Course Syllabus

CBE660: Intermediate Problems in Chemical and Biological Engineering - Fall 2016

Department of Chemical and Biological Engineering, University of Wisconsin-Madison

`http://zavalab.engr.wisc.edu/teaching/cbe660fall2016`

Goals

This course is intended to introduce incoming chemical and biological engineering graduate students to a variety of mathematical methods that are useful in solving research problems. The course focus is on analytical methods, but most of the ideas and techniques will be illustrated with computations and examples. It is also hoped that the students will gain sufficient background in applied mathematics to begin reading the science and engineering research literature.

The lectures introduce the concepts and present the theory. It is assumed that the interested students will read the referenced material for details left out in class. The HW problems enable the student to practice and become proficient at applying the methods.

The class website is `http://zavalab.engr.wisc.edu/teaching/cbe660fall2016`. The syllabus, homework assignments, and supporting materials will be posted there.

Prerequisites

Introductory courses in calculus, linear algebra, statistics, and differential equations.

Pre-survey

Please take survey `https://uwmadison.co1.qualtrics.com/SE/?SID=SV_0Tbvvlqfc1UhRpX`. This will give the instructor a better feel about your background on the topics covered.

Topics

Linear Analysis and Matrices, Differential Equations, Stochastic Methods.

Grading

Two Midterm Exams 50%, Final 25%, Homework & Computations 25%.

Note: All HWs should be typeset in LaTeX and submitted via gradescope: `https://gradescope.com`. For new LaTeXusers, you can request support from instructor and the TA. Templates for the HWs and example files will be posted on website to guide you through the process.

Lecture Time and Location

Monday, Wednesday, Friday 08:50 am-09:40 am. EH2239.

Exam Schedule

Two midterm exams will be given in the evening. You must notify the instructor a week before an exam if you will be unable to take the exam at the scheduled time. The final exam can only be given at the scheduled time.

- Midterm #1: Thursday, October 13th, 2016, 05:15 pm-06:45 pm, EH3024
- Midterm #2: Tuesday, November 15th, 2016, 07:15 pm-08:45 pm
- Final Exam: Tuesday, December 20th, 2016, 07:45 am-09:45 am.

Contact Information

- Instructor: Victor M. Zavala, `victor.zavala@wisc.edu`. Office hours Mondays 3-4 pm, EH2012.
- TA: Nishith Patel, `nishith.patel@wisc.edu`. Office hours Wednesdays 1-2 pm.

Textbook

M. D. Graham and J. B. Rawlings. Modeling and Analysis Principles for Chemical and Biological Engineers. Nob Hill Publishing, Madison, WI, 2013. 552 pages, 978-0-9759377-1-6.

References

- Main Reference
  - M. D. Graham and J. B. Rawlings. Modeling and Analysis Principles for Chemical and Biological Engineers. Nob Hill Publishing, Madison, WI, 2013. 552 pages, 978-0-9759377-1-6.
- General Applied Mathematics Texts
  - M. D. Greenberg. Foundations of Applied Mathematics. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1979.
  - F. B. Hildebrand. Advanced Calculus for Applications. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, second edition, 1976.
  - C. R. Wylie. Advanced Engineering Mathematics. McGraw-Hill, New York, fourth edition, 1975.
- Handbooks
  - M. Abramowitz and I. A. Stegun. Handbook of Mathematical Functions. National Bureau of Standards, Washington, D.C., 1970.
  - Rhyzik and Gradshteyn. Tables of Integrals, Series and Products. Academic, New York, fourth edition, 1980.
  - S. M. Selby. CRC Standard Mathematical Tables. CRC Press, twenty-first edition, 1973.
- Linear Analysis and Matrices
  - G. Strang. Linear Algebra and its Applications. Academic Press, New York, second edition, 1980.
  - E. Anderson, Z. Bai, C. Bischof, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenny, S. Ostrouchov, and D. Sorensen. LAPACK Users' Guide. SIAM, Philidelphia, 1992.
  - T. F. Coleman and C. Van Loan. Handbook for Matrix Computations. SIAM, Philadelphia, 1988.
  - G. H. Golub and C. F. Van Loan. Matrix Computations. The Johns Hopkins University Press, Baltimore, Maryland, third edition, 1996.
  - R. A. Horn and C. R. Johnson. Matrix Analysis. Cambridge University Press, 1985. C. L. Lawson and R. J. Hanson. Solving Least Squares Problems. Prentice-Hall, Englewood Cliffs, New Jersey, 1974.
- Differential Equations and Boundary Value Problems
  - R. B. Bird, W. E. Stewart, and E. N. Lightfoot. Transport Phenomena. John Wiley & Sons, New York, second edition, 2002.
  - H. S. Carslaw and J. C. Jaeger. Conduction of Heat in Solids. Oxford University Press, Oxford, second edition, 1959.
  - R. V. Churchill and J. W. Brown. Fourier Series and Boundary Value Problems. McGraw-Hill, New York, third edition, 1978.
  - J. Crank. The Mathematics of Diffusion. Oxford University Press, London, second edition, 1975.

- I. Stakgold. Green's Functions and Boundary Value Problems. John Wiley & Sons, New York, 1979.

- Stochastic Methods
  - J. L. Doob. Stochastic Processes. John Wiley & Sons, New York, 1953.
  - W. Feller. An Introduction to Probability Theory and Its Applications: Volume I. John Wiley & Sons, New York, third edition, 1968.
  - C. W. Gardiner. Handbook of Stochastic Methods for Physics, Chemistry, and the Natural Sciences. Springer-Verlag, Berlin, Germany, second edition, 1990.
  - A. H. Jazwinski. Stochastic Processes and Filtering Theory. Academic Press, New York, 1970.
  - A. Papoulis. Probability, Random Variables, and Stochastic Processes. McGraw-Hill, Inc., second edition, 1984.
  - N. G. van Kampen. Stochastic Processes in Physics and Chemistry. Elsevier Science Publishers, Amsterdam, The Netherlands, second edition, 1992.

Course Outline

1. Linear Analysis and Matrices
   - linear spaces
   - Gaussian elimination, QR factorization, LU factorization, SVD
   - vectors and linear independence, rank, and null space
   - matrices and matrix operations, partitioned matrices
   - existence and uniqueness, fundamental theorem of linear algebra
   - least-squares problems, networks and graphs
   - eigenvalues and eigenvectors, bases, self-adjoint matrices
   - matrix exponential and functions of matrices
2. Differential Equations
   - review of first-order and second-order ODEs
   - linear differential and difference equations
   - linear, constant coefficient differential equations
   - Bessel functions, gamma function, error function
   - Laplace transform
   - Green's function
   - boundary value problems, alternative theorem
   - differential/algebraic equations
   - elementary numerical methods, stiff ODEs, stability and accuracy
3. Probability, Statistics and Stochastic Methods
   - random variables and probability density function
   - expectation, mean and variance, sampling
   - normal distribution and central limit theorem
   - multivariate density and multivariate normal
   - least-squares estimation, confidence intervals
   - Brownian motion, random walk, and diffusion equation
   - stochastic kinetics problem
   - master equation of chemical kinetics