ASTE 535
Space Environment and Spacecraft Interactions
Course Syllabus

Astronautical Engineering Department
Viterbi School of Engineering
Los Angeles CA

Fall 2024
Tue 6:40-9:20pm
OHE 100C

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Course Description
Space Environment and Spacecraft Interactions is a survey course which provides a broad scientific and engineering background in the natural and artificial space environment as it affects spacecraft and supporting ground systems. The course introduces students to the space environment and spacecraft interactions, important for design and operations of space systems.

Course Calendar

Class #	Date	Lecture Topic	HW # Due
1	Aug 27	**Introduction to the space environment and spacecraft interactions** definitions; space physics; space weather; spacecraft interactions at GEO, LEO, atmosphere, ground; organizations; space weather drivers; standards activities	
2	Sep 3	**Solar and planetary relationships – I** atomic physics; photon radiation; solar interior, atmosphere; solar irradiances	1
3	Sep 10	**Heliosphere and planetary relationships – II** solar gravitational field; solar magnetic field, dynamo, MHD; local magnetic/bipolar fields, CMEs, flares; solar wind magnetic field, current sheet, electrons, protons; GCRs; comets, asteroids, dust, and gas in heliosphere	2
4	Sep 17	**Neutral atmosphere environment – I** gas kinetic theory; molecular and atomic collisions; atmospheric physics; Earth's neutral atmosphere: surface and lower atmosphere, upper atmosphere with solar, auroral, conduction, mixing heating, cooling by conduction and mixing, and dynamics	3
5	Sep 24	**Atmosphere environmental effects – II (neutral atmosphere)** kinetic energy: drag, perturbations, sputtering; chemical energy: atomic oxygen erosion, UV degradation, s/c glow; thermal: temperature control; particulate: contamination; standards/guidelines and models	4
6	Oct 1	**Ionosphere environment – I (Earth's ionosphere)** ionospheric physics; thermospheric coupling; electron-ion production and loss processes: solar EUV photoionization, charged particle precipitation, Joule heating, waves, winds; ionospheric structure and dynamics; ionospheric features	5
7	Oct 8	**Ionosphere environmental effects – II (ionosphere)** systems of models characterizing the ionosphere; physical environment; example models and data streams; GPS signal uncertainties: TEC variability and scintillation; radio propagation: reflecting layers and	6

		propagation; radar system: scatter and clutter, SuperDARN; standards and guidelines; models	
8	Oct 15 7-9pm	**Midterm Exam**	7
9	Oct 22	**Magnetosphere environment – I (Earth's magnetosphere)** plasma physics basics: Maxwell's equations, Ohm's law, equation of continuity, hydrodynamic equation; particle motion and drifts; magnetic mirroring; geomagnetism; IGRF, dipole field; geomagnetic coordinates; magnetospheric structure: bow shock, magnetosheath, magnetotail, plasma sheet, neutral sheet, polar cusps; magnetospheric variability: currents, convection, storms and substorms, magnetic variations, magnetic storms, magnetic indices	
10	Oct 29	**Magnetosphere environmental effects – II (plasma)** plasma effects: electron and ion surface interactions, current collection; spacecraft charging: sources, photoelectric effect, plasma bombardment, discharge; LEO charging: unbiased, biased (solar arrays), grounding, within auroras, field aligned currents; high altitude charging: GEO, SCATHA; electrostatic discharge (ESD): Paschen discharge and arcing, design considerations, materials selection and plasma contactors	8
11	Nov 5	**Radiation environment – I (plasmasphere and radiation belts)** magnetosphere: BL coordinate system, L-shells, magnetic rigidity; plasmasphere: ionosphere topside, composition, formation, variability; radiation physics: radiation-surface interactions (photons: photoelectric effect, Compton scattering, pair production), linear attenuation, radiation damage effects; radiation environment - Van Allen Belts: inner, outer, new belts and their sources; standards and guidelines	9
12	Nov 12	**Radiation environmental effects – II (radiation effects)** radiation physics: radiation-surface interactions (photons, electrons, ions, neutrons); radiation environment characteristics: radiation units (gray, Rad, dose), Van Allen belts, solar energetic photons, solar energetic particles, galactic cosmic rays; radiation (charged particle) effects: surface impacting effects (conducting material, solar arrays, optical surfaces), penetration effects (single event upsets, latchup, deep dielectric charging), example events (Mar 1991, Jan 1994 Anik, May 1998 Galaxy-4, Oct 28-31 2003), linear energy transfer, doses, radiation shielding, radiation hazards; standards, guidelines, models (AE8, AP8, JPL, CRÈME, L2-CPE)	10
13	Nov 19	**Micrometeoroid and orbital debris environment** micrometeoroid (MM) environment: sources, terrestrial effects, fluences, directionality; orbital debris (OD) environment: population/sources, types, detectability, fluences, perturbations/lifetime; effects: hypervelocity impacts (cratering, spallation, penetration, perforations, cracks), thickness of materials; mitigation paths for debris: ISO TC20/SC14 ODCWG; standards, guidelines, models	11
14	Nov 26	**Space environment and spacecraft interaction requirements for proposed missions** mining asteroids, planets; radiation challenge; closed-loop life support; space debris, Teledesic winter, Kessler syndrome; large space structures	12
15	Dec 3	**Conclusion to the space environment and spacecraft interactions** overview of course content; further discussion of requested topics; final exam preparation	
16	Dec 17 7-9pm	**Final Exam**	

Recommended (Optional) Textbooks
- Tribble, *The Space Environment: Implications for Spacecraft Design*, Princeton University Press, 2003
- Hastings and Garrett, *Spacecraft-Environment Interactions*, Cambridge University Press, 2004
- Wertz, Everett, and Puschell, *Space Mission Engineering: The New SMAD*, Microcosm Press, 2011

Grading Breakdown
- Your final course grade will be determined by three equally-weighted categories: **homework**, **midterm exam**, and **final exam**
- Final course grades will be standardized to a class-weighted curve, with letter allocations as follows: **A+** 100-96.67, **A** 96.66-93.33, **A-** 93.32-90, **B+** 89.99-86.67, **B** 86.66-83.33, **B-** 83.32-80, **C+** 79.99-76.67, **C** 76.66-73.33, **C-** 73.32-70

Additional Policies
- All course materials, including graded homework and solutions, will be posted on DEN's D2L course website http://courses.uscden.net/
- Homework must be submitted through D2L electronically before lecture begins at 6:40 pm. Late homework submissions will earn zero credit and not be graded.
- Midterm and Final exams for all students (on-campus and DEN) will be conducted fully online and electronically
- Academic integrity as defined by the USC Student Handbook https://policy.usc.edu/studenthandbook/ will be strictly enforced