

STATS 4864/9864A Course Outline

1. Course Information

Course Information

STATS 4864A/9864A -- Advanced Statistical Computing

Lectures -- Monday, Wednesday, and Friday 10:30-11:30am in UCC-60

List of Prerequisites

Statistical Sciences 2864A/B and Statistical Sciences 3859A/B.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

2. Instructor Information

Instructors	Email	Office	Phone	Office Hours
Dr. Simon Bonner	sbonner6@uwo.ca	WSC 276	519-661-2111 Ext 88205	TBD
Yijia Weng	yweng54@uwo.ca			TBD

Communication

Please use the Forums on the OWL site to post questions about course material. This helps other students who may have the same question, and I encourage you to help each other if you can. Note that you can use LaTeX to insert mathematical equations into your forum posts.

Please send me an e-mail if you need to discuss personal matters (e.g., a missed assignment). I recommended that you use your Western (@uwo.ca) email address.

3. Course Syllabus, Schedule, Delivery Mode

Course Description

Statistical computing is a very broad field that covers many different topics. On one hand, statistical computing involves aspects of developing and evaluating numerical algorithms required to conduct statistical inference when analytical solutions are not available. This includes techniques for optimization (key to the method of maximum likelihood inference, perhaps the most widely applied statistical procedure), integration (by which we compute expected values), and sampling from distributions (a crucial component of most modern Bayesian analyses). On the other hand, it refers to the

practicalities of implementing these procedures in modern software practices and on developing good programming skills.

Schedule and Delivery Mode

I am going to cover aspects of both the technical and practical side of computing. Each week will be divided with two days devoted to technical aspects and one day to practical. Every Monday and Wednesday I will present lectures based on the material in Givens and Hoeting (2012). Fridays will be dedicated to allow you time to work through the assignments at your own pace while the TA and I are available to help. Even during the lectures I may ask you to run code, so please bring your laptop to every class.

Schedule

I have included a tentative schedule at the end of the course outline including a list of topics and references for each week. You may notice that there appears to be A LOT of reading. I do not expect you to read all of the reference material each week. Some of the material is important and needs to be covered before the lectures or practical sessions, and I will let you know this ahead of time. However, there is too much material for you to learn at once. One of the important skills to develop as a programmer is to learn how to find the information that you need when you need it. Most programming language, including R, are so complicated and have so many add-on packages that it is impossible to remember everything that you need. In fact, some packages for R have so many functions and features that we could spend the entire semester looking at them. That would not be productive. Instead, you need to learn the basics first and then be able to find the rest when you need it. The references I have listed will provide the information you need for the course, and remember, Google is your friend!

Contingency plan for an in-person class pivoting to 100% online learning

In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, affected course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will **not** change. Any remaining assessments will also be conducted online as determined by the course instructor.

4. Course Materials

There is no required text for this course. My primary reference for theoretical material will be

Givens, G.H. and Hoeting, J.A. (2012) *Computational Statistics*. 2nd edition. Wiley & Sons, Inc.

[Complete access to an electronic version of this text](#) in either PDF or EPUB formats is available through the university library. Note that you will have to be on campus or else login through the proxy server to access the text. I will extract topics from this text and will not cover all of the material in the sections associated with the course. My lectures will be the primary reference for the material that I expect you to know.

References for practical topics will include the following. All are available for free by following the provided links.

1. Byran, J. and Hester, J. (2022) Happy Git and GitHub for the useR. Available online at <https://happygitwithr.com/index.html>

2. Wickham, H. (2019) Advanced R. 2nd Edition. Chapman and Hall/CRC Press. Available online at <https://adv-r.hadley.nz/index.html>.
3. Wickham, H. and Bryan, J. (????) R Packages. 2nd Edition. O'Reilly Media, Inc. Available online at <https://r-pkgs.org/>.
4. Wickham, H. and Golemund, G. (2016) R for Data Science. O'Reilly Media, Inc. Available online at <https://r4ds.had.co.nz/>

Students are responsible for checking the course OWL site (<http://owl.uwo.ca>) on a regular basis for news and updates. If you need assistance with the course OWL site, please check the OWL Help page or contact the Western Technology Services Helpdesk at 519-661-3800 or ext. 83800.

Technical Requirements

You must bring a laptop with R version 4.2.1 installed to every lecture. You are welcome to use any operating system (Windows, MacOS, Linux, or BSD). However, you must have access to install packages in R and further software required during the semester (e.g., github).

I will work in RStudio during the lectures in expect most of you will do the same. However, you are welcome to use any development environment. I have been programming in [emacs](#) for over 20 years and that's not going to change now, so I understand if you also have other preferences. However, I may not be able to help you if you are working in another environment (especially if you are using [vi](#)).

5. Methods of Evaluation

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The overall course grade will be calculated as listed below:

Assignments (4)	60%	(15% each)
Final Project	40%	

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The overall course grade will be calculated as listed below:

Assignments (4)	40%	(10% each)
Presentation	20%	
Final Project	40%	

Assignments

The following is a tentative list of the topics and due dates for each assignment. Exact details will be provided at least two weeks before the actual due date. Assignments will be posted on OWL and solutions will be made available as soon as possible.

- Assignment 1: October 3
 - o Optimization
 - o The Tidyverse
 - o RMarkdown
- Assignment 2: October 24
 - o Combinatorial Optimization
 - o EM Optimization

- Git and Github
- Assignment 3: November 14
 - Numerical Integration
 - Building R Packages
- Assignment 4: December 5
 - Simulation
 - Markov chain Monte Carlo
 - Bootstrapping
 - C++ in R

Graduate Presentations

Details will be provided in the middle of the semester.

Final Project

Details about the final project will be provided toward the end of the semester.

6. Student Absences

Attendance at lectures is not required, though I will record attendance for my own information. If you miss a lecture then it is your responsibility to check with your classmates to find out what material you missed. If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below.

Each assessment in this course is worth more than 10% of the final course grade and so you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible if you are unable to submit an assignment or the final project on time. For further information, please consult the University's medical illness policy at

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf.

The Student Medical Certificate is available at

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

If accommodation is granted then you will be able to submit your assignment or the final project late without penalty. The length of the accommodation will be determined by the academic counsellor.

Assignments that are submitted late without an extension or past the extension deadline will be penalized 10% per day up to 5 days. Assignments submitted past this point will receive a grade of 0.

7. Accommodation and Accessibility

Religious Accommodation

When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling

office of their Faculty of Registration. Please consult University's list of recognized religious holidays (updated annually) at

<https://multiculturalcalendar.com/ecal/index.php?s=c-univwo>.

Accommodation Policies

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at:

[https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Accommodation_disabilities.pdf).

8. Academic Policies

The website for Registrarial Services is <http://www.registrar.uwo.ca>.

In accordance with policy,

https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf,

the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at their official university address is attended to in a timely manner.

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

All required assignments and projects may be subject to submission for textual and structural similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All exercises submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of assignments subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario, Turnitin.com (<http://www.turnitin.com>), and Gradescope.ca (<http://www.gradescope.ca>).

9. Support Services

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: <https://www.uwo.ca/sci/counselling/>.

Students who are in emotional/mental distress should refer to Mental Health@Western (<https://uwo.ca/health/>) for a complete list of options about how to obtain help.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts at

https://www.uwo.ca/health/student_support/survivor_support/get-help.html.

To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at

http://academicsupport.uwo.ca/accessible_education/index.html

if you have any questions regarding accommodations.

Learning-skills counsellors at the Student Development Centre (<https://learning.uwo.ca>) are ready to help you improve your learning skills. They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Western University is committed to a thriving campus as we deliver our courses in the mixed model of both virtual and face-to-face formats. We encourage you to check out the Digital Student Experience website to manage your academics and well-being: <https://www.uwo.ca/se/digital/>.

Additional student-run support services are offered by the USC, <https://westernusc.ca/services/>.

10. Course Timetable (Tentative)

Week	Topics and References (with Sections)
1) Sept 5	The Tidyverse 1: Data Exploration - Wickham 1 -- 8
2) Sept 12	Optimization 1: Univariate Problems - Givens and Hoeting 2.1 The Tidyverse 2: Wrangling - Wickham 9 – 18
3) Sept 19	Optimization 2: Multivariate Problems - Givens and Hoeting 2.2 RMarkdown - Wickham 26 – 30
4) Sept 26	EM Optimization - Givens and Hoeting 4.1 & 4.2 Git and Github 1 - Bryan 1 -- 24
5) Oct 3	Combinatorial Optimization 1: Hard Problems and Local Searches - Givens and Hoeting 3.1 & 3.2 Git and Github 2 - Bryan 25 -- 34
6) Oct 10	Combinatorial Optimization 2: Simulated Annealing and Genetic Algorithms - Givens and Hoeting 3.3 & 3.4
7) Oct 17	Numerical Integration 1: Newton-Cotes Quadrature - Givens and Hoeting 5.1 Building R Packages 1: Getting Started - Wickham and Bryan 1 -- 9
8) Oct 24	Numerical Integration 2: Gaussian Quadrature - Givens and Hoeting 5.2 & 5.3 Building R Packages 2: Metadata and Documentation - Wickham and Bryan 10 – 12, 16, & 17
Oct 31	Reading Break
9) Nov 7	Simulation

	<ul style="list-style-type: none"> - Givens and Hoeting 6.1, 6.2, and 6.3 <p>C++ in R 1</p> <ul style="list-style-type: none"> - Wickham and Grolemund 25.1 – 25.4
10) Nov 14	<p>Markov chain Monte Carlo 1: MH Algorithm and Gibbs Sampling</p> <ul style="list-style-type: none"> - Givens and Hoeting 7.1 & 7.2 <p>C++ in R 2</p> <ul style="list-style-type: none"> - Wickham and Grolemund 25.5 – 25.7
11) Nov 21	<p>Markov chain Monte Carlo 2: Implementation</p> <ul style="list-style-type: none"> - Givens and Hoeting 7.3 <p>Graduate Presentations</p>
12) Nov 28	<p>Bootstrapping 1: Basic Methods and Bootstrap Inference</p> <ul style="list-style-type: none"> - Givens and Hoeting 9.1, 9.2, and 9.3 <p>Graduate Presentations 3 & 4</p>
13) Dec 5	<p>Bootstrapping 2: Bootstrapping Dependent Data</p> <ul style="list-style-type: none"> - Givens and Hoeting 9.5 <p>Graduate Presentations</p>