

# **BENG 100. Statistical Reasoning for Bioengineering Applications**

## **Course Syllabus**

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### **Prerequisites**

BENG 1; Math 20C or Math 31BH; Math 20D; Math 18; Phys 2A-B-C; or consent of the department.

### **Course Description**

General introduction to probability and statistical analysis, applied to bioengineering design. Topics include preliminary data analysis, probabilistic models, experiment design, model fitting, goodness-of-fit analysis, and statistical inference/estimation. Written ~~and software~~ problems are provided for modeling and visualization.

### **Textbook and Other Materials**

#### **Required Reading**

*Introduction to Probability, Statistics, and Random Processes*, Hossein Pishro-Nik, Kappa Research, LLC. August 24, 2014. ISBN-10: 0990637204. ISBN-13: 978-0990637202.

#### **Optional Reading**

*Introduction to Probability, 2nd Edition*, Dimitri P. Bertsekas and John N. Tsitsiklis, Athena Scientific. July 15, 2008. ISBN-10: 188652923X. ISBN-13: 978-1886529236.

*All of Statistics: A Concise Course in Statistical Inference*, 1st Corrected ed. 20 Edition. Springer Texts in Statistics. Springer. September 17, 2004. ISBN-13: 978-0387402727.

#### **Additional Materials**

Note that three copies of the required textbook have been put on reserve at the Library. In addition to the textbooks listed above, there is a plethora of available information on the Internet. This information includes peer-reviewed manuscripts, Wikipedia articles, YouTube videos of lectures from UCSD and/or other universities, and much more. Students are strongly encouraged to review additional online materials prior to each class.

### **Course Outcomes**

After successfully completing this class, a student will be able to:

- a. Understand basic concepts of set theory, probability theory, and statistics

- b. Understand probability measure and conditional probability
- c. Describe the properties of discrete and continuous distribution functions
- d. Assess the consistency, efficiency and unbiasedness of estimators
- e. Apply methods of maximum likelihood estimation
- f. Understand and apply the Central Limit Theorem
- g. Understand and use statistical tests in testing hypotheses on data
- h. Understand and use classical and Bayesian statistical inference

### **Class Schedule**

Students are expected to attend all lectures. Students should also select the most convenient time and attend at least one discussion section each week. A detailed schedule of lectures, homework assignments, and exams is provided at the end of this document.

### **Lectures**

Tuesday	2:00pm – 3:20pm	CENTR 115
Thursday	2:00pm – 3:20pm	CENTR 115

### **Discussion Sections**

The lectures are structured to follow the main textbook *Introduction to Probability, Statistics, and Random Processes* by Hossein Pishro-Nik. During each week, the lectures will cover approximately one chapter in the book (please refer to the Detailed Class Schedule in the end of this document for more details). While the lectures will predominately focus on theory, the discussion sections will be focused on solving problems. Each book chapter as well as most subchapters contain a number of solved problems. Teaching assistants will walk you through and explain these solved problems during the discussion sections. Please make sure that you review the solved problems for the appropriate chapter section(s) prior to attending any of the discussion sections. The schedule for discussion sections is provided below.

<b>Monday</b>	10:00am – 10:50am	Erik Bergstrom	CENTR 201
<b>Monday</b>	3:00pm – 3:50pm	David Calcagno	CENTR 220
<b>Monday</b>	4:00pm – 4:50pm	Michael Hu	CENTR 218
<b>Friday</b>	11:00am – 11:50am	Michael Hu	CENTR 220
<b>Friday</b>	12:00pm – 12:50pm	Michael Wiest	CENTR 207
<b>Friday</b>	1:00pm – 1:50pm	Edward Kantz	HSS 2152

### **Exams**

24 April	2:00pm – 3:20pm	Midterm Exam 1	CENTR 115
17 May	2:00pm – 3:20pm	Midterm Exam 2	CENTR 115
12 June	3:00pm – 5:59pm	Final Exam	TBA on TritonLink

### **Homework Assignments**

<b>Assignment</b>	<b>Date and Time Posted</b>	<b>Date and Time Due</b>	<b>Date and Time Solutions Posted</b>
Homework Assignment 1	3 April, 3:20pm	10 April, 3:20pm	10 April, 4:20pm
Homework Assignment 2	10 April, 3:20pm	17 April, 3:20pm	17 April, 4:20pm
Homework Assignment 3	26 April, 3:20pm	3 May, 3:20pm	3 May, 4:20pm
Homework Assignment 4	3 May, 3:20pm	10 May, 3:20pm	10 May, 4:20pm
Homework Assignment 5	22 May, 3:20pm	29 May, 3:20pm	29 May, 4:20pm

## Methods of Evaluation

The final course grade will be based on the maximum from the following two grading options:

### Option 1:

- Homework assignments (20%; 5 homework assignments each 4%)
- Midterm exams (40%; two midterm exams each 20%)
- Final exam (40%)

### Option 2:

- Final exam (100%)

All students are encouraged to submit all homework assignments and to take the midterm exams (i.e., option 1). In principle, option 2 should be regarded as a safety option that allows compensating any low grades on the homework assignments and/or midterm exams.

## Class Policies

- Neither the Instructor nor the Teaching Assistants will reply to emails unless it is for re-grading an assignment or in case of an emergency. Please use the scheduled lectures, discussion sessions, and office hours for any questions about the course materials and/or course structure.
- Homework assignments must be written clearly and neatly. Illegible homework will not be graded. Homework assignments may be discussed in groups but must be worked individually and not copied. The homework assignments are to be left after the lecture is over (not during the lecture) in class on the due date. No late homework will be accepted or graded.
- A solution to each homework assignment will be provided on TritonEd an hour after the homework assignment is due. Similarly, a solution to each exam will be provided on TritonEd an hour after the completion of the exam.
- All homework assignments will be graded within a week of the due date. Similarly, both midterm exams will be graded within a week of completion of the exams. The final exam will be graded by 15-June. All graded assignments and exams will be alphabetized and left at the Bioengineering students affairs office for student pick up.
- If there is a grade discrepancy, please submit, to one of the Teaching Assistants, the original homework or exam along with a written request for a re-grade within 48 hours from the date the assignment is returned. If re-grading is desired, then the entire assignment is subject to re-grading. Please note that partial credit given for any unsolved problem will not be changed.
- If a student does not take a midterm exam or does not submit a homework assignment, the final exam will be weighed more heavily. A final exam taken other than at the regularly scheduled date/time will be an oral exam that includes solving problems on a blackboard. Further, a final exam taken other than at the regularly scheduled date/time will be allowed only in exceptional circumstances.
- Academic dishonesty will not be tolerated. According to UCSD policy, consulting any unauthorized material that contains answers to any assignment is academic dishonesty. Any suspected incident will be dealt with in accordance with UCSD policy, including reporting the

misconduct to the Dean of Student Affairs. More information on UCSD's Policy on Integrity of Scholarship can be found at: <https://academicintegrity.ucsd.edu/process/policy.html>

- Each student will need to bring to a midterm exam a blue book, a calculator, and a maximum of one single-sided letter size cheat sheet (11in x 8.5in). The use of a digital device (laptop, tablet, phone, *etc.*) other than a calculator during a midterm exam is not allowed. Further, the use of textbooks or written materials other than the cheat sheet is not allowed. If a student is caught using a digital device, a textbook, or materials other than the ones that are allowed during a midterm exam, the student will be asked to leave the midterm exam and the student will receive an exam score of zero.
- Each student will need to bring to the final exam a blue book, a calculator, and a maximum of one double-sided letter size cheat sheet (11in x 8.5in). The use of a digital device (laptop, tablet, phone, *etc.*) other than a calculator during the final exam is not allowed. Further, the use of textbooks or written materials other than the cheat sheet is not allowed. If a student is caught using a digital device, a textbook, or materials other than the ones that are allowed during the final exam, the student will be asked to leave the final exam and the student will receive a final exam score of zero. Since the final exam accounts for a significant proportion of the final grade, a student with a score of zero on the final exam will most likely fail the class.

### Detailed Class Schedule

All lectures are held between **2:00pm – 3:20pm** on Tuesdays and Thursdays on the dates listed below (Location: CENTR 115). The final exam will be held on **12 June, 3:00pm – 5:59pm** (Location: TBA on TritonLink). All chapters in the notes refer to the required textbook *Introduction to Probability, Statistics, and Random Processes* by Hossein Pishro-Nik.

Week #	Date/Location/Time	Day	Lecture Topics	Reading Materials and Notes
<b>1</b>	3-Apr-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Course Introduction and Syllabus</b> What is probability and what is statistics? Brief Review of Set Theory	<b>Read:</b> Chapter 1.1 & 1.2 Homework Assignment 1 posted
	5-Apr-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Random Experiments and Probability</b> Brief Review of Set Theory (continued) Probabilities Measure	<b>Read:</b> Chapter 1.2 & 1.3
<b>2</b>	10-Apr-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Conditional Probability</b> Independence Conditional Independence Bayes' Rule	<b>Read:</b> Chapter 1.4 & 1.5 <b>Homework Assignment 1 due</b> Homework Assignment 2 posted
	12-Apr-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Combinatorics</b> Sampling with replacement Permutations & Combinations Binomial coefficients	<b>Read:</b> Chapter 2
<b>3</b>	17-Apr-2018 Location: CENTR 115	Tuesday	<b>Discrete Random Variables (Part 1)</b>	<b>Read:</b> Chapter 3.1

	2:00pm – 3:20pm		Probability Mass Function (PMF) Independent Random Variables Special Distributions	<b>Homework Assignment 2 due</b>
	19-Apr-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Discrete Random Variables (Part 2)</b> Cumulative Distribution Function (CDF) Expectation, Mean, and Variance Functions of Random Variables	<b>Read:</b> Chapter 3.2
<b>4</b>	<b>24-Apr-2018</b> Location: CENTR 115 2:00pm – 3:20pm	<b>Tuesday</b>	<b>MIDTERM EXAM 1</b>	<b>Bring:</b> a blue book, a calculator, and a maximum of <u>one single-sided</u> letter size cheat sheet (11in x 8.5in). Midterm exam 1 covers all the material discussed in <b>weeks 1 through 3</b> , which includes <b>chapters 1 through 3</b> of the textbook.
	26-Apr-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>General Random Variables (Part 1)</b> Probability Density Functions (PDF) Cumulative Distribution Function (CDF) Expectation, Mean, and Variance	<b>Read:</b> Chapter 4.1 Homework Assignment 3 posted
<b>5</b>	1-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>General Random Variables (Part 2)</b> Special Distributions Mixed Random Variables	<b>Read:</b> Chapter 4.2
	3-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Joint Distributions of Two Discrete Random Variables</b> Joint Probability Mass Function Joint Cumulative Distribution Function Conditioning and Independence	<b>Read:</b> Chapter 5.1 <b>Homework Assignment 3 due</b> Homework Assignment 4 posted
<b>6</b>	8-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Joint Distributions of Two Continuous Random Variables</b> Joint Probability Density Function Joint Cumulative Distribution Function Conditioning and Independence	<b>Read:</b> Chapter 5.2
	10-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Multiple Random Variables (Part 1)</b> Joint Distributions and Independence Sum of Random Variables Characteristic Functions	<b>Read:</b> Chapter 6.1 <b>Homework Assignment 4 due</b>
<b>7</b>	15-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Multiple Random Variables (Part 2)</b> Probability Bounds	<b>Read:</b> Chapter 6.2
	<b>17-May-2018</b>	<b>Thursday</b>	<b>MIDTERM EXAM 2</b>	<b>Bring:</b> a blue book, a calculator,

	Location: CENTR 115 2:00pm – 3:20pm			and a maximum of <u>one single-sided</u> letter size cheat sheet (11in x 8.5in). Midterm exam 2 covers all the material discussed in <b>weeks 4 through 6</b> , which includes <b>chapters 4 through 6</b> of the textbook.
<b>8</b>	22-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Limit Theorems</b> Law of Large Numbers Central Limit Theorem (CLT)	<b>Read:</b> Chapter 7.1 Homework Assignment 5 posted
	24-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Convergence of Random Variables</b> Types of Convergence Convergence in Distribution Convergence in Probability Convergence in Mean	<b>Read:</b> Chapter 7.2
<b>9</b>	29-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Classical Statistical Inference (Part 1)</b> Random Sampling Point Estimation Interval Estimation	<b>Read:</b> Chapter 8.1, 8.2, & 8.3 <b>Homework Assignment 5 due</b>
	31-May-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Classical Statistical Inference (Part 2)</b> Hypothesis Testing Linear Regression	<b>Read:</b> Chapter 8.4 & 8.5
<b>10</b>	5-Jun-2018 Location: CENTR 115 2:00pm – 3:20pm	Tuesday	<b>Review Session for the Final Exam</b>	Teaching Assistant(s) will solve multiple problems similar to the ones expected on the final exam.
	7-Jun-2018 Location: CENTR 115 2:00pm – 3:20pm	Thursday	<b>Bayesian Inference</b> Prior and Posterior Distributions MAP Estimation Conditional Expectation	<b>Read:</b> Chapter 9
<b>FINAL</b>	<b>12-Jun-2018</b> Location: TBA 3:00pm – 5:59pm	<b>Tuesday</b>	<b>FINAL EXAM</b>	The final exam covers all the material discussed throughout the quarter. <b>There is a review session by the TAs on Tuesday 5-Jun-2018 (see above).</b>  <b>Bring:</b> a blue book, a calculator, and a maximum of <u>one double-sided</u> letter size cheat sheet (11in x 8.5in). The use of a digital device (laptop, tablet, phone, <i>etc.</i> ) other than a calculator during an exam is

				not allowed. Further, the use of textbooks or written materials other than the cheat sheet is not allowed. If you are caught using a digital device, a textbook, or materials other than the ones that are allowed, you will be asked to leave the exam and you will receive an exam score of zero.
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