ASTE 599: Solid Rocket Propulsion

Spring 2018 // Thursdays // 6:40-9:20 PM // OHE 100C

Section 29109D (On Campus) // Section 29119D (DEN)

Course Description

This course covers advanced topics in solid rocket motor concepts and technology, including internal ballistics, performance prediction, combustion, propellant chemistry, structural design, 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 applied to the design of nozzles and thermal protection systems, and performance and safety aspects of typical propellant formulations will be explored.

Learning Objectives

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

- Understand solid rocket performance prediction methodologies and apply them in appropriate design contexts.
- Identify propellant families based on chemical composition, and recognize the advantages and limitations of each.
- Interpret the combustion characteristics of each propellant family with relevant flame models.
- Tailor propellant formulations for specific applications.
- Design propellant grains, igniters, and inert components to meet mission requirements.
- Evaluate rocket motor test data and apply the observations to full-scale motor designs.

Instructor – Dr. David A. Reese

Dr. David Reese is a project engineer in the Launch Operations Division at The Aerospace Corporation, specializing in solid and liquid rocket propulsion. He graduated from USC with a B.S. in Astronautical Engineering in 2009, and received an M.S. and a Ph.D. in Aeronautics and Astronautics from Purdue University in 2011 and 2014, respectively. He has authored numerous technical publications in leading scientific and engineering journals, and presented research at domestic and international conferences.

Prerequisite(s): ASTE 470 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).

Required & Supplementary Reading Material

There is no required textbook. The information provided in the course notes, lectures, and supplementary material will be sufficient to succeed in the class. Due to the fast-paced nature of the course, a few texts for "self-teaching" may be useful. Suggestions include:

- *Space Propulsion, Analysis, and Design*, Humble, R., McGraw-Hill, 1995. (ISBN: 0-07-031320-2)
- *Solid Rocket Propulsion Technology*, Davenas, A., Pergamon Press, 1993. (ISBN: 0-08-040999-7)
- *Principles of Solid Propellant Development*, Oberth, A. Chemical Propulsion Information Agency, 1987. (CPIA 469)
- *Rocket Propulsion Elements*, Sutton, G. P., 2016. (ISBN: 1-11-875365-8)
- *Mechanics and Thermodynamics of Propulsion*, Hill, P., 1992. (ISBN: 0-201-14659-2)

Homework

Generally, homework assignments will be analytical problems designed for you to demonstrate an understanding of relevant engineering principles discussed in the lectures. Homework will usually be assigned on a weekly basis. 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	30%
Midterm exam	30%
Final exam	40%

Assignment Submission Policy

Homework assignments are due at the beginning of each lecture, either in person or through D2L. After grading, assignments will be returned in the same manner as they were submitted. Solutions will be posted to D2L during the lecture, so late homework assignments cannot be accepted.

Grading Timeline

The teaching team will make every effort to have assignments graded and ready to return within a week of submission.

ASTE 599: Solid Rocket Propulsion
Notional Course Schedule

	Topic	Deliverables	Notes
Week 1	Course overview, SRM history, industrial base, components & terminology, performance parameters		Section 1
Week 2	Burning rate, ballistics, 1D flows	Survey, Article Review	Section 2
Week 3	Spatial performance variation, nozzle erosion, two-phase losses	HW1	Section 2
Week 4	Erosive burning, real-world effects	HW2	Section 2
Week 5	Burning stability, performance, energy density, hazard classification	HW3	Section 3
Week 6	*n*-base vs. composite, oxidizers, metals, catalysis, binders, bonding,	HW4	Section 3
Week 7	Aging, processing, exam review		Section 3
Week 8	Midterm (120 min, in class)		Sections 1-3
Week 9	Kinetics, diffusion, thermal waves, flame structures		Section 4
Week 10	Heterogeneous vs. homogeneous modeling, diagnostics	HW5	Section 4
Week 11	Metal combustion, smoke, combustion stability	HW6	Section 4
Week 12	Motor cases & closures, insulation, nozzles, flexseals	HW7	Section 5
Week 13	Thrust vector control, igniters, ordnance	HW8	Section 5
Week 14	Lab and full-scale measurements, acceptance testing	HW9	Section 6
Week 15	Reliability, performance validation, exam review	HW10	Section 6
Final	120 min, during scheduled time		Sections 1-6