I. Phenomenology & Dimensional Analysis

A. Lectures 2-3: Math and Python Review

Things you should know

- The difference between a linear and nonlinear equation
- What a scalar, vector and tensor are

Calculations you should be able to do

- Use Newton's method to find the root of a nonlinear equation
- Vector products (dot product, cross product) and vector partial derivatives (graident, divergence, curl) in Cartesian coordinates
- Surface and volume integals in Cartesian, polar/cylindrical or sphereical coordinates.

B. Lectures 4-6: Fluid Properties and Dimensional Analysis

Things you should know

- Definition of a fluid
- What the continuum approximation means
- What incompressibility means and whether liquids or gases are incompressible
- What density, surface tension and viscosity mean physically
- The concept of a dimensions and a unit system
- Identify common stress scales (viscous, intertial, etc.) in a fluid
- Definition and meaning of common dimensionless numbers (e.g. f, Re, Ca, C_D)
- Definition of similarity and its relation to dimensional analysis

Calculations you should be able to do

- Use density, specific gravity, specific weight, viscosity, & surface tension in calculations
- Use and convert between SI and English units
- Non-dimensionalize an equation
- Use the Pi theorem to determine the number of dimensionless groups and then find dimensionless groups that characterize a system
- Reason about scales and make order of magnitude estimates based on dimensionless numbers
- Use similarity to scale a process

C. Lectures 7-9: Pipe Flow

Things you should know

- Qualitative understanding of pressure drop and wall shear stress
- Definition and meaning of the friction factor & Reynolds number
- Identify and explain the qualitative regimes (laminar, turbulent) on the Moody chart; identify the transition Reynolds number.
- Definition and meaning of the dynamic pressure
- Newton's law of viscosity and non-Newtonian (shear-thickening, shear-thinning) constitutive laws

Calculations you should be able to do

- Given Q and D, calculate Re, f and/or ΔP for a circular, smooth pipe in laminar or turbulent flow using either a correlation or the Moody chart
- Calculate Re, f and/or ΔP for a pipe with height changes, wall roughness or non-circular pipes
- Calculate Re_{PL}, f and/or ΔP for a power-law fluid

D. Lectures 10-11: Drag

Things you should know

- Definition and meaning of the drag coefficient
- Difference between form and friction drag; what is streamlining
- Identify and explain the qualitative regimes (laminar, turbulent wake/laminar boundary layer, turbulent wake/turbulent boundary layer) of external flow on blunt objects of C_D versus Re; identify the transition Reynolds numbers.
- Explain the qualitative behavior of boundary layers on flat plates

Calculations you should be able to do

- Calculate the drag force for a blunt object using drag coefficient correlations or a plot of C_D
- Calculate the drag force for a flat plate using drag coefficient correlations or a plot of C_f
- Determine whether a boundary layer is laminar or turbulent and calculate its thickness
- Calculate a terminal velocity or use a terminal velocity to calculate a drag force

II. Fundamentals & Differential Theory

A. Lectures 12-13: Fluid Statics

Things you should know

- Pascal's law
- What a differential balance is and how to derive the static pressure equation
- What the static pressure equation is and what it means
- How manometers, barometers and hydraulics work

Calculations you should be able to do

- Determine pressures, forces, heights, etc. in manometers, barometers and hydraulics
- Determine the force due to pressure on boundaries (e.g. dams)
- Determine the force on submerged objects (e.g. buoyancy) due to pressure