

ME 6204
CONVECTIVE HEAT TRANSFER
2005-2006

INTRODUCTION

Lecturers: Professor Arun S. Mujumdar

Prof. K.C. Ng

**Textbook: Kays W M et al., Convective Heat and Mass
Transfer, McGraw-Hill, 4th Edition (2004)**

Supplementary reading:

Additional notes- to be posted on webpage

Practice problems

Webpage: visit for regular updates

<http://serve.me.nus.edu.sg/arun>

Teaching resources

Heat transfer

PPT presentations – useful for term paper

Grading: 30% Term Paper; 70% Final Exam.

Examination April 24th, 2006 9.00 a.m.

WHERE DO WE BEGIN?

➤ Background of class / Prerequisites:

- Undergraduate (UG) courses in fluid mechanics, heat transfer, engineering mathematics and thermodynamics**
- Review UG material, as needed**

➤ What is convection?

- Discuss; class participation expected**
- Read chapters 1-3 of the textbook before next class**
- Conservation laws – will look at 2-D problems for simplicity**

Recall following from UG texts:

- ❖ **Definitions of system, control volume**
- ❖ **Difference between equilibrium thermodynamics and heat transfer**
- ❖ **Conservation eqns. / BC's**
 - **Derivation of differential equations by applying conservation principles to differential control volumes**
- ❖ **Basics of math modeling**
 - **Different levels**
 - **Why model?**
- ❖ **Control volume vs. System**
 - **What is the difference ?**
- ❖ **Dimensional Analysis**
 - **Physical meaning of various dimensionless numbers**

For Self-Study

- **Write down the physical meanings of**
 - **Reynolds No.**
 - **Prandtl No.**
 - **Grashof / Rayleigh / Bousinesq numbers**
 - **Can these be treated as ratios of forces? Why not?**
- **Laminar vs. turbulent flows**
 - **Transition Reynolds no.**
 - **What is turbulence?**
- **Internal vs. external flows**
 - **Define heat transfer coefficients for these flow types. Why are they differently defined?**
- **Navier-Stokes Eqns. – Study from Textbook**
 - **Derive – Eq. 4.15, 4.17 (Text) (Read chapter 4 of textbook)**

Math Models of Convective Heat Transfer

➤ **Governing Eqns.**

- **Continuity – mass conservation**
- **Momentum eqns.**
 - **Navier-Stokes**
 - **Assumptions**
- **Limitations**
 - **Steady, laminar, incompressible**
 - **Newtonian fluids**
 - **What is a Newtonian fluid?**

➤ **Effect of geometry, B.C.'s**

- **ODE's vs. PDE's**
- **Importance of boundary conditions**

➤ **Analytical solutions (limited practical usage)**

- **Exact vs. approximate**
- **Numerical solutions- why do we need them in practice?**

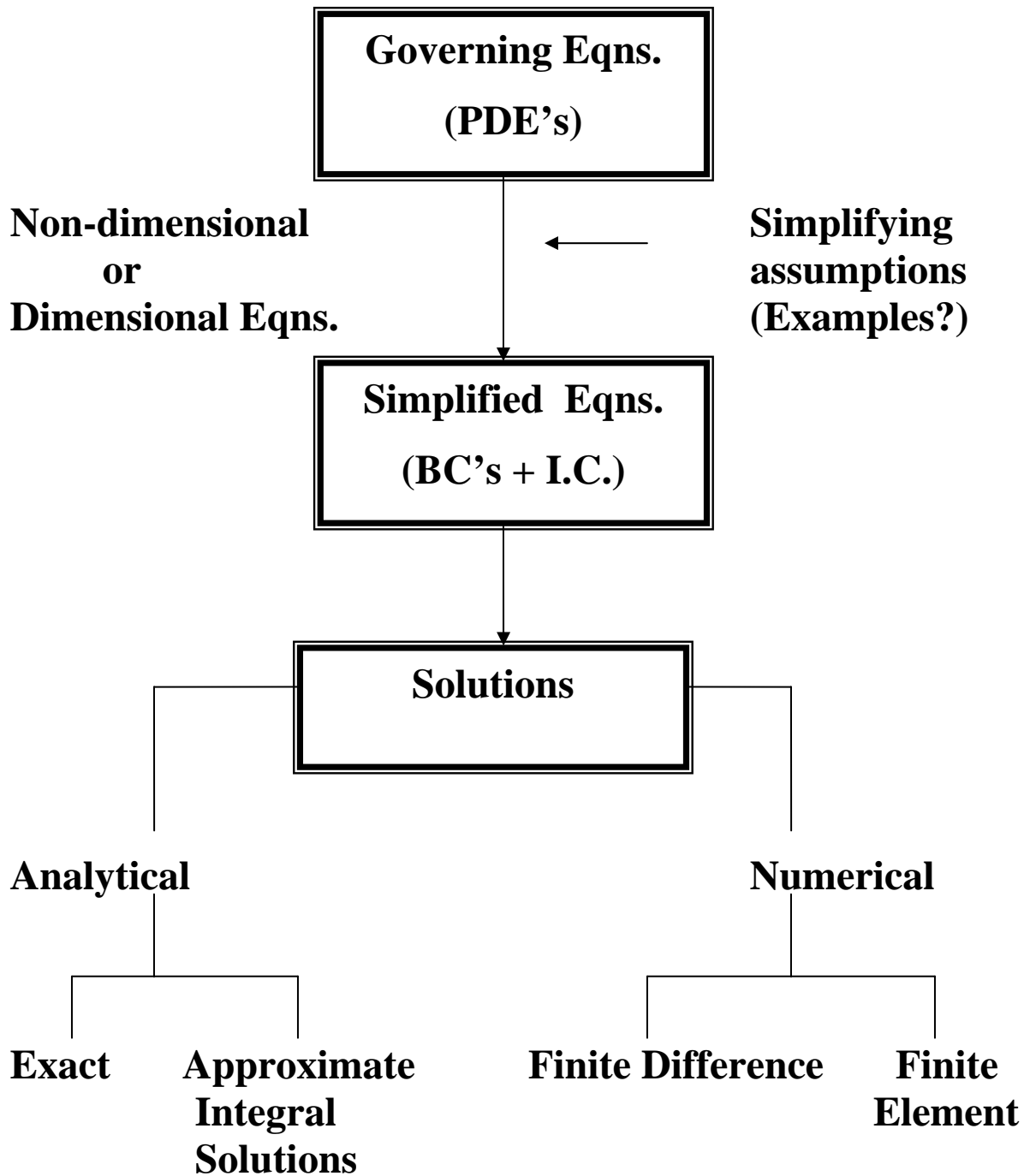
➤ **Methods of solution**

- **General discussion**

Math Modeling :Approach to solving real problems

- ❖ **Sketch physical model – simplify but keep key features**
- ❖ **List assumptions for math modeling**
 - **Include essential features**
 - **Exclude parameters of no or limited interest**
 - **Make it simple – not simpler (Einstein!)**
- ❖ **Basis for simplifications**
 - **Dimensionless numbers – dimensional analysis**
 - **Scaling of governing PDE's**
 - **Physical reasoning**
- ❖ **Why dimensional analysis? Its role in generation of correlations, simplifying experimentation etc.**
- ❖ **Dimensional analysis of**
 - a) **Governing eqns. / bc's**
 - b) **Parameters of physical system**

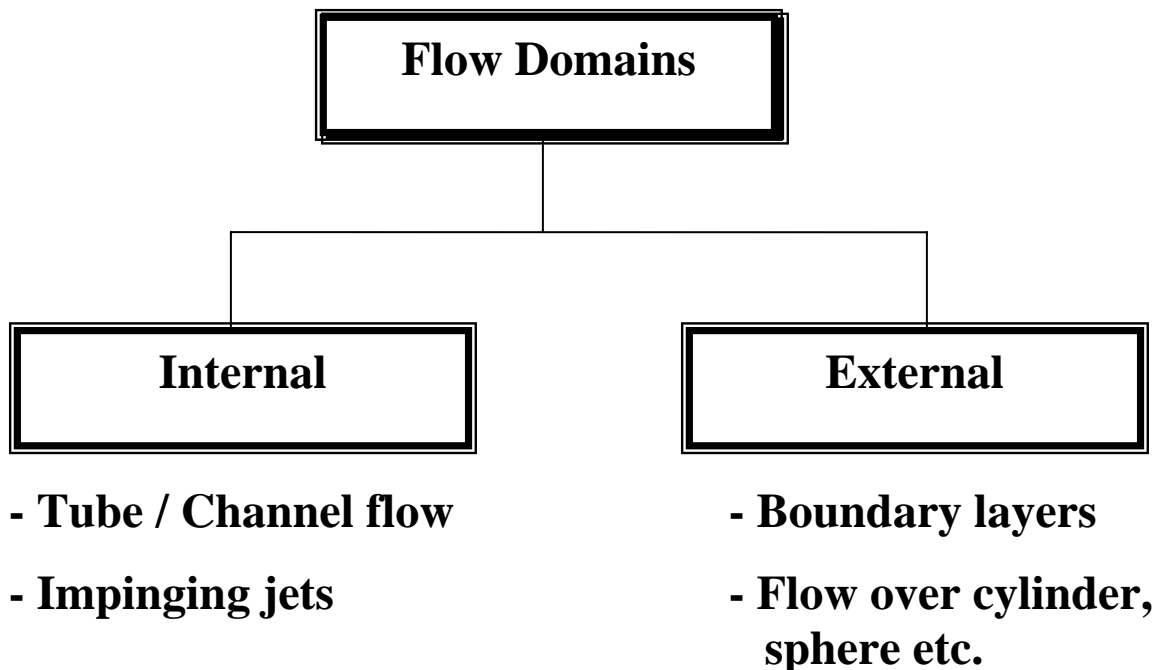
Math Models for Transport Processes



In convection, momentum eqns./bc's are most important; hence domain geometry is critically important.

Dimensional Analysis (to be covered briefly)

- ✚ Different methods to obtain dimensionless numbers
(read UG text)
- ✚ Physical significance of dimensionless numbers
- ✚ Scaling of transport equations to obtain meaningful groups
- ✚ Advantages & limitations of dimensional analysis



Define heat transfer coefficient, Nusselt number for internal and external flows.