270.307: Geoscience Modeling
Spring Semester 2016.

Tuesdays & Thursdays 1:30pm–3:30pm
Olin 346 & Olin Computer Lab.

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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 will be featured, from fields including: oceanography, climate dynamics, paleoclimate, seismology, planetary science, and medical physics.

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 and apply 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 (the final will probably be a take-home exam). We may also have impromptu, but ungraded, quizzes to review material and test understanding. Be aware that the marking and grading schemes used in this class are not like those used in K–12 schools. Attendance and active participation in the computer assignments are essential to achieving a good grade.

Ethics

The following guidelines are taken seriously in this class:

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In addition, the specific ethics guidelines for this course are: *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! Unless specifically told otherwise, the write-ups of the computer assignments must be done individually, without any collaboration other than sharing of printouts of your programs and results. If you have questions about this policy, please ask the instructor.*

You may consult the associate dean of student affairs and/or the chairman of the Ethics Board beforehand. See the guide on "Academic Ethics for Undergraduates" and the Ethics Board Web site (http://e-catalog.jhu.edu/undergrad-students/student-life-policies/#UAEB) for more information.

On every exam, you will sign the following pledge: "I attest that I have completed 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 a few years ago. I will also distribute an example test paper for practice, if you wish.

Disability Services

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Student Disability Services, 385 Garland, (410) 516-4720, studentdisabilityservices@jhu.edu

Illness and Class Attendance

If you are sick you should focus on getting well again and worry about class later. You should obtain a note from a medical professional when possible: I will be flexible in accommodating students who miss class due to illness. Students who have flu symptoms should not attend class and should isolate themselves to the extent possible until they have been fever-free for 24 hours. You will not be academically penalized for following the advice of health care professionals!

Religious Holidays

Religious holidays are valid reasons to be excused from class. Students who must miss a class or an examination because of a religious holiday must inform me as early as possible in order to be excused from class or to make up any work that is missed.

Drop/Withdraw Deadlines

The last day to drop the class is 6 March. We should have completed the first two graded assignments by then. The last day to withdraw from the class is 15 April.

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.

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 346, and half in the Computer Classroom on the 2nd floor of Olin Hall. Our schedule is: Tuesdays and Thursdays at 01:30–03:30pm. 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 will be rearranged because I'll be absent.

- Week 1: 26, 28 Jan. Introduction to class. Linear algebra refresher.
  Computer lab.: Matlab introduction.
- Week 2: 2, 4 Feb. Probability and Statistics refresher.
  Computer lab.: Matlab introduction.
- Week 3: 9, 11 Feb. Educated guessing: Interpolation, extrapolation, and regression.
  Computer lab.: Ocean Tides.
- Week 4: 16, 18 Feb. Celestial mechanics and the Copernican revolution.
  Computer lab.: Ocean Tides.
- Week 5: 23, 25 Feb. Hypothesis testing: Discovery of Neptune.
  Computer lab.: Celestial Mechanics.
- Week 6: 1, 3 Mar. Gauss and least squares.
  Computer lab.: Celestial Mechanics.
- Week 7: 8, 10 Mar. Revision class for mid-term exam. MID-TERM EXAM.
  Computer lab.: Celestial Mechanics.
- Week 8: 15, 17 Mar. Spring Break
- Week 9: 22, 24 Mar. Mid-term de-brief.
  Computer lab.: catch-up.
- Week 10: 29, 31 Mar. Snowballs and hot-houses: Modeling planetary climates.
  Computer lab.: Climate model.
- Week 11: 5, 7 Apr. (continued...)
  Computer lab.: Climate model.
- Week 12: 12, 14 Apr. El Niño Southern Oscillation: Climate chaos.
  Computer lab.: ENSO model.
- Week 13: 19, 21 Apr. (continued...)
  Computer lab.: ENSO model.
- Week 14: 26, 28 Apr. Wrap-up. Revision class for final exam.
  Computer lab.: catch-up.
- FINAL EXAM: 9-12pm Friday 6 May.