UNIVERSITY OF MICHIGAN
Department of Civil & Environmental Engineering
Flow in Open Channels - CEE 591
FALL 2010

Instructor: Nik Katopodes
Lecture: TuTh 2:30-4:00, 1008 EECS
Office Hours: TBA, 121 EWRE
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Text: Will be provided

Grading: Homework 30%; Mid-term Exam 30%; Final Exam 40%.

Course Description:

Flow patterns in the environment cover a wide range of spatial and temporal scales. Examples include the mechanics of colloidal particle formation in water, details of flow around individual fish, the evolution of the Muskegon River delta, gravity currents downstream of mine outfalls in Lake Superior, wind-driven currents in Lake Michigan, tidal waves in the Bay of Fundy, and the planetary circulation of water in the oceans. Fundamentally, however, all of these flows are governed by the same physical laws, which form the basis of the field of fluid mechanics.

CEE 591 considers the application of fluid mechanics to the environment. The course introduces the fundamentals of fluid flows and develops the corresponding governing equations. Solutions to environmental applications include irrotational flows, surface waves, internal waves and turbulent flows. Emphasis is placed on scaling and simplifying the governing equations for various environmental flows, the effects of turbulent mixing in the environment, the impact of the earth's rotation, density stratification, and boundary resistance.

Course Rules:

The **Honor Code** is based on integrity, a characteristic that is built into the profession. It is reflected in the original and reliable work of all good engineers. When students accept the Honor Code, they acknowledge that it is dishonorable to receive credit for work which is not the result of their own efforts. **Homework** sets are due at the beginning of the lecture period, one week following assignment. Late homework will be penalized 20% for each day it is overdue. All **exams** will be "closed-book" and will cover both theory and applications. You may use, however, one sheet (two pages) of information that may be helpful in the examination.

COURSE SCHEDULE

Month	Day	Topic
September	7	Introduction to Environmental Flows; Scales of fluid motion; Ideal and real fluids.
	9	Newtonian Mechanics; Lagrangian and Eulerian approaches; The concept of continuum; Fluid properties; Laws of thermodynamics.
	14	Mathematical background; Scalar, vector and tensor fields; Index notation;
	16	Gradient, divergence and curl of a vector field;
	21	Kinematics of Fluid Flow; Material coordinates; Streamlines, pathlines and streaklines; Rate of strain.
	23	Conservation of Mass, Momentum and Energy; Scaling of the governing Equations;
	28	Integral approach to conservation laws; Green, Gauss and Reynolds transport theorems.
	30	Vorticity and circulation. Irrotational flow; The velocity potential and stream function.
October	5	Boundary-Layer flow; laminar and turbulent layers; Flow separation and streamlining of immersed bodies.
	7	Turbulent Flows; Temporal and spatial averaging of turbulent fluctuations; Reynolds stresses; Jets, plumes and boundary layers.
	12	Scales of turbulent motion; Parallel shear and vortex flows; Surface and form resistance.
	14	Models of turbulent flows; Mixing-length theory; Karman-Prandtl equations; Reynolds-Averaged Navier-Stokes model; Large-Eddy Simulation.
	19	**Study Break**
	21	**Mid -Term Exam**

November	26	Geophysical Flow Applications; Effects of rotation and stratification.
	28	The Boussinesq approximation; Shallow-water approximation; Gravity and tidal waves; Coriolis Acceleration.
	2	Taylor-Proudman phenomenon;
	4	Wind-driven currents; Ekman layer; Rossby Waves.
	9	Transport and Mixing in Rivers; Fundamentals of diffusion; Impulse load and response function;
	11	Convolution of elementary solutions; Continuous sources and complex initial distributions.
	16	Multi-dimensional applications of the diffusion model; Boundary conditions; The method of images.
	18	Advection-Diffusion-Reaction models; The method of characteristics; Advection- and diffusion-dominated solutions; Importance of the Peclet number.
	23	Point, line and area sources; Time scales for spreading and mixing of contaminants.
	25	**Thanksgiving Holiday**
December	30	Turbulent diffusion in channel flow; Integral time scales; Relative diffusion of particles.
	2	Shear flow dispersion in laminar flow; Taylor dispersion
	7	Turbulent velocity profiles and vertical mixing; Dispersion in turbulent flow; Dispersion in estuaries.
	9	Flocculation and settling of colloidal particles; Effects of shear and Stratification.
	17	**Final Exam – 4:00-6:00 pm**

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