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 4:30-7:30PM

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 pervious 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

Detailed list of topics

Week 1. *(August 22)[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. *(August 29)[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 5)[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 12)[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 19)[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. *(September 26)[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 3)[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 10)* Mid-term exam. This will cover chapters 1-5 of BH.

Week 9. *(October 17)[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 24[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. *(October 31)[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 7)[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 14)[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 21 T/giving week)* Review. No assigned reading. We will spend the class doing exercises taken from the entire course syllabus

Week 15. *(November 29)[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 12, I think, but to be confirmed)* **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 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 stars 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 INTEGRITY:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus,* the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://web-app.usc.edu/scampus/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.