RUTGERS UNIVERSITY
Department of Chemical and Biochemical Engineering

155:507 Analytical Methods in Chemical & Biochemical Engineering (3 credits) **Fall 2018**
(Course Section: 02)

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Class Timings: Wednesdays at 5:00-8:00 p.m.
Class Location: Science & Engineering Resource Center - Room 207
https://dcs.rutgers.edu/classrooms/science-and-engineering-research-center-room-207

Course Description:
Matrices & Linear Algebra, First and higher order ODEs, Numerical solutions to ODEs, Systems of Differential Equations, Linear and nonlinear PDEs; Using Matlab to solving chemical and biochemical engineering relevant ODE focused problems.

Course Objectives and Outcomes: In this course, students will develop the necessary mathematical tools to address advanced chemical engineering problems using a quantitative formulation. Analytical solutions to deterministic mathematical models encountered in chemical and biochemical engineering, including environmental and safety systems. Emphasis is on purpose, philosophy, classification, development, and analytical solutions of models occurring in transport phenomena, thermochemical, and reactor systems.

PREREQUISITES

In addition, undergraduates are expected to have a solid background in calculus (differential and integral calculus), differential equations, linear algebra, thermodynamics, fluid mechanics, and chemical kinetics or require special permission of the graduate director/course instructor. Students are expected to be fairly conversant with setting up basic elemental balance equations (e.g., mass, momentum, energy) for a variety of chemical engineering problems as covered in a typical undergraduate program. Please review additional reference material to review these concepts as a pre-requisite for this course (one example reference textbook to review similar concepts is given below).

- Bird, R.B., Stewart, W.E., and Lightfoot, E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition.

REFERENCE TEXTBOOKS AND SOFTWARE

Textbooks: In this course we will be referring to multiple textbooks and journal publications to closely examine analytical and numerical methods used to solve problems in chemical/biochemical engineering. However, Rice and Do is the required textbook that will be closely followed by the instructor.

- **Rice, R.G. and Do, D.D. Applied Mathematics And Modeling For Chemical Engineers, Wiley, 2nd Edition, 2012.** *(For each lecture, students are encouraged to review assigned chapters from this textbook. See course timetable for details.)*

Other reference texbooks are also listed below as well. The student are welcome to consider referring to other suitable undergraduate/engineering mathematics textbook to brush up on basics of ODEs and Matrix Algebra.

Chemical engineering analytical/numerical methods specific references

- Beers, Kenneth. Numerical Methods for Chemical Engineering: Applications in MATLAB®. New York, NY: Cambridge University Press, November 2006.
- Varma, Arvind and Morbidelli, Massimo. Mathematical Methods in Chemical Engineering. Oxford University Press. 1997.
- Cutlip, M.B. and Shacham, M. Problem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB, Pearson, Second edition.
- Loney, Norman W., Applied Mathematical Methods for Chemical Engineers, CRC Press – Taylor & Francis Group, Boca Raton, 2nd edition, 2007.

Advanced mathematics specific references

- Zill, D.G. and Wright, W.S. Advanced Engineering Mathematics. Jones & Bartlett Publishers, Fifth edition. **(For each lecture, students are highly encouraged to review assigned chapters from this textbook to review additional basics before attending the lecture. See course timetable for details.)**
- Kreyszig, E. Advanced Engineering Mathematics. Wiley, 10th Edition, 2011.

MATLAB Software: This is a numerical computing software package that can be used for solving problems relevant to this course and working knowledge of Matlab is a pre-requisite for this course. **Students are expected to self-learn using this software for solving homework problems or projects, if they are not familiar with it.** It is installed on all computers in the Microcomputer Laboratory (rooms C233, C241, B125, and D110). Students can also access Matlab in the campus computing labs or via http://apps.rutgers.edu. ***Material to help with learning how to use Matlab is freely available online in video format from MathWorks*** **(https://www.mathworks.com** and **https://matlabacademy.mathworks.com).**

The following textbooks could also be used to help learn Matlab for beginners;
D. Hanselman and B. Littlefield, "Mastering MATLAB 7," Pearson, NJ (2005)
W.J. Palm III, "Introduction to MATLAB 7 for Engineers: McGrawHill (2005)

CLASS PARTICIPATION, HOMEWORK AND GRADING POLICY

Homework problems will be assigned, collected, and graded on a regular basis during the semester. All homeworks will be posted on the Sakai course webpage. Students are requested to turn in their homework assignments in-class (unless specifically instructed otherwise). No late homeworks will be accepted. There are going to be several unannounced quizzes held in class. There will be one midterm exam, one final exam, and a term project. Class participation and attendance are critical to do well in this course (*additional instructions regarding class attendance and homework submission policy will be given in class*). The course grade will be determined as follows:

Surprise Quizzes	5%
Homeworks	20%
Mid-Term Exam	30%
Final-Term Exam	30%
Project	15%

ACADEMIC INTEGRITY

Students caught cheating on homework assignments, projects, or exams will be reported for disciplinary action in accord with the university policy on academic integrity, in addition to likely failing the course! Therefore, students are expected to familiarize themselves with and adhere to the Rutgers policy on academic integrity at: http://academicintegrity.rutgers.edu/policy-on-academic-integrity.

It is understood that a student's name on any individual homework assignment, quiz, or exam indicates that he/she neither gave nor received unauthorized aid. On individual homework assignments, *authorized* aid includes discussing: 1) interpretation of the problem statement, 2) concepts involved in the problem, 3) approaches for solving the problem. Anything beyond this constitutes unauthorized aid and violates the academic integrity policy.

A student's name on a group assignment indicates that he/she contributed to the assignment. Quizzes and exams are tests of individual performance. The student is not permitted to obtain assistance from any other person (or persons) during quizzes or exams. The student must adhere strictly to the instructions provided by the professor regarding what is permissible to be used during the exam. **Use of lecture notes, computers, laptops, and cell phones without prior authorization of instructor is PROHIBITED during exams.**

COURSE MATERIAL COPYRIGHT

All course material posted on the Sakai course website is copyrighted and may not be posted on any other web site at or outside of Rutgers without permission from the course instructor. Noncompliance with this policy will be treated as a violation of the Code of Student Conduct and will be referred to the Office of Student Conduct for action.

TENTATIVE COURSE TIMETABLE

The course will tentatively follow the timeline indicated below. Reading from the reference textbooks will be critical to keep up in the class. Additional reading will be assigned from other sources and maybe posted on the Sakai course website. Some lecture slides will be available to the students as pdf files on the Sakai web site, however, ***students are expected to prepare their own notes in the classroom to complement the reference textbook material***. Additional material may be distributed as handouts in-class. A week-by-week schedule of the course, lecture topics, textbook references, and relevant lecture description is given below *(please follow announcements on the Sakai course webpage for any changes to the following schedule!)*. ***Students are advised to complete reading and practice problem assignments prior to attending the lecture to keep up in this course!***

****Note Change in Class Schedule: Class on November 21, 2018 rescheduled to Nov 30, 2018 at SOE CBE C115 from 5pm to 8pm. The rescheduled class will be used for completing assigned syllabus.**

2018 Outline (155:507 Chundawat Section 2)

Week	Date	Lecture Number/Title	Lecture Description	Rice-Do Book (Required)	Tentative Due Dates	Zill-Wright Book (or Extra)
Week 1	5-Sep	1. Introduction	Introduction to CBE Modeling & Matrix Algebra (Eigenvalue Problem)	Chapter 1		Chapter 8
Week 2	12-Sep	2. Solutions to lower-order ODEs	Recap to solve general first-order and second-order ODEs problems	Chapter 2	HW 1 Assign	Chapter 1, 2
Week 3	19-Sep	3. Solutions to higher-order ODEs	Complementary and particular solution methods	Chapter 2	HW 2 Assign	Chapter 3
Week 4	26-Sep	4. Solutions to higher-order ODEs	Series based solutions (e.g., Method of Frobenius)	Chapter 3		Chapter 5
Week 5	3-Oct	5. Solutions to higher-order ODEs	Continued from lecture 2-4	Chapter 3, 4	HW 1 Due	Chapter 5
Week 6	10-Oct	6. Solving systems of linear ODEs	Matrix methods to solve linear ODEs & Classical Kinetics Eigenvalue Problem	-	HW 2 Due	Chapter 8, 10
Week 7	17-Oct	**7. Mid-term Exam**	*3 hr exam based on all material covered in weeks 1-6*			
Week 8	24-Oct	8. Solving systems of non-linear ODEs	Matrix methods to analyze non-linear ODEs & recap for Eigenvalue Problem	-	HW 3 Assign, Project assigned	Chapter 2, 11 + Extra Notes
Week 9*	31-Oct	9. Using MATLAB to solve ODEs	Numerical solutions for ODEs (initial value ODEs): RK type methods	Chapter 7, Appendix A	Project/Matlab in-class discuss	Chapter 6 + Extra Notes
Week 10	7-Nov	10. Using MATLAB to solve ODEs	Numerical solutions for ODEs (initial value ODEs): Eigvalue Kinetics Problem	Chapter 7, Appendix A	Project/Matlab in-class discuss	Extra Notes
Week 11	14-Nov	11. Solving boundary value ODEs	Method of weighted residuals	Chapter 8	HW 4 Assign	Extra Notes
Week 13	28-Nov	12. Solving boundary value ODEs	Method of weighted residuals (contd) + MATLAB based analysis of BVP	Chapter 8	HW 3 Due	Extra Notes
Week 13**	30-Nov	13. Solutions to PDEs	Method of combination of variables	Chapter 10		Extra Notes, Chapter 12, 13
Week 14	5-Dec	14. Solutions to PDEs	Method of separation of variables (Sturm-Liouville Problem)	Chapter 10	Project Report Due	Extra Notes, Chapter 13
Week 15	12-Dec	15. Solutions to PDEs	Method of separation of variables (contd) + Group Project Presentations	Chapter 10	HW 4 Due, Project Presentation	Extra Notes, Chapter 13
Week 16	19-Dec	**16. Final-Term Exam**	*3 hr exam based on cumulative syllabus covering all lectures*			