MARS 7380: Quantitative Methods in Marine Science

Instructor:	Adrian Burd
E-mail:	adrianb@uga.edu
Web:	marsci.uga.edu/adrianburd
Office Hours:	By appointment or drop by
Office:	110K Marine Sciences Building
Semester:	Every Fall Semester
Class Times:	Mon-Wed-Fri, 11:15–12:05
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 in mathematics. 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 techniques that you may have learned a long time ago but rarely used, and hopefully 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.

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).
- *Mathematical Modelling of Zombies*, by Robert Smith (University of Ottawa Press, ISBN 978-0-7766-2168-5). This is a fun book that deals with some of the more advanced topics we cover, as well as goes beyond this course.

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.

Homeworks & Exams

There will be regular assignments throughout the course. There will be two exams during the course: Exam 1 will be held during the semester and Exam 2 will be held after the end of classes (see *Important Dates* below). 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.

Course Grading

So much of the course grade will come from exams, class participation, and assignments (both large and small). The breakdown of the total grade for the class into individual categories will be:

Exam 1: 20%.

Exam 2: 20%.

Online Quizzes: 5%.

In Class Work & Participation: 15%.

Homework Assignments: 40%.

A final letter grade will be posted for the course. The correspondence between percentages and letter grades is given below The interpretation of the major letter grades is (**Note that you must**

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.

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

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.

Special Accommodations

If you need special accommodations for exams (e.g. additional time for taking exams) 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

Thursday, August 11, 2016	First day of classes
Monday, September 5, 2016	Labor Day (no classes)
Wednesday, October 5, 2016	Exam 1
Tuesday, October 18, 2016	Withdrawal Deadline
Friday, October 28, 2016	Fall Break (no classes)
November 21 – 25, 2016	Thanksgiving (no classes)
Monday, December 5, 2016	Last day of classes
Friday, December 9, 2016 (12:00 – 3:00)	Exam 2

Please note that the dates of Exam 1 and Exam 2 may change. If they do, you will be notified well in advance.

Academic Honesty

All students are directed to review and take to heart UGA's policies and procedures on academic dishonesty, *A Culture of Honesty*. All academic work must meet the standards explained in that

document. It is the responsibility of each student to inform themselves of these standards and the consequences for not adhering to them. In particular, 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.

Course 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.

Week Starting	Day	Topic
8-8-16	F	Course introduction
8-15-16	M	Back of the envelope calculations
	W	Dimensional analysis
	F	Buckingham Pi Theorem
8-22-16	M	Loading & installing software
	W	Computers, arithmetic, R introduction
	F	More basic R & RStudio
8-29-16	M	Scientific computing & ethics
	W	Basic functions: lines & curves
	F	Basic functions: trigonometric functions
9-5-16	M	No Class (Labor Day)
	W	Basic functions: logarithms & exponentials
	F	Vectors I
9-12-16	M	Vectors II
	W	Vectors III
	F	Vectors IV
9-19-16	M	Visualization
	W	The Proper Care and Feeding of Data
	F	Communication skills: Presentations & Writing
9-26-16	M	Matrices I
	W	Matrices II
	F	Matrices III
10-3-16	M	Matrices IV
	W	Exam 1
	F	Derivatives I
10-10-16	M	Derivatives II

Week Starting	Day	Topic
	W	Derivatives III
	F	Integrals I
10-17-16	M	Integrals II
	W	Integrals III
	F	Probability I
10-24-16	M	Probability II
	W	Discrete Distributions I
	F	No Class (Fall Break)
10-31-16	M	Discrete Distributions II
	W	Continuous Distributions I
	F	Continuous Distributions II
11-7-16	M	Continuous Distributions III
	W	Central Limit Theorem
	F	Hypothesis Testing
11-14-16	M	Hypothesis Testing
	W	Linear Regression
	F	Linear Regression
11-21-16	M	No Class (Thanksgiving)
	W	No Class (Thanksgiving)
	F	No Class (Thanksgiving)
11-28-16	M	Multilinear Regression
	W	Nonlinear Regression
	F	Time Series
12-5-16	M	Time Series

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 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.

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.

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!**.