

EG308: Gas Dynamics Fall 2008

Meetings: MWF 10:00 AM - 10:50 AM

Location: DW104

3 Credits

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II. Course Description: This course provides student an opportunity to study the one-dimensional and quasi-one-dimensional compressible fluid flow that emphasizes on supersonic speed. The fundamental equations (continuity, momentum, and energy equations) that govern the characteristics of compressible flow are derived. The Mach number and various flow regimes are introduced. The phenomena and sources of normal shock wave, oblique show wave, and Prandtl-Meyer expansion wave and techniques of their analysis are described. Other topics are: nozzles, diffusers, one-dimensional flow with heat addition (Rayleigh flow), one-dimensional flow with friction (Fanno flow) and shock tubes, linearized supersonic theory, moving shock waves. Transonic flow and hypersonic flow are also covered in brief. An introduction to the method of characteristics is presented.

- **Pre-requisite:** MA302 Differential Equations, EG209 Thermodynamics and EG201 Fluid Mechanics
- **Recommended Co-requisite:** Aerodynamics (For Aero major)

III. Required Texts:

Modern Compressible Flow, Third Edition, John D. Anderson, McGraw-Hill, 2003

Recommended text:

1. **Gas Dynamics**, 3rd edition, J.E. John and T.G. Keith, Prentice Hall, 2006
2. **Fundamentals of Gas Dynamics**, R.D. Zucker, O. Biblarz, Wiley, 2002
3. **Compressible Fluid Flow**, 2nd edition, M.A. Saad, ISBN: 0-13-161373-1, published by Prentice-Hall, Upper Saddle River, N.J., 1992.

IV. Objectives:

1. To develop an understanding of features of compressible flow; and mathematical and theoretical bases of compressible flow.
2. To develop the ability to differentiate between features of subsonic, transonic, transonic and hypersonic flows
3. To develop the ability to analyze several supersonic flow phenomena such as normal shock wave, oblique shock wave, Prandtl-Meyer expansion wave, flow with friction, flow with heat added.
4. To develop the ability to analyze one-dimensional flow, two dimensional flow, moving shock waves, reflected shock waves

V. Outcomes

Upon completion of this class, the student will be able to:

1. understand the mathematical and theoretical bases of compressible flow
2. an ability to predict the type of shock waves happening, when a supersonic flow is deflected; or in a supersonic nozzle
3. an ability to calculate the flow properties (e.g. pressure, temperature, density) behind shock waves
4. ability to analyze the supersonic flow with normal shock wave; oblique shock wave; friction; and heat
5. an ability to calculate the flow properties when having moving shock waves inside a shock tube
6. predict flow properties using linearized subsonic theory and linearized supersonic theory
7. understand the basic fundamentals of transonic flow and hypersonic flow

VI. Expectations

1. Class attendance is required. In this course you will be expected to act in a professional manner.
2. You are responsible for all work covered in class, whether or not you are in attendance.
3. You are expected to read the assigned material before coming to class.
4. You and I are expected to show up on time for class.
5. You are encouraged to work together on homework assignments, but not off of one another. All work on exams is to be done by the individual.
6. All members of the class will abide by the DWC Honor Code.
7. The classroom is to be a cooperative learning environment.
8. You should arrive in class with your textbook, and your notebook every lecture section.
9. I will provide copies of old exams for you to look at.
10. I will post all assignments on "Angel" one day in advance.
11. The grades of all assignments are posted on Blackboard weekly.

12. The solutions of all assignments and tests are posted on “Angel” one day after its due date.
13. You are strongly encouraged to ask questions in class.

VII. Course Policies

1. Homework is assigned every week. To be fair to all the students, the later homework or lab report is given 20% reduction in points for the first time, 40% for the second time, and no third later homework are allowed. No later homework is allowed for more than 24 hours.
2. Any student found to be cheating during an exam will receive a failing grade for the class and will be reported to the Academic Dean.
3. I will happily work with you to reschedule an exam if you inform me of a conflict in advance. I am much less likely to reschedule an exam after the fact.
4. Active participations (including asking questions and answering questions asked by me) in class activities are expected. Participation points are given based on my subjective impression.
5. Classroom activities such as chatting, web surfing, using ipod, cell phone and other electronics are not allowed.

VIII. Evaluation

You will be evaluated in a number of different ways including homework, laboratory exercises, and examinations. The percentage breakdown of these pieces is as follows:

20 %	Homework
5 %	Class participation
10%	Project
35 %	Final Exam
30 %	Three Exams @ 10% Each

Grade Scale:

A/A-	$\geq 90\%$
B+/B/B-	80-89%
C+/C	70-79%
D	60-69%
F	$< 60\%$

I will not make a determination of where the +/-'s will be until the end of the semester.

Homework: I will post assignments online for the work I want you to submit. Assignments will be turned in by hand. I will also post a selection of Problems from the text for additional practice. These should be thought of as a minimum set of problems to solve to be able to pass the class. For those who wish to earn a higher grade I would suggest doing additional problems in the assigned sections.

Exams: An exam will follow the completion of the each section. During the exams you will need to bring an engineering calculator. I am interested in you developing the ability to work with and understand formulae rather than memorizing them. As such, you may bring the textbook to use during the exam. I will make previous exams from another class available to you. The idea is to give you a chance to practice exam problems as well as giving you a look at the type of questions I like to ask on exams. Keep in mind the material covered on these old exams will not be identical as this semester's exams. I will post the solutions of all homework and tests after the homework due date and tests date.

IX: Topics:

1. The fundamental equations (continuity, momentum, and energy equations)
2. Normal shock wave
3. One-dimensional flow with heat addition (Rayleigh flow) and with friction (Fanno flow)
4. Oblique shock wave
5. Prandtl-Meyer expansion wave
6. Quasi-one-dimensional compressible fluid flow
7. Nozzles and diffusers
8. Unsteady wave motion
9. Shock tube
10. Linearized flow
11. Numerical technique for steady supersonic flow (the method of characteristics)
12. Transonic flow and hypersonic flow

IX. Additional Assistance

1. Seek me out during office hours or set up an appointment.
2. Use email to ask questions.
3. Make use of the Math/Science Center.
4. Work with one another outside of the classroom.
5. Consult with the Academic Support Center.

X. Academic Honesty

While it is assumed that no student/group would submit any material, be it homework, exam, or any other assignment for grading which is not solely his/her own work, the following policy shall be implemented in cases of academic dishonesty:

- First offense, all persons involved will receive no credit for the assignment or test.
- Second offense, all persons involved will receive a grade of F for the course.

All offenses will be reported to the Dean of Academic Affairs.

XI. Americans with Disabilities Act

Students with any type of disability that may require accommodation should contact the instructor as early in the semester as possible to discuss the needs. In addition, as mandated by

Federal Law, if you require any modifications or accommodations for this class, please contact the Director of Academic Resources to fill out the appropriate paperwork.

XII. Homework Policy

Homework provides you with an opportunity to practice the materials that are covered in class in order to develop facility with the materials and to provide ongoing preparation for tests. It also provides an opportunity for you to develop and hone your technical communication skills.

1. There will be a weekly homework. It will be due the same day the following week.
2. Homework will be collected at the beginning of class.
3. Late homework will not be accepted and will result in a grade of zero for that assignment. If you are late for class and homework has been collected at that point, yours will be considered late and not accepted.
4. Show all your works. This includes references, figures, equations, substitutions, units, and final answer.
5. Your writing must be legible. You are expected to use correct spelling, grammar, and punctuation.
6. Your work must be neat, orderly and uncrowded, without a lot of erasures and no frazzled page edges.
7. Only the material relevant to the homework must be in the submitted work.
8. Each homework pages should include page number and must be arranged in numerical order.
9. Each problem is to begin with a problem number and problem statement, followed by your work. You must provide enough written explanation so that the grader can follow your work.
10. The grade on homework assignments will be based both on the technical quality of your work and the written presentation of the work.
11. Generally, each problem should start on a new page. However, for short problems, you may put more than one on a page, but no more than three.
12. In using any equation, the reference must be addressed. If the equation is not from any reference (e.g. textbook), the derivation must be clearly illustrated. For example, if the derivation has used new forces or new coordinate system, a figure is needed.
13. Always perform the sanity check. If the result of a problem is highly off limit, there is a negative point on that. For example, if the wing area of an aircraft is found to be $10,000,000,000 \text{ m}^2$, this is clearly wrong. Thus the results must be reasonable.
14. In the calculation process, the number of digits after decimal point must be reasonable. For example, if the answer is between 10 and 20, you cannot use more than two digits after the decimal point. If the answer is in the order of 1,000,000, you should not use any

decimal at all. For example the answer of $x = 8.249874564874$ has a negative point. Thus you must round the answers to the nearest number.

15. Be consistent. For instance, you should not use a symbol (i.e. a) for two different purposes in the same problem.
16. Do not manipulate the numbers. You must not change the numbers to look right. A wrong answer is far better than a manipulated number.
17. Always show unit of any answer.
18. Draw a box around the final answer.
19. If you are drawing a technical device, it must look like the real one to the outside observer. For instance the drawing of an aircraft must not look like a car.
20. If you are including a figure in your assignment, it must have figure number, plus figure name. Furthermore, each coordinate must have a name, numbers and a unit.
21. The division of each coordinate must be reasonable. For example a coordinate of a figure cannot be divided into only two pieces or into 500 pieces. Something around 5 to 10 pieces is reasonable.
22. Do not include any page or any writings that is not related to the assignment.
23. If the homework assignment is more than a page, the pages must be stapled or tied together or bound. If the papers are stapled, nothing must be under staples.
24. Each homework assignment must have at least homework number, name of the student, course name (and course code), and date of submission.
25. If you are using an engineering software (i.e. MathCad, Excel,...), make sure you know its principles.
26. If you are using MathCad, the length of an equation must not exceed one page.
27. If you are using MathCad, show the answer of each equation with the relevant unit.
28. If you are using Excel, you must show all equations in a separate space, since the Excel only prints the results.
29. If you are not using an engineering software for your calculation, you must show all substitutions.
30. Do not include any unused number, unused calculation and unused figure in your assignment.
31. If you type the homework assignment, you will earn extra 10% in the grade of that assignment.

XIV. Project Report Format

1. Most items in section XIII (Homework policy) apply to a project report.
2. A project needs a separate first page, a table of contents, list of symbols (with their names and units), and references at the end.
3. Divide your project into less than 10 sections. Each section must have a number and a name.
4. A project needs to have an introduction and a problem statement.

5. If you are making a decision (selection) that influences the whole aircraft (such as engine type and tail configuration), you must provide a reasonable reason. The reason must support the decision and relates your selection to the design requirements. The length of reasoning must be at least half a page.
6. Most important part of a project is analysis. Bunch of numbers without interpretation and analysis worth nothing. Each section must have an analysis part to demonstrate your conclusion from those answers.
7. Do not copy a full sentence or paragraph or picture from any book or paper or website, without proper citation. When you quote from a reference, you must properly cite the source.

XIII. Calendar

Week no	Date	Topic	Chapter	HW/Test
1	4-5 Sept	Introduction	1	
2	8-12 Sept	Brief review of thermodynamics	1	HW 1
3	15-19 Sept	The fundamental equations (continuity, momentum, and energy equations)	2	HW 2
4	22-26 Sept	Normal shock wave	3	HW 3
5	29 Sept-3 Oct	One-dimensional flow with heat addition (Rayleigh flow) and with friction (Fanno flow)	3	HW 4
6	6-10 Oct	Oblique shock wave	4	Test 1
7	13-17 Oct	Prandtl-Meyer expansion wave	4	HW 5
8	20-24 Oct	Quasi-one-dimensional compressible fluid flow	5	HW 6
9	27- 31 Oct	Nozzles and diffusers	5	HW 7
10	3-7 Nov	Unsteady wave motion	7	Test 2
11	10-14 Nov	Shock tube	7	HW 8
12	17-21 Nov	Linearized flow	9	HW 9
13	24-25 Nov	Numerical technique for steady supersonic flow (the method of characteristics)	11	HW 10
	26-30 Nov	Thanksgiving Break		
14	1-5 Dec	Transonic flow and hypersonic flow	14, 15	HW 11
15	8-12 Dec	Review		Test 3
	15-19 Dec	Final Exam		