BIOLOGICAL ENGINEERING COURSE DESCRIPTION

BE 373 – Transport Phenomena

Designation: Core course.

Catalog description: 3 Credits. Fundamental principles and applications relating to mass, momentum, and energy transfers in biological and other systems for engineers and scientists.

Prerequisites: CHEM 161 or 181A; PHYS 170; MATH 242 or MATH 252A; or consent.

Required texts: *Transport Processes and Separation Processes Principles (4th Ed.)*, Cristie J. Geankoplis. 2003. Prentice Hall (ISBN 0-13-101367-X)
Course notes (https://laulima.hawaii.edu/portal).

Learning outcomes: After completion of this course, student would learn to:

- setup overall balances for conservation of momentum, energy and mass;
- understand and apply flux laws in balances;
- understand and apply interphase transport relationships;
- employ shell balance equations to obtain desired profiles for velocity, temperature and concentration;
- reduce and solve the appropriate equations of change to obtain desired profiles for velocity, temperature and concentration;
- reduce and solve appropriate macroscopic balances for conservation of momentum, energy and mass;
- utilize information obtained from solutions of the balance equations to obtain engineering quantities of interest;
- recognize and apply analogies among momentum, heat and mass transfer;
- recognize relevance of transport principles in diverse applications in biological and engineering;
- understand the role of biological engineers in facing societal challenges.

Topics covered:

1. Introduction and Basic Concepts

- General overview of transport phenomena including various applications, transport of momentum, heat and mass , transport mechanism, level of transport, driving forces, molecular transport (diffusion), convective transport (microscopic).

2. Properties, Units and other Physical Parameters

- Unit systems, temperature, mole, concentration, pressure, gas laws, laws of conservation, energy and heat units.

3. Momentum Transport

- Basic concepts in fluid mechanics, force, unit and dimensions, pressure in fluid, head of fluid, molecular transport for momentum, heat and mass transfer viscosity of fluids, Newton's law, momentum transfer, Newtonian and non-Newtonian fluids, fluid flow and Reynolds number, overall mass balance, control volume and continuity equation, overall energy balance, Bernoulli's equation, overall momentum balance, shell momentum balance and velocity profile, pressure drop and friction losses, drag coefficient, Stokes law, flow in packed beds, Darcy laws, flow in fluidized bed,

4. Energy Transport

- Basic concepts in heat transfer, Heat transfer mechanisms, Fourier's law of heat conduction, thermal conductivity, convective heat transfer co-efficient Conduction heat transfer through- flat slab/wall, hollow cylinder and sphere, solids in series and parallel, combined convection and conduction and overall coefficient, conduction with internal heat generation, critical thickness, contact resistance, critical thickness, forced convection heat transfer inside pipes, heat transfer outside various geometrics in forced convection, general discussion on natural convection heat transfer, heat exchangers, general discussion on radiation heat transfer.

5. **Mass Transport**
    - Basic concepts in mass transport, some application examples, modes of mass transfer, molecular diffusion**-** Fick's law, analogy between mass, heat and momentum transfer, dispersion, chemical kinetics and activation energy, film theory, convective mass transfer, liquid-solid mass transfer, liquid-liquid mass transport, gas-liquid mass transfer, aeration and oxygen transport, air stripping.

6. **MAT LAB:** Use of MATH LAB for solving design problems in Momentum, Heat and Mass Transfer.

7. **Laboratory Works:** Conduct experiment to determine the volumetric mass transfer co-efficient for oxygen and carbon monoxide in aqueous phase under different flow rates, mixing conditions and temperature.

Schedule: Three 50-minute classes per week.

Contribution to Meeting Professional Component:

Mathematics and Basic Sciences: Apply the knowledge of math and basic sciences in the design of systems involving momentum, heat/energy and mass transports. Physical, chemical, and biological sciences are used to understand the underlying principles exploited in various transport processes.

Engineering Topics: The course focuses on momentum, heat/energy and mass transfer and design of systems that apply these transport phenomena in biological systems.

General Education: Students are expected to understand the impact of biological engineering practice/designs on the greater context, demonstrate an ability to communicate ideas during classroom discussion, and intelligently discuss contemporary issues/ challenges.

Relation to BE Program Outcomes: BE 373 contributes to outcomes:

(a) solve problems involving differential equations;
(c) solve engineering problems involving statics, dynamics, fluid mechanics, and thermodynamics;
(d) design a system, component, or process in which biology plays a significant role;
(e) design and conduct experiments to gather information for engineering designs;
(f) use modern engineering techniques, skills, and tools to define, formulate, and solve engineering problems;
(i) communicate effectively in large and small groups;
(j) understand the impact of engineering solutions on the surrounding context;
(k) recognize the need for life-long learning, and;
(l) intelligently discuss contemporary issues.

Prepared by: Samir K Khanal, 03/27/09.