

MECH 5390 Special Topics Mechanical Engr.

Compressible Flow

Course Syllabus

Spring 2024

COURSE MOTIVATION

This course builds on the students' background in Fluid Mechanics and Thermodynamics to deal primarily with flows (low-speed and high-speed) relevant to aerospace applications.

SCHEDULED MEETING TIMES

Section CRN	Time	Location
27661	T R 01:30 pm - 02:50 pm	Miners Hall 300

INSTRUCTOR: Dr. Md Mahamudur Rahman

E-MAIL: mrahman15@utep.edu

OFFICE HOURS: By Appointment (via e-mail)

OFFICE: Engr. Bldg. A#118

TEXTBOOK: Fundamentals of Aerodynamics, 5th, or 6th, or 7th Edition by John Anderson

BLACKBOARD: Instructor will be using Blackboard for uploading lecture videos, updating the syllabus (if necessary), and communicating with students via "Announcements" and email.

COURSE OBJECTIVES:

The objectives of this course are to examine the fundamentals of flowing fluids that can be treated as compressible and viscous, and to use this foundation to analyze and predict the dynamics of fluid flow fields in applied engineering and science. To this end, we will come to understand what it means to be compressible and viscous fluid, analyze and develop subsonic, supersonic and hypersonic flow field expressions, and make use of computational fluid dynamics (CFD) simulation on supersonic and hypersonic vehicles.

TOPICS

- Preliminary aspects of compressible flow
- Normal shock waves
- Oblique shock and expansion waves
- Compressible flow through nozzles, diffusers, and wind tunnels
- Subsonic compressible flow over airfoils
- Linearized supersonic flow
- Numerical techniques for nonlinear supersonic flow
- Hypersonic flow
- Fundamental principles of viscous flow
- Exact solution of Navier-Stokes equation
- Laminar and turbulent boundary layers
- Computational fluid dynamics (CFD) simulation of supersonic and hypersonic flows

COURSE SCHEDULE

Week	Week of	Reading	Lecture Topic	Due
1	01/15	7.1 – 7.2	Part#1: Inviscid Compressible Flows Chapter 7: Preliminary Aspects 1. Review of thermodynamics	
2	01/22	7.2 – 7.3 2.3	2. Review of thermodynamics 3. Definition of compressibility 4. Reynolds transport theorem	
3	01/29	2.4 – 2.5	5. Conservation of mass 6. Conservation of linear momentum	HW-1
4	02/05	2.7	7. Brief tutorial on NX CAD drawing 8. Conservation of energy	
5	02/12	7.4 – 7.5 8.1 – 8.2	9. Inviscid compressible flow governing equations. 10. Total (stagnation) conditions Chapter 8: Normal Shock Waves 11. Normal shock equations	
6	02/19	8.3, 8.6	12. Special forms of energy equation 13. Normal shock-wave properties	HW-2 Project#1
7	02/26	8.6, 8.5 9.1 – 9.2	14. Normal shock-wave properties 15. When is a flow compressible? Chapter 9: Oblique Shock and Expansion Waves 16. Introduction 17. Oblique shock relations	HW-3 Quiz#1
8	03/04	9.3 – 9.6	18. Supersonic flow over wedges and cones, Shock interactions and reflections, Detached shock wave in front of a blunt body. 19. Prandtl-Meyer expansion waves	HW-4 Quiz#2
9	03/11	No Class (Spring Break)		
10	03/18	11.2 – 11.6	Chapter 11: Subsonic Compressible Flow over Airfoils: Linear Theory 20. The velocity potential equation, The linearized velocity potential equation 21. Prandtl-Glauert compressibility correction, Improved compressibility corrections, Critical Mach number, The supercritical airfoil 22. Exam#1 (Ch. 7 – 9)	HW-5 Exam#1
11	03/25	12.2 – 12.3 13.2, 13.4	Chapter 12: Linearized Supersonic Flow 23. Linearized supersonic pressure coefficient, supersonic airfoils. Chapter 13: Numerical Techniques for Nonlinear Supersonic Flow 24. Method of characteristics, Finite-difference methods 25. Brief tutorial on NX StarCCM+ (Supersonic / Hypersonic)	HW-6 Project#2 Quiz#3

12	04/01	14.1 – 14.2	Chapter 14: Hypersonic Flow 26. Qualitative aspects of hypersonic flow, Newtonian theory Chapter 10: Compressible Flow Through Nozzles, Diffusers, and Wind Tunnels 27. Governing equations for quasi-1-D flow 28. Nozzle flows, Diffusers	HW-7 Quiz#4
13	04/08	14.3 15.2 – 15.5 16.3	29. Supersonic wind tunnel Part#2: Viscous Flows Chapter 15: Introduction to the Fundamental Principles and Equations of Viscous Flow 30. Qualitative aspects of viscous flow 31. Viscosity and thermal conduction, The Navier-Stokes equations, Viscous flow energy equation Chapter 16: Couette Flow 32. Constant property Couette flow	HW-8 Quiz#5
14	04/15	17.2 – 17.3	Chapter 17: Boundary Layers 33. Boundary-layer properties, The boundary-layer equations	HW-9 Quiz#6
15	04/22	18.5 19.1 – 19.2	Chapter 18: Laminar Boundary Layers 34. Stagnation point aerodynamic heating Chapter 19: Turbulent Boundary Layers 35. Turbulent boundary layers on a flat plate 36. Exam#2 (Ch. 10 – 19)	HW-10 Exam#2
16	04/29	19.1 – 19.2	37. Project report due 38. 3-D printed prototype due 39. Project presentations	HW-11 Project#3

GRADING: Your grade for the course will be determined using the following formula:

Exams	12.5%	×2	25%
Class Project	15%	×3	45%
Quizzes	10%		10%
Homework	15%		15%
Class Participation	05%		05%

A (100-90): B (89-80): C (79-70): D (69-60): F (59 and Below)

ABET PROGRAM OUTCOMES: This class addresses the following ABET objectives:

Outcomes 1 - 7	Evidence
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	Homework, Exams, Quizzes, Projects
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Homework, Exams Quizzes, Projects, Classroom discussions
3. An ability to communicate effectively with a range of audiences	Design project report and in-class participation
4. An ability to recognize ethical and professional responsibilities in engineering solutions and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts	Classroom discussion of sustainability; Design project
5. An ability to function effectively on a team whose members together provide leadership, create collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Design project
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions	Design project; classroom example and homework problems
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Homework; Final report for the design project

ACCOMODATIONS: If you have a disability and need classroom accommodations, please contact the Center for Accommodations and Support Services (CASS) at 747-5148, or by email to cass@utep.edu, or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at www.sa.utep.edu/cass.

Department's Policies

ACADEMIC HONESTY

During exams and quizzes, you are not allowed to use any form of wifi enabled electronic device, including cell phones or other electronic communication devices or methods (wrist watches, earbuds, etc.). No wrist watch or other electronic device may be worn. Calculators and watches may be subject to inspection. You may be asked to temporarily remove glasses to allow for their inspection.

You may not bring backpacks, hats, bulky coats or hoodies into the exam room. Lockers are not available at the exam site so plan and leave your belongings in a secure location. You may NOT sit them in a corner of the exam room.

You must show your work for all problems. You must use the paper provided by the instructor. If no work is shown you may not receive credit. After the exam, the instructor may require you to explain how you solved a problem on the exam. If you refuse to or cannot explain your work you may be subject to disciplinary action.

No electronic version of the book, loose paper print-outs of the book or extra sheets of paper of any kind are allowed unless explicitly mentioned in writing by the instructor. As a part of the zero-tolerance policy, if you have a cellphone or other electronic device capable of communication on your person; or if any proctor sees or hears any electronic device during the exam or if you share your work with someone else, you will be reported to the proper authorities and you may receive a zero on the exam or an F in the class. Other actions including suspension may also be pursued.

No one will be allowed to leave the room during an exam. This includes restroom breaks.

University approved recording devices may be located at various locations in the room and may be out of sight of the students. These recordings will be managed according to the UTEP approved regulations for such media. The instructor may create a record of your activity during the exam and may take photographs of your work during the exam.

If you are suspected of scholastic dishonesty you may or may not be directly confronted about your conduct by the instructor or proctor. You will however, be reported to the Office of Student Conduct and Conflict Resolution (OSCCR) and your exam may not be admissible. Your grade in the class may not be available until OSCCR makes a final ruling, this may adversely impact your ability to enroll in other classes.

If you arrive more than 15 minutes late to an exam, you will not be allowed to take the examination. There will be no makeup exams administered. If you have a university approved excuse, your instructor will have a process for determining how to handle the missing grade outlined in the syllabus. However, no makeup exams will be given.

If you miss more than one exam, the instructor may choose to administratively drop you from the class. This may adversely impact a visa and financial aid.

No food or drink may be brought into the examination room.

Departmental policy allows for the use of assigned seats. All students must present their UTEP issued ID prior to and during every exam and may be required to sign in. Not having a UTEP issued ID when asked will result in forfeiture of the exam. No other IDs will be accepted.

Scholastic dishonesty on homework, lab assignments and all other class assignments will be held to the same standards and requirements of academic honesty as quizzes and exams.

CLASS ATTENDANCE POLICY

Attendance is mandatory. Anyone with 5 or more absences will be dropped from the class. A drop for not attending will count toward the State Allowed Six Drop Limit. If you are failing the class at the time of the drop you may also be given a WF designation. Be advised that a drop could adversely impact visa status, financial aid and other programs.

As per UTEP rules, you may be asked to show a UTEP ID at any time during class. Anyone who is present and not registered in the class will be subject to disciplinary action unless the instructor gives prior approval.

EXCUSED ABSENCE FOR EXAMS

The UTEP catalog allows Exam Absence to be excused **ONLY** for University-Recognized Activities and very specific other situations. Medical absence is **NOT** allowed in the UTEP catalog. For consistency with the catalog, students will **NOT** be excused from exams due to illness.

HARASSMENT POLICY

The University (see Handbook of Operating Procedures 1.2.2.4) has a zero-tolerance policy for harassment. Engagement in any behavior considered harassment will be reported to the proper authorities. In addition to generally understood forms of harassment, the department also treats the following behavior as harassment:

- Repeated emails and/or calls regarding subjects that have already been addressed. Once a decision has been made or a question answered, a student who continues to ask the same question will be given a warning by the recipient of the email/call. If the student continues, the behavior will be reported. Questions that seek understanding of course material are not harassment; but repeated questions about a grade or an administrative decision are.
- Grades are **NOT** negotiable, ever. If you believe a grading mistake has been made, you must follow the process described in the UTEP catalog. Any request for a grade elevation that is **NOT** based on a mistake is considered harassment and will be reported immediately.
- Remaining in an office after the occupant requests you leave is considered harassment and potentially threatening. You will be reported immediately without warning and depending on the severity, may be reported to law enforcement.

Similar behavior towards department staff, and student advisors will also be treated as harassment, including persistent phone calls, emails, and badgering. Department staff and student advisors are there to help students, and should be treated with due respect.