

**University of Kentucky  
Chemical and Materials Engineering Department**

**CME 550-001: Chemical Reactor Design  
Fall 2005**

Instructor: Dr. Stephen Rankin                      159 FPAT (Anderson Tower)  
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Class Meetings: Monday, Wednesday and Friday 9:00-9:50 am, 207 RGAN

Office hours: Tu 11:00 am-12:00 pm, Th 1:00-2:00 pm, or by appointment

Teaching assistant: Michael Danquah (office hours and contact info TBA)

Textbook: Octave Levenspiel, *Chemical Reaction Engineering*, 3<sup>rd</sup> ed. John Wiley & Sons, 1999. ISBN 0-471-25424-X

Course web site: <http://www.engr.uky.edu/~srankin/cme550.htm>

Prerequisites: CS 221 (or equivalent), CME 420, CME 425, and engineering standing, or consent of instructor.

### **Course description**

Chemical reactors play a central role in all chemical processes. The control of chemical changes for practical applications is a defining concept in chemical engineering. *Reaction engineering* entails the manipulation of chemical reactions by adjusting the size and shape of a reactor, the flow conditions, and the operating conditions (temperature, pressure, etc.). Possible goals might be to minimize reactor size, to optimize the yield of a certain product, to avoid byproduct production, or to make a process safer or more environmentally friendly. In this course, you will learn to interpret chemical reaction rate data and to use those data to develop performance equations for single and multiple reactor systems.

### **Objectives**

At the conclusion of the course, students should be able to:

1. Identify, formulate and solve isothermal homogeneous batch and flow reactors
2. Identify, formulate and solve design equations for reactors in series
3. Identify, formulate and solve equations for reversible and multiple reactions
4. Identify, formulate and solve nonisothermal reactor problems
5. Identify, formulate and solve heterogeneous reaction problems related to catalysis

6. Analyze and interpret reaction rate data in the context of reactor design equations
7. Optimize the design of isothermal and nonisothermal reactors
8. Use numerical packages (Maple, Aspen, etc.) to solve reactor design problems
9. Retrieve information effectively from the library and internet and present the information in the form of a written report
10. Successfully complete a multidisciplinary team reactor design project

### Important Dates

August 24 .....	First day of class.
September 5.....	Labor Day – No Class.
September 23.....	Exam 1
October 7 .....	Fall Break – No Class.
October 17.....	Midterm of semester.
October 24.....	Exam 2
October 31.....	AIChE Annual Meeting. Class cancelled.
November 2 .....	AIChE Annual Meeting. Class cancelled.
November 23 .....	Exam 3
November 25 .....	Thanksgiving break - No Class.
December 9.....	Last day of class.
December 9.....	Written group project (details TBA) report due
December 13.....	<b>Final Exam, 8:00-10:00 am, 207 RGAN.</b>

### Grading

Each of the grading components will be normalized by the maximum possible score and weighted by the percentages (see below) to arrive at a final overall percentage for the course. The following percentage ranges will guarantee that a student receives that grade. If the average for the class falls below 75%, the grade cutoffs may be adjusted, always in favor of higher grades.

90 to 100% : A      80 to 89% : B      70 to 79% : C      60 to 69% : D      <60% : E

If a student receives a “D” or “E” on all exams and quizzes, homework and group project grade (see below) will not be counted (and the score will be renormalized).

### Grading Components

Final Exam	30%
Exams (3)	15% each
Group Project	10%
Homework	10%
Class Participation and Preparation	5%

## Participation and Preparation

Class participation will be graded based on *attempting* to answer questions in class. Students will be called upon randomly from the class roster, but they also will be given the opportunity to volunteer an answer. Questions will be based on current reading assignments, homework, and material covered in the course. Brief, unannounced quizzes will occasionally be given to test preparation, and will be counted towards the participation and preparation score.

## Reading and Homework

Reading assignments will be posted on the course web site. You will make the best use of your time in class if you keep up with the assignments, and come prepared for class. You may have an easier time doing the homework if you review the reading and notes before starting. Treat it like an exam – make sure that you understand the general ideas before you start to apply them. It is difficult to prevent students from consulting each other while doing homework, but you will be more confident and better prepared for exams if you at least try to work on problems yourself before asking for help. Note that the instructor does not think of homework as a way of preparing for exams, but as a learning tool to help you test and develop your understanding of the course material.

## Tentative Sequence of Topics

It will be important to check the course web site occasionally for changes in the timing and sequence of covering these topics, but the tentative sequence will be:

1. Introduction [Levenspiel (OL) Chapter 1]
2. Chemical Kinetics and Analyzing Kinetic Data [OL Ch. 2-3]
3. Ideal reactors: batch, mixed flow (CSTR) and plug flow [OL Ch. 4-5]
4. Design for single reactions [OL Ch. 6]
5. Design for parallel reactions [OL Ch. 7]
6. Series and multiple reactions [OL Ch. 8]
7. Temperature and pressure effects [OL Ch. 9]
8. Choosing the right reactor [OL Ch. 10]
9. Heterogeneous catalysis [OL Ch. 17-18]
10. Enzyme fermentation [OL Ch. 27]

## What you should review

Most of the equations that arise in reaction engineering are either sets of algebraic equations, or first-order ordinary differential equations. It would be a good idea to review how to solve ordinary differential equations. Can you solve this?

$$\frac{dC}{dt} = -kC$$

Numerical solution will be required for some problems in this class. The problems will be sets of ordinary differential equations. The default numerical package for this course will be Maple. It will help you to review the syntax that Maple uses, especially to solve differential equations. You may use another numerical package at your own risk (I will help as much as I can, but I may not be familiar with other packages).

The other chemical engineering course most closely related to this one is heat and mass transport. If you do not remember how to do differential balances, you should review how today. Limits on reactor design also come from the thermodynamics of reacting systems. Review the calculation of equilibrium coefficients for chemical reactions from thermodynamics.

### **Attendance**

The instructor will not take attendance, but the preparation and participation grade will be adversely affected if you are absent. Acceptable reasons for missing class are enumerated in student regulation S.R. 5.2.4.2 (reasons reproduced below). Please notify the instructor of any absences as much in advance as possible.

- 1) serious illness;
- 2) illness or death of family member;
- 3) University-related trips;
- 4) major religious holidays;

**This syllabus is subject to change. All changes will be announced in class, and an up-to-date version of the syllabus, with all changes, will be posted on the course web site.**