Transport Phenomenon

* In engineering, three types of transport phenomena are encountered:
  + Transport of momentum: fluid dynamics
  + Transport of heat: heat transfer
  + Transport of mass: mass transfer
* Any real engineering design such as food processing or biological systems or reaction system will involve one or all flows depending on the conditions
* Focus of this course: momentum transport, which is basically how forces are acting on system to move the system

Fundamental Mechanisms Behind Transport Phenomenon

* For each transport phenomenon there is a driving force
* On a fundamental level, each flow has a molecular origin which is the molecular interaction defining the properties
  + Viscosity: important for momentum transport
    - Molecular and bulk transport of momentum
  + Thermal conductivity: important for heat transport
  + Diffusion/Diffusivity: important for mass transfer

Scales of Study

* When you study a system or you want to design a system for a particular purpose, such as moving fluid from one place to another you can think about different scales to be able to design the right system
* Choice of scale depends on purpose
* In this course, we will see how analysis at different scales are giving different information to be used.
* Macroscopic: high level, study inputs and outputs
  + Macroscopic balance equations
  + Useful in studying very complex geometries of instruments to analyze energy and mass for the system
* Microscopic: instead of studying whole system, interest is to study a small section to understand what is happening in that part
  + Diagnose the impact of a part of a system or enhance design to change flow in a small part
  + Equations of change
  + Most important topic for understanding any transport phenomenon
* Molecular: developing more fundamental understanding of a particular transport phenomenon such as at molecular level.
  + Understand role of complex molecules, extreme physical conditions where standard equations do not apply
  + First principle understanding
  + Newton’s law of viscosity: molecular theory for fluid flow properties applicable to certain kinds of fluid
* At each scale, conservation laws are applied

Relation Between Multiple Scales

* Molecular theories are used to develop equations at macroscopic levels
* Equations from microscopic scale are used to write balances at macroscopic scale

Types of Flows Encountered in Real Situations

* Pure fluids at constant temperature
  + Emphasis on viscous and convective momentum transport
* Pure fluids with varying temperature
  + Momentum
  + Emphasis on conductive, convective, and radiative energy transport
* Flow of fluid mixtures with varying composition
  + Emphasis on diffusive and convective mass transport

Tips for Making Fluid Mechanics Easy

* Remember to relate all mathematical equations to a physical system
* If the reason behind a step is not clear, stop the instruction and ASK!
* No substitute for hand-writing! When given handouts in class, always fill in the lecture in your own handwriting. Again, if not clear, ASK!
* Attempt homework problems on your own before working in group to match solutions (collaborative learning helps when you have thought about the problem in advance)
* Occasionally problems will be given in class. Class problems are also not graded, so solve it on your own or in groups in class.