CHE 325 CHEMICAL REACTION ENGINEERING
Spring 2011 Syllabus and Schedule

Instructor: Professor Brian Anderson
Room 435 ESB, Chemical Engineering
Telephone: ext 304-293-9334
email: brian.anderson@mail.wvu.edu

Lecture Room: Rm 401 ESB

***Lecture Time*:** Tue, Thurs 12:30pm – 1:45pm ***Office Hours*:** Mon 1:00pm – 3:00pm

Co-requisite: *CHE 312*

Text: Fogler, H.S., *Elements of Chemical Reaction Engineering* (4th ed.), Prentice Hall PTR, 2006. [defined in class notes as HF]

Related Texts and Recommended Reading: *Safety, Health, and Loss Prevention in Chemical Processes*, Center for Chemical Process Safety of the American Institute of Chemical Engineers, 1990. [SHLP]

Course Goal: In this course, students will learn to apply knowledge of mass and energy balances, chemical kinetics, and chemical reaction equilibrium to achieve the design objectives for isothermal and nonisothermal batch, plug flow, and continuous stirred tank reactors.

Course Objectives:

1. Students will understand how to apply material balances to ideal reactors such as batch reactors (BR), plug flow reactors (PFR), and continuous stirred tank reactors (CSTR).
2. Students will be able to design ideal isothermal, isobaric BRs, PFRs, and CSTRs.
3. Students will be able to design ideal isothermal, non-isobaric BRs, PFRs, and CSTRs.
4. Students will be able to design ideal, multiple reactor schemes.
5. Students will understand selectivity and yield for multiple reactions and how to choose reactor conditions and design reactors to maximize one or both of these parameters.
6. Students will be able to design non-isothermal, BRs, PFRs, and CSTRs.
7. Students will be able to design reactors under non-steady-state conditions.
8. Students will understand the effects of diffusion on reactions and on reactor behavior.
9. Students will be able to design heterogeneous, catalytic reactors.
10. Students will use software and other numerical methods to study, understand, and explain the behavior of chemical reactors.
11. Students will be able to use Chemcad to solve the above problems.
12. Students will gain an appreciation for the environmental and safety aspects of chemical engineering through solution of applicable reactor design problems.
13. Students will be able to apply the above knowledge to the solution of a design problem.
14. Students will increase their proficiency in oral and written communication.
15. Students will become more proficient at working in groups.
16. Students will be able to use Matlab to solve the above problems.

Teaching Approach: Chemical reaction analysis and reactor design is unique to chemical engineering. There are relatively few concepts and design equations that are needed to describe most situations at the undergraduate level. However, there are many different reactors and reactor situations. This course starts with a rigorous mathematical development of the defining design equations and then this set of equations is used to solve problems in the different reactors and reactor situations. The course strives to show how simple and complex problems are solved with the same set of equations and how the concepts learned on one system are directly applicable to other systems. By completing the homework exercises, you will develop proficiency in applying the concepts presented in the lectures and the text. Problems that you will encounter in the future may be more time consuming to solve, but they will not be any more difficult conceptually.

Knowledge, Abilities, and Skills Students Should Have Entering this Course:

1. A comprehensive knowledge of transport phenomena is essential. This course relies on shell balances and the constituent equations to develop the material and energy balances for the various reactors, and to develop the balances in heterogeneous catalysts that account for diffusion with reaction. Transport phenomena concepts are used to appreciate the consequences of turbulent flow on velocity, temperature and concentration profiles that form the basis of the one-dimensional models (CHE 310, CHE 311, and CHE 315).
2. Knowledge of heat transfer processes is needed for nonisothermal reactors (CHE 311 and CHE 315).
3. Understanding of reaction equilibria and heat of reaction is required (CHE 320 and CHE 326).
4. The ability to solve linear differential equations (MATH 261).
5. The ability to solve ODEs using explicit numerical methods and to have a working knowledge of how these methods work (CHE 230).
6. The ability to solve sets of linear and nonlinear algebraic equations using numerical methods (CHE 230).
7. The students need an appreciation of numerical optimization techniques (CHE 230).
8. The students need to have a working knowledge of MATLAB and CHEMCAD numerical software that operates on the computers in the Departmental Computer Laboratory (CHE 230).

Course Policies (exceptions at discretion of instructor):

Grading

1. There are no make-up exams except by prior arrangement with instructor.
2. A late assignment = no assignment.
3. Exam grading appeals must be submitted in writing on the day the exam is returned. If you miss that class, you lose the opportunity for regrading.

Homework

4. All problem sets are due at the beginning of class or at the stated time.
5. You may (and are encouraged to) work in groups on problem sets. However, what you submit must be your own work except for assignments that are designated as group assignments. Assignments that are obviously copied will receive no credit.
6. Problem sets and exams should be neat and easy to follow. Each problem should start on a new page. Your answer should be boxed, have units as appropriate, and have the correct number of significant figures. Problems should be worked in the units provided (SI or American). No credit will be given for answers without work. Credit will be deducted for missing or incorrect units, sloppy work that is hard to follow, and for the incorrect number of significant figures. You should round off the final answer to the correct number of significant figures. If you round off intermediate calculations, thereby making your final answer inaccurate, significant credit will be deducted.

Exams

7. There will be three tests during the semester and a comprehensive final exam. All tests will be open-book, closed-notes. You can use two 8.5”x11” sheets (front and back) of paper with notes.

Design Project

8. If you do not participate in the design project as part of your assigned group, your grade for the entire course will automatically be an F, regardless of other grades earned in this class.
9. You must be in the audience for all of the junior design presentations. This means in the classroom, not in the hall or in the computer room. Failure to do so will result in reduction by one full letter on your design project grade.

Class

10. Any classes canceled due to inclement weather (or any other reason) will be rescheduled.
11. If the fire alarm goes off during an exam, the resolution of the situation is solely at the discretion of the instructor.
12. If you carry a cellular phone, it should be turned off during class. All cell phones are expected to be turned off or silenced during all class lectures and during exams. This type of interruption is disruptive to fellow classmates and will not be tolerated.
13. Consistent with WVU guidelines, students absent from regularly scheduled examinations because of authorized University activities will have the opportunity to take them at an alternate time. Make-up exams for absences due to any other reason will be at the discretion of the instructor.

Grading:			
Three Exams @ 17.5%	52.5%	The nominal grading scale is	≥90% A
Final Exam (Tue, 5/3: 3pm)	20.0%		≥80% B
Problem Sets	10.0%		≥70% C
Design Project	17.5%		≥60% D
			<60% F

At the instructor's discretion, this scale may be lowered, but not raised.

Days of Special Concern:

WVU recognizes the diversity of its students and the needs of those who wish to be absent from class to participate in Days of Special Concern, which are listed in the Schedule of Courses. Students should notify their instructors by the end of the second week of classes or prior to the first Day of Special Concern, whichever is earlier, regarding Day of Special Concern observances that will affect their attendance. Further, students must abide by the attendance policy of their instructors as stated on their syllabi. Faculty will make reasonable accommodation for tests or field trips that a student misses as a result of observing a Day of Special Concern.

Social Justice:

West Virginia University is committed to social justice. I concur with that commitment and expect to maintain a positive learning environment based upon open communication, mutual respect, and non-discrimination. Our University does not discriminate on the basis of race, sex, age, disability, veterans status, religion, sexual orientation, color or national origin. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration.

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Disability Services (293-6700).

Approximate Syllabus

(There may be some class switches with CHE 315. These will be announced later. Reading is from HF unless otherwise noted.)

Class	Date	Topic	Reading	Assignment Due
1	1/11	Introduction, Mole Balances for Reactors	1	
2	1/13	Reactor Design Equations, Examples	2	
3	1/18	Batch Reactor Design	4	PS 1
4	1/20	Flow Reactor Design		
5	1/25	Design of Multiple Reactors, Pressure Effects in Flow Rxtrs		PS 2
6	1/27	Pressure Effects in Flow Rxtrs, Unsteady State Rxtr Design		
-	2/1	No CHE 325 – Class will be CHE 312		PS 3
7	2/3	More Reactor Design Examples, Exam Review		
8	2/8	11am-12pm – **Exam 1**		
9	2/8	12:15-1:45 – Multiple Reactions	6	
10	2/10	Multiple Reactions		
11	2/15	Heat Effects in Reactors	8	PS 4
12	2/17	Adiabatic and Non-isothermal CSTR and PFR Design		
13	2/22	Adiabatic and Non-isothermal Reactor Design Examples		PS 5
14	2/24	Temperature Effects in Equilibrium Reactions, Multiple Steady States		
15	3/1	Multiple Steady States and Reactor Safety Examples		PS 6

16	3/3	**Exam 2**		
17	3/8	Types of Reactors, Equipment		
18	3/10	Temperature Effects with Multiple Reactions, Unsteady State Adiabatic and Non-isothermal Reactors	9	
19	3/15	External Diffusion Effects	11	PS 7
20	3/17	External Diffusion Effects		
-- SPRING RECESS --				
21	3/29	Pore Diffusion Effects in Catalysts	12	PS 8
22	3/31	Pore Diffusion Effects in Catalysts		
23	4/5	Example problems		PS 9
24	4/7	Review		
25	4/12	**Exam 3**		
26	4/14	No Class - Work on Design Project		
27	4/19	No Class - Work on Design Project		
	4/20	Design Presentations – 1-3 pm, 401 ESB		
28	4/21	Design Presentations – 11am-1:45pm, 401 ESB		
29	4/26	Non-ideal Reactor Models, Residence Time Distributions	13	
30	4/28	Project and Course Review		PS 10
	5/3	Final Exam, 3-5 pm, 401 ESB		