CHE 3102 – HEAT AND MASS TRANSFER
SPRING 2018
LOUISIANA STATE UNIVERSITY

Instructor:	Assistant Professor Christopher G. Arges 3315S – Patrick Taylor Hall Phone #: 225-578-3060 E-mail: carges@lsu.edu (please begin subject line with 3102) Office Hours: Friday 3:30 PM to 4:30 PM or by appointment
Class:	Room 0006 Lockett 8:30 AM to 10:20 AM Tuesday and Thursday (note: 10 minute break at 9:20 AM)
Teaching Assistants:	Luis Manuel Office hours: 11:45 to 12:45 AM Tuesday 3304N PFT E-mail: lmanu14@lsu.edu Subarna Kole Office hours: 11:45 to 12:45 AM Thursday 3304N PFT E-mail: skole1@lsu.edu
TA led Discussion:	Optional for students. Occurs every Friday from 1 to 1:50 PM in 1126 PFT. Dates of no discussion section: 01/12, 03/02, 03/30, 04/06. Last date for discussion will be 04/27.
Course Objectives:	*Promote problem formulation and solving abilities required for the analysis of heat and mass transport phenomena occurring in chemical, biological, and materials engineering.*

Key Learning Objectives:

1.) Students should be able to determine the concentration and temperature profiles, as function of space and/or time, by formulating conservation equations (either differential form or shell balance form) and selecting appropriate constitutive relationships. Additionally, they should be able to calculate the total molar fluxes and heat flux. To do this, students should be able to:

- Make justifiable assumptions about the system from the problem statement
- Simplify their conservation equations from assumptions and given information in the problem statement.
- Formulate appropriate boundary and initial conditions
- Draw diagrams that depict the direction of fluxes
- Solve the conservation equation(s) analytically or numerically

2.) Students should be able to determine heat and mass transfer coefficients from correlations (e.g., Sherwood # and Nusselt #).

3.) Students should be able to analyze heat and mass transfer resistances using dimensionless parameters (e.g., Biot #, and Péctlet #). This includes deriving dimensionless parameters by making conservation equations dimensionless.

4.) Students should be to select appropriate proportionality constants for their constitutive relationships (e.g., pseudobinary diffusion for dilute species in a liquid or Knudsen diffusion for gases in macroporous solid).

Prerequisites: A grade of "C-" or better in CHE 3101

On-line: Additional class materials will be posted on Moodle

Textbook: BSLK: *Introductory Transport Phenomena, 1st Edition*, R. B. Bird, W.E. Stewart, E. N. Lightfoot, and D.J. Klingenberg, John Wiley & Sons, Inc. (2014)

Supplemental Texts: *Transport Processes and Separation Process Principles 4th Edition*, C. J. Geankoplis, Prentice Hall (2003)

Analysis of Transport Phenomena 2nd Edition, W. M. Deen, Oxford University Press (2011)

Grading:

Homework:	0%
In-class pop quizzes:	15% (multiple quizzes will be given – 2 lowest scores will be dropped) – 20 minute quizzes
Exams:	85% (3 exams) – Two midterm exams and one final exam. The lowest score of the three exams will count 15%, while the other two scores count for 35% each. Final exam will be cumulative.
Note:	One numerical method assignment will be given as extra credit. The assignment will be graded by me.

Exam schedule:
Midterm #1: 8:30 AM Tuesday, February, 27th, 2018 – 0006 Lockett
Midterm #2: 8:30 AM Thursday, April, 5th, 2018 – 0006 Lockett
Final Exam: 12:30 PM Thursday, May, 3rd, 2018 – 0006 Lockett

Exam format: Closed book, equation sheet provided, no calculator allowed. Phones and computers are prohibited during exam.

Grade policy:	The Cain Department of Chemical Engineering "C" requirement policy went into effect at the beginning of the Fall 2016 semester. The quality point deficiency/drop system is no longer in use. Under the new policy, students must earn a "C-" or better in 9 core sophomore and junior classes to enroll in subsequent classes that list those classes as prerequisites.
Course policies:	Students with Accommodation Letter: Submit your letter in person to me during office hours or at a scheduled appointment. I will not take the letter after class.

Homework will not be graded. Homework feedback can be provided upon request to the TA.

The intent of the Homework is to help you learn the material so you can do well on the exam. I encourage you to work together on the homework.

Attending the class and studying the material in real-time will help you do well on the quizzes and will curtail cramming material before an exam.

Students are expected to take each examination on the pre-arranged dates. Excused absences from exams will follow LSU Policy Statement 22 (PS-22).

A make-up exam for an excused absence will be given the week before Finals. The exam will be cumulative and will count 35% toward your final grade (i.e., it can not count as your lowest score).

Regrade requests for exams must be made in writing. Please specify which part of the exam that you want regraded and please justify your request. The regrades will be due at the start of the next class period after returning exams. Late regrade requests will not be accepted. You can earn or lose points from a regrade request.

Violation of academic integrity will be immediately reported to Student Advocacy and Accountability (SAA). I will recommend to SAA that the student fail the course for any integrity violation.

Topics	Reading materials
Part 1: Introduction to Transport Phenomena	
Construct of transport phenomena; levels and length scales, constitutive relationships; continuum approximation	Deen – Chapter 1 – sections 1.1 to 1.3 and 1.6; Appendix A – all BSLK – Chapter 0 – all BSLK – Appendix A – sections A.4, A.5, and A.7 Geankoplis – Chapter 6 – sections 6.1A and 6.1B
General forms of conservation equations (control volumes, point/differential balances, interfacial balances); Gauss's theorem; material derivative;	Deen – Chapter 2 – sections 2.1 to 2.8

Part 2: Mass Transport	
Introduction to mass transfer: Continuity equation and the total conservation of mass, Fick's 1st Law of Diffusion, conservation balance of individual chemical species	BSLK – Chapter 17 – all sections BSLK – Chapter 18 – sections 18.1 to 18.3, 18.6 to 18.7 BSLK – Chapter 19 – sections 19.1 to 19.3 (pages 563 to 471) Deen – Chapter 1 – pages 3 to 5 Deen – Chapter 2 pages 41 to 44 Geankoplis – Chapter 6 – sections 6.1 to 6.5
Steady-state mass transfer examples *without source terms*	
Expressions for diffusion coefficients: Binary diffusion coefficient, pseudo-binary diffusion coefficient, self-diffusion coefficient Diffusion coefficients dependence on concentration Predicting diffusion coefficients Diffusion in porous solids: Knudsen diffusion coefficient, permeability coefficient Mass transfer coefficient	
Simultaneous heat and mass transfer: Soret Effect	Deen Chapter 14 – sections 14.4 BSLK Chapter 19 – sections 19.3
Steady-state mass transfer examples *with source terms* and making conservation equations dimensionless	BSLK – Chapter 18 – sections 18.4 to 18.5, 18.10 Deen – Chapter 3 – examples 3.2-1, 3.2-2, 3.2-3, 3.2-4, 3.2-7, 3.4-3, 3.5-1
Transient mass transfer via diffusion – solving PDEs via similarity technique (method of combination of variables)	Deen – Chapter 4 – sections 4.2 and example 4.2.1 BSLK – Chapter 19 – sections 19.5 and examples 19.5-1 and 19.5-2
Introduction to coupled fluxes via Stefan-Maxwell Approach	BSLK – Chapter 24 – sections 24.1 to 24.2, 24.5 to 24.7 Deen – Chapter 14 – section 14.5
Steady-state mass transfer via forced convection in confined flows	Deen – Chapter 10 – sections 10.1 to 10.3 and example 10.3-1 BSLK – Chapter 18 – sections 18.8 and 18.9, Chapter 19 – section 19.1
Mass transfer coefficient correlations: relating Sherwood# to Reynolds # and Schmidt#	Deen – Chapter 10 – sections 10.3 Class notes
Macroscopic mass balances and operating-equilibrium line analysis	BSLK – Chapter 23 – sections 23.1, 23. 5 to 23.6

Part 3: Heat Transport	
Introduction to steady-state heat transfer and Fourier's Law Steady-state heat transfer via conduction between solids and solids/fluids with and without source terms. Introduction to Biot #	BSLK – Chapter 9 – section 9.2 BSLK – Chapter 10 – sections 10.1 to 10.7 Deen – Chapter 10 – examples 3.2-5 & 3.4-2 Geankoplis – Chapter 4 – sections 4.1 to 4.7
Heat transfer mechanisms: expressions for thermal conductivity coefficients and the heat transfer coefficient	de Pablo & Schieber Handout from Molecular Engineering Thermodynamics BSLK – Chapter 9 – sections 9.5 to 9.11
Steady-state heat transfer via convection: free convection, forced convection in (confined geometries and unconfined geometries). Introduction to the Péctlet # Heat transfer coefficient correlations: relating Nusselt # to Reynolds # and Prandtl#.	BSLK – Chapter 9 – section 9.1 BSLK – Chapter 10 – sections 10.9 to 10.10 BSLK – Chapter 14 – sections 14.1 to 14.6 Deen – Chapter 10 – sections 10.1 to 10.2 and example 10.2-1 Geankoplis – Chapter 4 – sections 4.5 to 4.7
Other topics in heat transfer: • Radiation heat transfer • Introduction to the overall, macroscopic energy balance – accounting for mechanical effects in thermal transport • Transient heat transfer • Dealing with phase changes	BSLK – Chapter 11 – sections 11.5 & 11.6 BSLK – Chapter 16 – sections 16.2, 16.5, and example 16.4-2 Deen – Chapter 2 section 2.5 – pages 39 to 41 only Deen – Chapter 10 section – section 10.6 Geankoplis – Chapter 4 – sections 4.10 to 4.11 Geankoplis – Chapter 5 – sections 5.1 to 5.4
Part 4: Transport Principles Applied to Unit Operations (tentative)	
Heat exchangers	Geankoplis – Chapter 4 – section 4.9
Mass transfer unit operations for separations: • Gas-liquid operations: gas absorption, evaporation, & distillation • Liquid-liquid separations (e.g., extraction) • Solid-fluid operations: adsorption/absorption and chromatography • Membrane separations	Readings to be assigned later on