ME 3251 – Fluid Dynamics II

Credits and Contact Hours: 3 Credits. Three 50 minute or two 75 minute lectures per week.

Instructors: Thomas Barber

Textbook: *Compressible Fluid Flow*, by M. Saad, 2nd Edition, Prentice Hall, NJ, 1994.

Specific Course Information:

a. Catalog Description: One-dimensional compressible flow with applications to propulsion systems and gas-dynamic testing devices. Flows with friction and heat addition. Normal and oblique shock waves. Prandtl-Meyer flow. Selected topics in liquid flow.

b. Prerequisites: ME 3250 or CE 3120.

c. Required, Elective or Selected Elective: Elective

Specific Goals:

a. Course Outcomes:

After completing ME 3251 students should be able to:

1. Understand the difference between an incompressible fluid and a compressible fluid.
2. Calculate pressure drops in realistic piping systems involving incompressible fluids.
3. Understand the origin of pump, fan, and turbine operating curves and apply scaling laws to these devices.
4. Balance head loss curves and fan or pump curves to determine operating characteristics of realistic piping systems.
5. Calculate the speed of sound for ideal gases and calculate Mach numbers. Recognize subsonic, transonic, supersonic and hypersonic flow regimes.
6. Combine conservation of mass, momentum and energy principles with gas equations of state and the second law of thermodynamics to determine the effects of variable cross-sectional area on sub- and supersonic flows. Calculate resulting thrust forces, flow rates, and thermodynamic properties.
7. Combine conservation of mass, momentum and energy principles with gas equations of state and the second law of thermodynamics to analyze normal shocks, oblique shocks, and Prandtl-Meyer flow to quantify their impact on the performance of various systems.
8. Determine lift and drag forces on simple airfoils under supersonic conditions.
9. Apply conservation of mass, momentum and energy principles with gas equations of state and the second law of thermodynamics to analyze compressible flows with significant friction and heat transfer effects.

b. Relationship of Course Outcomes to Criterion 3 Student Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering:

apply knowledge of multivariate and vector calculus, fluid dynamics to analyze compressible flows. Emphasis is placed on simplification of complex mathematical problems to yield solutions to engineering problems.

b) an ability to design and conduct experiments, as well as analyze and interpret data: *not applicable*

c) an ability to design a system, component, or process to meet desired needs: *Students apply compressible flow theory to design supersonic inlets and supersonic duct to provide uniform supersonic inlet flow to a wind tunnel test section.*

d) an ability to function on multi-disciplinary teams: *not applicable*

e) an ability to identify, formulate, and solve engineering problems: *Students learn to identify the basic principles involved, formulate and solve compressible flow related engineering problems*

f) an understanding of professional and ethical responsibility: *not applicable*

g) an ability to communicate effectively: *not applicable*

h) the broad education necessary to understand the impact of engineering solutions in a global and societal context: *not applicable*

i) a recognition of the need for, and an ability to engage in life-long learning: *Fluid Dynamics II is an essential course for understanding the application of fluid dynamics to advanced aerospace products.*

j) a knowledge of contemporary issues: *Students are exposed to current issues in engineering through class lectures on the state of technology*

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice: *Students learn to use advanced CFD tools to complement their in-class analytical work to support and contrast reduced order compressible fluid models*

Topics Covered:

- Gas Intro., Thermo Review, Conservation Laws
- Integral Forms, Coordinate Systems, 1-D Forms
- 1D Isentropic, Quasi-1D
- Normal Shock Theory
- Oblique Shock Theory
- Expansion Waves, Fanno/Rayleigh Lines
- Complex Quasi-1D Problems, Nozzles
- Unsteady 1D Flows
- Differential Form of Conservation Laws
- Limiting Forms, Use of Coordinate Systems
- Velocity Potential Eqn., Linear Potential Eqn.
- Method of Characteristics
- Intro to Acoustics
- Acoustics, Real Gases