

# Keck School of Medicine of USC

## **PM 520: Advanced Statistical Computing**

**Units:** 3 units

**Term–Day–Time:** Spring 2021, Mon 1:00 PM-3:30 PM

**Location:** Zoom

### **Course Coordinator(s):**

Name: Paul Marjoram Contact: pmarjora@usc.edu

Office: Office Hours: Friday 1pm

### **Course Instructor(s):**

### **Teaching Assistant(s):**

## Course Description

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The objective of the course is to give you the skills to enable you to both be able to program, and better understand, statistical machinery using the R programming language. Note that this is not really a course about R, as such. Instead, we use R as a way of illustrating how to write code to perform a number of probabilistic and statistical procedures. We will introduce the R details as we go, but students will be expected to invest some time of their own each week, outside class, in which they improve their R programming skills if necessary.

Each week's lecture (60-90 minutes) will focus on one or more areas in probability and statistics, describing how those procedures are performed. The rest of the class (90-120 minutes) will be a lab in which students will sit down and start to code those procedures in class. Students will be encouraged to show their work "in progress". For example, you've written 30 lines of code and it isn't working properly: we will put the code on the screen and we will all try to work out what is wrong. In other words, we will learn by doing, and by learning from our mistakes, rather than relying upon the traditional method of listening to a member of faculty drone on for 3 hours. In doing so we hope to make the course more interactive. As the saying goes: turn-about is fair play. So, as the instructor, I will also display bugged code of my own to the rest of the class, so that we can learn from my mistakes as well.

The course will be examined by a number of projects during the course. These projects will involve writing R code to perform a particular task (optimize a function, fit a regression, simulate a stochastic process,...). That code will be turned in to me and I will run it on some test problems to see how it does. In addition, the final exam will consist of your giving small group (2-3 people) presentations regarding statistical computing methods.

## Learning Objectives

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1. The course will be examined by a number of projects during the course. These projects will involve writing R code to perform a particular task (optimize a function, fit a regression, simulate a stochastic process,...). That code will be turned in to me and I will run it on some test problems to see how it does. In addition, the final exam will consist of your giving small group (2-3 people) presentations regarding statistical computing methods.

Prerequisite(s):

Co-Requisite(s):

Concurrent Enrollment:

**Recommended Preparation:** Some experience with R will be useful. Students will need to have a basic understanding of probability.

## Teaching & Assessment Methods

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### Teaching Methods

- Classroom lecture
- Laboratory

### Assessment Methods

- Small group evaluation
- Laboratory skills

## Course Notes

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## Communication

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## Technological Proficiency and Hardware/Software Required

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Ability to code in R.

## Required Materials

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- there are no required materials.

## Optional Materials

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- Recommended Textbook: “Scientific Programming and Simulation Using R” – Owen Jones, Robert Maillardet and Andrew Robinson, CRC Press.
- There are any number of books to help you with coding in R. But the best bet these days is to use one of the many free online books. For example:
  - Mastering Software Development in R, 2017. Roger Peng, Sean Kross, Brooke Anderson. <https://bookdown.org/rdpeng/RProgDA/>
  - R for Data Science, 2017 Garrett Golemund and Hadley Wickham. <http://r4ds.had.co.nz/>
  - Advanced R, 2014, Hadley Wickham, CRC press. <http://adv-r.had.co.nz/> (Second edition is available in print on June 28 <https://www.amazon.com/gp/product/0815384572/>, online here: <https://adv-r.hadley.nz/>)
  - R Packages, 2015, Hadley Wickham, O’Reilly. <http://r-pkgs.had.co.nz/> (work on a second edition is in development here <https://r-pkgs.org/> starting as of 2019-02)
  - Advanced Statistical Computing, 2018 Roger Peng (<https://bookdown.org/rdpeng/advstatcomp/>)

## Description and Assessment of Assignments

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Course will be assessed via 4-5 projects that are to be turned in during the semester, and one final project to be presented in exam week.

## Grading Breakdown

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| <b>Assignment</b>  | <b>% of Grade</b> |
|--------------------|-------------------|
| Projects           | 70                |
| Final presentation | 20                |
| Participation      | 10                |
| <b>Total</b>       | <b>100</b>        |

## Grading Scale

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Course final grades will be determined using the following scale.

|    |              |
|----|--------------|
| A  | 95-100       |
| A- | 90-94        |
| B+ | 87-89        |
| B  | 83-86        |
| B- | 80-82        |
| C+ | 77-79        |
| C  | 73-76        |
| C- | 70-72        |
| D+ | 67-69        |
| D  | 63-66        |
| D- | 60-62        |
| F  | 59 and below |

## Course-specific Policies

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### Assignment Submission

We will be using Github for handling of project up- and down-load.

### Grading Timeline

A week or so after submission, typically.

### Late work

### Technology in the classroom

You will need a github account (see <http://github.com/>)

## Academic integrity

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A grade of zero will be applied to submitted work that does not comply with the USC standards of academic conduct. Such work may not be resubmitted for a new grade. Academic integrity is included at the end of the syllabus.

## Attendance

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## Classroom norms

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## Expectations on Student Engagement

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10% of your final grade is for "participation", which means being actively involved in class/lab. i.e., offering thoughts/comments, asking or answering questions, sharing your code, helping others with their code. The goal is to create a classroom that is collaborative in nature.

## Course evaluation

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## Policy on Learning & Assessment Feedback (LAF)

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Feedback on examinations will be provided using the following methods. Please indicate which method(s) you will use in the course.

- Complete examination will be returned and a key will be made available

## Course Schedule: A Weekly Breakdown

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| Date                            | Topic  | Lecturer |
|---------------------------------|--|----------|
| Mon 01/25/21<br>01:00p - 03:30p | Week 1: Introduction – Using Github; Random number generation and Monte Carlo Estimation. How to estimate things that you cannot calculate. Coin-tossing. Occupancy problems. Hypercubes. Golf |          |

|                                 |   |  |
|---------------------------------|---|--|
| Mon 02/01/21<br>01:00p - 03:30p | Week 2: More Monte Carlo Estimation: Estimating pi, Random variable simulation, Likelihood Estimation. Bayesian methods. Accept/Reject Algorithms |  |
| Mon 02/08/21<br>01:00p - 03:30p | Week 3: Methods for finding function roots and fixed points. Math as art.   |  |
| Mon 02/22/21<br>01:00p - 03:30p | Week 4: Probability and Stochastic Simulation – Urn Models  |  |
| Mon 03/01/21<br>01:00p - 03:30p | Week 5: Optimization and Regression   |  |
| Mon 03/08/21<br>01:00p - 03:30p | Weeks 6-8: Markov Chain Monte Carlo [MCMC] Methods. Adaptive MCMC, Parallel Tempered-MCMC, Code-breaking  |  |
| Mon 03/15/21<br>01:00p - 03:30p | Weeks 6-8: Markov Chain Monte Carlo [MCMC] Methods. Adaptive MCMC, Parallel Tempered-MCMC, Code-breaking  |  |
| Mon 03/22/21<br>01:00p - 03:30p | Weeks 6-8: Markov Chain Monte Carlo [MCMC] Methods. Adaptive MCMC, Parallel Tempered-MCMC, Code-breaking  |  |
| Mon 03/29/21<br>01:00p - 03:30p | Week 9: Gibbs Sampling, Accept/Reject Algorithms  |  |
| Mon 04/05/21<br>01:00p - 03:30p | Week 10: Permutation tests, Numerical Integration and Importance Sampling   |  |
| Mon 04/12/21<br>01:00p - 03:30p | Week 11: Approximate Bayesian Computation, ABC-Rejection, ABC-MCMC  |  |
| Mon 04/19/21<br>01:00p - 03:30p | Week 12: Sequential Monte Carlo Methods, Regression-adjusted ABC  |  |
| Mon 04/26/21<br>01:00p - 03:30p | Week 13: Hidden Markov Models, Genetic Algorithms   |  |

## Statement on Academic Conduct and Support Systems

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### Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other

forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

### **Support Systems:**

*Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call*

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. [engemannshc.usc.edu/counseling](http://engemannshc.usc.edu/counseling)

*National Suicide Prevention Lifeline – 1 (800) 273-8255*

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. [www.suicidepreventionlifeline.org](http://www.suicidepreventionlifeline.org)

*Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call*

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. [engemannshc.usc.edu/rsvp](http://engemannshc.usc.edu/rsvp)

*Sexual Assault Resource Center*

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: [sarc.usc.edu](http://sarc.usc.edu)

*Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086*

Works with faculty, staff, visitors, applicants, and students around issues of protected class. [equity.usc.edu](http://equity.usc.edu)

*Bias Assessment Response and Support*

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. [studentaffairs.usc.edu/bias-assessment-response-support](http://studentaffairs.usc.edu/bias-assessment-response-support)

*The Office of Disability Services and Programs*

Provides certification for students with disabilities and helps arrange relevant accommodations. [dsp.usc.edu](http://dsp.usc.edu)

*Student Support and Advocacy – (213) 821-4710*

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. [studentaffairs.usc.edu/ssa](http://studentaffairs.usc.edu/ssa)

*Diversity at USC*

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. [diversity.usc.edu](http://diversity.usc.edu)

*USC Emergency Information*

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. [emergency.usc.edu](http://emergency.usc.edu)

*USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.*

Provides overall safety to USC community. [dps.usc.edu](http://dps.usc.edu)