AE 5332 HYPERSONIC FLOW (Fall 2010) M, W, F 10:00 – 10:50 am Woolf Hall 221

1. Instructor:

Dr. Luca Maddalena, WH 315E, maddalena@uta.edu, Ph: 272-1123

2. Catalog Description:

A study of the basic principles of hypersonic flow. Inviscid and viscous hypersonic flow. Application of numerical methods. High temperature flow. Consideration of real gas and rarefied flow. Applications in aerodynamic heating and atmospheric entry.

3. Office Hours:

Wednesday 4:00 pm - 5:00 pm or by appointment (you are welcome to come to my office anytime, however an appointment will make sure that I am in my office).

4. Textbook:

Hypersonic and High-Temperature Gas Dynamics, John. D. Anderson, Jr., 2nd Edition, 2006, AIAA Education Series. (*Available to AIAA members with discount from http://www.aiaa.org)*

5. Supplementary References:

1. *Hypersonic Aerothermodynamics*, J. J. Bertin, 1994, AIAA.
2. *Elements of Gasdynamics*, H. W. Liepmann and A. Roshko, 1957, Reprinted by Dover Pub.

8. Grading:

Homework: 25% Project: 25% 2 Tests 25% each

Final letter grade distribution based on the overall points obtained from tests and assignments:

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

9. Policy on missing tests and late homework:

a. No make-up test will be given for the missed tests unless the student has a credible, documented excuse on the test date or an emergency, which should be also approved by the instructor (i.e., a report from doctor's office to document illness, an official document signed by the responsible university personnel for school related activities, etc.)
b. No late homework will be accepted unless the student has a credible excuse approved by the instructor

1. **Policy on academic dishonesty:** It is the philosophy of The University of Texas at Arlington that academic dishonesty is a completely unacceptable mode of conduct and will not be tolerated in any form. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures.

2. **Students with disability:** The University of Texas at Arlington is on record as being committed to both the spirit and letter of federal equal opportunity legislation. As a faculty member, I am required by law to provide "reasonable accommodation" to students with disabilities, so as not to discriminate on the basis of that disability. Student responsibility primarily rests with informing faculty at the beginning of the semester and in providing authorized documentation through designated administrative channels.

3. **Student support services available:** The University of Texas at Arlington supports a variety of student success programs to help you connect with the University and achieve academic success. These programs include learning assistance, developmental education, advising and mentoring, admission and transition, and federally funded programs. Students requiring assistance academically, personally, or socially should contact the Office of Student Success Programs at 817-272-6107 for more information and appropriate referrals.

Course Outline

1. Introduction & Fundamentals (Chapter 1, 9 & notes)
a. Definition of hypersonic flow and its significance in aerospace engineering
b. Classification of hypersonic vehicles
c. Trajectory equations for hypersonic vehicles and velocity-altitude maps
d. Definition of ballistic and lifting entry
e. Characteristics of hypersonic flow

2. Gas Dynamics of High Temperature Flows in Equilibrium (Chapters 9, 10, 11 & notes)
a. Brief review of thermodynamics for calorically perfect gases (Constant specific heats)
b. Definition of frozen, equilibrium, non-equilibrium flow
c. Thermodynamics of chemically reacting flows in equilibrium
d. Equilibrium properties of air at high temperatures

3. Shocks & Expansion Waves in hypersonic flows (Chapters 2, 14, & notes)
a. Analysis with perfect gas assumption
b. Iterative solution approach for equilibrium gas shock and expansion waves
c. Mach number independence
d. Hypersonic Similarity parameter

4. Hypersonic Aerodynamics: Pressure Distributions (Chapter 3 & notes)
a. Wedge and Stagnation point solutions
b. Local inclination methods (Newtonian flow, Modified Newtonian Method, Tangent-Wedge and Tangent-Cone Methods, Shock Expansion Methods)

i. Theory & range of applicability
ii. Numerical implementation and examples

5. Viscous Hypersonic Flow / Aerodynamic heating (Chapter 6 & notes)
a. Importance of viscous effects and role of aerodynamic heating in hypersonic flows
b. Hypersonic Laminar Boundary Layers
i. Self-similar solutions (flat plate and stagnation point solution)
ii. Fay-Riddell Correlation for stagnation point heating
c. Transition and turbulent boundary layers
d. Reference Temperature Method

6. Aerothermodynamics of Hypersonic Vehicles –Brief Overview (notes and project presentations)
a. Ballistic Entry
b. Lifting capsule re-entry (Apollo, CEV/Orion)
c. High-lift re-entry: Space Shuttle
d. Air-breathing Hypersonic Vehicles