Syllabus
(Updated: 8-26-2019)

(BIOS:7330:001)
Advanced Biostatistical Computing

University of Iowa
College of Public Health
Department of Biostatistics

Fall 2019
C401 CPHB
2:00-3:20 PM (Tu/Th)
icon.uiowa.edu
grantbrown.github.io/BIOS-7330
bios7330.com/

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Goals/Content: This course covers advanced topics in biostatistical computing, with a combined emphasis on advanced computing techniques and algorithms relevant to statistics and scientific computing, as well as tools and best practices for implementing them. This course is designed for Biostatistics PhD students who wish to pursue computationally intensive thesis topics and want to expand their computational skills. The course may also be of interest to other students with a background in probability and statistics and a working familiarity with the R statistical computing environment. Topics covered by this course will include:

- Matrix decomposition and sparse matrices
- Deterministic and stochastic optimization techniques
- Numerical integration and sampling techniques with application to Bayesian computing
- A focus on implementing these techniques using computational tools and resources, including but not limited to campus HPC facilities, Rcpp, Knitr, and Git.

Instruction will combine in-class lecture and discussion with external reading and tutorial work One of the most important skills of a statistical practitioner is the ability to learn new tools and skills on their own. Coupled with the wide array of excellent online tutorials in nearly all aspects of computing and statistics, this course aims to provide the best of both worlds while avoiding redundancy. To get the most out of each topic, you should plan to do self-directed study outside of class time (e.g., try searching for "____ tutorial" to get an alternate perspective/more practice with ____.

Class time will be comprised of a combination of short lectures and practical interactive computing exercises, and homework will involve both computing

assignments and web-based tutorials and reading assignments. In-class exercises will combine a selection of whole class, group, and individual work, and will serve as the basis for approximately weekly homework assignments.

Tentative Schedule (subject to change)

Week of 8/27

- **Code/Tech:** R review, source control, Linux
- **Theory:** Computer Arithmetic, Numerical Precision
- **Exercise:** Numerical stability and computer memory
- **Challenge:** Basic Programming

Week of 9/3

- **Code/Tech:** Functions, Environments, Errors
- **Exercise:** Functions
- **Challenge:** Simple statistics on large data sets

Week of 9/10

- **Code/Tech:** Basic R Package Structure
- **Theory:** Matrix Decomposition
- **Exercise:** Packages, Matrix Decomposition
- **Challenge:** Graham Schmidt

Week of 9/17

- **Code/Tech:** Packages continued, C++, Rcpp, RcppEigen
- **Exercise:** Linear regression
- **Challenge:** Linear regression

Week of 9/24

- **Code/Tech:** Optim
- **Theory:** Optimization
- **Exercise:** Optimization
- **Challenge:** Simple statistics on large data sets (revisited with C++)

Week of 10/1

- **Theory:** Optimization
- **Exercise:** Optimization
- **Challenge:** Optimization

Week of 10/8

- **Code/Tech:** Profiling, Debugging
- **Exercise:** Profiling, Debugging
- **Challenge:** TBD

Week of 10/15

- **Code/Tech:** Campus HPC Resources, Cloud Computing
- **Exercise:** Campus HPC

Week of 10/22

- **Code:** Object Systems in R (S3, S4, RC)
- **Theory:** Object Oriented Programming
- **Exercise:** TBD

Week of 10/29

- **Theory:** Bayesian review, Intro to Bayesian Computing

- **Exercise:** Metropolis Hastings
- **Challenge:** Metropolis Hastings

Week of 11/5

- **Theory:** Hamiltonian Monte-Carlo
- **Exercise:** HMC
- **Challenge:** HMC

Week of 11/12

- **Code/Tech:** Process level parallelism
- **Theory:** Approximate Bayesian Computing, Parallel Programming
- **Exercise:**

Week of 11/19

- **Code/Tech:** Low level parallelism (OpenMP/Threads)
- **Theory:** General parallel programming
- **Exercise:** Low level parallelism
- **Challenge: TBD**

Week of 11/26
Thanksgiving Break

Week of 12/3

- **Code/Tech:** Low level parallelism (continued)
- **Theory:** General parallel programming (continued)

Week of 12/10

- **Presentations**

Course Materials

This course makes use of several web resources, linked at the top of the syllabus. The course ICON page will be used for homework assignment submissions, as well as to host reading material and lecture recordings. The GitHub site (grantbrown.github.io/BIOS-7330) will be used to post homework assignments, notes, challenge announcements, and supplemental material. Challenge submissions and results can be accessed at the challenge site (bios7330.com/)

No textbook is required - reading materials will be drawn from a number of sources.

Below are several important resources which will be used in the course:

1. R packages: http://r-pkgs.had.co.nz/
2. Advanced R: http://adv-r.had.co.nz/
3. Writing R Extensions: https://cran.r-project.org/doc/manuals/r-release/R-exts.html
4. Numerical Linear Algebra for Applications in Statistics: http://www.springer.com/us/book/9780387985428

Additional supplemental resources will be posted throughout the semester.

Assignments:

Assignments will take several forms, depending on the nature of the topic material, and may emphasize computational, statistical, and/or mathematical

concepts. All assignments will be announced on ICON, along with submission instructions. These will be divided into traditional homework assignments, which are submitted via ICON, and programming challenge submissions, which are submitted via the challenge website.

The challenges have a leaderboard, where placement is based on a combination of computational efficiency and correctness.

Final Project:

Students will select a computational problem to serve as the basis of a final project. This could be an aspect of a student's dissertation work, an extension to one of the course competitions, the implementation of an algorithm from a scholarly publication, or another computationally intensive statistical problem.

The project will involve a concise writeup (no *more* than 5 pages, excluding graphs/tables), and a presentation in a format determined by the presenter.

A rubric defining the final project grading criteria will be posted mid-course.

Grading Procedures:

This course will use +/- grading. Homework assignments will account for 60% of the final grade, while the final project will account for 30%. A participation grade will be assigned, accounting for 10% of the final grade. Participation includes regular attendance, contribution to classroom discussions, presentation of the final project, and participation in small, informal, presentations about the course competitions (students with winning or otherwise notable submissions will be asked to lead an informal overview of their work).

Relative placement in the computations will not impact homework grades, though correctness and completion will be important aspects of the grade.

In addition, assignments which involve coding will be graded on readability. No formal style is required, but students are encouraged to review style guides which have been adopted by other organizations:

http://adv-r.had.co.nz/Style.html
https://google.github.io/styleguide/Rguide.html
https://jef.works/R-style-guide/

Students are encouraged to work to in groups and assist one another on assignments and challenges, however each submission should be your own. No direct copying is permitted.

Expectations for Attendance and Participation:

Students are expected to regularly attend courses, though students will not be penalized for leaving early during lab-exercise portions of the course, provided they've completed the work and participated in class discussion.

As previously noted, both extensive in-class and electronic participation in this course are expected.

Communication: Students are strongly encouraged to address questions and comments to the discussion page of the ICON course – getting practice in asking technical questions online is good preparation for participation in communities like StackExchange. Students are also encouraged to attend instructor office hours as needed. The instructor will also be available by Email, however technical questions will be referred to the ICON discussion page. The instructor will attempt to respond to questions within 24 business hours. Students are expected to regularly check their University of Iowa email addresses.

Exams: There are no formal exams in this course.

Prerequisites: MATH:2700 and BIOS:5510 and STAT:4101

Recommendations: BIOS:5510, proficiency in R, basic familiarity with the Linux command line

Credit Hours: 3

Course Competencies:

Competency	*Evaluated*
1B9. Interprets quantitative and qualitative data	Assignments, Project
1B11. Uses information technology to collect, store, and retrieve data	Assignments, Project
1B12. Uses data to address scientific, political, ethical, and social public health issues	Assignments, Project
6C7. Critiques the limitations of research findings	Assignments, Project

Administrative Home

This course is given by the College of Public Health. This means that class policies on matters such as requirements, grading, and sanctions for academic dishonesty are governed by the College of Public Health. Students wishing to add or drop this course after the official deadline must receive the approval of the Associate Dean for Academic Affairs in the College of Public Health. Details of the University policy of cross enrollments may be found at:
Cross-Enrollment Policy

Electronic Communication

University policy specifies that students are responsible for all official correspondences sent to their standard University of Iowa e-mail address (@uiowa.edu). Students should check this account frequently.

Accommodations for Disabilities

The University is committed to provide an educational experience that is accessible to all students. If you have a diagnosed disability or any other condition that would impair your ability to complete the course requirements as stated above, please inform me as early in the semester as possible, but no later than two weeks prior to the scheduled activity. Students needing accommodations must register with Student Disability Services, (SDS): https://sds.studentlife.uiowa.edu/students/apply to obtain a Letter of

Accommodation (LOA). The letter will specify what course accommodations are reasonable for that student. The office is located at 3015 Burge Hall, (319) 335.1462.

A video about SDS is available here:
https://www.youtube.com/watch?v=9qIaOIgn8Cs&amp=&feature=youtu.be

Students with complaints about disability accommodation should notify Student Disability Services in addition to the offices listed above, and may be counseled to file a complaint with the Office of Equal Opportunity and Diversity. Read more about Disability Resources at https://diversity.uiowa.edu/disability-resources.

Academic Misconduct

Academic misconduct is defined by the University of Iowa in its Code of Student Conduct here: Policies & Regulations Affecting Students. Please take the time to read this short description. Academic misconduct refers primarily to plagiarism or cheating. **It is the student's responsibility to seek clarification from the course instructor of any situation in which he/she is uncertain whether academic misconduct is/has been involved.**

Plagiarism includes but is not limited to the following:

- presentation of ideas of others without credit to the source;
- use of direct quotations without quotation marks and without credit to the source;
- paraphrasing without credit to the source;
- participation in a group project which presents plagiarized materials;
- failure to provide adequate citation for material obtained through electronic research;
- downloading and submitting work from electronic databases without citation;
- submitting material created/written by someone else as one's own, including purchased term/research papers;

Cheating includes but is not limited to the following

- copying from someone else's exam, homework, or laboratory work
- allowing someone to copy or submit one's work as his/her own;
- accepting credit for a group project without doing one's share;
- submitting the same paper in more than one course without the knowledge and approval of the instructors involved;
- using notes or other materials during a test or exam without authorization;
- not following the guidelines specified by the instructor for a "take-home" test or exam.

Academic misconduct is a serious matter and is reported to the departmental DEO and to the Associate Dean for Education and Student Affairs. Instructors and DEOs decide on appropriate consequences at the departmental level while the Associate Dean enforces additional consequences at the collegiate level. For example, an incident involving plagiarism will result in consequences to the student ranging from a grade of 0 for that assignment to being terminated from his/her graduate program. Egregious acts of misconduct, such as cheating on a final exam, may result in the course grade being reduced to an F. Additional details concerning the consequences associated with acts of plagiarism, including a student appeals process, is provided in the Graduate College Manual section IV.F.

Addressing Student Concerns in the College of Public Health

Students who have a concern about a faculty action should first address the issue with the instructor, then the course supervisor (if there is one), and then the departmental DEO. Students may also contact

the Associate Dean for Academic Affairs in the College of Public Health. Another resource for students is the Office of the University Ombudsperson. If a complaint cannot be resolved at the departmental and/or collegiate level, students may file a formal complaint utilizing the procedure specified in the Operations Manual (II-29.7) https://opsmanual.uiowa.edu/community-policies/hearing-regulations-alleged-violations-regents-rules/initial-steps

Sexual Harassment/Misconduct and Class Accommodations

Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff. **The University will not tolerate sexual harassment, nor will it tolerate unwelcomed behavior of a sexual nature toward members of the University community** when that behavior creates an intimidating or hostile environment for employment, education, on-campus living, or participation in a University activity. As a member of the university community you have a responsibility to report concerns of sexual harassment immediately at the Office of the Sexual Misconduct Response Coordinator: https://osmrc.uiowa.edu/.

If you or someone you know may be a victim of sexual assault, sexual harassment, dating/domestic violence, stalking, or any other behaviors prohibited under this policy, you are strongly encouraged to seek assistance and support. Assistance is available 24 hours a day, 7 days a week, from:

• Rape Victim Advocacy Program (RVAP) — confidential, certified victim advocacy services.

319-335-6000

• Domestic Violence Intervention Program (DVIP) — confidential, certified victim advocacy services. 319-351-1043 or 800-373-1043

• Emergency Department, University of Iowa Hospitals and Clinics — confidential medical services.

319-356-2233

• University of Iowa Department of Public Safety — law enforcement services.

319-335-5022, or 911 from any campus phone

During business hours, you may also seek assistance from the University of Iowa Office of the Sexual Misconduct Response Coordinator, 319-335-6200. (https://opsmanual.uiowa.edu/students/sexual-misconduct-datingdomestic-violence-or-stalking-involving-students)
Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff. All members of the UI community have a responsibility to uphold this mission and to contribute to a safe environment that enhances learning. Incidents of sexual harassment should be reported to the UI Office of Sexual Misconduct Coordinator (OSMRC), or to the Office of Equal Opportunity and Diversity (EOD). Students impacted by a Title IX issue (sexual misconduct, dating/domestic violence, or stalking) may be eligible to request an academic accommodation. See the OSMRC for assistance, definitions, and the full University policy at Office of the Sexual Misconduct Response Coordinator. Additional information about confidential resources for students subject to sexual harassment/misconduct is available at Confidential Resources for Students.

Mental Health

Students are encouraged to be mindful of their mental health and seek help if they are feeling overwhelmed and/or incapable of meeting course expectations. For assistance with the class, students are encouraged to talk to their faculty member. For additional support and counseling, students are encouraged to contact The University Counseling Service (UCS) in 1950 University Capital Centre Suite or 3223 Westlawn South. Call 319.335.7294 to schedule appointments (Mon-Fri. 8AM-4:30PM). Find out more about the UCS at http://counseling.uiowa.edu. After hours, call the Johnson County Crisis Line at 319.351.0140 or 911 if you are having a mental health emergency.

Nondiscrimination in the Classroom and the College

The University of Iowa prohibits discrimination and harassment against individuals on the basis of race, class, gender, sexual orientation, national origin, and other identity categories set forth in the University's Human Rights policy. For more information, contact the Office of Equal Opportunity and Diversity at diversity@uiowa.edu or diversity.uiowa.edu.

Students are invited to optionally share their preferred names and pronouns with their instructors and classmates. Students are also able to state this information in the MyUI system under Student Information. https://myui.uiowa.edu/my-ui/student/records/documents/preferred-name-pronoun.page

Reacting Safely to Severe Weather
In severe weather, class members should seek appropriate shelter immediately, leaving the classroom if necessary. The class will continue if possible when the event is over. For more information on Hawk Alert and the siren warning system, visit Hawk Alert

hawkalert.uiowa.edu
emergency.uiowa.edu