Spring 2017 Syllabus: ASTE 574
Title: Space Launch Vehicle Design

Wednesdays, 15:30-18:10, OHE 100D studio

Course Instructor: **Dr. Don Edberg**
Author Affiliation: **Professor of Aerospace Engineering, Cal Poly Pomona**
Phone: **909-869-2618** (but email is preferred; don't check office phone much)
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Course Scope and Objectives

This course is intended to provide basic knowledge and practice in the design skills for initial sizing of vehicles for powered flight to orbit. Topics include propulsion, the launch environment, ascent to orbit, performance and optimization of single and multistage rockets, internal layout, structural design, loads, stability and control, range safety, failures and lessons learned. Students will practice skills in engineering design, analysis, and problem solving by completing a series of homework assignments on a single launch vehicle design problem assigned by the instructor. The schedule for the class lectures and assignments due is given below.

Students should have exposure to engineering fields such as fluid mechanics, statics and dynamics. Exposure to aerospace-specific fields of aerodynamics, vehicle performance, and structural analysis will be very helpful. Note that assignments are numerically intensive, and good working knowledge of (and access to) a spreadsheet program such as Excel® and/or a numerical program such as MATLAB®, is *essential*.

Course Format

Class simultaneously offered remotely through VSOE Distance Education Network

Course Grading

Assignments* 60%
Midterm Design project 15%
Final exam.....25%
Total 100%

*All students will upload assignments and design projects to BlackBoard no later than the time of class start. Assignments will have a LEGIBLE cover summary / explanation sheet with name, assignment no./title, date, and a summary of the material required to be found in the assignment. Include plots, supporting spreadsheets, and calculations. Plots should have descriptive titles and legible units on axes.

Recommended Texts and materials:

There is no text. Course materials are contained in the instructor's class notes. Information for purchasing a printed version of instructor's notes will be provided.

References:

Manned Spacecraft Design Principles, Sforza, Elsevier, 2016, ISBN 9780128044254
Space Vehicle Design, Griffin and French, AIAA, 2004, ISBN 1563475391.
Elements of Space Technology, R. Meyer, Academic Press, 1999, ISBN 0124929400
Astronautics, U. Walter, WILEY-VCH, 2008, ISBN 9783527406852

SPACE LAUNCH VEHICLE DESIGN – ASTE 574

Class	Subject	Notes Chapter	Assignment Due
1	Organization of the class. LV introduction. History of rocketry & launch vehicles.	(Syllabus) Notes 1 2	
2	Current & future launch vehicles. Orbit/trajectory requirements and missions.	2 (cont.) 3	1
3	Rocket propulsion: generation of thrust, the rocket equation. Specific impulse, types of engines. Launch vehicle parameters & performance.	4 5	2
4	Staging. Structure & propulsion design trades.	5 (cont.)	3
5	Powered flight. Gravity loss. Ascent through the atmosphere, drag loss. Vehicle coordinates, moving coordinate systems. The local horizon frame. Motion of the launch site. Ascent trajectories. The gravity-turn trajectory. Numerical calculation of trajectories.	6A 6B	4
6	Application of MATLAB®/Excel® to trajectory calculation. Optimization principles. Introduction to GPOPS2 program & application to launch optimization. Structures: tanks, inter-tank & inter-stage structure, thrust structure, separation systems.	6B (cont.) 7	5
7	Δv & initial sizing, inboard profile & layout. Engine selection. Preliminary mass estimation	8	
8	Loads from ground winds. Loads during flight: thrust, aero, & inertial forces. Trimmed flight. Max-*q*. Calculation of internal forces, moments, shears.	9A	6 (trajectory simulation projects)
9	Calculation of stresses due to external loads, internal pressurization. Tank & interstage structural design. Vibration, shock, acoustic, and thermal effects.	9B 10	7
	Spring Break (no class 15 Mar. 2017)		
10	VS&A, thermal, concluded Guidance, stability & control	10 (cont.) 11A	8
11	Structural flexibility effects, Instabilities. Manufacturing. Launch pad & facilities.	11B 12A 12B	9
12	Ground testing. Safety & flight termination systems. Launch vehicle failures and reliability.	13A 13B 13C	10
13	Cost estimation including design, development, Testing, launch ops. Videos of LV development, Discussion.	14	11
14	More videos, Discussion.		12
15	Open		13
	TBD: Field trip/tour of local rocket-related facility		
16	**FINAL EXAM: Friday 05 May 2017**		14 (summary report)

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

Instructor

Don Edberg is an engineering professor, lecturer, researcher, and consultant. Currently he is Professor in Aerospace Engineering at the California State Polytechnic University, Pomona, and Lecturer on Space Launch Vehicle Design, and Spacecraft Design, at both UCLA Extension and Taksha University. He has worked in the aerospace industry for 28 years at General Dynamics Convair Division, the Jet Propulsion Laboratory, AeroVironment Inc., was a Technical Fellow at McDonnell Douglas (*Silver Eagle* award winner) and Boeing, a Visiting Faculty Researcher at the Air Force Research Laboratory, Edwards Air Force Base, and a Faculty Fellow at NASA Marshall Space Flight Center, Huntsville AL. He has worked on aircraft, launch vehicles, and spacecraft and is one of the original inventors and patent holders for the microgravity isolation system known as STABLE, the first actively-controlled microgravity isolation system, demonstrated on the space shuttle during the US Microgravity Laboratory-2 mission in 1995. He also holds several patents in vibration isolation for launch vehicles.

In 2001 Edberg began teaching full-time in the Aerospace Engineering Department at California State Polytechnic University, Pomona. He teaches the university's capstone three-quarter Flight Vehicle Design classes in launch vehicle design, spacecraft design, and aircraft design, as well as eight other astronautics, aeronautics, and propulsion classes. He has spearheaded Cal Poly Pomona's Astronautics emphasis, and is director of Cal Poly Pomona's Astronautics Laboratory. He also provides short courses in spacecraft and launch vehicle design across the U.S.

Don Edberg has a B.A. in Applied Mechanics and Engineering Sciences from University of California, San Diego (Summa Cum Laude), an M.S. in Aeronautics and Astronautics from Stanford University, and a Ph.D. in Aeronautical and Astronautical Sciences from Stanford University. He has authored or co-authored six journal papers and 20 conference publications, holds or co-holds ten U.S. patents, and is an Associate Fellow of the American Institute of Aeronautics and Astronautics.