

# Probability & Statistics for Mathematics & Science

MAT 3360

Winter 2012

Statistics is...“the most important science in the world, for upon it depends the practical application of every other science and of every art. The one science essential to all political and social administration, all education, all organization based on experience, for it only gives the results of our experience.”

– Florence Nightingale

**Instructor:** Dr. Brian Gill

**Office:** OMH 209

**E-mail:** [bgill@spu.edu](mailto:bgill@spu.edu)

**Phone:** 281-2954

**Web page:** <http://myhome.spu.edu/bgill>

**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 Overview:** *Statistics* is the science of collecting and analyzing data for the purpose of drawing conclusions and making decisions. There are three main topics of statistics: *data collection*, *descriptive statistics*, and *inferential statistics*. One of the primary goals of statistics is *inferential statistics*, which can be defined as drawing conclusions and/or making decisions concerning a large population based only on data about a *sample* from the population. When trying to draw conclusions about an entire population based only on a sample, it is essential that the sample be *representative* of the population. Poorly collected data can lead to misleading (if not completely meaningless) conclusions. As a result, proper *data collection* is a fundamental concern. Once data has been collected, it needs to be organized, summarized, and effectively presented in both graphical and numerical forms in order to facilitate understanding of the data. These methods are known collectively as *descriptive statistics*.

We'll begin the course with a brief treatment of descriptive statistics, and then move on to an introduction to *probability theory*, which is the mathematical study of randomness and uncertainty. Formal methods of inferential statistics are based heavily on probability theory, and our coverage of probability theory will emphasize its application to statistics and data analysis. The concept of probability represents the connection between the unpredictability of a single event in a random process and the predictability and uniformity of multiple events. Probability theory allows us to make very accurate predictions about the *pattern* of variation of a random process *in the long term*. Topics in this course will include basic rules of probability, combinatorial methods, independence and conditional probability, discrete and continuous probability distributions, expected values, sampling distributions, and the central limit theorem.

For the remainder of the course, our primary goal will be to study two main topics from inferential statistics: *estimation* and *hypothesis testing*. Even when data is carefully and properly collected, a sample will not typically mirror the population exactly, and different samples from the same population will each give somewhat different results (this is called *sampling variability*), so estimates obtained from samples will involve some sampling error. We will study some properties of good estimators and construct *confidence intervals*, which provide a probabilistic “margin of error” for our estimates. Finally, we will look at hypothesis testing, which involves making a decision regarding two competing claims (hypotheses) about the population based only on data about a sample.

**Learning Objectives:** By the end of the course, you should be able to:

- construct, analyze, and interpret verbal, numerical, and graphical summaries of data;
- understand fundamental concepts of the mathematical theory of probability, including conditional probability, independence, random variables, probability distributions, and expectations;
- perform basic probability computations;
- articulate the role that probability plays in statistical inference;
- apply the central limit theorem and explain the role that it plays in statistics;
- understand key properties of estimators, including bias, variance, and efficiency;
- understand fundamental statistical concepts, including variability, randomization, estimation, association, causation, confidence, testing, and significance;
- understand fundamental concerns involved in data collection and critique various methods of data collection;
- produce, analyze, and interpret confidence intervals for means;
- conduct and interpret tests of hypotheses for means;
- approach and solve practical problems and analyze genuine data using statistical and probabilistic reasoning;
- use a computer to analyze data, conduct simulations, and solve statistical problems; and
- communicate the results of statistical analyses through graphical and verbal means.

**Prerequisites:** Mastery of the material from MAT 1234, 1235, and 1236 (Calculus I, II, and III) is required.

### Course Materials:

**Textbook:** The primary textbook for the course is *A Modern Introduction to Probability and Statistics: Understanding Why and How* by Dekking, Kraaikamp, Lopuhaä, and Meester. Some additional supplementary materials will be distributed in class.

**Statistical Software:** We will make use of Microsoft Excel and the statistical software package Minitab (version 16) to perform calculations, to create graphics for analyzing data, and to conduct simulations to approximate long-run behavior of random phenomena. Minitab and Excel are available for your use on all computers in labs on campus, including labs in OMH and in the library. If you wish to use Minitab on your own computer, you can purchase a license for at [www.onthehub.com/minitab](http://www.onthehub.com/minitab). The cost is \$29.99 for a license which expires at the end of the academic year or \$99.99 for a permanent license. (Make sure that you purchase version 16, not 15.)

**Classroom Response System:** We will make use of the TurningPoint Response System to collect data from students in the class, conduct polls, collect results from in-class activities and exercises, and administer online quizzes in class. This system will use smart phones and/or the computers in the classroom and will provide instant results in class. You will be required to purchase a three-month license for the system for \$10.

### Grading and Course Expectations

**Attendance:** Unless you have an acceptable excuse *and* make special arrangements with me *before* class begins, you are expected to attend class every day, arrive on time, and remain until class is over. During class, you are expected to actively participate in all activities and to work *only* on probability and statistics – texting, doing work for other classes, surfing the internet, checking e-mail, or chatting about your weekend social activities will be considered equivalent to being absent for the day’s class. Attendance and class participation will count as a part of your course grade.

If you will be absent from class, you must contact me *before* class begins (in person or by phone or e-mail) to make arrangements for the day. Failure to do so will reduce your attendance/class participation grade and will result in a grade of zero for any exam or in-class activities that day.

**NOTE:** Things such as oversleeping or lack of preparation are NOT acceptable excuses. Acceptable excuses include illness, a death in your family, and official SPU athletics trips. If requested, *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 9:30 (not 9:31) on the day it is due; late homework will not be accepted for any reason. If you have an excused absence and contact 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.

**Exams:** There will be a midterm exam and a cumulative final exam. The midterm is tentatively scheduled for Monday, February 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 (8:00-10:00 on Thursday, March 15). Most of the questions on the in-class exams will be *very* similar to exercises from the homework. You also may be expected to be able to state some definitions and to provide proofs of certain key theorems from the course.

**Course Grades:** Homework assignments will be worth 30% of your course grade, class participation and in-class quizzes will be worth 10%, the midterm exam will be worth 25%, and the final exam will count for 35% of the overall grade. 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 regular office hours will be immediately before class, 8:30-9:20 MWF in OMH 209. 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 at my office – any time that my door is open you are welcome to drop in to talk to me, even if it is not during my scheduled office hours. I will typically be around for much of the afternoon on MWF, and I will often be available on Thursdays as well. I will not be on campus at all on Tuesdays, so 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-83 or TI-85 will be allowed. However, calculators such as the TI-89 or TI-92 which are capable of symbolic manipulation will NOT be 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. If you do not use your SPU e-mail account, there is a utility available through Banner to set up your SPU e-mail account to forward messages to some other e-mail address. I strongly recommend doing this so that you do not miss any important messages.

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 e-mails 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.

**Inclement Weather:** SPU maintains an Emergency Closure Hotline (206-281-2800). In the event of inclement weather or an emergency that might close the university, please call the Hotline for the most up-to-date closure information or check the SPU website. Both will be updated before 6:00 a.m.

**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.

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

“... statistical techniques are tools of thought, and not substitutes for thought.”

– Abraham Kaplan

“It is easy to lie with statistics, but it is easier to lie without them.”

– Frederick Mosteller

While nothing is more uncertain than the duration of a single life,  
nothing is more certain than the average duration of a thousand lives.

– Elizur Wright

In God we trust, all others bring data.

– William Edwards Deming

(Attribution to Deming is ironically not supported by data)

## Tentative Class Schedule

The table below provides a very tentative schedule of topics to be covered in class. The exact dates on which material will be covered WILL vary somewhat from this list. Topics may be added to or removed from this list at any time.

Date	Material to be Covered
1/4	Introduction (Ch. 1); Descriptive Statistics (Ch. 15, 16); Intro to Minitab
1/6	More Descriptive Statistics (Ch. 15, 16); Intro to Minitab
1/9	Basics of Probability (Ch. 2)
1/11	Conditional probability and independence (Ch. 3)
1/13	More on conditional probability and Bayes' Theorem
1/16	<b>No class – Martin Luther King Jr. Birthday</b>
1/18	Discrete random variables (Ch. 4)
1/20	More on discrete random variables: Bernoulli and binomial distributions (Ch. 4)
1/23	Continuous random variables (Ch. 5)
1/25	Expectation and variance (Ch. 7)
1/27	More on continuous random variables
1/30	Moment generating functions (supplemental material)
2/1	Joint distributions and independence (Ch. 9)
2/3	Review/Catch-up
2/6	<b>Midterm Exam</b>
2/8	The law of large numbers (Ch. 13)
2/10	Sampling distributions and the central limit theorem (Ch. 14)
2/13	Sampling distributions and the central limit theorem, continued
2/15	Basic Statistical Models (Ch. 17)
2/17	Unbiased estimators (Ch. 19)
2/20	<b>No class – Presidents' Day</b>
2/22	Efficiency and mean square error (Ch. 20)
2/24	More on estimation
2/27	Confidence intervals for the mean (Ch. 23)
2/29	More on confidence intervals (Ch. 24)
3/2	Testing hypotheses: essentials (Ch. 25)
3/5	Testing hypotheses: elaboration (Ch. 26)
3/7	The t-test (Ch. 27)
3/9	Comparing two samples (Ch. 28)
3/12	<b>Review/Wrap-up</b>
3/15	<b>Final Exam – 8:00 to 10:00</b>

“Probability is the very guide of life.”

– Cicero

“Everything existing in the universe is the fruit of chance.”

– Democritus

“Chance is perhaps a pseudonym of God when he does not wish to sign his work.”

– Anatole France

“You believe in a God who plays dice, and I in complete law and order.”

– Albert Einstein in a letter to Max Born

“The conception of chance enters into the very first steps of scientific activity in virtue of the fact that no observation is absolutely correct. I think chance is a more fundamental conception than causality; for whether in a concrete case, a cause-effect relation holds or not can only be judged by applying the laws of chance to the observation.”

– Max Born

“God knows I am no friend of probability theory.

I have hated it from the first moment our dear friend Max Born gave it birth”

– Erwin Schrödinger to Albert Einstein

“How dare we speak of the laws of chance? Is not chance the antithesis of law?”

– Bertrand Russell