

# **BMED 3300 Biotransport**

**Credit:** 4-0-4

**Prerequisite(s):** BMED 2210 (w/minimum grade of “C”)

## **Catalog Description**

Fundamental principles of fluid, heat, and mass transfer with particular emphasis on physiological and biomedical systems.

## **Text**

*Fundamentals of Momentum, Heat, and Mass Transfer*, J.R. Welty, C.E. Wicks, R.E. Wilson, G. Rorrer, 4<sup>th</sup> ed, John Wiley & Sons, Inc., New York, NY, 2001.

## **Objectives**

The overall objective of this course is to introduce students to the fundamentals of momentum, heat and mass transfer for their application to biotransport problems.

## **Outcomes**

Specifically at the end of the course students will be able to:

1. formulate differential equations that represent the physical situation of biomedical problems involving mass, momentum and/or heat transfer and determine appropriate boundary conditions. (Program Outcomes 1 and 2)
2. apply conservation laws of fluid flow to describe the system for various geometries, particularly for flow through conduits. (Program Outcomes 1 and 2)
3. distinguish between modes of heat transfer or mass transfer, explain analogies between heat and mass transfer and apply the correct equations to describe each mode. (Program Outcomes 1 and 2)
4. apply differential mass or heat balances to determine concentrations or temperatures at a particular point or concentration/temperature profiles with and without (biochemical) reactions, and to determine mass/heat fluxes, respectively. (Program Outcomes 1 & 2)
5. determine convective mass/heat transfer coefficients using appropriate analogies for the geometric situation. (Program Outcomes 1 and 2)

## **Topical Outline**

### **1. Fundamental Molecular Mass Transfer**

Concentrations, mass and molar velocities, fluxes

Fick's law, diffusivity

Rate equations for mass transfer in a binary mixture

Membrane permeability, molecular/pore diameter, partition coefficient, solute molecular weight

Convection mass transfer definition, mass transfer coefficient

### **2. Differential Equations of Mass Transfer**

Differential species mass balances – control volume, equation of continuity

Special forms of the continuity equation – Fick's second law, Laplace equation

Common boundary conditions

Shell Mass balances

Steps for modeling processes involving molecular diffusion

Diffusion with chemical reaction and diffusional resistances in series

### **3. Convective Mass Transfer**

Dimensionless parameters

Concentration boundary layer analysis

Mass, energy, and momentum analogies

Transport of solute between a capillary and the surrounding tissue

Overall mass transfer coefficient

Solute transport in a vascularized bed

Membrane processes, fluid side mass transfer coefficient with a permeable membrane

### **4. Fundamental Fluid Mechanics**

Fluid properties – point, system, element

Velocity and acceleration of fluid elements

Shear stress vs. shear rate, viscosity, wall shear stress, wall shear rate

Newtonian and Non-Newtonian fluids

Steady Flow in a circular pipe

### **5. Principles of Fluid Flow**

Macroscopic mechanical energy balance

Bernoulli Equation and applications

Friction losses – friction factor, friction loss and pump work

Hydraulic networks – pipes in series and pipes in parallel

Flow past immersed bodies – wall drag and form drag and drag coefficients

### **6. Fundamental Heat Transfer**

Conductive heat transfer, thermal conductivity, resistances

Convection and radiative heat transfer

Combined mechanisms of heat transfer, resistances in series, overall heat transfer coefficient

### **7. Differential Equations of Heat Transfer**

Differential equation for heat transfer

Bioheat equation

Special forms of the differential energy equation

Common boundary conditions

Conduction in systems with heat sources

Heat transfer with phase change

### **8. Convective Heat Transfer**

Dimensionless parameters

Convective heat transfer coefficient correlations – Natural and forced convection, laminar flow, turbulent flow, different geometries

### **9. Transient Heat Transfer**

Lumped parameter analysis

Transient conduction charts, 2D and 3D transport

Heat transfer into a semi-infinite medium

### **10. Heat Exchangers**

Single-pass heat-exchanger analysis

Crossflow and shell-and-tube heat exchangers

Overall heat transfer coefficient