MAT 4363 – Mathematical Statistics

Spring 2011

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University and Departmental Mission: Seattle Pacific University seeks to be a premier Christian university fully committed to engaging the culture and changing the world by graduating people of competence and character, becoming people of wisdom, and modeling grace-filled community. The mathematics department at Seattle Pacific University seeks to provide excellent instruction to enable our students to be competent in the mathematics required for their chosen fields, and to share our expertise with the community through service and leadership. Hence, common goals for students in mathematics courses include 1) becoming competent in the topics covered in the course, 2) demonstrating skills and attitudes which contribute to professional, ethical behavior, 3) the ability to communicate mathematically, in both written and verbal form, and 4) learning to appreciate the beauty and utility of mathematics.

Course Objectives: The goal of this course is to build on your knowledge of probability and statistics, delving deeper into the theory and applications of statistical inference. By the end of the course, you should be able to

- apply a wider variety of probability distributions;
- apply the methods of moments and maximum likelihood to find estimators for population parameters;
- draw inferences on populations based on a wide variety of statistical tests, including one and two sample tests for means and proportions, goodness of fit tests, and chi-square tests for independence;
- apply linear regression and draw inferences on populations based on regression;
- design basic experiments and analyze the results;
- approach and solve practical problems and analyze genuine data through statistical and probabilistic reasoning;
- prove a variety of theorems relating to the course content listed above;
- provide written explanations of the ideas behind key concepts from the course;
- use a computer to analyze data and to solve statistical problems from a variety of fields; and
- effectively communicate the results of statistical analyses through graphical and verbal means.

Students should also gain an increased appreciation of statistics as part of the language of science and as a study in itself. Finally, I hope that you will have fun accomplishing all of these objectives, even if the material is difficult and the course takes a lot of time and effort.

Prerequisites: A solid grasp of the basics of probability and statistics from MAT 3360 is essential. In addition, mastery of the material from Calculus (MAT 1234, 1235, 1236, and 3238) is required. However, MAT 3238 may be taken concurrently with instructor approval. Some use may also be made of basic material relating to vectors and matrices from MAT 2401 (Linear Algebra).

Course Materials:

Textbooks: We will use two textbooks for the course: ***Stat Labs: Mathematical Statistics Through Applications***, by Deborah Nolan and Terry Speed and ***A Modern Introduction to Probability and Statistics: Understanding Why and How*** by Dekking, Kraaikamp, Lopuhaä, and Meester.

Supplemental Materials: In addition to the textbooks, there will be supplementary handouts given out in class which include some topics which are not in the text and present some material in different ways from the text. In particular, we'll go into deeper mathematical detail on some topics than is contained in the textbook. You are responsible for all material contained in the handouts and class lectures.

Computer Software: We will make fairly extensive use of computers to perform calculations, create graphics for analyzing data, and to conduct simulations to approximate long-run behavior of random phenomena. We will make substantial use of Minitab and Excel and may also make some use of Maple and R.

Grading and Course Expectations

Modifications to the course requirements can be made at any time.
It is <u>your</u> responsibility to know all course requirements as described here or announced in class.

Attendance: Attendance will not be taken, but if you expect to succeed in this course, it is essential that you come to class every day. Unless you have an acceptable excuse ***and*** make special arrangements with me ***before*** class begins, missing an exam or failing to turn in an assignment on time will result in a grade of zero. Late homework will not be accepted for any reason, but if you have an acceptable excuse and contact me before class, I will drop the homework score.

NOTE: Things such as oversleeping, lack of preparation, work conflicts, or sneezing twice are NOT acceptable excuses. Acceptable excuses include a death in your immediate family or a substantial illness, and *you are responsible for providing me with documentation of your excuse.*

Homework: The only way to truly learn mathematics is to work as many exercises as possible. You cannot learn to do mathematics by watching someone else do mathematics or listening to someone else talk about mathematics – you must actually do it yourself and practice, practice, practice. Furthermore, the material each class period builds on what came before, so it is essential to keep up with the work every day. As a result, there will be homework assignments given virtually every class period which will often be collected at the next class meeting.

General homework policies:

- Homework must be turned in by 2:00 (not 2:01) on the day it is due; late homework will not be accepted for any reason. If you have an excused absence and make arrangements with me *before* class starts, the homework score will be dropped.
- You are strongly encouraged to come to my office to ask me questions about the homework.
- You are also encouraged to work with other students on the homework, but unless otherwise indicated for a particular assignment, you must individually write up and turn in your own solutions.
- *You are required to list on your paper all other individuals that you worked with or that gave you assistance with the homework* – failure to do so will be considered cheating (turning in someone else's work as your own).
- Homework must be neat and easily readable or you will receive NO credit.
- You must show all of your work–a correct answer with no justification will also be worth NO credit.
- In addition to regular homework, there will be some in-class activities and group work which may be collected. These will be included in your homework grade.

Your lowest homework score will be dropped from your final grade.

Projects: Throughout the course, our study of statistical theory will center on several case studies. Each case study will present a scientific question which will be used as the starting point for developing statistical theory. We will work through some of the case studies entirely in class, while others will be left as projects to be worked on outside of class. You will be asked to write up detailed reports for approximately 3 of the case studies, in some cases working in groups of 2 or 3 with other students in the class.

Exams: There will be two exams: a midterm and a final. The midterm is tentatively scheduled for Friday, May 6. The cumulative final exam will be given in two parts. The first part will be take-home, and the second part will be in-class during the regularly scheduled final exam period (1:00-3:00 on Tuesday, June 7). Most of the exercises on the in-class exams will be very similar to problems from the homework. You will also be expected to be able to state some definitions and to provide some proofs on the exams.

Course Grades: Grades will be determined by a weighted average of homework assignments (25% of the overall grade), projects (15%), the midterm (25%), and the final exam (35%). Course grades will be based on the following scale:

	93-100% A	90-92% A-
87-89% B+	83-86% B	80-82% B-
77-79% C+	73-76% C	70-72% C-
67-69% D+	60-66% D	Below 60% E

A grade of I (incomplete) is only given for non-academic reasons such as a severe illness that prevents you from completing the course. You must have a passing grade on the material that you have completed in order to receive an incomplete.

Academic Dishonesty: The current edition of the SPU Undergraduate Catalog describes the University's commitment to academic integrity, which is breached by academic dishonesty of various kinds. Examples of academic dishonesty include copying another's work on an exam, bringing concealed answers to an exam, turning in another person's work as your own, committing plagiarism, assisting another student in cheating, or lying to the instructor. The *minimum* penalty for academic dishonesty in any form will be a zero for the assignment or exam in question; in severe cases, academic dishonesty will result in a failing grade for the course. In addition, all students have an obligation to make efforts to prevent other students from cheating and to report incidents of cheating or plagiarism.

Office Hours: My office hours will be announced in class during the first week of class. They will also be posted on the course web pages and outside my office door. You are strongly encouraged to drop by my office to ask questions, discuss problems, and just to get to know me better. If you are unable to meet with me during my scheduled office hours, I am available at other times by appointment. I also maintain an "open door" policy – any time that my office door is open, you are welcome to drop in to talk to me, even if it is not during my scheduled office hours. *Please note that I also work as the statistician for a research lab at the University of Washington, so my availability on campus on Tuesdays (and sometimes on Thursdays) will be limited. Please plan accordingly.*

Additional Notes:

Calculators: Calculators will be permitted on all exams. Any basic scientific calculator or a graphing calculator such as the TI-81, TI-82, or TI-85 will be allowed. However, calculators which are capable of symbolic manipulation (such as the TI-89 or TI-92) are *NOT* permitted. If you have any doubt as to whether or not your calculator is acceptable, please ask me as soon as possible.

E-mail: All SPU students have an SPU e-mail address. I will occasionally make use of these SPU e-mail addresses to send information to all members of the class, so you should check your e-mail regularly.
Please note that while it can be a great tool for quick communication (such as scheduling an appointment to talk with me face-to-face), *e-mail is rarely a good substitute for face-to face conversations and is very poorly suited for answering mathematical questions*. When you come to my office to ask me questions, I engage you in a discussion about the problem, ask questions about what ideas you have for approaching the problem, explore various possible approaches (and what goes wrong with some of them), etc. In the process, I can usually find out precisely where your difficulties lie and help you to learn how to get past them. Such a conversation is impossible by e-mail. Furthermore, typing and e-mailing mathematical symbols is very time consuming, and the resulting equations in the e-mail often come out garbled (or even completely missing).

Students with Disabilities: In accordance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, students with specific disabilities that qualify for academic accommodations need to contact Disabled Student Services in the Center for Learning. Disabled Student Services in turn will send a Disability Verification Letter to me indicating what accommodations have been approved.
Once you have done this, you should also make an appointment to meet with me as early as possible in the quarter to discuss the details of how we will implement the accommodations in this course.

Emergency Procedure: Please note the emergency procedures posted in the classroom and note all emergency exits. In case of an emergency (fire, earthquake, hazardous material spillage, bomb threat, etc.), the class will evacuate the building and gather in the Alumni Center parking lot outside Otto Miller Hall. Please try to stay together so that we can check that everyone has made it safely out of the building.

Tentative Course Schedule:

The table below provides a tentative listing of topics that I plan to cover. The exact details of both what we cover and when we will cover it will almost certainly vary somewhat from this list. Topics may be added to or removed from this list at any time. In particular, it is possible that I will replace some of these topics with other topics based on the interests of students in the class.

Approx. Dates	Topics
3/30, 4/1, 4/4, 4/6	**The German Tank Problem** ❑ Review of basic properties of estimators ❑ Minitab & simulation ❑ Review of properties of expected values and variances ❑ Covariance and correlation ❑ Introduction to hypothesis testing
4/8, 4/11, 4/13, 4/15, 4/18, 4/20	**Patterns in DNA (Stat Labs Chapter 4)** ❑ The Poisson process ❑ Review of exponential, gamma, and chi-square distributions ❑ Estimating parameters: method of moments and method of maximum likelihood ❑ Information, the Rao-Cramer lower bound, and minimum variance unbiased estimators ❑ Chi-square goodness of fit tests
4/25, 4/27, 4/29, 5/2, 5/4	**Can She Taste the Difference? (Stat Labs Chapter 5)** ❑ Basic principles of design of experiments ❑ Two-way tables, the hypergeometric distribution, and Fisher's exact test ❑ Test for the difference between two proportions ❑ Contingency tables and chi-square tests for independence ❑ Type I and type II errors and the power of a statistical test
5/6	**Midterm Exam**
5/9, 5/11, 5/13	**Dungeness Crab Growth (Stat Labs Chapter 7)** ❑ Covariance and correlation ❑ Least squares regression ❑ Conditional distributions and the bivariate normal distribution
5/16, 5/18, 5/20	**Calibrating a Snow Gauge (Stat Labs Chapter 8)** ❑ The simple linear model: more on regression, inference for linear model parameters, prediction intervals ❑ Model checking and transformations of data
5/23, 5/25, 5/27, 6/1	**Down's Syndrome: More Patterns in DNA (Stat Labs Chapter 11)** ❑ The analysis of variance ❑ Randomized block designs
6/3	Review and Wrap-up
6/7	**Final Exam** 1:00-3:00