**Advanced Programming in R and the CHPC**

**Spring 2023**

Description:

This course develops students’ ability to write R scripts which address complex questions that cannot be otherwise addressed with existing R packages. The nature of these scripts are often intensive and require sophistication to debug and increase the efficiency of run time. Topics covered include: functions and vectorized programming, debugging and code optimization, parallel computing, C/C++ to R coding, R package creation, the linux environment, and running jobs on the university’s high performance computing nodes. Students will learn through seeing (lectures), doing (homeworks), and teaching (helping one another improve coding). This course is aimed for students with at least moderate proficiency in R programming and/or strong proficiency in another programming language such as Python and C/C++.

Professor:

Jonathan Chipman, PhD

Assistant Professor

Division of Biostatistics, Department of Population Health Sciences

Cancer Biostatistics, Huntsman Cancer Institute

Phone: (317) 385-3348

Email: jonathan.chipman@hci.utah.edu

Tentative Guest Lecturers:

George Vega Yon

Andrew Redd

Anita Orendt

Julia Silge

Rebecca Barter – R package creation (starts mid-December)

Locations and Times

Lectures: T/Th 3-4:30pm

In-person: TBD

Office hours: TBD

Pre-Requisites: Students must be able to write their own functions and submit homework solutions in R markdown or latex. Prior to the course, students may ask the professor for an example problem to assess their comfort with R programming.

Required Materials:

TARP: *The Art of R Programming: A Tour of Statistical Software Design*. Norman Matloff

Course structure:

Course objectives:

1. Write R functions to use in conjunction with vectorization (rather than using for loops)
2. Learn local-machine parallel computing methods
3. Be able to degub and optimize scripts
   1. Know the debugger functions
   2. Know the Rprof function
4. Write complex scripts / algorithms
   1. Newton-Raphson convergence
   2. Expectation Maximization
5. Know the CHPC environment
   1. Linux and vim
   2. Available help
   3. Cluster usage
6. Submit a job to CHPC using a SLURM script
   1. Know difference in job parameter settings
   2. Know how to parallel jobs and collate results

Course content: Rough/tentative schedule

At home readings of basics

In class advanced

Week 1: Class introduction and document preparation

* Syllabus and schedule
* Github: Reproducible code and version control
* Quarto: Document preparation
  + Students can choose options for collating if desired (such as bookdown)

Week 2: R Essentials

* At home reading:
  + Classes: Vectors (Chapter 2), Matrices and Arrays (Chapter 3), Lists (Chapter 4), Data Frames (Chapter 5)
  + Set operations (Chapter 8)
* In Class:
  + Handling matrixes that are out of memory
  + data.table
  + Matrixes and arrays more efficient than data frames
  + Lists great tools for simulations and holding differently structured data
* String manipulation (Chapter 11)
  + Control structures (Chapter 7)
* Writing and calling functions (Chapter 7)

Week 3: Exploiting R functions for intensive scripts

* Split, apply and combine;
* Top-down design and scoping (Chapter 7),
* Simulations (Chapter 8)

Week 4: Optimization

* Debugging (Chapter 13)
* Vectorizing code (Chapter 14)
* Parallel R (Chapter 16)

Week 5: Rccp

* Writing C/C++ to be called from R (Chapter 15)
* Guest lecture: George Vega Yon

Week 6-7: Algorithms and teaching each other

* Guest lecture: George Vega Yon – Phylogenetics and tree pruning
* Expectation Maximization
* Newton-Raphson convergence

R-Package creation

Week 8: Intro to CHPC

* Lecture 1:
  + Guest lecture: Anita Orendt – Intro to Linux and
  + vim
* Lecture 2: slurm

Week 9: Intro to CHPC and SLURM scripts

* Guest lecture: Anita Orendt -- CHPC environment
* SLURM

Weeks 10-12: Example SLURM calls

* Guest lecture: Andrew Redd
* Examples from research

Week 13: Student examples

* Presentations
* Improvements

Week 14: slurmR

* Guest lecture: George Vega Yon

Week 15: Work on final project in class

Week 16: Presentations

Grading

TBD

**COVID-19 Campus Guidelines**

You can remain current with the University’s policies on COVID-19 here: <https://coronavirus.utah.edu/> As of August 1, there are no requirements for proof of COVID-19 vaccination for students and faculty, and no requirements for masks and face coverings on UU campus. However, I would like us each to consider how we can best protect ourselves, our colleagues, and our broader community from COVID-19.

***Vaccinations:*** I strongly encourage everyone to get vaccinated if they have not done so already. This is the single most powerful way that you can protect yourself, your friends/families and to keep the virus from mutating. [Free vaccinations](https://alert.utah.edu/covid/vaccine/) are available on campus.

***Masking*:** CDC guidelines (updated July 27) recommend masking in indoor public spaces (regardless of vaccination status) because breakthrough infections are possible and do occur. **Given this guidance,** **the Honors College requests that all faculty and students wear masks while indoor in classrooms until further change in COVID infection rates.**  In setting our own community standards, the Honors College will continue to monitor epidemiological data on [COVID cases from the Utah Department of Health](https://coronavirus.utah.gov/case-counts/) and [CDC’s evidence-based guidance for COVID-19](https://www.cdc.gov/coronavirus/2019-ncov/communication/guidance.html).

**Drop/Withdrawal Policies**

Students may drop a course within the first two weeks of a given semester without any penalties.

Students may officially withdraw (W) from a class or all classes after the drop deadline through the midpoint of a course. A “W” grade is recorded on the transcript and appropriate tuition/fees are assessed. The grade “W” is not used in calculating the student’s GPA.

For deadlines to withdraw from full-term, first, and second session classes, see the U's [Academic Calendar](https://registrar.utah.edu/academic-calendars/index.php).

**Plagiarism & Cheating**

It is assumed that all work submitted to your instructor is your own work. When you have used ideas of others, you must properly indicate that you have done so.

Plagiarism and cheating are serious offenses and may be punished by failure on an individual assignment, and/or failure in the course. Academic misconduct, according to the University of Utah Student Code,

“...Includes, but is not limited to, cheating, misrepresenting one’s work, inappropriately collaborating, plagiarism, and fabrication or falsification of information…It also includes facilitating academic misconduct by intentionally helping or attempting to help another to commit an act of academic misconduct.”

For details on plagiarism and other important course conduct issues, see the U's [Code of Student Rights and Responsibilities](http://regulations.utah.edu/academics/6-400.php).

**Course Material Copyright**

**The Content is made available only for your personal, noncommercial educational and scholarly use.** You may not use the Content for any other purpose, or distribute, post or make the Content available to others, unless you obtain any required permission from the copyright holder. Some Content may be provided via streaming or other means that restrict copying; you may not circumvent those restrictions. You may not alter or remove any copyright or other proprietary notices included in the Content.

Please see the [Code of Student Rights and Responsibilities](https://regulations.utah.edu/academics/6-400.php), Section III.A.5 regarding use and distribution of class Content and materials.

<https://regulations.utah.edu/academics/6-400.php>  
Section III.A.5. prohibits the following:  
Sale or distribution of information representing the work product of a faculty member to a commercial entity for financial gain without the express written permission of the faculty member responsible for the course. (“Work product” means original works of authorship that have been fixed in a tangible medium and any works based upon and derived from the original work of authorship.)

**Safety at the U**

The University of Utah values the safety of all campus community members. You will receive important emergency alerts and safety messages regarding campus safety via text message.

For more information regarding safety and to view available training resources, including helpful videos, visit [safeu.utah.edu](http://safeu.utah.edu/).

To report suspicious activity or to request a courtesy escort, contact:

**Campus Police & Department of Public Safety**

801-585-COPS (801-585-2677)

[dps.utah.edu](https://dps.utah.edu/)

1735 E. S. Campus Dr.

Salt Lake City, UT 84112

**Wellness at the U**

Your personal health and wellness are essential to your success as a student. Personal concerns like stress, anxiety, relationship difficulties, depression, or cross-cultural differences can interfere with a student’s ability to succeed and thrive in this course and at the University of Utah.

Please feel welcome to reach out to your instructor or TA's to handle issues regarding your coursework.

For helpful resources to manage your personal wellness and counseling options, contact:

**Center for Student Wellness**  
801-581-7776  
[wellness.utah.edu](http://wellness.utah.edu/)  
2100 Eccles Student Life Center  
1836 Student Life Way  
Salt Lake City, UT 84112

**Women's Resource Center**  
801-581-8030  
[womenscenter.utah.edu](https://womenscenter.utah.edu/)  
411 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

**Addressing Sexual Misconduct**

Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran’s status, or genetic information.

If you or someone you know has been harassed or assaulted, you are encouraged to report it to university officials:

**Title IX Coordinator & Office of Equal Opportunity and Affirmative Action**  
801-581-8365  
[oeo.utah.edu](https://oeo.utah.edu/)  
135 Park Building  
201 Presidents' Cir.  
Salt Lake City, UT 84112

**Office of the Dean of Students**  
801-581-7066  
[deanofstudents.utah.edu](https://deanofstudents.utah.edu/)  
270 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

To file a police report, contact:

**Campus Police & Department of Public Safety**  
801-585-COPS (801-585-2677)  
[dps.utah.edu](https://dps.utah.edu/)  
1735 E. S. Campus Dr.  
Salt Lake City, UT 84112

If you do not feel comfortable reporting to authorities, the U's Victim-Survivor Advocates provide **free, confidential** and **trauma-informed** support services to **students, faculty, and staff**who have experienced interpersonal violence.

To **privately** explore options and resources available to you with an advocate, contact:

**Center for Student Wellness**  
801-581-7776  
[wellness.utah.edu](http://wellness.utah.edu/)  
328 Student Services Building  
201 S. 1460 E.  
Salt Lake City, UT 84112

**American with Disabilities Act (ADA)**

The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities.

All written information in this course can be made available in an alternative format with prior notification to the Center for Disability & Access (CDA). CDA will work with you and the instructor to make arrangements for accommodations. Prior notice is appreciated. To read the full accommodations policy for the University of Utah, please see Section Q of the [Instruction & Evaluation regulations](http://regulations.utah.edu/academics/6-100.php).

If you will need accommodations in this class, or for more information about what support they provide, contact:

**Center for Disability & Access**  
801-581-5020  
[disability.utah.edu](https://disability.utah.edu/)  
162 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

**Diverse Student Support**

Your success at the University of Utah is important to all of us here! If you feel like you need extra support in academics, overcoming personal difficulties, or finding community, the U is here for you.

Student Support Services (TRIO)

TRIO federal programs are targeted to serve and assist low-income individuals, first-generation college students, and individuals with disabilities.

Student Support Services (SSS) is a TRIO program for current or incoming undergraduate university students who are seeking their first bachelor's degree and need academic assistance and other services to be successful at the University of Utah.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Student Support Services (TRIO)**  
801-581-7188  
[trio.utah.edu](https://trio.utah.edu/)  
Room 2075   
1901 E. S. Campus Dr.  
Salt Lake City, UT 84112

American Indian Students

The AIRC works to increase American Indian student visibility and success on campus by advocating for and providing student centered programs and tools to enhance academic success, cultural events to promote personal well-being, and a supportive “home-away-from-home” space for students to grow and develop leadership skills.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**American Indian Resource Center**  
801-581-7019  
[diversity.utah.edu/centers/airc](https://diversity.utah.edu/centers/airc/)  
Fort Douglas Building 622  
1925 De Trobriand St.  
Salt Lake City, UT 84113

Black Students

Using a pan-African lens, the Black Cultural Center seeks to counteract persistent campus-wide and global anti-blackness. The Black Cultural Center works to holistically enrich, educate, and advocate for students, faculty, and staff through Black centered programming, culturally affirming educational initiatives, and retention strategies.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Black Cultural Center**  
801-213-1441  
[diversity.utah.edu/centers/bcc](https://diversity.utah.edu/centers/bcc/)  
Fort Douglas Building 603  
95 Fort Douglas Blvd.  
Salt Lake City, UT 84113

Students with Children

Our mission is to support and coordinate information, program development and services that enhance family resources as well as the availability, affordability and quality of child care for University students, faculty and staff.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Center for Childcare & Family Resources**  
801-585-5897  
[childcare.utah.edu](https://childcare.utah.edu/)  
408 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

Students with Disabilities

The Center for Disability Services is dedicated to serving students with disabilities by providing the opportunity for success and equal access at the University of Utah. They also strive to create an inclusive, safe, and respectful environment.

For more information about what support they provide and links to other resources, view their website or contact:

**Center for Disability Services**  
801-581-5020  
[disability.utah.edu](https://disability.utah.edu/)  
162 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

Student of Ethnic Descent

The Center for Ethnic Student Affairs offers several programs dedicated to the success of students with varied cultural and ethnic backgrounds. Their mission is to create an inclusive, safe campus community that values the experiences of all students.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Center for Ethnic Student Affairs**  
801-581-8151  
[diversity.utah.edu/centers/cesa/](https://diversity.utah.edu/centers/cesa/)  
235 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

English as a Second/Additional Language (ESL) Students

If you are an English language learner, there are several resources on campus available to help you develop your English writing and language skills. Feel free to contact:

**Writing Center**801-587-9122  
[writingcenter.utah.edu](http://writingcenter.utah.edu/)  
2701 Marriott Library  
295 S 1500 E  
Salt Lake City, UT 84112

**English for Academic Success (EAS) Program**801-581-8047[linguistics.utah.edu/eas-program](https://linguistics.utah.edu/eas-program/)  
2300 LNCO  
255 S. Central Campus Dr.  
Salt Lake City, UT 84112

**English Language Institute**801-581-4600  
[continue.utah.edu/eli](http://continue.utah.edu/eli)  
540 Arapeen Dr.  
Salt Lake City, UT 84108

Undocumented Students

Immigration is a complex phenomenon with broad impact—those who are directly affected by it, as well as those who are indirectly affected by their relationships with family members, friends, and loved ones. If your immigration status presents obstacles that prevent you from engaging in specific activities or fulfilling specific course criteria, confidential arrangements may be requested from the Dream Center.

**Arrangements with the Dream Center will not jeopardize your student status, your financial aid, or any other part of your residence.** The Dream Center offers a wide range of resources to support undocumented students (with and without DACA) as well as students from mixed-status families.

For more information about what support they provide and links to other resources, view their website or contact:

**Dream Center**801-213-3697  
[dream.utah.edu](http://dream.utah.edu/)  
1120 Annex (Wing B)  
1901 E. S. Campus Dr.  
Salt Lake City, UT 84112

LGBTQ+ Students

The LGBTQ+ Resource Center acts in accountability with the campus community by identifying the needs of people with a queer range of [a]gender and [a]sexual experiences and responding with university-wide services.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**LGBTQ+ Resource Center**  
801-587-7973  
[lgbt.utah.edu](http://lgbt.utah.edu/)  
409 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

Veteran & Military Students

The mission of the Veterans Support Center is to improve and enhance the individual and academic success of veterans, service members, and their family members who attend the university; to help them receive the benefits they earned; and to serve as a liaison between the student veteran community and the university.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Veterans Support Center**  
801-587-7722  
[veteranscenter.utah.edu](http://veteranscenter.utah.edu/)     
418 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

Women

The Women’s Resource Center (WRC) at the University of Utah serves as the central resource for educational and support services for women. Honoring the complexities of women’s identities, the WRC facilitates choices and changes through programs, counseling, and training grounded in a commitment to advance social justice and equality.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Women's Resource Center**  
801-581-8030  
[womenscenter.utah.edu](https://womenscenter.utah.edu/)  
411 Union Building  
200 S. Central Campus Dr.  
Salt Lake City, UT 84112

Inclusivity at the U

The Office for Inclusive Excellence is here to engage, support, and advance an environment fostering the values of respect, diversity, equity, inclusivity, and academic excellence for students in our increasingly global campus community. They also handle reports of bias in the classroom as outlined below:

Bias or hate incidents consist of speech, conduct, or some other form of expression or action that is motivated wholly or in part by prejudice or bias whose impact discriminates, demeans, embarrasses, assigns stereotypes, harasses, or excludes individuals because of their race, color, ethnicity, national origin, language, sex, size, gender identity or expression, sexual orientation, disability, age, or religion.

For more information about what support they provide and links to other resources, or to report a bias incident, view their website or contact:

**Office for Inclusive Excellence**801-581-4600  
[inclusive-excellence.utah.edu](https://inclusive-excellence.utah.edu/)  
170 Annex (Wing D)  
1901 E. S. Campus Dr.  
Salt Lake City, UT 84112

Other Student Groups at the U

To learn more about some of the other resource groups available at the U, check out:

[getinvolved.utah.edu/](https://getinvolved.utah.edu/)

[studentsuccess.utah.edu/resources/student-support](https://studentsuccess.utah.edu/resources/student-support/)