BBE 4013 **Transport in Biological Systems**

NOTE: All references in this document to Visual Basic programming are dropped starting in Fall, 2010 as the course will convert to 3 credit and will not have a lab. The programming/calculations part of the present course will be moved to the proposed revised Introduction to Design course.

(3 cr; prereq [3013 or Concurrent registration is required (or allowed) in BBE 3013 or ChEn 3701], CE 3502, [ME 3331 or ChEn 4101], upper div IT); A-F only; 3 lect per week,).

Course Description: Application of thermodynamics, fluid flow, heat/mass transfer to design problems involving biological processes and materials at cell, organism, and system level. Agricultural, environmental, food, and bioprocessing applications. There are also some applications related to the biomedical field as well. Computer applications with Visual Basic programming.

Instructors: Professor Mrinal Bhattacharya, Room 212, BAE Bldg, 5-5234, bhatt002@umn.edu
Professor John L. Nieber, Room 203, BAE Bldg, 5-6724, Nieber@umn.edu
Mr. Michael Talbot, Room 307, BAE Bldg, 5-3782, talbo024@umn.edu

Class Times: Lecture 12:50-1:40 PM MWF. BAE 106

Students completing this course should be able to:

1. Derive constitutive relationships for fluid flow, energy and mass transport in biological systems
2. Formulate the governing conservation equations for energy and mass transport in biological systems
3. Formulate equilibrium and non-equilibrium relationships for energy and mass transport in biological systems
4. Recognize analytical solutions to well-posed mathematical formulations related to energy and mass transport in biological systems
5. Understand the fundamentals and application of discrete methods for solving well-posed mathematical formulations related to energy and mass transport in biological systems
6. Solve practical problems involving energy and mass transport in biological systems
7. Develop computer applications using Visual Basic.

Text: Biological and Bioenvironmental Heat and Mass Transfer by Ashim K. Datta. Marcel Dekker AG. (2002).

References: Biological Process Engineering, An analogical approach to fluid flow, heat transfer and mass transfer applied to biological systems by A.T. Johnson, John Wiley and Sons, (1999).

Transport Phenomena in Biological Systems by GA Truskey, F. Yan and DF Katz. Second Ed. Pearson Prentice Hall, (2008).

Basic Transport Phenomena in Biomedical Engineering by Ronald L Fournier. Second Ed. Taylor and Francis (2007).

Homework assignments:

1. All work done in pencil with legible writing/graphics.
2. Clearly defined problem statement.
3. Clearly defined solution steps and solution results.

GRADING: Three Hour Exams – 30% each, Homework 35%, Project 35%

The final exam is optional. You may choose to retake either one of the three exams for your final. In the event you choose to retake the exam, your earlier grade for the exam you have decided to substitute will be replaced by your final grade.

BBE 4013

Lecture 1:	Introduction to Transport Processes (Chapter 1)
Lecture 2:	Modes of Heat Transfer (Chapter 2)
Lecture 3/4:	Governing equation and BC's for Heat Transfer (Chapter 3)
Lecture 5/6:	Steady State Heat Transfer (Chapter 4)
Lecture 7-9:	Unsteady State heat Transfer (Chapter 5)
Lecture 10-12:	Convection Heat Transfer (Chapter 6)
Lecture 14/15:	Radiation heat Transfer (Chapter 8)
Lecture 16:	Introduction to Momentum transfer
Lecture 17:	Conservation Relations and Momentum Balances
Lecture 18:	Constitutive Equations
Lecture 19-21:	Application of Momentum Balances
Lecture 22	Bernoulli's Equation
Lecture 23:	Introduction to Mass Transfer (Chapter 9)
Lecture 24:	Modes of Mass Transfer (Chapter 10)
Lecture 25:	Governing equation and BC's for Mass Transfer (Chapter 11)
Lecture 26-27:	Steady State Mass transfer (Chapter 12)
Lecture 28-30:	Unsteady state mass transfer (Chapter 13)
Lecture 31-33:	Convection Mass Transfer (Chapter 14)

		Reading Assignment
Jan 20	Introduction	Chapter 1
Jan 22,25	Modes of Heat Transfer	Chapter 2
Jan 27, 29	Equations of Heat Transfer	Chapter 3
Feb 1, 3	Steady State Heat Transfer	Chapter 4
Feb 5, 8, 10, 12	Unsteady State Heat Transfer	Chapter 5
Feb 15, 17, 19	Convection Heat Transfer	Chapter 6
FEB 22	**HOUR EXAM 1**	
Feb 24, 26	Radiation Heat Transfer	Chapter 8
Mar 1	Introduction to Momentum transfer	Notes
Mar 3	Conservation Relations and Momentum	Notes
Mar 5	Constitutive Equations for Fluids	Notes
Mar 8, 10	Application of Momentum Balances	Notes
Mar 12	Bernoulli's Equation	Notes
Mar 15, 17, 19	**SPRING BREAK**	
Mar 22	Review	
MAR 24	**HOUR EXAM II**	
Mar 26	Introduction to Mass Transfer	Chapter 9.1, 9.2, 9.3
Mar 29, 31	Modes of Mass Transfer	Chapter 10
Apr 2	Modes of Mass Transfer	Chapter 10
Apr 5, 7	Equations of Mass Transfer	Chapter 11
Apr 9, 12,14	Steady State Mass Transfer	Chapter 12
Apr 16, 19, 21, 23	Unsteady State Mass Transfer	Chapter 13
Apr 26, 28, 30	Convection Mass Transfer	Chapter 14
May 3	Review	
MAY 5	**HOUR EXAM III**	
May 7	WRAP UP	
MAY 11	**Final Exam 1:30-3:30**	