

- The basics
  - Velocity field, Euler and Lagrangian descriptions
  - Pressure
  - Viscous force (microscopic and macroscopic descriptions)
  - Stress tensor
  - Stream lines/streak lines/path lines
- Derivation of the governing equations
  - Conservation of mass
  - Conservation of momentum
  - Conservation of energy
- Boundary Conditions
- Reynolds number and dynamic similarity
- Bernoulli's law in different forms
- Vorticity, Circulation, and Vorticity Equation, Kelvin's theorem
- Exact solutions
  - 1D pipe and channel flow
  - Taylor Couette Flow
  - Flow down an inclined plane
  - Planar shear flow (shear flow between two parallel plates, unsteady flow next to an impulsively started plane)
  - Spinning down of a line vortex
- Self-Similarity and Dimensional Analysis
- Aerodynamics
  - General discussion on forces on a moving object in Stokes flow and in flow at finite Reynolds numbers
  - Newton's particle theory
  - Kutta-Joukowski theory of aerodynamic lift
  - Potential flow (irrotational flow), Laplace equation, and complex variable analysis
  - Blasius theorem
  - Joukowski Transformation (from a circle to a plate, to an ellipse, to an airfoil)
  - Kutta condition

- Signature of thrust, thrust generated by reciprocal motions
- Low Reynolds number flow phenomena (Stokes flow)
  - History independent
  - Time reversibility
  - Linear in  $U$
  - Drag on a moving sphere
  - Scallop theorem
- Thin Film Theory
  - Flow in a Hele-Shaw cell
  - Lubrication theory
  - Flow through porous media
  - Adhesion between two plates with a thin film gap
- Boundary Layer equation and Boundary Separation
  - Derivation of the equation
  - Self-similarity solution, scaling arguments
  - Physical picture of the vorticity generation, and the subsequent diffusion and advection
  - Boundary layer separation condition
- Jets
  - Self-similar solution
  - Mass flux and entrainment
- Computational Methods
  - Finite Difference Scheme
  - Wave equation ( FTCS scheme, Lax Scheme)
  - Diffusion equation ( FTCS scheme, Implicit Scheme, Crank-Nicholson Scheme)
  - Diffusion equation with non-constant coefficients
  - Von Neumann Stability Analysis
  - Courant Friedrich Levy (CFL) conditions
- Relevant Math
  - Vector Calculus, Divergence/Stokes Theorems
  - Reynolds transport theorem
  - Partial Differential Equations
  - Self-Similarity Solutions
  - Complex Variable Analysis
  - Taylor Series
  - Finite Difference Schemes