Department of Mechanical Engineering

ME451– INTRODUCTION TO AERODYNAMICS

Elective

Catalog Description: **ME 451 (3-0-3)**

Introduction to the basic principles and properties of fluid flow around immersed bodies. Topics include the kinematics and dynamics of fluid fields, the thin airfoil, finite wing theory, and one-dimensional compressible flow.

Prerequisites: ME 304 – Fluid Mechanics
ME 311 – Thermodynamics I

Textbook(s) Materials Required:
Kuethe and Chow, Foundations of Aerodynamics, 5th Ed., J. Wiley.

Reference(s) (Not Required): None

Course Supervisor: Dr. P. Singh

Pre-requisite by topic

1. Calculus
2. Ordinary differential equations
3. First Law and property relations
4. Statics and dynamics
5. First and second law of thermodynamics
6. Elementary fluid mechanics

Course Objectives[1]: The following are the key objectives:

1. To learn the role of circulation in lift generation. (A,B,C,E)
2. To learn to apply the Bernoulli's equation for irrotational flows. (A,B,C,D)
3. To learn the principle of superposition of flows, and the use of source, doublet and vortex flows to construct complex flow fields. (A,B,C,D)
4. To learn the compressible flows, supersonic flows, shock waves, and compressible duct flows. (A,B,C,E)

Topics[2] :

1. Physical properties of air, kinematics, and ideal fluids (6 hrs)
2. Euler's equation, and Bernoulli's equation for irrotational flows (3 hrs)
3. Superposition; source, doublet and vortex flows (3 hrs)
3. Flow past bodies, thin airfoil theory, Kutta-Joukowski theorem and finite-wing theory (6 hrs)
5. Governing equations for compressible fluids, energy relations (3 hrs)
6. One-dimensional compressible flows (6 hrs)
7. Flows in converging-diverging nozzles (3 hrs)
8. Prandtl-Meyer flow and Normal shock waves (6 hrs)

Evaluation Method:

1. Quizzes

2. Exam
3. Homework
4. Project

Schedule: Lecture Recitation: 3 hours, per week
Professional Component: Engineering Science
Program Objectives Addressed: A, B, C, D, E

Course Outcomes[3] :

Objective 1

1.1 Students will demonstrate an ability to understand the role of circulation in lift generation, and basic airfoil shapes that result in the generation of circulation (1,2,3) (a,d,e,h,k)

Objective 2

2.1. Students will demonstrate an ability to apply the Bernoulli's equation for irrotational flows to calculate the pressure distribution on the surface of a body. (1,2,3) (a,d,e,h,k)

2. 2. Students will demonstrate the ability to calculate the force acting on a body (1,2,3) (a,c,d,e,h,k)

Objective 3

3. 1. Students will demonstrate an ability use the principle of superposition of flows to construct complex flows (1,2,3) (a,d,e,h,k)

3. 2. Students will use the basic source, doublet and vortex flows to construct flow around bodies, such as a source, vortex and rotating cylinder. (1,2,3,4) (a,c,d,e,h,k)

3. 3. Students will demonstrate an ability to determine the lift generated by a body when circulation around it is known. (1,2,3) (a,d,e,h,k)

3. 4. Students will use software to solve some exercises. (4) (a,c,d,e,h,k)

Objective 4

4.1. Students will demonstrate familiarity with the mass, momentum and energy conservation equations for subsonic and supersonic one-dimensional compressible flows. (1,2,3) (a,d,e,h,k)

4.2. Students will demonstrate an ability to design a converging-diverging nozzle for a given Mach number. (1,2,3)(a,b,c,e,h,k)

4.2. Students will demonstrate an ability to compute the Mach number for normal and oblique shock waves. (1,2,3)(a,c,e,h,k)

Prepared by: Dr. P. Singh Date: October 12, 2006

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[1] Capital Letters in parenthesis refer to the Program Objectives of the Mechanical Engineering
Department. Listed in Sec 2 d Tables B-2-9, B-2-12. Table B-2-8 links Program Objectives with the ABET a-k Criterion.

[2] Topi**c** numbers in parenthesis refer to lecture hours. (three hours is equivalent to 1 week)

[3] Outcome numbers in parenthesis refer to evaluation methods used to assess the student performance. Lower case letters in parenthesis refer to ABET a-k outcomes.