Transport with Reactions in Biological Systems
BIEN 270
Spring 2017

COURSE OUTLINE

Course Time: LEC: (T Th) 08:10 A.M. - 10:00 A.M., WCH 011
DIS: (W) 9:10 A.M. - 10:00 A.M., WCH 011

Instructor: V. G. J. Rodgers (215 MS&E) victor.rodgers@ucr.edu
W 3:10 -5:00 PM and by appointment (please email)

T.A.: Dieanira Erudaitius (A133 Bourns Hall) derudait@gmail.com
Office Hours TBD

Textbooks: *Transport Phenomena in Biological Systems*, G. Truskey, F. Yuan, D.F. Katz, Pearson Prentice Hall, New Jersey, 2004, ISBN: 0-13-042204-5

Suggested Supplemental Books:

Chemical Reacting Flow: Theory & Practice, John Wiley & Sons, Inc., NY, Robert J. Kee, Michael E. Coltrin and Peter Glarborg (2003) ISBB: 0-471-26179-3

Kinetic Theory and Irreversible Thermodynamics, Wiley Interscience, B. Eu (1992) ISBN 0-471-61524-2

The Chemical Reactor Omnibook, Octave Levenspiel, 2002.

Transport Phenomena, 2nd Edition, John Wiley & Sons, Inc., NY, R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot (2002) ISBN: 0-471-41077-2

Analysis of Transport Phenomena, William M. Deen, Oxford Press, 1998. ISBN: 0-19-508494-2

CRC Standard Mathematical Tables and Formulae, 31th Edition, CRC Press, Editor-in-Chief Daniel Zwillinger (2002) ISBN**:** 1584882913

Molecular Theory of Gases and Liquids, John Wiley & Sons, Inc., NY, J. O. Hirschfelder, C. F. Curtiss, and R. B. Bird, 1954, ISBN: 0-471-40065-3

Course Description:

The Ph.D. biomedical engineer should bring the ability to fundamentally and effectively apply conservation laws and reactive systems processes to both the traditional and interdisciplinary biomedical engineering research problem. It only takes a moment to see the importance of understanding reaction behavior in such designs as bioreactor designs, artificial liver design, signal transduction and gene therapy. As interdisciplinary research continues to become increasingly more complex, it remains paramount that the research-grade bioengineer is truly grounded in chemical reaction kinetics.

It is the goal of this course to move the graduate student (and advanced undergraduate student) from the introductory level of reaction engineering (undergraduate) to a level that will allow them to communicate, be confident, and be effective in researching reaction-related topics in a variety of biomedical engineering and biochemical engineering areas. This is a goal-oriented course that will; 1) provide the student with a competitive foundation in reaction kinetics, 2) demonstrate the applicability of reaction kinetics to practical

biomedical engineering problems, and 3) allow the student to develop and practice analysis of real problems with an appreciation for solution approximation methods, their limitations and their use in evaluating computed solutions. The emphasis will be reaction-based systems in biological systems.

The book *Transport Phenomena in Biological Systems* and the class notes will be used throughout the course. The book will be used to cover the fundamentals of reactions in biotransport phenomena and to discuss the development of tools to address chemical reactions in biological systems. Generally, the class notes will guide the class structure with the textbook used as an important reference. Because flow systems in biological systems are emphasized, COMSOL will also be used for modeling the transport characteristics of problems that are assigned or selected by the students.

This is a goal-orientated course, and, as such, it is project based. However, so that the student has formal development of fundamental training, three closed-book exams (Confidence Builders) are offered with one ongoing, project that will be due at the end of the quarter. The project will be based on one suggested by the student on a problem of significance to the student. The project goals will be introduced early on in the course and Professor Rodgers will approve it. The project will require the graduate student to develop and, then, solve a tractable problem related to an area of their interest (this may be their research area). A series of short presentations will be used for the student to develop the project as well as share with the class what they are doing. The final professional report and presentation of the project are due at the end of the semester.

The homework will be reviewed with the primary concern being effort and professionalism rather than correctness. This is because the philosophy of graduate education is to develop the ability to teach ourselves new subject matter and to be accountable for our technical performance. Thus students will not be penalized for incorrectness during the "intermediate stages" of learning (homework) but they will be accountable for knowing the correct approach to a problem in the exams. Therefore it is essential to the student that they are responsible for their understanding of the problems and their assigned purpose.

This course will be rigorous but in a supportive setting. To this end, I will have an open-door policy for help and support with any aspect of this course. Take advantage of soliciting for help as often as necessary. Answers to the homework (where available) will be made available on for the course the day after the homework is due. No homework will be accepted late. Professional and technical qualities are of the utmost importance.

Exam Schedule and Grading:

	POINT	**DATE**
Homework	100	
1st Confidence Builder	250	Thursday, May 11, 2017
2rd Confidence Builder	250	Thursday, June 8, 2017
Final Project Due	400	June 16, 2017
TOTAL	**1000**	

Collaboration Policy:

Any questions about homework problems should be addressed to Professor Rodgers. Discussion of homework problems with other students in the class is acceptable but direct copying of complete or part of an assignment is ***not*** allowed. Cheating on exams and/or plagiarism in projects will result in an **F** grade given for the course.

Schedule

WEEK	TENTATIVE TOPICS	MATERIAL
1	Introduction to Statistical Thermodynamics	Notes
2	Mass Action Kinetics, Reaction Rate Theory	Notes
3	Mass Transfer and Biochemical Interactions	Notes and (K) Ch. 10
4	Mass Transfer and Biochemical Interactions	(T) Ch. 10
5	Reaction Mechanisms	(K) Ch. 13 and (T) Ch. 10
6	Cell-Surface Ligand-Receptor Kinetics	(T) Ch. 11
7	Cell Adhesion Modeling	(T) Ch 12
8	Gas/Blood Interaction	(T) Ch 13
9	Drug Transport in Solid Tumors	(T) Ch. 15
10	Transport in Organs and Organisms	(T) Ch. 16

(T): Chapters from: *Transport Phenomena in Biological Systems*, G. Truskey, F. Yuan, D.F. Katz, Pearson Prentice Hall, New Jersey, 2004, ISBN: 0-13-042204-5

(K): *Chemical Reacting Flow: Theory & Practice*, John Wiley & Sons, Inc., NY, Robert J. Kee, Michael E. Coltrin and Peter Glarborg (2003) ISBB: 0-471-26179-3

ONLINE ASPECTS

All exams will be proctored. This course involves the following four components: A course management system, e.g., UCR's iLearn (BlackBoard) system, which UCR has been using for many years and with which most UCR faculty are already familiar. For online consultation with TAs and faculty, a web-based meeting system that includes shared desktop, audio, and possibly video communication. Remotely available online video recordings of classroom lectures (e.g., Flash 7.0+) with accompanying presentation graphics (e.g., PowerPoint slides). Remotely proctored exams, for which we will initially follow UCLA's policies and protocols.

1) The Course Management System. UCR has deployed an online, full-service website, iLearn (based on BlackBoard), that provides student and faculty access to courses and associated materials. Assignments, answer sheets, announcements, lecture slides, lecture notes, etc., may be uploaded by the faculty and easily accessed and downloaded by the student. It also provides threaded forums by which student questions are addressed by the instructor or TA, as well as, possibly, by other students. An e-mail tool is built in that allows the instructor to easily send information to the students of the class.

2) Course Schedule. All online courses follow up the standard schedules of 10-week offerings during the academic year; the Committee on Courses can consider alternative scenarios under exceptional circumstances on a case-by-case basis.

3) Interaction with Students. The Program will be delivered over the Internet. Students of the Program will receive all course materials, including lectures, in an "online" manner. The current mode of delivering many

courses within the Bourns College of Engineering (BCOE) relies heavily upon information technology, using learning-management systems. That is, currently, BCOE students receive course lecture notes, assignments, announcements, and other items via WEB interfaces, and they participate in online forums for questions and answers with instructors and TA's. In addition, prepared lectures will be available online for the students of the online M.S. in Engineering Program.

4) The Online Lectures for the Program. There are, of course, several technologies for producing online lectures. We have decided that it is best to have the instructor visible and speaking directly to the remote audience. We have decided upon producing video-audio synchronized PowerPoint lectures. Many faculty members of BCOE have a good deal of experience with the production of such lectures. Considerable effort is required of the instructor to create such video-synchronized PowerPoint lectures for an entire course. When the lecture has been constructed, various files are published (uploaded) to two servers, for the purpose of streaming the lecture material. Each of these servers acts as a backup for the other. This technology enables the student to have complete control of the streamed lecture material. The student may stop (pause) the flow of the presentation to carefully view a particular slide, the student may easily move from the present slide to any other slide and its concomitant video explanation, and, of course, the student may repeat a lecture or portions of a lecture as often as desired. When the student "clicks" on the appropriate hyperlink, the lecture is streamed to that student's machine and displayed in the machine's browser.

5) Online Consultation. In addition to instructor-recorded lectures, live online discussion sessions will be held by the instructor and TA, times TBA. Students will have access to the instructor at specified time frames. The course description would include the manner of such contact hours. Similarly the number and manner of TA contact hours would be included in the course description. The consultation component of the online courses will be done through various collaborative software technologies (e.g. Skype plus VNC). This will enhance office hours beyond the usage of online forums, allowing audio and visual contact between the instructor and several students of the class, even if such students are geographically dispersed. In addition, UCR has deployed an online, full-service website, iLearn (based on BlackBoard), that provides student and faculty access to courses and associated materials. Assignments, answer sheets, announcements, lecture slides, lecture notes, etc., may be uploaded by the faculty and easily accessed and downloaded by the student. It also provides threaded forums by which student questions are addressed by the instructor or TA, as well as, possibly, by other students. An e-mail tool is built in that allows the instructor to easily send information to the online students.

6) Examinations. Evaluation methods will include: (1) online homework and quizzes (no change from existing physical course using iLearn tools) making up a small portion of the grade with the clear purpose of preparing students for exams; and (2) a midterm exam and final exam accounting for the majority of the course grade (typically 50% or more). The exam(s) will be taken at either (a) an approved proctored test facility or (b) for those students who are employed in organizations with which we are familiar and for which the examination (e.g., midterm, final) can be taken at a given time and location within Company X. For this latter situation, we will have arranged in advance (at least one week) for a trusted proctor (e.g., a member of the office of the "VP of University Relations" or direct supervisor). The proctor will agree to adhere and sign a code of conduct as part of the proctor arrangement. For either (a) or (b) we will also have an "open link" with the proctor to be able to answer typical clarification questions that arise during an examination. The students' examinations would then be scanned and sent back to the instructor via e-mail or by FTP to a protected site. As the program develops beyond the initialization stage, we will develop arrangements with organizations, including other schools, at which examinations may take place in a trusted, proctored environment.

7) Intellectual Property. UC policy is that "The University owns the copyright to recordings of classroom lectures, but faculty own the copyright to their own lecture notes and teaching aids." It is the College's position that studio-based pre-recorded lectures are teaching aids and, therefore, the property of the faculty member who created those lectures. No other faculty member may use them without the explicit approval of the creator. Neither the College nor its representatives will distribute those lectures to others without the explicit approval of the creator of those materials.

8) Materials accessibility. Relevant materials available to students residing at or near UCR is also available to online students; this includes library material available electronically.

9) Computer Requirements. When applicable, software and hardware requirements and the manner in which course-specific items can be obtained, are specified and included in the course syllabus.