ASTE 572 Advanced Spacecraft Propulsion
Notional Spring 2025 Schedule

Tuesday 6:40 – 9:20 P.M. DEN Remote Broadcast 3 Units

Date	Subject	Book	Notes	HW due
1/14	Organization of the class. Definitions. Intro. to advanced propulsion.	HP2 Chap. 10, Jahn chap. 1	1	
1/21	Mission ΔV and orbital mechanics. Review of rockets. System sizing.	HP2 Chap. 10, Jahn chap. 1	2	*
1/28	Review of thermodynamics and compressible gas dynamics.	HP2 Chap. 3	3,4,5	1
2/4	Review of thermal rockets. Heat transfer.	HP2 Chap. 11	6, 7	2
2/11	Heat transfer, Power systems. Nuclear reactions.	HP1 chap. 15	8	3
2/18	Nuclear thermal rockets. Solar & Nuclear electric propulsion systems.	JPL notes, NASA NTR notes	8	4
2/25	Electromagnetic theory: electric charges and fields, currents, and magnetic fields, and applications to ionized gases.	HP1 chap. 5 Jahn chap. 2	TBD	5
3/4	Ionization. Introduction to rarified gases. Charged particle motion. Introduction to plasma physics. Electrode phenomena.	Jahn chaps. 4 and 5, V&K, HP1 chap. 5	10	6
3/11	MIDTERM EXAM, in class, 1.5 hours			paper approvals due
3/18	Spring Break			
3/25	Introduction to arc discharges and cathodes	Jahn chap. 6	10	7
4/1	Electrostatic acceleration: 1-D space charge model, ion thrusters, ion production, beam optics, beam neutralization.	Jahn chap. 7 HP1 chap. 16	9	8
4/8	Electromagnetic acceleration: MHD channel flow; Magnetoplasmadynamic (MPD) thrusters, description and thrust derivation, operating limits, and performance calculation.	Jahn chap. 8 HP1 chap. 16	9	9
4/15	Hall Current Thrusters (HCT): physics and technology. Unsteady electromagnetic acceleration: pulsed plasma thruster (PPT). (HCT special guest lecture by Justin Pucci)	Jahn chap. 9	9	10
4/22	Electrothermal acceleration: 1-D model and frozen flow losses. Resistojet thrusters. Arcjet thrusters. Propulsion systems	Jahn chap. 6	9	11 and paper reviews due
4/29	Electric propulsion systems and spacecraft integration. Overview of advanced concepts: sails, beamed energy, fusion propulsion, antimatter propulsion.	APC Notes		12 (reistojet design project)

May13 Final Exam 7:00 – 9:00 in class

HP1 = Hill and Peterson 1st ed. (out of print, copies of needed chapters on class DEN web site
HP2 = Hill and Peterson 2nd ed.
V&K = *Intro to Physical Gas Dynamics*, Vincenti and Kruger

* Class survey, email addresses, and obtain additional needed materials for unfamiliar topics.

The first half of the course focusses on fundamentals and some systems level concepts (nuclear and solar power). We quickly review rocket basics, orbital mechanics, thermodynamics and compressible gas dynamics topics that are covered in ASTE 470/575. Additional introductory material on nuclear physics, rarefied gases, and plasma physics is covered. The second half of the class focuses on electric thruster characteristics (electrostatic, electrothermal and electromagnetic acceleration).

Instructor:

Prof. Keith Goodfellow
email: preferred keith.goodfellow@usc.edu

Communication by email is welcome and encouraged. It is reliable as well as providing a saved transcript.

TA: To be announced

TA will set up office hours/discussion section which are usually recorded and posted on D2L for those that could not attend the live session.
Instructor office hours are not formally set but can be arranged on an individual basis around work schedules and time zone differences.

Prerequisite: ASTE 470 / ASTE575 Spacecraft Propulsion or equivalent. You should be familiar with rocket performance, simple orbital mechanics (such as Hohmann transfer), compressible gas dynamics and nozzles, and basic heat transfer. We will quickly review these areas. You will also need to review basic electrostatics and magnetostatics from your physics classes.

Required Text:

Physics of Electric Propulsion, Robert Jahn, McGraw-Hill, 1968.
Reprint in paperback from Dover Publications (2006), ISBN-10: 0486450406, ISBN-13: 978-0486450407, about $15 - $25 from several online book stores. (about $22 at Amazon.com)

Recommended Text:

Mechanics and Thermodynamics of Propulsion 2nd ed., P. Hill and C. Peterson, Addison-Wesley Publishing Company, 1992 ISBN 0-201-14659-2. (same text as ASTE 470 and ASTE575 so you should already have it) An excellent book covering the fundamentals of propulsion. It covers both rockets and air-breathing. Not as much details on rockets as the following 3 textbooks, but it is a better textbook for fundamentals.

Additional References:

1. *Rocket Propulsion Elements 8th ed.*, G. P. Sutton and O. Biblarz, John Wiley & Sons, 2001. An excellent book for the fundamentals of variety of chemical rocket elements (propellants, feed system layouts, thrust vectoring, etc.). The 7th and 8th editions are much better than the previous editions.

2. *Fundamentals of Electric Propulsion: Ion and Hall Thrusters*, D.M. Goebel and I. Katz, JPL Space Science and Technology Series, 2008, Hardcopies published by John Wiley & Sons. Great book for Ion engines and Hall thrusters but targeted more towards people working in the field than as a textbook.

3. *Space Propulsion Analysis and Design*, R. W. Humble, G. N. Henry and W. J. Larson, McGraw-Hill Inc, 1995.
This book focuses more on the design methodologies of spacecraft propulsion systems and missions rather than on the fundamentals. It covers chemical, electric and nuclear systems.

4. *Introduction to Physical Gas Dynamics*, W. G. Vincenti and C. H. Kruger, Krieger Publishing, 1986.
Good book for molecular gas dynamics, statistical thermodynamics and real gas properties. Was out of print but has been recently reprinted. Sections of this text will be used for the rarefied gas material. Textbook for ASTE501a.

5. *Partially Ionized Plasmas*, M. Mitchner and C. H. Kruger, John Wiley and Sons, 1974.
Excellent book for plasmas, lots of details. Out of print but copies are available on web.

6. *Introduction to Plasma Physics and Controlled Fusion 2nd ed*., F. F. Chen, Plenum Press, 1985.
Excellent introductory book for plasmas.

7. *Fundamentals of Plasma Physics 3rd ed*., J.A. Bittencourt, Springer Publishing , 2004.
Excellent introductory book for plasmas.

8. *Any Sufficiently Advanced Technology is Indistinguishable from Magic*, R. L. Forward, Baen Publishing 1995.
An excellent combination of science fact and science fiction on advanced propulsion. Paperback (about $6).

Hand-Outs. Will consist of homework assignments and notes that are essential and mandatory to the course. Course notes, homework assignments and homework solutions will be posted on the DEN ASTE 572 Web site.

Class Procedure: Teaching will be done directly from the notes and additional in class notes. It is advisable to review the appropriate material before the lecture and bring the appropriate material to class.

Homework: As scheduled. One homework score (30 points) will be dropped for a total of 11 recorded scores. Problem set 12 (resistojet design) is worth 90 points. The homework is worth 30% of the total grade and the exam questions are often based on the homework. Therefore, if you fail to do the homework, it is unlikely you will receive a good grade for the course. No "special" problems, projects, or extra work will be given.

Homework is due at class time on the specified date. Homework is considered late if received after 9:00 AM on morning after class (Wednesday morning). Homework will be posted on the class D2L site and the assignments will be turned in there to be graded. Late homework can be submitted up to one week after the due date and will be graded and reduced by a 50% factor. No homework will be accepted after the homework has been returned or the solutions have been posted. If you have grading questions please see the TA first and then contact the instructor if there is still a problem. The Resistojet project is due on the assigned date (last class) and will not be accepted after that date.

Paper Review: Each student will write a one-page review of a student selected technical publication. Papers may be on any topic related to the course. (electric propulsion, nuclear propulsion, advanced concepts, etc.) The paper must be a technical conference or journal publications and be at least 5 pages long. A PowerPoint presentation will not be accepted as a technical paper.

Exams: Midterm exam: notionally Tuesday, March 11, 6:40– 8:10 PM. Class time
Final exam: Tuesday, May 13, 7:00 – 9:00 P.M.

Exams are closed book and closed notes. One 8 ½ inch by 11 inch sheet of notes (both sides) is allowed for the Midterm exam and 2 sheets are allowed for the Final exam. Exams will be on campus for local students and by arrangement through DEN Exams office for off campus students.

Make-up Exams: Make-exams will be given only for special circumstances. Make-up exams will be more difficult than the regular exams.

Grading:

Homework	= 30%
Midterm	= 30%
Final	= 40%