ASTE 571: Solid Rocket Propulsion
Fall 2022 // Thursdays // 7:00-9:40 PM
Section 28490R (Online) // Section 28491D (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 senior 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

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	Course overview, SRM history, industrial base, components & terminology, performance parameters		Section 1
Week 2	Burning rate, ballistics, 1D flows	Assessment 0 Project 0	Section 2
Week 3	Spatial performance variation, nozzle erosion, two-phase losses	Assessment 1	Section 2
Week 4	Erosive burning, real-world effects	Assessment 2	Section 2
Week 5	Oxygen balance, chemical equilibrium, transport properties, multiphase flow, computational tools		Section 3
Week 6	Energetics definitions, sensitivity testing, hazard classification, propellant families	Project 1	Section 3
Week 7	Oxidizers, burning rate catalysis, particle characterization, exam review	Assessment 3	Section 3
Week 8	Midterm (120 min, in class)		Sections 1-3
Week 9	Polymer binders, mechanical properties		Section 3
Week 10	Insulation, nozzles, thrust vector control, cases	Assessment 4	Section 4
Week 11	Igniters, attachments, diffusion, droplet evaporation		Sections 4-5
Week 12	Kinetics, thermal wave, flame structures, elements of combustion		Section 5
Week 13	Combustion models, aluminum combustion, slag, combustion stability	Project 2	Section 5
Week 14	Systems, optimization methods, performance evaluation	Assessment 5	Section 6
Week 15	Summary, exam review		
Final	120 min, during scheduled time		Sections 1-6