

Mechanical Engineering and Mechanics

MEM 320: Fluid Dynamics I

Fall 2006/Spring 2007

Designation: Elective

Catalog Description: Covers equation of motion for compressible flow; static, total, and stagnation concepts; one-dimensional isentropic, normal shock, including Fanno and Rayleigh flows and choked flow; two-dimensional supersonic flow, including Prandtl-Meyer flow and oblique shocks; analysis and design of compressible flow devices, including supersonic nozzles, diffusers, wind tunnels, inlets, and combustors

Prerequisites: MEM 220, Basic Fluid Mechanics

Textbook(s) and other required material:

Required: Fundamentals of Gas Dynamics (2nd edition) by Robert D. Zucker and Oscar Biblarz, John Wiley and Sons, 2002.

Course webpage through Drexel University and WebCT

Course Objectives:

The course aims to provide Mechanical Engineering students in their junior year with the fundamentals of gas dynamics principle. The course is also a recommended 3-credit course for a concentration in Aerospace. The emphasis is on understanding the physical principles and applying them to solve simplified engineering problems involving high-speed gas motion. Specific objectives are:

1. Develop the ability to apply mass, momentum, and energy conservation equations to the analysis of fluids.
2. Recognize the assumptions associated with incompressible flow and their limitations in analyzing compressible flow.
3. Determine from the flow conditions when compressibility must be accounted for to analyze the fluid motion.
4. Determine when a shock wave will develop in a flow and analyze the flow conditions upstream and downstream of normal and oblique shocks.
5. Analyze isentropic compression and expansion processes.
6. Explain and analyze the operation of supersonic nozzles and diffusers.

Topics Covered

1. Equation of motion for compressible flow;
2. Static, total, and stagnation concepts
3. One-dimensional isentropic, normal shock
4. Two-dimensional supersonic flow
5. Analysis and design of compressible flow devices

Class Schedule: 3 hours/week lecture (3 credits)

Contribution to Professional Component:

Introduces students to the foundation of high-speed aerodynamics and prepares them for design, research and/or management responsibilities in any industry that deals with high-speed fluid flow.

Relationship to Program Outcomes:

0 = No content; 1 = Some content; 2 = Significant content

Outcomes a - k	Content	Explanation	Evidence
a. An ability to apply knowledge of mathematics, science and engineering	2	This course requires the students to extend their knowledge of incompressible flows to high-speed compressible flows and develop, apply and hone their knowledge of fluid dynamics using mathematical analyses. The students learn how to apply and synthesize their knowledge of fluid mechanics, mathematics, science, and engineering.	Homework, Quizzes Exams.
b. An ability to design and conduct experiments as well as to analyze and interpret data	1	Real-world examples and experimental data involving shock waves and their associated temperature, pressure, velocity jumps are provided.	In-class examples involving shuttle reentry and rocket propulsion are discussed.
c. An ability to design a system, component or process to meet desired needs	1	This course requires the student to use the course material to design a supersonic nozzle (converging-diverging) given input parameters.	Homework, In-class problems
d. An ability to function on multidisciplinary teams	0	NA	NA
e. An ability to identify, formulate and solve engineering problems	2	The problems discussed require students to identify, formulate and solve engineering problems, specifically as they pertain to compressible flows.	Homework, Quizzes Exams
f. An understanding of professional and ethical responsibility	0	NA	NA
g. An ability to communicate effectively	1	In-class discussions.	In-class discussions
h. The broad education necessary to understand the impact of engineering solutions in a global/societal context	1	The impact of high-speed flows on the environment (e.g., sonic boom), economy, and society are addressed.	In-class discussion of environmental issues, safety issues, and importance of compressible flows for high speed transport.

i. A recognition of the need for and an ability to engage in lifelong learning	0	NA	NA
j. A knowledge of contemporary issues	1	Environmental & real-world issues that affect society today and high-speed transport are addressed.	NASA examples are provided with emphasis on current events, as well as in-class discussions pertaining to applications of compressible flow.
k. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice	1	The analytical tools needed to solve real-world compressible flow problems are addressed.	Homework, Quizzes, Exams

Prepared by Dr. T. A. Miller, Nov. 27, 06