AE 2011 – Fluids Fundamentals

HOURS: 2-0-2

CATALOG DESCRIPTION:

Flowfield concepts, fluid properties, conservation equations for flows, isentropic flow, shocks and expansions, introduction to flows with friction and heat transfer. Applications to aerospace devices.

PREREQUISITES:

ME 3322 with minimum grade of C
Math (2551 or 2561 or 25x1 or 2401 or 2411 or 24x1) with minimum grade of C

TEXTBOOKS:

Fundamentals of Aerodynamics, John Anderson, 6th ed., McGraw-Hill, 2017.

COURSE OBJECTIVES:

1) Provide students a fundamental understanding of the conservation laws and properties used to analyze fluid flows;
2) Enable students to analyze basic compressible flows, including applications to nozzles, diffusers and simple airfoils.
This is a bridge course to meet the AE 2010 (Thermodynamics and Fluids Fundamentals) requirement for AE majors who transferred from outside GT or changed majors into AE and have already received credit for ME 3322 (Thermodynamics). Students seeking the AE minor who have already taken ME3322 can also use this bridge course to meet the AE2010 requirement. The course is taught in conjunction (cross-listed) with AE 2010; so students are responsible for half the course material in 2010. Some of the material is covered in the first half of the semester, most is covered in the last third of the semester. The specific lectures and homework problems for which AE2011 students are responsible will be identified.

LEARNING OUTCOMES:

Students will gain a master level understanding of:

1. Properties of fluids (temperature, density, pressure, viscosity, speed of sound)
2. Conservation equations (integral and differential forms) for fluid mechanics
3. Bernoulli equation, hydrostatics, streamlines
4. Physical characteristics and similarity parameters associated with continuum flow regimes (subsonic, transonic, supersonic, hypersonic, steady, unsteady, viscous, inviscid)
5. Static and stagnation properties
6. Propagation of and property variation due to disturbances (Mach, shock, compression, and expansion waves)
7. Quasi-1d analysis of compressible internal flows

Students will gain a basic level understanding of:

8. Derivation of the basic conservation equations for fluid mechanics

Students will gain an exposure level understanding of:

9. Relevant applications to aerospace systems

LEARNING ACCOMMODATIONS:

If needed, we will make classroom accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the Office of Disability Services. (http://disabilityservices.gatech.edu).

ACADEMIC INTEGRITY:

Academic dishonesty is not tolerated. This includes cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code. Plagiarism includes reproducing the words or visual/graphical expressions of others without clear attribution and citation. Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code, available online at http://osi.gatech.edu/content/honor-code.

TOPICAL OUTLINE:

Topic	Lecture Hrs
I. Introduction and Overview	**1**
II. Basic Concepts and Properties of Fluids	**2**
A. Continuum vs rarefied viewpoints of fluids	
B. Flow field concepts and definitions	
1. Velocity	
2. Reference frames, fluid elements: Eulerian and Lagrangian approaches	
3. Streamlines, streaklines and pathlines	
C. Transport Properties	
1. Thermal conductivity and viscosity: diffusion	
2. Boundary layers	
3. Similarity parameters: Prandtl, Reynolds, and Mach numbers	
III. Conservation Equations	**5**
A. Mass conservation for open systems (control volumes)	
1. Differential forms and material derivatives	
B. Reynolds transport theorem	
C. Conservation of linear momentum	
1. Integral and differential forms	
2. Hydrostatic examples: atmospheric pressure, manometers, buoyancy	
3. Aerodynamic examples: lift, drag, lift coefficient and drag coefficients	
4. Propulsion examples: thrust	
5. Bernoulli equation	
6. Differential form for quasi-1D steady flows	
D. Stagnation temperature and pressure	
IV. Compressible Flows	**19**
A. Isentropic compressible flows	
1. Wave propagation in compressible substances: sound speed, Mach angle	
2. Steady, quasi-1d flow equations	
3. Steady isentropic flow with area change: Mach relations and choking	
4. Isentropic nozzle analysis and back pressure	
B. Shock waves	
1. Formation of Shock Waves - Compression	
2. Normal Shock Waves	
3. Oblique Shock Waves	
C. Prandtl Meyer expansions and compressions	
1. Flow equations - mach relations	
2. Maximum turning angle	
3. Continuous expansions and compressions	
D. Reflected waves	
1. Reflections of compression and expansion waves	
2. Application to under & overexpanded supersonic nozzles	
3. Plug and aerospike nozzles	
E. Application to lift and (wave) drag on simple airfoils	
F. Overview of flows with friction and heat transfer	
Tests/Exams/Reviews	**1**
Total	**28**