ASTE 501a Physical Gas Dynamics
Fall 2023 Schedule

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

Date	Notional Topics (schedule may change)	Book	HW due
8/23	Organization of the class. Definitions. Intro. to kinetic gas, equilibrium kinetic theory. Pressure, Temperature, and internal energy, Particle collisions	V&K chap 1	
8/30	Distributions (properties, particle, velocity, speed), transport properties	V&K chap 2 S&V chap 3	survey *
9/6	Statistical Mechanics. - probability, distinguishable and indistinguishable particles	V&K chap 4 S&V chap 2	1
9/13	Statistical Mechanics - equilibrium distribution	V&K chap 4 S&V chap 2	2
9/20	Thermodynamics. – conservation laws, Maxwells relations, chemical equilibrium	V&K chap 3 S&V chap 4	3
9/27	Quantum Mechanics – Bohr atom, Schrodinger wave equation, translation	V&K chap 4 S&V chap 5	4
10/4	Quantum Mechanics – rigid rotator, harmonic oscillator, general rotation-vibration	V&K chap 4 S&V chap 5	5
10/11	MIDTERM EXAM, in class, 1.5 hours no lecture or homework due		
10/18	Monatomic gases	V&K chap 4 S&V chap 6	6
10/25	Diatomic and polyatomic gases	V&K chap 4 S&V chap 8	7
11/1	Equilibrium gas properties	V&K chap 5 S&V chap 9	8
11/8	Plasmas – Saha equation, sheaths, plasma frequency, nonequilibrium effects	TBD	9
11/15	rocket plumes, Newtonian hypersonic approximation, rarified lift and drag and reentry	TBD	10
11/22	Thanksgiving break – no class		
11/29	Intro to numerical methods (numerical techniques, DSMC, PIC)	TBD	11

12/6 Final Exam 7:00 – 9:00 in class

V&K = *Intro to Physical Gas Dynamics*, Vincenti and Kruger
S&V Intro to Statistical Thermodynamics, Sonntag and Van Wylen
* Class survey, email addresses, and obtain additional needed materials for unfamiliar topics.

Instructor:

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

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

This class is being taught off campus through the DEN system using WebEx. Tuning in to the live lectures is strongly encouraged, since it enables students to ask questions and bring up topics for discussion. Questions and discussions are encouraged.

TA: To be announced

Required Text:
Introduction to Physical Gas Dynamics, W. G. Vincenti and C. H. Kruger, Krieger Publishing, 2002.

Additional Text:

Introduction to Statistical Thermodynamics, R. E. Sonntag and G. J. Van Wylen, Krieger Publishing 1985.
Book is out of print. Copies of key chapters will be available on our class D2L web site.

Additional References that may be useful (not required):

1. *Molecular Gas Dynamics and Direct Simulation of Gas Flows*, G.A. Bird, Oxford 1998.
2. *Molecular Gas Dynamics*, G. A. Bird, Clarendon Press, 1976. Out of print
3. *Thermodynamics, Kinetic Theory, and Statistical Thermodynamics*, F.W Sears and G.L. Salinger, Addison-Wesley 1986 Out of print
4. *Introduction to Plasma Physics and Controlled Fusion 2nd ed*., F. F. Chen, Plenum Press, 1985. Excellent introductory book for plasmas.
5. *Fundamentals of Plasma Physics 3rd ed*., J.A. Bittencourt, Springer Publishing , 2004. Excellent introductory book for plasmas.
6. *Plasma Physics Via Computer Simulation*, C. K. Birsall and A. B. Langdon, Taylor & Francis Publishing 2005.
7. *Hypersonic and High Temperature Gas Dynamics*, J. D. Anderson, AIAA Publishing, 2000.

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 501a Web site. The DEN home page is: https://courses.uscden.net/d2l/login Our class site will contain the notes for each lecture, the homework assignments, the homework and exam solutions, and the annotated lecture notes from each class. At the end of each lecture I will post the annotated lecture notes. You can download these notes if you miss anything during the lecture. They are usually posted the day after our class. The class web site is available to both on-campus and off-campus students. Everyone should have an account.

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.

Discussion Forum on DEN site. The DEN ASTE 501a web site has discussion forums in the areas of class lectures, homework and areas of interest. This is a good place to ask clarification questions on the lectures or homework that would be of interest to everyone. Please do not post solutions and keep it professional. Violators will be removed from the forum. Areas of Interest could be anything you think the rest of the class would be interested in or questions you may have.

Homework: As scheduled. One homework score (30 points) will be dropped for a total of 11 recorded scores. 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. Extra credit problems may be given at times. No other "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 (Thursday 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 call of see the TA first and then contact the instructor if there is still a problem.

Students are encouraged to work together and share ideas but each student must turn in their own work. Plagiarism, either from another's work or from previous homework solutions will not be allowed and will result in loss of credit for the assignment. Repeat offenders may be dropped from the course and expelled from the department.

If you are a distant student and would like to know if there are others in your region, let me know. I will provide a local contact list for anyone wanting it. Your contact information will not be shared to others without your written approval (email).

Exams: Midterm exam: Wednesday, 10/18, 6:40– 8:10 PM. Class time
Final exam: Wednesday, 12/6, 7:00 – 9:00 P.M.

Exams are open book and open class notes. Both exams will be taken remotely using the USC DEN D2L system. More details will be provided in class.

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%

Attendance: Up to you. We will not be keeping track.

Religious Holy Days: Please arrange in advance to make up work missed on those days.

Questions: Discussion is always welcome and encouraged on all aspects of astronautics and space explorations as well as on the topic at hand. Given the wide variety of topics in this class, there are few areas of spacecraft propulsion or power (including your favorite sci-fi vehicles) that would be considered "off topic."

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.

Biography:

Keith Goodfellow, Chief Engineer, Arcjet Thruster and Ion Engine Systems, Aerojet Rocketdyne Space Systems / L3 Harris, Redmond, WA; and Adjunct Associate Professor of Astronautics Practice, USC.

Keith Goodfellow got his B.S. in mechanical engineering with a minor in physics from the University of Utah in 1986 and his M.S. in mechanical engineering from Purdue University in 1988. At Purdue his pursued coarse-work in solid and liquid propellant rockets, hypersonic aerodynamics and performed research on electric propulsion thrusters and plasma physics. He received his Ph.D. in aerospace engineering from USC in 1996. His work was on the interactions of plasma-arc-discharges and electrodes in electric propulsion thrusters. He was a member of the Advanced Propulsion Technology Group at the Jet Propulsion Laboratory (JPL) from 1988 until 2004. At JPL he was involved with the performance and endurance testing of many different types of electric thrusters (arcjet thrusters, Hall thrusters, ion engines, MagnetoPlasmaDynamic (MPD) thrusters, and innovative thrusters), plasma diagnostics, facility and data acquisition system development, evaluation of advanced propulsion concepts, development and testing of solar and microwave driven sails, mission studies, spacecraft design, spacecraft thermal and vacuum testing, and flight operations support (Deep Space One). At the Lockheed Martin Advanced Development Programs (Skunk Works) from 2004 to 2013 he was a member of the Revolutionary Technology Programs group and performed research and development work in propulsion systems, plasma devices, advanced materials, and vehicle conceptual design. He is currently the Chief Engineer of the Arcjet Thruster and Ion Engine Systems (thrusters and Power Conditioning Units (power electronics boxes)) for Aerojet Rocketdyne L3 Harris in Redmond, WA. He is a member of the American Institute of Aeronautics and Astronautics (AIAA) Electric Propulsion Technical Committee. He has been developing and teaching courses at USC since January 2000. He codeveloped and taught ASTE 470 Spacecraft Propulsion and ASTE 280 Introduction to Astronautics and the Space Environment; and developed and teaches ASTE 572 Advanced Spacecraft Propulsion.

