MECHANICAL ENGINEERING PROGRAM

ABET COURSE SYLLABUS

ME 400: Intermediate Fluid Mechanics (3 credits): Elective Course

Course Description (2008-2010 Catalog):

Basic laws and equations of fluid flow; very viscous flow solutions; boundary layer flows; potential flows; wave phenomena; transport phenomena; turbulence.

Prerequisite Course: ME 380

Prerequisite by Topic:

- Fluid dynamics for mechanical engineers

Textbooks: (1) David C. Wilcox, "*Element of Fluid Mechanics,*" 1st Edition, 2005, DCW Industries, Inc. (2) Ronald L. Paton, "*Incompressible Flow,*" 3rd Edition, 2005, John Wiley & Sons, Inc.

Other Reference Materials: (1) Frank M. White, "*Fluid Mechanics*," 6th Edition, 2008, McGraw-Hill Companies, Inc. (2) I.G. Currie, "*Fundamental Mechanics of Fluids*," 3rd Edition, Marcel Dekker, Inc., 2003. (3) Frank M. White, "*Viscous Fluid Flow*," 3rd ed., New York: McGraw-Hill, 2006. (4) Van Dyke, "*An Album of Fluid Motion*," Stanford, Calif.: Parabolic Press, 1982. (5) M. Samimy, K. S. Breuer, L. G. Leal, and P. H. Steen, "*A Gallery of Fluid Motion*," Cambridge University Press, 2003. (6) Hermann Schlichting, "*Boundary-Layer Theory*," 8th Edition, Springer-Verlag, 1999. (7) R. B. Bird, W. E. Stewart, and E. N. Lightfoot, "*Transport Phenomena,*" 2nd Edition, John Wiley & Sons, Inc., 2002. (8) David J. Acheson, "*Elementary Fluid Dynamics,*" New York: Oxford University Press, 1990. (9) Rutherford Aris, "*Vectors, Tensors, and the Basic Equation of Fluid Mechanics*," Courier Dover Publications, 1989. (10) D. J. J. Tritton, "*Physical Fluid Dynamics*," 2nd ed., Oxford University Press, 1988.

Course Coordinator: Yi-Tung Chen, Professor

Course learning outcomes:

(a) Lead students toward a clear understanding and firm grasp of the fundamentals of the subject with a balance between physics, mathematics, and applications of fluid mechanics.
(b) Learn basic vector and tensor calculus to apply into fluid mechanics.
(c) Understand the elementary motions of a fluid particle (kinematics) of translation, solid-body rotation, and deformations.
(d) Derive two major independent dynamical laws in continuum mechanics: the continuity and momentum equations.
(e) Learn the Kelvin's theorem that circulation about any closed path moving with the fluid is a constant.
(f) Determine rotational or irrotational flows using vorticity equation.
(g) Understand incompressible inviscid flow and Euler's equations in streamline coordinates and apply the Bernoulli equation between any two points on a streamline.

(h) Learn stream function and velocity potential for two-dimensional, irrotational, incompressible flow. Then apply elementary plane flows to superposition plane flows.
(i) Distinguish Newtonian and non-Newtonian fluids and derive the Navier-Stoke equations from the equation of motions.
(j) Learn a few types of exact solutions of viscous flows of incompressible fluid flow such as Couette (wall-driven) steady flows, Poiseuille (pressure-driven) steady duct flows, unsteady duct flows, unsteady flows with moving boundaries, duct flows with suction and injection, and similarity solutions.
(k) Understand the fundamentals of computational fluid dynamics (CFD) and able to apply the CFD solution procedure to simple nonlinear equations and assigned class project.
(l) Learn and solve flows at low-Reynolds-number (i.e. creeping flows or Stokes flows) for the applications of an oil-lubricated bearing, the flow of groundwater, oil, or natural gas through porous rock, or leading edge of a flat plate aligned with free stream etc. in the future.
(m) Understand important phenomena of boundary layers and how to calculate boundary layer thickness and apply it to Blasius flow over a flat plate.
(n) Learn the basics of hydrodynamics stability, turbulence, flow separation, and wave phenomena.
(o) Model the variety of phenomena that occur in real fluid situations.

Relationship of Course to Mechanical Engineering Program Educational Outcomes:

Goal1: Provide mechanical engineering graduates with technical capabilities.					Goal 2: Prepare the mechanical engineering graduates to have effective workplace skills.				Goal 3: Instilling a sense of responsibility as a professional member of society.			
1.a	**1.b**	**1.c**	**1.d**	**1.e**	**2.a**	**2.b**	**2.c**	**2.d**	**3.a**	**3.b**	**3.c**	**3.d**
H		**M**	**H**	**H**	**H**			**M**			**L**	**H**

(L)ow (M)edium (H)igh

Topics Covered:

1. Introduction of scalar, vector, and tensors
2. Basic conservation laws and transport phenomena
3. Kinematics of fluid flow
4. Kelvin's theorem
5. Bernoulli equation, Crocco's equation, and vorticity equation
6. Two-dimensional potential flows
7. Viscous flows of incompressible fluid flow
8. Exaction solutions
9. Computational fluid dynamics (CFD)
10. Low-Reynolds-number solutions
11. Boundary layers
12. Hydrodynamics stability, turbulence, and flow separation
13. Wave phenomena

Laboratory Projects: None

Class/Laboratory Schedule: 75 minutes lecture two sessions per week

Assessment of Student Progress toward Course Objectives

Homework assignments, one CFD project, one written midterm exams, and final exam

Class/Laboratory Schedule: TR 4:00-5:15 PM (Fall Semester)

Contribution of Course for meeting Professional Component:

(a)	Mathematics and basic sciences:	0 credit
(b)	Engineering Topics (Design/Science):	3 credit
(c)	General Education:	0 credit
(d)	Others:	0 credits

Prepared By: **Date:**

Yi-Tung Chen September 28, 2009