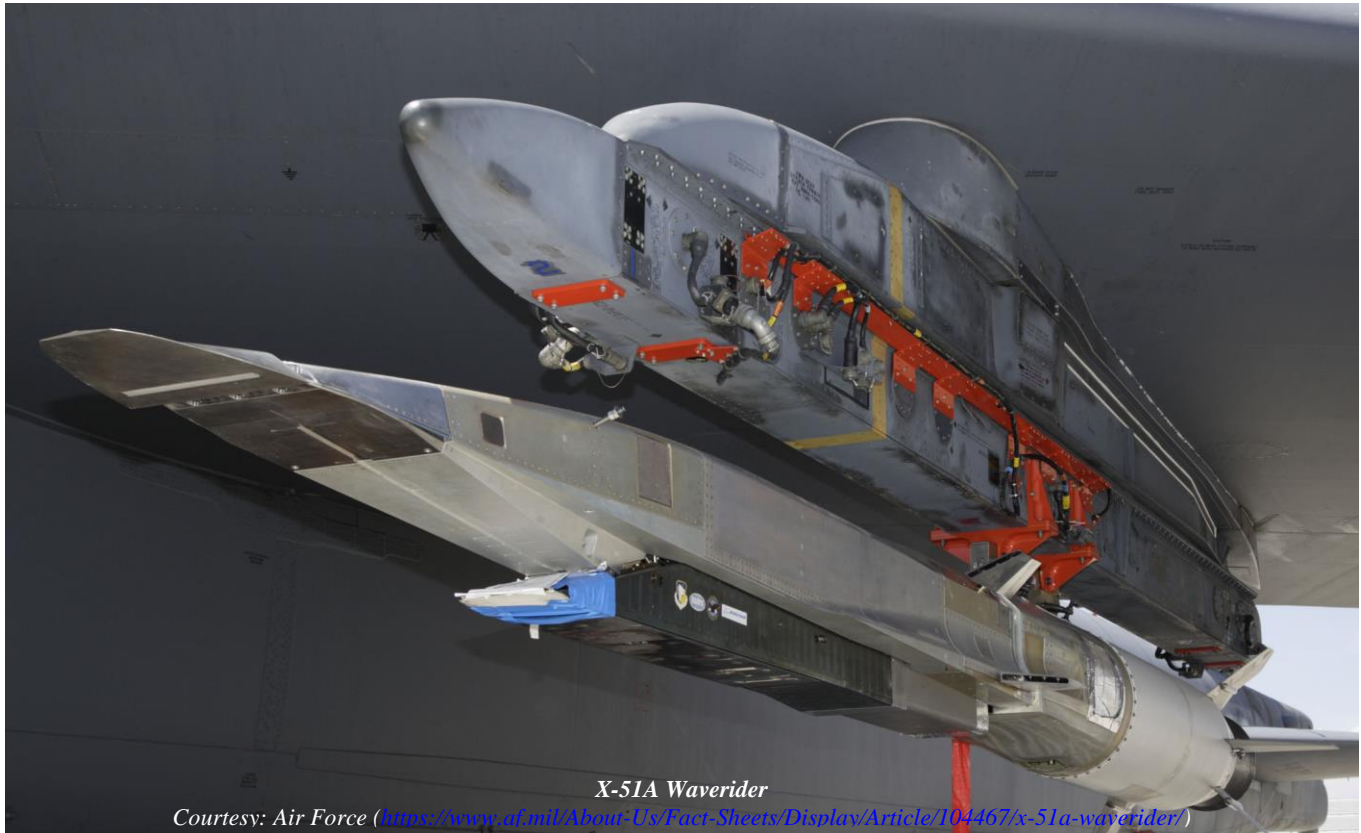


San José State University
Aerospace Engineering
AE164 – Aerothermodynamics – Fa11 2019



Instructor:	Prof. Fabrizio Vergine
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Email:	fabrizio.vergine@sjsu.edu
Office Hours:	Tuesday and Thursday: 11:30am – 12:30pm Friday: 10:00am – 12:00pm.
Class Days/Time:	Tuesday, Thursday and Friday / 1:30pm – 2:55pm
Classroom:	E341
Prerequisites:	“C” or better in PHYS 052 and AE 160

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the [Canvas Learning Management System course login website](http://sjsu.instructure.com) at <http://sjsu.instructure.com>. You are responsible for regularly checking with the messaging system through [MySJSU](http://my.sjsu.edu) at <http://my.sjsu.edu>.

Course Description

Thermodynamic laws. Shock and expansion waves with applications to supersonic airfoils and wings. Nozzle flow. Flow with heat addition and friction. Aerodynamic heating. Conduction, convection and radiation heat transfer.

Course Goals

Introduce students to:

- *Accounting for energy and determining the efficiency of thermodynamic processes.*
- *Modeling of internal and external high-speed flows.*
- *Estimation of the aerodynamic forces on super/hypersonic vehicles.*
- *Estimation of aerodynamic heating on super/hypersonic vehicles.*
- *Aerothermodynamic design principles for super/hypersonic vehicles.*

Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

- 1) *Use the 1st and 2nd laws of thermodynamics to calculate heat transfer, work done and entropy changes in a thermodynamic system.*
- 2) *Use the equation of state and the definition of enthalpy to calculate thermodynamic properties.*
- 3) *Calculate the isothermal and isentropic compressibility of a gas for given conditions.*
- 4) *Use thermodynamics and conservation equations to calculate flow parameters at various points of a flow field.*
- 5) *Calculate stagnation and critical conditions at various points of a flow field for isentropic flow, adiabatic flow, flow with heat addition and flow with friction.*
- 6) *Explain physically what happens to flow parameters when the flow (a) crosses a normal shock wave, (b) is heated or cooled and (c) is subjected to friction.*
- 7) *List the differences between a Mach wave and a shock wave.*
- 8) *Explain the conditions under which you get (a) a bow shock in front of a body or a compression corner, and (b) an oblique shock at the nose of a body or at a compression corner.*
- 9) *Explain the differences between the flow over a cone and the flow over a wedge.*
- 10) *Calculate the flow properties downstream of a Mach wave, an oblique shock wave, and a Prandtl-Meyer expansion wave.*
- 11) *Calculate the lift and drag on supersonic airfoils using shock-expansion theory.*
- 12) *Calculate the flow properties downstream of a reflected / refracted shock wave.*
- 13) *Explain mathematically and physically the relationship between flow cross-sectional area and local Mach (or flow speed).*
- 14) *Explain an (a) ideally expanded, (b) over-expanded and (c) under-expanded nozzle.*
- 15) *Calculate the flow properties at various locations of an (a) ideally expanded, (b) over-expanded and (c) under-expanded nozzle.*
- 16) *Calculate the location of a shock in a Laval nozzle (assuming there is one).*
- 17) *Design a supersonic / hypersonic wind tunnel (i.e. select the appropriate reservoir, throat and nozzle exit conditions to get the desirable test section conditions).*
- 18) *Identify when heat transfer occurs as conduction, convection, or radiation.*
- 19) *Setup and solve conduction problems using Fourier's Law.*
- 20) *Explain the difference between natural and forced convection, and the tradeoffs associated with them.*
- 21) *Setup and solve convection problems using Newton's Law of Cooling.*
- 22) *Estimate aerodynamic heating on supersonic and hypersonic vehicles.*

- 23) *Select appropriate nose shapes for different Mach numbers, and explain the tradeoffs associated with the different shapes.*
- 24) *Work effectively in a team to define and solve open-ended problems that combine compressible flow and jet / rocket engine performance.*

Course Relationship to BSAE Program Outcomes

	A	B	C	D	E	F	G	H	I
<i>Learning Outcomes</i>									
1 – 24	++	O		O	O			O	O

- +: Skill level 1 or 2 in Bloom’s Taxonomy
- ++: Skill level 3 or 4 in Bloom’s Taxonomy
- +++: Skill level 5 or 6 in Bloom’s Taxonomy
- O: Skill addressed but not assessed

Required Texts/Readings

Textbook

Anderson, J.D., Fundamentals of Aerodynamics, 6th edition, ISBN 978-1-259-12991-9

Other Readings

Instructor’s slides posted on Canvas. Additional research material will be required for the completion of the final project.

Course Requirements and Assignments

Basic proficiency with Microsoft Excel, Matlab or any other programming tools is encouraged.

Homework

Homework may be assigned but it will not be graded. Students are strongly encouraged to solve it and bring questions either to class or to office hours.

Workouts

Group efforts. Approximately 6 to 8 assignments during the semester. Assigned problems will be solved during class time by groups of 4 students and must be turned-in at the end of the meeting unless differently specified by the instructor. Dates and times of the workouts will be communicated in class. Some workouts will require work prior to class time.

Policies:

- *Attendance will be taken on the day of the Workout. Students who are absent will receive a zero in the assignment.*
- *Assignments turned-in with unclear writing, unclear steps and/or unprofessional plots (when required) will not be graded.*
- *Each member of the group must provide a short paragraph with a wet signature describing the work accomplished by him/her. Failure to do so will result in a zero in the assignment to that member.*
- *No late work assignments will be accepted.*
- *No remedial work will be given.*

Quizzes

Three individual quizzes will be provided during class times. Dates and times of the quizzes will be communicated in class one week in advance.

Policies:

- *No remedial quizzes will be given.*
- *Specific rules for each quiz will be communicated in class and posted on Canvas on the day of the announcement.*
- *In case of absence, make-up quizzes may be granted at the instructor's discretion only in these cases:*
 - *the absence is justified by a letter signed by a medical doctor in case of illness;*
 - *the absence is justified by a signed supervisor's statement, in case of work duties.*

Midterm exam

Individual midterm examination. The date of the midterm will be communicated in class.

Policies:

- *Specific rules for the midterm will be communicated in class and posted on Canvas on the day of the announcement.*
- *In case of absence, a make-up exam may be granted at the instructor's discretion only in these cases:*
 - *the absence is justified by a letter signed by a medical doctor in case of illness;*
 - *the absence is justified by a signed supervisor's statement, in case of work duties.*

Project

Teams of 4 students will be required to choose an aerothermodynamics topic with possible application in a real-life supersonic aircraft or wind tunnel facility. All groups must submit a "project proposal" which must include:

- *Abstract.*
- *Project objectives and expected outcomes.*
- *An outline of the project with a tentative schedule of the various steps required for completion and the description of the simplifications and assumptions to be made.*
- *Names of the team members with a clear and balanced assignment of tasks.*
- *Appropriate literature survey.*

Once the proposals are reviewed and approved (adjustments may be required), it is the responsibility of each group to organize meeting times and work schedule.

Additional required and graded material includes:

- *A written midterm report (dates and times TBD).*
- *A final written report due on the last day of class.*
- *A presentation of the work (dates and times TBD)*

Policies:

- *Projects must be typed. Assignments turned-in with unclear writing, unclear steps and/or unprofessional plots (when required) will not be graded.*
- *Each member of the group must provide one page with a wet signature describing the work accomplished by him/her throughout the semester. Failure to do so will result in a zero in the project to that member.*
- *No late work assignments will be accepted.*
- *No remedial work will be given.*
- *Extra credit: (up to max 10% of the final score in the project) can be assigned based on the quality of the work and the depth reached in the analysis.*

Final Exam

Individual, comprehensive final examination.

Policies:

- *Specific rules for the exam will be communicated in class and posted on Canvas on the day of the announcement.*
- *No make-up final exams will be granted.*

“Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally 3 hours per unit per week with 1 of the hours used for lecture) for instruction or preparation/studying or course related activities including but not limited to internships, labs, clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus.”

Grading Information

-	Workouts	15%
-	Quizzes	20%
-	Midterm exam	20%
-	Final exam	30%
-	Project	
	Project proposal	Pass/ Re-Submit
	Midterm report	1%
	Final report	10%
	Final presentation	4%

A plus	> 97%
A	93% - 97%
A minus	90% - 92%
B plus	88% or 89%
B	83% - 87%
B minus	80% - 82%
C plus	78% or 79%
C	73% - 77%
C minus	70% - 72%
D	60% - 69%
F	< 60%

Both for workouts and project: each individual in a group will receive the same grade as the group as a whole. For workouts only: in order to evaluate a group's performance, the instructor may periodically and randomly call students to explain the solution of the problem/problems solved by the group as a whole.

Classroom Protocol

No cellphone use is permitted in class. Respect for others is required and expected.

Academic Integrity

A student found guilty of academic dishonesty in any form (cheating, fabrication, plagiarism etc.) will automatically fail the course and will be reported to the Office of Student Conduct and Ethical Development.

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' [Syllabus Information web page](http://www.sjsu.edu/gup/syllabusinfo/) at <http://www.sjsu.edu/gup/syllabusinfo/>.

AE Department and SJSU policies are also posted at <http://www.sjsu.edu/ae/programs/policies/>

Course Schedule

The schedule may be subject to change. Any changes will be notified with fair notice through official announcements both in class and on Canvas.

Week	Topics, Readings, Assignments, Deadlines
1	Fundamentals of thermodynamics
2	Fundamentals of thermodynamics
3	Control Volume Analysis
4	1D compressible flows: total and critical quantities, speed of sound
5	1D adiabatic compressible flows: normal shocks
6	1D non-adiabatic, inviscid compressible flows: Rayleigh flow
7	1D adiabatic viscous compressible flows: Fanno flow
8	2D adiabatic supersonic flows: oblique shocks
9	2D isentropic supersonic flows: Prandtl-Meyer expansion waves
10	Supersonic airfoil theory
11	<u>Midterm Exam (tentative date: 10/31/2019)</u> Quasi 1D flow: de Laval nozzles, diffusers and supersonic wind tunnels
12	Heat transfer: conduction
13	Heat transfer: convection
14	Heat transfer: radiation
15	Elements of hypersonic flows
Final Exam	<u>Final Exam</u> ENG331, Monday, December 16 from 12:15pm to 2:30pm