Chemical Kinetics and Reactor Design
ECH 4504
Class Periods: T,R | Period 8 - 9 (3:00 PM - 4:55 PM)
Location: LAR 0330
Academic Term: Spring 2020

Instructor:
Carl Denard
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Office Phone Number: TBA
Office Hours: M, W: 1 PM- 2:30 PM, 419 Chemical Engineering Bldg. (CHE)

Teaching assistants
- There are no teaching assistants assigned this semester

Course Description
Homogeneous and heterogeneous reaction kinetic modeling and data analysis. Analysis and design of ideal batch, mixed, plug and recycle reactors. Heterogeneous catalysis and reactor design.

Course Pre-Requisites / Co-Requisites
ECH 3264 and ECH 4123

Course Objectives
Chemical Kinetics and Reactor Design is a unique course in the chemical engineering curriculum that distinguishes this field from other engineering disciplines. In this regard, this course can be viewed as a culmination of your undergraduate education in chemistry, material and energy balances, transport phenomena, numerical methods, and thermodynamics. Upon completion of this course, a student should be able to:
1. Express reaction rate dependence on temperature and species concentration
2. Formulate rate equations based on a sequence of elementary reactions
3. Evaluate rate equations based on experimental data
4. Apply material balances to size and analyze reactors
5. Apply energy balances to size and analyze reactors
6. Evaluate catalyst performance and recognize transport effects in heterogeneous catalysis

Professional component (ABET)
This course prepares chemical engineering students with deep discipline knowledge, critical thinking, and problem solving skills. Students in the class will interpret and apply chemical kinetic data to make educated decisions about reactor design. Problems in class will be have varied realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Relation to Program Outcomes (ABET):

COURSE #	ECH4504
SHORT NAME	KINETICS
SEMESTER	7
PROBLEM SOLVING	**Assessed**
DESIGN	**Assessed**
COMMUNICATE	
ETHICS	
TEAMWORK	
EXPERIMENTATION	
LIFE LEARNING	

Required Textbook

- Chemical Reactions and Chemical Reactors (Two books on reserve in UF MARSTON LIBRARY)
- George W. Roberts
- 2009
- ISBN-13 978-0471742203

Required software

- Polymath or Solver add-in in Excel

Course notes are developed by the instructor and not from published sources

Additional recommended materials

- Learn ChemE , Educational Resources from ChemE from University of Colorado Boulder (http://www.learncheme.com/screencasts/kinetics-reactor-design).
- http://www.umich.edu/~elements/5e/

A few illustrative examples and quiz questions may be taken from this resource.

Tentative Course Schedule

Date	Topic	Reading	HW assigned	HW due	Quiz
7-Jan	Introduction, reactions and stoichiometric relations	Ch. 1.1-1.3			
9-Jan	Stoichiometric relations and components of the rate law – generalizations	Ch. 1.4, 2	#1		
14-Jan	Components of the rate law – generalizations	Ch.2			#1
16-Jan	Design equations for ideal reactors	Ch. 3	#2	#1	
21-Jan	Design equations and reactor sizing – Homogeneous reactions in batch reactors	Ch. 3-4			#2
23-Jan	Design equations and reactor sizing – Flow systems		#3	#2	
28-Jan					#3
30-Jan	Design equations and reactor sizing – Flow systems, recycle and multiple reactors			#3	
4-Feb	**Exam I (in class)**				

6-Feb	Design equations and reactor sizing – Flow systems, recycle and multiple reactors	Ch. 4	#4		
11-Feb	Reaction rate fundamentals – Elementary reactions and the Steady-State Approximation (SSA)	Ch. 5.1-5.3			
13-Feb	Reaction rate fundamentals – Closed Sequences and the Rate-Limiting Step (RLS) Approximation	Ch. 5-4, 5-6	#5	#4	#4
18-Feb	Analysis of experimental data	Ch. 6			
20-Feb				#5	#5
25-Feb	Pressure drop in reactors	Instructor notes			
27-Feb	**Exam II (in class)**				
3-Mar	Holiday				
5-Mar					
10-Mar	Conversion, selectivity and yield. Reactor design and analysis for multiple reactions	Ch. 7	#6		#6
12-Mar					
17-Mar					
19-Mar	Macroscopic energy balances (heat effects) Isothermal and adiabatic reactors	Ch. 8	#7	#6	7
24-Mar	Multiple steady states, blowout and hysteresis (CSTR)				
26-Mar	Nonisothermal and nonadiabatic batch and PFRs Feed-product heat exchangers			#7	8
31-Mar	Heterogeneous catalysis	Ch. 9	#8		
2-Apr	**Exam III (in class)**				
7-Apr	Heterogeneous catalysis	Ch. 9			9
9-Apr				#8	
14-Apr	Introduction to Enzyme Kinetics and special topics on bioreactors	Instructor notes	#9		
16-Apr					
21-Apr	No lecture - will be used if we fall behind			#9	
28-Apr	**Final Exam**				

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance is strongly encouraged.
Excused absences must be consistent with university policies in the Graduate Catalog (http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance) and require appropriate documentation. Additional information can be found here:
https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx

Quizzes

The quizzes will generally cover lecture material from the previous few class periods and will require 10-15 minutes to complete. Quiz solutions will be posted on Canvas after class. Quizzes are closed book, closed notes. Use of cell phones is not allowed during quizzes.

Homework grading policy
Homework problems will be graded on a 0-2 scale (0 = no effort, 1 = little effort, 2 = significant effort). No credit will be given without work being shown. One or two of your lowest homework scores will be dropped. HW due dates are on the schedule and should be turned in in class, or worse case, in my mailbox by 5 pm. Late HW is docked 50% if it is a day late. HW *will not* be accepted beyond 24 hours after the due date (so 5 pm the following day). Include your name, date, and HW number on the first page. Write only on one side of paper and staple pages. Students are encouraged to help each other on HW, but copying someone else's solution or allowing someone else to copy yours is cheating and a violation of academic honesty policy. Rule of thumb: Discuss the HW, but don't look at anyone else's work or show them your work. Homework solutions will be posted on canvas two days after the due date.

Evaluation of Grades
Homework will be graded but will not count to the final grade unless it helps your grade. In that case, it will be worth up to 10% of the grade. Only one problem will be graded randomly on each homework. There is no final exam. One of your homework with the lowest grade will be dropped.

Table 1. Grade evaluation if homework is counted towards final grade

Assignment	**Percentage of Final Grade**
Homework	10%
Quizzes	10%
Exam with lowest grade	10%
Three remaining exams	70/3%

Table 2. Grade evaluation if homework is not included

Assignment	**Percentage of Final Grade**
Homework	0%
Quizzes	20%
Exam with lowest grade	10%
Three remaining exams	70/3%

Grading Policy
The final grade will be determined by scaling every score to the highest score, and then choosing cutoffs for grades A, A- and so on.

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and

respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim

Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://care.dso.ufl.edu.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.