

## Review for Final Exam: Fluid Dynamics I, December 2005

1. Kinematics of velocity. Eulerian versus Lagrangian representation. Streamlines, pathlines, streaklines. Definition of material derivative. Calculations of Lagrangian coordinates in one dimension.
2. Derivation of equations of motion (mass, momentum, + pressure-density relation) for an inviscid, barotropic fluid. Definition of an incompressible fluid, and equations for it. Boundary conditions for an inviscid fluid at a rigid boundary.
3. Bernoulli's theorem for steady barotropic or constant-density inviscid fluid. Potential flow. Bernoulli's theorem for an inviscid, unsteady potential flow.
4. Vorticity. Helmholtz' laws for a barotropic fluid and potential body forces. Statement and proof of Kelvin's theorem. Vortex lines and their material property. Vorticity intensification by vortex stretching.
5. 2D Flows with vorticity: The 2D point vortex. Steady flow of an inviscid fluid of constant density- vorticity is constant on streamlines.
6. Potential flow. Use of complex variables in 2D. The source and point vortex in 2D. The source in 3D. Elementary flows in 2D. Uniqueness of potential flows.
7. Lift in steady 2D potential flow. The Kutta condition and the lift on a flat plate (use of conformal map). The Blasius theorems.
8. Prandtl's lifting line theory. Induced drag.
9. Definition of apparent mass in unsteady potential flow.
10. The stress tensor for Navier-Stokes viscous flows. General form for a fluid of constant density and viscosity. Elementary solutions: Couette and Poiseuille flows, oscillating plane. Definition and meaning of the Reynolds number.
11. Stokes' equations as an approximation for low Reynolds number.
12. The boundary layer as an approximation for high Reynolds number. Derivation of Prandtl's boundary-layer equations. The Blasius solution for the boundary layer on a flat plate. (Use of similitude.) The boundary layer as a singular perturbation.