

PM522a – SYLLABUS

**DIVISION OF BIOSTATISTICS
DEPARTMENT OF PREVENTIVE MEDICINE
KECK SCHOOL OF MEDICINE
UNIVERSITY OF SOUTHERN CALIFORNIA**

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Office hours: by appointment

Teaching Assistant: To be determined

Sessions schedule: Tues 4:35-7:30PM

Room: To be determined

Units: 3

Course content

This course is a rigorous non-measure theoretic introduction to probability theory with an emphasis on the results and methods that are most relevant to statistical inference. PM522a and PM522b are to be taken in sequence; PM522a covers probability and PM522b covers statistical inference. These two courses form the core statistical-theory of the Biostatistics program, providing a sound theoretical basis

for understanding applied statistical methods and pursuing more advanced Theory. The sequence PM522a-b is required for all the Biostatistics PhD tracks and it is also open to quantitatively oriented students in Epidemiology and other population-based sciences. A detailed list of the topics is given below.

Course objectives

- To acquire skill in the basic computations involving probabilities and to develop probabilistic thinking
- To gain intuition and understanding of probabilistic concepts with the aid of computer-based simulation and visualization.
- To become familiar with common parametric families of distributions and their applications.
- To understand the key probability theory results that are fundamental to statistical inference.

IMPORTANT! - Method of instruction

Unlike most courses you will be taking here, this course will be taught using the “flipped classroom” style. This means that students will be expected to study the relevant textbook sections, and work through the exercises for that chapter, ahead of each session. There will be a 30-minute ‘quiz’ at the start of each week’s class. This quiz will in part cover the basics of the material read for that week, but will also include one or two of the text-book exercises from the material from the previous week of class. These quizzes will count (25%) towards final grading. Much of the class time will then be used as an opportunity to ask for clarifications, or further discussion of parts of the material that were unclear, ask questions about exercises you struggled with, go through more examples or exercises, have group discussions of related issues, review important concepts, and so on. Please see the course schedule below to see what you are expected to have completed before arriving for that week’s class. (And note that the nature of the course means that there are things you are expected to have completed before week 1’s class!). **You are expected to read sections 1.1-1.5 of chapter 1 of the Blitzstein book before attending the first class, but there will be no quiz on week 1.**

Assessment/Grading

Weekly 'in class' quiz: 25%;

Biweekly homework assignments: 20%;

A midterm exam: 25%;

A final exam: 30%;

Grading Scale:

Final grades will be determined on the percentage of points earned by each of the assignments and exams described above.

Required Textbook: Introduction to Probability, by Joseph Blitzstein and Jessica Hwang, Chapman & Hall/CRC Texts in Statistical Science [Referred to as BH below]

Additional Reference:

Statistical Inference, 2nd Ed. [CB] Casella G, Berger RL. Wadsworth & Brooks, 2002

Other Resources:

If you would like to see some recorded lectures covering the material of the course, try the following free iTunes university course:

<https://itunes.apple.com/us/course/statistics-110-probability/id502492375>

You can also find it on Youtube at:

<https://www.youtube.com/watch?v=KbB0FjPg0mw&list=PL2SOU6wwxB0uwwH80KTQ6ht66KWxbzTIo>)

Detailed list of topics

Week 1. (August 27)[Sections 1.1-1.5 of BH] Probability and Counting; "Pebble" spaces; Probability on Finite Sample Spaces; Basic set theory. Story Proofs. *Assignment 1 out.*
Work you are expected to complete before attending class: Read through and study Sections 1.1-1.5 of the course text, Blitzstein and Hwang [BH hereafter]. Attempt many

of the exercises in that section. (i.e. At least one of those may be on next week's quiz.)
Optional: Watch lectures 1, 2 and 3 of the iTunes course, (you can skip over the first 15 minutes of lecture 1, which is general chit-chat).

- Week 2.** (September 3)[Sections 1.6-2.4 of BH]. Non-naïve Definition of Probability, Bayes' Rule, Conditional Probability. **Work you are expected to complete before attending class:** Read through and study Sections 1.6-2.4 of BH. Attempt many of the exercises in that section. (i.e. At least one of those may be on next week's quiz.) Optional: Watch lectures 4 and 5 of the iTunes course.
- Week 3.** (September 10)[Sections 2.5-2.10 of BH]. Independence, Coherency of Bayes' Rule, Conditioning as a Problem Solving Tool. **Work you are expected to complete before attending class:** Read through and study Sections 2.5-2.10 of BH. Attempt many of the exercises in that section. (i.e. At least one of those may be on next week's quiz.) Optional: Watch lectures 6 and 7 of the iTunes course.
- Week 4.** (September 17)[Chapter 3 of BH]. Random Variables and Their Distributions, Classic Discrete Distributions, Probability Mass Functions, Cumulative Distribution Functions, functions of Random Variables. **Work you are expected to complete before attending class:** Read through and study Chapter 3 of BH. Attempt many of the exercises in that section. (i.e. At least one of those may be on next week's quiz.) Assignment 1 Due. Assignment 2 out. Optional: Watch lecture 8 of the iTunes course.
- Week 5.** (September 24)[Chapter 4 of BH]. Expectation. Properties of Expectation. Geometric and Negative Binomials, Indicator Variables, Variance, Poisson and connections with Binomial. **Work you are expected to complete before attending class:** Read through and study Chapter 4 of BH. Attempt many of the exercises in that chapter. Optional: Watch lectures 9-11 of the iTunes course.

- Week 6.** (October 1)[Chapter 5 of BH] Continuous r.v.s, PDFs, Common continuous r.v.s, Poisson Processes, symmetry of r.v.s. **Work you are expected to complete before attending class:** Read through and study chapter 5 of BH. Attempt many of the exercises in that chapter. Optional: Watch lectures 12-14 & 16 of the iTunes course. Assignment 2 Due. Assignment 3 out.
- Week 7.** (October 8)[Chapters 1-5 of BH]. Mid-term review. We will use this week to go over a variety of problems from the first 5 chapters of BH in preparation for next week's mid-term. . Optional: Watch lecture 15 of the iTunes course.
- Week 8.** (October 15) Mid-term exam. This will cover chapters 1-5 of BH.
- Week 9.** (October 22)[Chapter 6 of BH]. Moments as a summary of distributions, Interpretation, Sample Moments, MGFs and their uses. **Work you are expected to complete before attending class:** Read through and study chapter 6 of BH. Assignment 2 Due. Assignment 3 out. Attempt many of the exercises in that chapter. Optional: Watch lectures 17 & 18 of the iTunes course. Assignment 3 Due. Assignment 4 out.
- Week 10.** (October 29)[Chapter 7 of BH]. Joint Probability Distributions Function; Covariance and correlation. Multinomials and Multivariate Normals. **Work you are expected to complete before attending class:** Read through and study chapter 7 of BH. Attempt many of the exercises in that chapter. Optional: Watch lectures 19-21 of the iTunes course.
- Week 11.** (November 5)[Chapter 8 of BH] Transformations. Change of Variables, Convolutions, Betas and Gammas and their unearthly offspring, Order Statistics **Work you are expected to complete before attending class:** Read through and study chapter 8 of BH. Attempt many of the exercises in that chapter. Optional: Watch lectures 22-25 of the iTunes course. Assignment 4 Due. Assignment 5 out.

- Week 12.** (November 12)[Chapter 9 of BH] Conditional Expectation given events and r.v.s, Properties, Conditional Variance, *Read and study chapter 9 of BH. Attempt many of the exercises in that chapter. Watch lectures 26 & 27 of the iTunes course.*
- Week 13.** (November 19)[Chapter 10 of BH]. Inequalities and Limit Theorems, Law of Large Numbers, Central Limit Theorem; Chi-Square and Student-t. Read and study chapter 10 of BH. *Attempt many of the exercises in that chapter. Optional: Watch lectures 28-30 of the iTunes course. Assignment 5 Due. Assignment 6 out.*
- Week 14.** (November 26 *T/giving week*) Review. No assigned reading. We will spend the class doing exercises taken from the entire course syllabus
- Week 15.** (December 3)[Chapter 11 of BH]. Markov Chains, the Markov Property, states, Stationary Distributions, Reversibility, Monte Carlo methods, Accept/Reject Methods. Read and study chapter 11 of BH. (note that a couple of subjects listed for this week are not covered in BH – lecture notes will be provided for those) *Attempt many of the exercises in that chapter. Optional: Watch lectures 31-33 of the iTunes course.* Assignment 6 due.
- Week 16.** (December 17) **Final Exam.** Good luck!

Recommended preparation for PM522a:

There is a basic set of mathematical skills you are expected to have acquired before you take this class. These are listed below, along with some resources you can use to brush up on these skills. Please make use of these resources if necessary.

- **Basic set theory:** Finite, countable, and uncountable sets; union and intersections of arbitrary families of sets (finite, countable or infinite); proofs by induction.

- **Functions:** domain, range, preimage, injectivity, surjectivity, bijectivity; inverse function.
- **Calculus:** limits, convergence of sequences and series, continuity (sequence-based, delta-epsilon and topological definitions); epsilon-delta proofs; derivation and integration in \mathbb{R}^n ; change of variables theorem; Taylor expansions;

A good resource for a refresher or for filling gaps on this material is the open MIT multivariate calculus course:

<http://ocw.mit.edu/courses/mathematics/18-02sc-multivariable-calculus-fall-2010/>

- **Linear algebra:** Linear transformations; matrices; linear independence; basis; change of basis; inner products; orthogonality; eigenvalues and eigenvectors; diagonalization; symmetric matrices;

The MIT multivariate calculus course starts with an intro to linear algebra that maybe a good starting point for the first few topics in the list above. For more in depth coverage and for the remaining topics a good resource is the open MIT linear algebra course:

<http://ocw.mit.edu/courses/mathematics/18-06sc-linear-algebra-fall-2011/>

STATEMENT FOR STUDENTS WITH DISABILITIES:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

STATEMENT ON ACADEMIC CONDUCT AND SUPPORT SYSTEMS

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

Support Systems:

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

engemannshc.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

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

engemannshc.usc.edu/rsvp

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086

equity.usc.edu, titleix.usc.edu

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421

studentaffairs.usc.edu/bias-assessment-response-support

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

studentaffairs.usc.edu/ssu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.