terse, but it is more up to date and has more information on actual missions.

Midterm Exams: Thursday, September 27, in class. Thursday, November 1, in class.

Final Exam: Thursday, December 6, 11:00 AM-1:00 PM in the regular classroom.

Homework: Assigned weekly. Due on Fridays in class.

Grading: Homework, 25%; each midterm, 20%; final exam, 35%.

Software used:

Matlab: A general-purpose numeric computation environment, with some symbolic capability. An interpreted C-like language, extended with vector and matrix syntax, is coupled with mathematics and graphics libraries. The student who is comfortable with Matlab will be able to do numeric solution of any problem he or she is faced with, as well as provide graphical representation of the solutions.

NX (Siemens): A package for computer-aided design (CAD) and analysis. Used in AME coursework, so if you do not already have it installed, you will soon need to in any case. In this class, NX is used for thermal and structural analysis, particularly analysis of resonant vibration frequencies.

STK (Systems Toolkit): A package for setting up, simulating, and visualizing the operation of space missions. Launch, orbits and stationkeeping, attitude dynamics and control, communications, and ground station operations can all be simulated. ASTE has a site license for STK through a donation from the company, [Analytical Graphics Inc. \(AGI\)](http://www.agi.com). For installation and licensing of STK, see <http://astro.usc.edu/stk>



Course Material:

The times and topics given below are approximate, and the list may change as the semester progresses. We will see how things go and take more or less time on each topic as seems appropriate.

			Reading	
Week	Date	Topics	Pisacane	SMAD
1	08/21 & 08/23	Intro to spacecraft systems and the notion of tradeoffs. Intro to space environment: Solar cycle, atmospheric composition.	Ch. 2, secs. 1, 3, 4	Ch. 7, sec. 1

2	08/28 & 08/30	Geomagnetic field. Van Allen belts. South Atlantic anomaly. Orbit decay. Microgravity.	Ch. 2, secs. 2, 5-7	Ch. 7, sec. 2-5
3	09/04 & 09/06	Start on attitude and orbital control system (AOCS). Quaternions. Converting between attitude representations: Euler, RPY, transformation matrix, quaternion. Dynamics of rigid body rotation. Moment of inertia: Parallel axis theorem, similarity transform. Equations of rotational motion: Euler's equations, rate of change of quaternion. Intro to reaction wheels/momentum wheels. Attitude accuracy and jitter. Precession. External torques on spacecraft.	Ch. 5	Ch. 19, sec. 1
4	09/11 & 09/13	Attitude sensors: Sun, Earth horizon sensors. Attitude control: Gravity gradient, thrusters. Generalized parallel axis theorem. Angular momentum dumping. Gyroscopes. Equations of motion for spacecraft with reaction wheel. Control moment gyros. Magnetic torque rods.	Ch. 5	Ch. 19, sec. 1
5	09/18 & 09/20	Start spacecraft power systems. Electric circuits: voltage, current, power, resistors, diodes, MOSFETs. Eclipse in LEO. Photovoltaics: Basic performance, I-V characteristics.	Ch. 6	Ch. 21, sec. 2
6	09/25 & 09/27	Radiation degradation of solar cells. Solar array topology and shading. Batteries. Power system design. FIRST MIDTERM EXAM.	Ch. 6	Ch. 21, sec. 2
7	10/02 & 10/04	Spacecraft thermal subsystem. Thermal sources. Absorptance and emittance of surfaces and coatings. Heat exchange mechanisms. Thermal control techniques: Heat pipes, MLI, heaters, louvers.	Ch. 7	Ch. 22, sec. 2
8	10/09 & 10/11	Equilibrium temperature of simple object. Radiative heat transfer. Lumped approximation for time-dependent heat transfer equations. Analysis of thermal performance.	Ch. 7	Ch. 22, sec. 2

9	10/16 & 10/18	Start on spacecraft structures. Intro to structural analysis using NX.	Ch. 8	Ch. 22, sec. 1
10	10/23 & 10/25	Structures, continued.	Ch. 8	Ch. 22, sec. 1
11	10/30 & 11/01	Structures, continued. SECOND MIDTERM EXAM.	Ch. 8	Ch. 22, sec. 1
12	11/06 & 11/08	Intro to S/C communications. Gain, loss in decibels. Electromagnetic propagation: Latency, polarization, refraction. Atmospheric refractive dip. Transmission of atmosphere. Rain attenuation. Diffraction. Reflective focusing of radiation. Sampling and Nyquist limit. Digitization of analog signals. Communications architectures. Communication link design. Noise temperature. Shannon channel capacity. Antenna gain.	Ch. 9	Ch. 16
13	11/13 & 11/15	Tradeoff: Antenna gain vs. power. Noise sources. Bit error probability. Modulation and coding. Types of antennas. Transmitter and antenna mass. Multiplexing. Optics and remote sensing. Optical systems. Diffraction and shot noise limits. Imaging of Earth from space.	Ch. 9	Ch. 16; Ch. 17, sec. 1
14	11/20 & 11/22	Intro to S/C command and telemetry.	Ch. 10	Ch. 21, sec. 1
15	11/27 & 11/29	Review.		

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism — presenting someone else's ideas as your own, either verbatim or recast in your own words — is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in [SCampus](#) in Part B, Section 11, [Behavior Violating University Standards](#). Other forms of academic dishonesty are equally unacceptable. See additional information in [SCampus](#) and University [policies on scientific misconduct](#).

Support Systems

Student Counseling Services (SCS) — (213) 740-7711 — 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops,

and crisis intervention. <https://engemannshc.usc.edu/counseling/>

National Suicide Prevention Lifeline — 1-800-273-8255

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

<http://www.suicidepreventionlifeline.org>

Relationship & Sexual Violence Prevention Services (RSVP) — (213) 740-4900 — 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. <https://engemannshc.usc.edu/rsvp/>

Sexual Assault Resource Center

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website:

<http://sarc.usc.edu/>

Office of Equity and Diversity (OED)/Title IX compliance — (213) 740-5086

Works with faculty, staff, visitors, applicants, and students around issues of protected class. <https://equity.usc.edu/>

Bias Assessment Response and Support

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response.

<https://studentaffairs.usc.edu/bias-assessment-response-support/>

Student Support & Advocacy — (213) 821-4710

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. <https://studentaffairs.usc.edu/ssa/>

Diversity at USC — <https://diversity.usc.edu/>

Tabs for Events, Programs and Training, Task Force (including representatives for each school), Chronology, Participate, Resources for Students