ASTE 571: Solid Rocket Propulsion

Fall 2024 // Thursdays // 7:00-9:40 PM

Section 28490 (Online) // Section 28491 (DEN)

Course Description

This course covers advanced rocket propulsion concepts, including gas dynamics, combustion, internal ballistics, propellant chemistry, structures, and testing. Both homogeneous and heterogeneous propellants will be discussed, providing a fundamental basis for understanding real-world behaviors. Concepts from engineering heat transfer and thermochemistry will be employed as a basis for evaluating thermal and structural environments, and general performance and safety aspects of broad propellant families will be explored.

Learning Objectives

Upon completion of this course, you should be able to:

- Understand and apply solid rocket performance prediction methodologies
- Identify propellant families based on chemical composition and recognize the relative advantages and limitations of each
- Interpret and apply relevant flame models to explain propellant family combustion characteristics
- Predict theoretical thermochemical and safety characteristics of propellant formulations
- Employ motor test data for anchoring of performance models and predictions

Instructor – Dr. David A. Reese

Dr. David Reese graduated from USC with a B.S. in Astronautical Engineering and received his M.S. and Ph.D. degrees in Aeronautics and Astronautics from Purdue University. He has authored numerous technical publications in leading scientific and engineering journals and presented research at domestic and international conferences.

Prerequisite(s): ASTE 470, ASTE 575, or approval of instructor

Co-Requisite(s): None

Concurrent Enrollment: None

Course Notes

For each class, you will need to download course notes in PDF format from the VSoE D2L site, print them (or download to a device that you can “write” on), and have them with you as you watch the lecture. These notes form the basis of the course material—during each session, we will supplement the provided notes with additional insights. Since this course is being offered both in person and via the Distance Education Network, course lectures will be webcast and recorded; all students will have access to these recordings via D2L.

Technological Proficiency and Hardware/Software Required

Internet access is required for viewing course notes, lectures, and other materials on D2L. Students must be able to view and print PDF documents. Some homework problems may require the use of computational solution tools of students’ choice (e.g., MATLAB, Python, or Excel).

Reading Material

- *Rocket Propulsion Elements*, Sutton, G. P., 2016. (ISBN: 1-11-875365-8)
- *Space Propulsion, Analysis, and Design*, Humble, R., McGraw-Hill, 1995. (ISBN: 0-07-031320-2)
- *Mechanics and Thermodynamics of Propulsion*, Hill, P., 1992. (ISBN: 0-201-14659-2)

Homework

Assigned homework will consist of analytical problems designed for you to demonstrate an understanding of relevant engineering principles discussed in the lectures. Assignments will be divided into two categories: smaller assessments, graded via D2L, and larger projects, graded by hand. Collaboration with other students is encouraged, however **all work submitted for grading must be demonstrably independent from that of other students**. USC's academic integrity policies, as set forth in SCampus, will be thoroughly enforced in this class.

Grading

Homework Assessments	20%
Homework Projects	30%
Midterm Exam	25%
Final Exam	25%

Assignment Submission Policy

Homework is due online at the beginning of each lecture through D2L. Detailed feedback will be provided for projects, which will require significant grading time. Solutions for all assignments will be made available at the beginning of each lecture, so late homework assignments cannot be accepted.

ASTE 571: Solid Rocket Propulsion
Notional Course Schedule

	Topic	Homework Due	Notes
Week 1 August 29	Course overview, history, component terminology, performance parameters		Section 1
Week 2 September 5	Burning rate, ballistics, 1D flows	Assessment 0 Project 0	Section 2
Week 3 September 12	Performance corrections, spatial performance variation, two-phase losses, erosive burning	Assessment 1	Section 2
Week 4 September 19	Oxygen balance, chemical equilibrium, transport properties, multiphase flow	Assessment 2	Section 3
Week 5 September 26	Energetic materials, sensitivity testing, hazard classification, propellant families	Assessment 3	Section 3
Week 6 October 3	Oxidizers, fuels, burning rate catalysis, particle characterization, binder chemistry		Section 3
October 10	Fall Recess		
Week 7 October 17	Binder mechanical properties, exam review	Project 1	Section 3
Week 8 October 24	Midterm Exam 120 min, in class		Sections 1-3
Week 9 October 31	Thermal analysis, thrust vectoring, structures, attachments, ignition		Section 4
Week 10 November 7	Diffusion, droplet evaporation, kinetics	Assessment 4	Section 5
Week 11 November 14	Thermal wave, flame structures, combustion models		Section 5
Week 12 November 21	Aluminum combustion, slag, combustion stability	Project 2	Section 5
November 28	Thanksgiving Holiday		
Week 13 December 5	Risks, communication, exam review	Assessment 5	Section 6
Week 14 December 12	Final Exam 120 min, during scheduled time		Sections 1-6