ENG ME 422 Fluid Mechanics II

2008 - 2009 Catalog Data:
ENG ME 422 Fluid Mechanics II Prereq: ENG ME 303; coreq: ENG ME 400. Flow kinematics: pathlines, streamlines, streaklines, rate-of-strain, dilatation, and vorticity. Stream function and velocity potential in two-dimensional flows. Potential flow theory: flow past a cylinder, circulation, and lift. Viscous flow: stress in a Newtonian fluid, the continuity, Euler and Navier-Stokes equations. Introduction to turbulence. Fully developed laminar and turbulent flows. Analysis of pumps and turbomachinery. Laminar and turbulent boundary layers. Includes lab and computer use. Cannot be taken in addition to ENG ME 421. 4 cr.

Class/Lab Schedule: 4 lecture hours per week, Two 2 hour labs per semester

Textbook(s) and/or Other Required Material: D. C. Wilcox, Basic Fluid Mechanics, DCW Industries Inc., La Canada, California, (1997), V. Yakhot, Lecture notes

Coordinator: Victor Yakhot, Professor, Mechanical Engineering

Prerequisites by Topic:
1. Basic fluid mechanics (integral approach)
2. Vector field theory
3. Ordinary and partial differential equations

Goals:
This course aims to introduce the student to the differential (as opposed to integral) analysis of inviscid and viscous fluid motion. The student is expected to attain a detailed understanding of flow kinematics (e.g., streamlines, pathlines, vorticity, rate-of-strain) and dynamics (the Navier-Stokes and continuity equations, potential and viscous flows) and to use these principles for engineering analysis of both internal and external fluid flows.

Course Learning Outcomes:
As an outcome of completing this course, students will:

i. Be able to analyze a broad range of engineering and environmental fluid phenomena and connect between mathematical, numerical and experimental approaches. This includes examples solved by potential flow theory or using the differential equations of fluid mechanics, compared with the results of numerical and experimental studies (labs). (A, B, D, E)
ii. Apply the universality concepts for qualitative understanding of complex fluid processes.
Understanding of the origins of separation, vortex formation, turbulence and their role in evaluation of the drag and lift forces. The ideas, demonstrated by exact mathematical solutions of classic fluid theory problems, will be applied for a qualitative analysis of complex engineering flows including drag on the bluff bodies, stall of the airfoils,

turbines etc. Based on theoretical knowledge, the students will be asked to come up with the idea of flow control and drag reduction. (A, E, K, L)
iii. Realize that a limited number (only few) of partial differential equations can be used for a quantitative description of a huge variety of engineering problems. The students are supposed to be able to formulate and solve some of the problems analytically and understand that the same equations can be used for computer aided engineering (CAE) in various branches of engineering. (A, E, L)
iv. Appreciate the role of numerical methods in CFD. The invited lecturers from the industry will show a broad range of applications of the large-scale computing to various real-life engineering design solutions in car and airspace industries including the business and marketing aspects. (J)
v. Be exposed to the basics of presentation and report writing. The students are required to periodically present their results of homework and quiz problems in front of the class. The students are required to submit lab reports of acceptable technical format for both lab experiences. (G)

Course Learning Outcomes mapped to Program Outcomes:
(For Program Outcomes, please see attached page or Department Web Site)

Program:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Course:	i,-iii	i		i	ii, iii		v			iv	ii	ii		
Emphasis:	5	3	1	2	5	1	4	1	1	2	2	4	1	1

Topics (time spent in weeks):
1. Fluids; continuum description; Elements of kinetic theory; derivation of viscosity and pressure (1)
2. Kinematics; acceleration; streamlines/pathlines; fluxes; vorticity (1)
3. Conservation laws; continuity, Euler and Navier-Stokes equations; Euler equation; Boundary conditions; vorticity; vortex force; Hydrostatics: barometric formula; shapes of the fluid surfaces. The Bernoulli equation and its simplest applications (2)
4. Kelvin's theorem; Incompressible fluids; Potential flows; 2D examples: uniform flow; sinks and sources; vortex; doublets and multi-pole expansion; Flow past cylinder; Drag and lift; Joukovskii theorem; Accelerating cylinder and cylinder + vortex: Thin airfoil theory; Panel method (3)
5. The Navier Stokes equations; Reynolds number; Laminar- Couette, channel and pipe flows. Flow separation; Friction and drag coefficients; Similarity variables; II Stokes problems and I; Introduction to nanofluidics. Nanoresonators. Prandtl laminar boundary layer theory; turbulent boundary layers; Pumps; Industrial CFD (Invited Lecture) (5)

Contribution of Course to Meeting the Professional Component:
Engineering topics: 100%

Status of Continuous Improvement Review of this Course:
Date Last Reviewed: February 18, 2009 **Reviewed by:** Thermal/Fluids Committee
Prepared by: Victor Yakhot **Date:** 5/21/09