TH Witten Examination
(Qualifying Exam)

Prof. Ishii

Prerequisites

- Thermodynamics
- Fluid NUCL 350, 355
- Heat Transfer NUCL 351
- Mass, Momentum & Energy Transfer NUCL 551
- Not required, but advantageous NUCL 552

NUCL 551

- Single Phase Flow Conservation Principles
  - Mass
  - Momentum
  - Energy
- Constitutive Relations
  - Equation of State
  - Newton's Law of Viscosity
  - Fourier's Law of Conduction
- Basic Solution of Laminar Flow
  - Parabolic Velocity Profile
- Basic Characteristics of Sudden Transient Problems
  - Solid Conduction – Thermal Penetration Depth
  - Sudden Motion – Momentum Penetration Depth
- Control Volume Analysis for Reactor System
  - Mass & Energy Balance
    - Application to Loss of Coolant Accidents
    - Application to Loss of Heat Sink Accident
    - Application to Loss of Flow Accident
    - LOCA Phenomenology
    - ECCS Design Criteria
- Non-Dimensional Scaling Parameters

  Definitions, Physical Meaning & Significance
  - Re
  - Fr
  - Pr
  - Ec
  - Gr
- Turbulent Flow Characteristics
  - Origin of Turbulence
  - Reynolds Stress (Turbulent Stress): How to obtain it
  - Shear Distribution (Total, Viscous & Turbulent)
  - Characteristics of Wall Turbulence
  - (Laminar Sub-layer, Buffer Layer, Turbulent Core)

Prandtl's Mixing Length Model
Universal Log Velocity Profile
Approximate Velocity Profile (1/7 Power Law)

- Single Phase Flow 1-D Formulation
  - Pressure Drop, Forced Convection, Natural Convection
  - Friction Factor (Parametric Dependence, Re, $\frac{\varepsilon}{D}$)
  - Heat Transfer Coefficient – Nusselt Number (Parametric Dependence, Re, Pr)
  - Modification to Natural Circulation Application
  - Boussinesq Assumption
  - Integral Momentum Equation
  - Application to Transients of Reactors
    - Power Change
    - Loss of Flow
    - Single Phase Natural Circulation
- Basic Concepts of Two-phase Flow & Boiling
  - Void Fraction
  - Critical Heat Flux
  - Drag Force
  - Two-phase Flow Regimes
  - Taylor Instability (Mechanism)
  - Kelvin- Helmholtz Instability (Mechanism)

NUCL 350, 351, 355

- Heat Conduction with Heat Generation
  - Energy Equation, Conduction Equation
  - Application to Nuclear Fuel
- Hydrostatic Pressure
- Bernoulli Principle (Assumptions, Applicable Condition)
- Pressure Gradient & Pressure Drop