MARS 7380: Quantitative Methods in Marine Science

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Office Hours:	By appointment or drop by
Office:	291A Marine Sciences Building
Semester:	Every Fall Semester
Class Times:	Tuesday & Thursday, 12:30–1:45
Classroom:	Marine Sciences 239

Course Description

Good quantitative skills are an essential component of any modern marine scientist's toolbox. The tools used to analyze the data we collect are becoming increasingly sophisticated and rely on more and more sophisticated mathematical techniques. Mathematical and computer models are increasingly being used, and although you might not develop or use such a model yourself, you are likely to find yourself having to talk to a modeler.

All this is not to say that one has to become an *expert* mathematician. It does mean however, that you need to be cognizant of the mathematics being used and the implicit assumptions you need to make when you use data analysis tools or models. Without that level of understanding, you will increase your chances of making a bad mistake.

In this course we will revisit some of the mathematical and data analysis techniques that you may have learned a long time ago but rarely used, and introduce you to some new ones that will be useful for you in your research.

Course Objectives

After completing this course, students should have sufficient skills in quantitative methods to understand and interpret the equations they will come across in their research, derive simple relationships and manipulate equations, understand the mathematical assumptions and limitations behind common data analysis techniques, recognize what data analysis techniques to use in different circumstances, and be able to use R to perform them.

Topical Outline

The following contains a schedule of topics that we will cover in the course. Please note that this schedule is preliminary, and details may change throughout the semester.

Topic 1 — Estimation: Using back-of-the-envelope calculations to obtain estimates — developing a *numbers bank*

Topic 2 — Dimensional Analysis: Dimensions and units of quantities — developing equations using dimensional analysis — The Buckingham Pi Theorem.

Topic 3 — Introduction to R: Using computers — reproducible research — introducing R and RStudio.

Topic 4 — Elementary functions: The properties and manipulation of elementary functions and their use in oceanography (e.g. equation of state, attenuation, wave analysis)— using R to plot functions and solve equations.

Topic 5 — Vectors & Matrices: Introduction to vectors and matrices — matrices as transformations — matrices in data analysis — vectors and matrices in R.

Topic 6 — Derivatives: The meaning of the derivative — calculating a derivative — using the derivative in marine sciences — error propagation.

Topic 7 — Integrals: The meaning of the integral — calculating an integral analytically and numerically — calculating an integral from data — using integrated quantities in marine sciences — using R to calculate integrals.

Topic 8 — Probability: Probability in science — rules and paradoxes of probability —- conditional probability — probability distributions (discrete and continuous) — using probability distributions in marine science — calculating probability in R.

Topic 9 — Basic Data Analysis: Exploratory data analysis — data visualization — — hypothesis testing — the care and feeding of data — using R for data analysis in marine science.

Topic 10 — Fitting Data: Comparing data with theory — linear regression — goodness of fit — nonlinear regression — using R for regression.

Textbooks

There are no required textbooks for this course, all required information will be conveyed through the lectures and online readings. However, here are some books that you might find useful to supplement the class notes and readings:

- *Consider a Spherical Cow* by John Harte (University Science Books, ISBN 0-935702-58-X).

- *Mathematical Methods for Oceanographers: An Introduction* by Edward Laws (John Wiley and Sons, ISBN 0-471-16221-3).
- *Used Math: For the first two years of college science*, by Clifford E. Swartz (American Association of Physics Teachers, ISBN 0-917853-50-4).

Computers & Software

We will make use of several open source software packages during the course, and we will be working through problems in class. **So please make sure that you have access to a laptop computer that you can bring to class and that you have administrative privileges on this computer, or can ask someone who does, to install the software.** Full instructions on installing and using the software will be giving during the course. The packages that we will be using will include:

R This is a package for the statistical analysis and visualization of data. The system comes as a base package that you will install on your computers, and additional packages that you will install as they are needed.

RStudio This is a graphical front end for R. It also allows the user to produce nicely typeset reports and presentations of their work, as well as providing for a number of other useful features such as version control.

LaTeX This is a typesetting language that RStudio uses for typesetting reports.

Readings

There will be regularly posted readings on ELC. When they are assigned, these should be read **before** the next class. After the on-line readings there will often be a small quiz to measure comprehension and understanding: your grades on these small quizzes will count towards your final grade.

Coursework

There will be regular in-class and homework assignments throughout the course. There are no mid-term or final exams for the course, instead there will be cumulative tests at the end of each topic — successive tests will also require knowledge and understanding of material from all previous topics. All work handed in must be legible — if you have bad handwriting, you might consider using a word processor or typesetting system to type up your homework. This is particularly important for mathematics!

Course Grading

The breakdown of the total grade for the class into individual categories will be: Cumulative tests (50%, 5% each), Online Quizzes (5%), in-class work and class participation (10%), homework assignments (35%). A final letter grade will be posted for the course. The correspondence between percentages and letter grades is given below in Table 1.

A : 93 – 100%	B+: 87 – 90%	C+: 77 – 80%	D: 60 – 65%
A-: 90 – 93%	B : 83 – 87%	C : 70 – 77 %	F : 59% and below
	B- : 80 – 83%	C- : 65 – 70%	

Table 1: Table of the correspondence between final letter grades and total percentages.

The interpretation of the major letter grades is:

A This grade is used to recognize work that is excellent and of the highest calibre and that stands out from that of other students. Students who achieve this grade have demonstrated a mastery of all the content of the course.

B This letter grade is used to signify competent work. A student who achieves this grade has demonstrated proficient understanding of the concepts and content of the course sufficient for effective use of these concepts and techniques in their research.

C This letter grade signifies adequate work. A student who has achieved this grade has demonstrated a general understanding of the concepts covered in the course but with significant flaws in either their understanding or execution of techniques.

D This letter grade indicates that the work is inadequate, and that the student has not demonstrated the requisite skills and understanding to use these techniques in their research.

F This letter grade signifies work that is unacceptable.

Note that you must receive a C or better for the course, and that the average over all your graduate level courses must be a B.

Special Accommodations

If you need special accommodations for tests (e.g. additional time for taking tests) or other activities because of a disability, please make an appointment to see the instructor as soon as possible or before the end of the first full week of classes.

Test-Out Policy

Some students entering marine sciences come from a highly quantitative background (e.g. engineering or physics). Such students may, after discussion with their advisor, elect to test-out of the course. In order to successfully test out, students must sit an equivalent of the final exam for the course and achieve a B-grade or better. Ideally, students will contact me during the summer prior to taking the course and express their intent to test-out (I will provide them with lists of the topics covered, study resources, and sample questions). If you have not previously contacted me and wish to test out, please let me know **on the first day of class.**

Absences From Class

Absences from class are sometimes unavoidable, especially in a discipline where research is conducted in the field or at sea. For planned absences due to field work or research cruises, please inform me **at least two weeks prior to your absence** — prolonged absences (i.e. more than 10 days) for field work may result in you having to drop the class and take it next year. For absences due to illness or other unforeseen events, please inform me as soon as possible.

Important Dates

Wednesday, August 14, 2019	First day of class
Thursday, August 15, 2019	First class of the course
Monday, October 21, 2019	Withdrawl deadline
November 27 – 29, 2019	Thanksgiving (no classes)
Tuesday December 3, 2019	Last class of the course

Table 2: A table of important dates for the Fall 2019 semester.

Academic Honesty

As a University of Georgia student, you have agreed to abide by the University's academic honesty policy, "A Culture of Honesty," and the Student Honor Code. All academic work must meet the standards described in "A Culture of Honesty" found at:

https://ovpi.uga.edu/academic-honesty/academic-honesty-policy

Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. Questions related to course assignments and the academic honesty policy should be directed to the instructor.

All students are expected to hand in work that is their own — discussion of homework assignments among students is permitted (and encouraged), but the work you hand in **must be your own**. Any student found cheating or plagiarizing will be disciplined according to the University's rules and policies. Examples of plagiarism include, but are not restricted to

- Copying someone else's calculations or solutions and presenting them as your own.
- Copying someone else's computer codes and presenting them as your own.

Some Tips on the Course

This course may, at first glance, appear somewhat esoteric and different from the other courses that you take in graduate school. However, having a good understanding of basic mathematics will allow you to better understand the papers you read and allow you to bring more to your science and excel in your other courses — especially the Marine Sciences Core Courses (MARS 8010, *Biological Oceanographic Processes*, MARS 8020, *Chemical Oceanography*, and especially

MARS 8030, *General Physical Oceanography*). The skills you learn in this course also lay at the foundations of many data analysis techniques you will come across, so having an understanding of how these techniques work can help you spot errors in your analyses.

In class activities will include a mixture of: presentations using slides, blackboard work, discussion, and students working through examples. Because a lot of the material and examples will be worked through on the blackboard, it is essential that you have with you something on which you can take notes — pen and paper is by far and away the preferred method, even though some may think it old fashioned.

Course Reading

Although there is no official textbook for the course, there will be readings posted online. Sometimes these will take the form of papers, and at other times they will serve as introductions to the material we are about to cover in class. I will expect you to have read these materials **before** class. At times there will be a small test that accompanies the reading. These are designed to pick up any misunderstandings or difficulties with the material. By taking these tests before class, I will be able to see in advance what areas need attention during the class itself.

In Class

There will frequently be problems to be solved and analyses to be performed during class. So please, make sure you have access to a working laptop that you can bring to class. You should actively participate in these activities because they will help you learn the material. Also, feel free to ask questions in class — do not be intimidated, in all my years teaching I have yet to come across a genuinely daft question. The chances are that, if there is something you do not understand, then others in the class also don't understand it. So by asking your question, you are helping your classmates.

I will also ask questions during class, and in general, I expect someone in class to answer. Again, you should not feel intimidated by this. If you answer is correct, then you can assume that your understanding of the problem is good. If your answer is incorrect, then you should ask yourself where your understanding broke down and re-adjust your intuition.

The combination of in-class problems and your participation in answering and asking questions in class contribute to your overall grade!

Homework Assignments

The homework assignments are meant to test your understanding of various concepts that we cover as well as give you practice in the techniques we cover.

- Don't spend more than a couple of hours on the homework assignments. If you find that they are taking you longer than a couple of hours, then come and talk to me.
- Make sure you understand what the question is asking you!
- Always check your units! A volume should never have units of square meters etc.

- Always check that your answers are reasonable. For example, if you find a value for the circumference of the Earth is a sphere whose radius is greater than the distance between the Sun and Jupiter, then you've made a mistake!
- Feel free to discuss homework assignments with your classmates (it's a good way to learn), but **all the work you hand in must be your own!**.

The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary.