MAP 5431
INTRODUCTION TO FLUID DYNAMICS

FALL 2009

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COURSE OUTLINE

I. ***CONTINUUM DESCRIPTION OF THE MOTION OF FLUID***
1. The continuum hypothesis
2. The continuity equation
3. Convective derivative
4. Stress tensor
5. Strain rate tensor
6. The momentum equation
7. Newtonian fluid
8. The Navier-Stokes' equation and boundary conditions
9. Equations of motion in a rotating frame of reference
10. Some exact solutions
11. Inviscid fluid; Euler's equation, Bernoulli's equation
12. Examples of steady irrotational, inviscid, incompressible flow
13. Conditions at the boundary between two media, surface tension, water waves
14. High Reynolds number limit : Boundary layer concept
15. Low Reynolds number limit : Slow viscous flows and Stokes approximation
16. Darcy's law of flow through a porous medium

II. ***KINEMATICS OF FLOW FIELDS***
1. Eulerian and Lagrangian description
2. Stream lines, stream tubes, stream functions
3. Circulation, velocity potential
4. Kinematics properties of rotational flows, vortex tubes, vortex filament

III. ***DYNAMICS OF INVISCID BAROTROPIC FLUIDS***
1. Generalization of Bernoulli's equation — rotational flows, barotropic flows, unsteady flows
2. Dynamical properties of rotational flows — Kelvin's theorem, Helmholtz theorem

IV. ***THE ENERGY EQUATION AND OTHER TRANSPORT PHENOMENA***
1. Transport phenomena, Fourier's law (heat conduction), Fick's law (diffusion)
2. The energy equation

V. ***DIMENSIONAL ANALYSIS AND SIMILITUDE***
1. Buckingham Pi-theorem
2. Similitude in fluid dynamics
3. Application to turbulent flows

VI. ***COMPRESSIBLE FLOWS***
1. Perfect gas and compressible flow equations
2. Acoustics