270.307: Geoscience Modeling
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Synopsis

This course is an introduction to ways to build and interpret conceptual and numerical models. We will learn how scientists and engineers synthesize measurements and theoretical knowledge to make new discoveries and predictions. Topics include: model building, hypothesis testing, and hands-on experience in a computer lab. Practical examples from environmental sciences, geosciences, engineering, and medical physics will be featured.

There will be a three-way focus on: Philosophy and Theory, Real-World Applications, and Hands-on Practical experience. The course is basically about data analysis, model building, and scientific method - which are used in all kinds of real-life scientific problems. Along the way we'll cover some interesting applications. We'll also spend about one half of our time in a computing classroom working on assignments that illustrate the theoretical ideas. This part of the course introduces the powerful Matlab software which is widely used in science and industry. The class is worth 4 credits because we'll spend significant time in the computer lab.

Prerequisites (in decreasing order of importance) are: linear algebra, statistics, basic physics, and calculus. Much of the course is quantitative with only brief refreshers on background math. Basic familiarity with a programming language is an advantage but not essential.

Class materials will be posted to Blackboard.

Assessment

Five computer assignments will be written up and turned in for credit. In addition there will be 2 tests (1 will probably be a take-home exam). We may also have impromptu, but ungraded, quizes to review material and test understanding.

Ethics

The following guidelines are taken seriously in this class:

Cheating is wrong. Cheating hurts our community by undermining academic integrity, creating mistrust, and fostering unfair competition. The University will punish cheaters with failure on an assignment, failure in a course, permanent transcript notation, suspension, and/or expulsion. Offenses may be reported to medical, law or other professional or graduate schools when a cheater applies.

Violations can include cheating on exams, plagiarism, reuse of assignments without permission, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. Ignorance of these rules is not an excuse.

In this course, collaboration on computer assignments in the classroom is encouraged. I also encourage you to ask questions throughout our classes; this is a habit that you should practice! The

write-ups of the computer assignments must be done individually, however, without any collaboration other than sharing of printouts of your programs and results. If you have questions about this policy, please ask the instructor.

On every exam, you will sign the following pledge: "I agree to complete this exam without unauthorized assistance from any person, materials or device. [Signed and dated]"

Old exams from this course may be found at MSE Reserves, although be aware that the course content (and name) was revised recently.

For more information, see the guide on "Academic Ethics for Undergraduates" and the Ethics Board web site (http://ethics.jhu.edu).

Textbooks

There is no required textbook for this class. One day, I hope to write my own text with your help! Relevant recommended texts are: *Menke* [1989] and/or *Wunsch* [2006] which cover everything on data analysis, statistics, and probability, but also extend way beyond. *Tung* [2007] covers the material on model building; we'll be using examples from this book. It also extends much further than we need to go, however. If you have a strong geophysics background, you may be interested in the textbook by *Gubbins* [2004]. Finally, *Gauch* [2003] is a wonderful introduction to scientific method, including much wisdom on statistics and probability.

Wunsch [2006] and *Tung* [2007] are available at the book store. There should also be student editions of Matlab available there if you want your own copy of the software.

Gauch, H. G. (2003), *Scientific method in practice*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 435 pages.

Gubbins, D. (2004), *Time Series Analysis and Inverse Theory for Geophysicists*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 272 pages.

Menke, W. (1989), *Geophysical data analysis: Discrete inverse theory*, 2nd ed., 289 pp. pp., Academic Press, San Diego, vol. 45 in International Geophysics Series, edited by R. Dmowska and J. R. Holton.

Tung, K.-K. (2007), *Topics in mathematical modeling*, 1st ed., Princeton University Press, Princeton, New Jersey and Woodstock, United Kingdom, 300 pp.

Wunsch, C. (2006), *Discrete Inverse and State Estimation Problems*, 1st ed., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 371 pp.

Schedule

We will meet twice a week for two 2 hour classes. About half of this time will be spent in Olin 304, and half in the Computer Classroom on the 2nd floor of Olin Hall. Our schedule is: Mondays and Wednesdays at 01:30–03:20. These times are somewhat flexible - please let me know if you'd like to attend class, but have a conflict. We may also arrange access to the Computer Classroom at other times so you have chance to complete your assignments. The tentative schedule is as follows. A few classes may need to be rearranged because I'll be absent.

- Week 1: 31, 2 Feb. Introduction to class. Linear algebra refresher.
  Computer lab.: Matlab introduction.
- Week 2: 7, 9 Feb. Probability and Statistics refresher.
  Computer lab.: Matlab introduction.
- Week 3: 14, 16 Feb. Educated guessing: Interpolation, extrapolation, splines, and regression.
  Computer lab.: Ocean Tides.
- Week 4: 21, 23 Feb. Celestial mechanics and the Copernican revolution.
  Computer lab.: Ocean Tides.
- Week 5: 28 Feb, 2 Mar. Hypothesis testing: Discovery of Neptune.
  Computer lab.: Celestial Mechanics.
- Week 6: 7, 9 Mar. Gauss and least squares.
  Computer lab.: Celestial Mechanics.
- Week 7: 14, 16 Mar. Revision class for mid-term exam. Mid-term exam.
  Computer lab.: Celestial Mechanics.
- Week 8: 21, 23 Mar. Spring Break!
- Week 9: 28, 30 Mar. Mid-term de-brief.
  Computer lab.: catch-up.
- Week 10: 4, 6 Apr. Snowballs and hot-houses: Modeling planetary climates.
  Computer lab.: Climate model.
- Week 11: 11, 13 Apr. (continued...)
- Week 12: 18, 20 Apr. El Niño Southern Oscillation: Climate chaos.
  Computer lab.: ENSO model.
- Week 13: 25, 27 Apr. (continued...)
- Week 14: 2, 4 May. Wrap-up. Revision class for final exam.