MATH/STAT 300

Modern Probability & Statistics

Description

A Calculus-based introduction to probability and the application of mathematical principles to the collection, analysis, and presentation of data. Modern probability concepts, discrete/continuous models, and applications; estimation and statistical inference through modern parametric, nonparametric, and simulation/randomization methods; maximum likelihood; Bayesian methods. This course prepares students for the preliminary P/1 exam of the Society of Actuaries and Casualty Actuarial Society.

Prerequisites

MATH 191 (co-requisite) or equivalent math placement. Students should have facility with algebra and a comfort with mathematical concepts and notation. No previous knowledge of probability or statistics is assumed.

Materials

Required: Print activities from Blackboard or www.bradthiessen.com

Recommended:

- *Essentials of Mathematical Statistics* by Albright (ISBN: 978-1-4496-8534-8)
  (clear explanations, lots of examples of practice problems, calculator/computer guides)
- *Probability & Statistics with Applications* by Asimow & Maxwell (ISBN: 978-1-56698-721-9)
  (problem-solving book w/800 exercises; rec. for students interested in actuarial science)
- *Mathematical Statistics with Applications* by Wackerly (ISBN: 978-0-49511081-1)
  (more mathematical derivations, homework solutions available online)

Student Learning Outcomes

Develop statistical literacy

- Use correct statistical notation
- Define statistical terms
- Make valid conclusions from visual displays of data
- Accurately interpret output from statistical applications

Develop statistical computation skills

- Apply Calculus skills and understanding to derive formulas, calculate probabilities
- Describe data using appropriate, meaningful summaries
- Use formulas to calculate basic probabilities and to carry-out statistical analyses

Develop statistical communication skills

- Communicate statistical analyses and results using appropriate terminology and notation
- Develop appropriate, meaningful, effective visual displays
- Practice questions from Exam P/1 of the Society of Actuaries (SOA) and Casualty Actuarial Society (CAS)

Develop statistical reasoning

- Develop and evaluate competing hypotheses
- Explain statistical processes
- Fully interpret results of analyses
- Choose appropriate analysis methods
- Identify and explain sources of variation
- Explain and evaluate assumptions for analysis methods
- Apply knowledge in novel situations

Develop statistical thinking

- Explain the need for data and analysis
- Explain the importance of data production
- Develop models to simulate & explore random phenomena
- Recognize how, when, and why inferential tools can be used
- Make appropriate conclusions from statistical analyses
- Quantify variability
- Explore data numerically and graphically
- Evaluate visual displays
- Estimate probabilities

(214 specific learning objectives available on course website)

Fall 2013
Hayes 100
T/R 9:20-10:40

Instructor:
Dr. Brad Thiessen
Office: Ambrose Hall 430
Contact: thiessenbradleya@sau.edu
Site: www.bradthiessen.com

Hours: _____
Phone: x6160
Twitter: @Thiessen

Course procedures and expectations:

This course introduces students to modern conceptualizations, methods, and applications of probability (the mathematical study of uncertainty) and statistics (the science of gaining insight from data).

We will introduce each topic through guided classroom activities (available online). Working together, we will derive and apply important concepts and formulas. During these activities, I will ask **LOTS** of questions. If you attend class, participate in these activities, and review your notes periodically, you **will** learn the material. You will also be able to use these activities (and any notes you write on them) on the unit exams.

The schedule outlines the activities, readings, practice assignments, and homework exercises that will help you master the course outcomes. I recommend briefly reading about each topic (in your textbook or online) and attempting the exercises before class. That way, you'll get more out of the in-class activities and can ask me targeted questions. You can check the answers to the exercises immediately and you can also download extra exercises and solutions from the course website. While we may not spend class time reviewing homework questions, I'm more than willing to help you work through any difficult problems.

The last two times I taught this course, I set no deadlines for assignments. Students were able to turn in any assignment (for credit) at any time prior to finals week. When you turn-in an assignment, I will email you a copy of the solutions. If you turn-in assignments when I recommend, I may also give you more detailed feedback on your work. On all assignments (but not tests), I encourage you to work with other students.

Exams will be open-note but not open-book. If we're in a computer lab, I may allow you to use the computers, too. The only restriction is that you cannot work with any other living human on the exams. You can expect the exams to contain a variety of items designed to check your mastery of the course outcomes. Test questions will only sample content we cover in class. Students who choose to complete homework exercises will show me their work following each exam (see grading section).

I am not interested in your ability to memorize formulas and apply algorithms; I want you to learn to think and communicate like a statistician. To do this, I expect you to come prepared to learn each class period. This means participating in class discussions, completing practice problems, and seeking help when needed.

Do not fall behind in this class! If you have any questions or need assistance, feel free to work with other students, send me questions (via email, twitter, or voicemail), or visit my office during my posted office hours.

> ...the sexy job in the next 10 years will be statisticians. The ability to take data – to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it – that's going to be a hugely important skill in the next decades...
>
> – Hal Varian, Chief Economist at Google (The McKinsey Quarterly, 1/09)

Attendance policy:

Many concepts and methods will be presented in class through activities that cannot be fully reproduced outside of class. Because of this, it is important that you attend class and arrive on-time. While I will not deduct points from your grade for absences, students with poor attendance generally do poorly in this class.

If you must miss class, I'd appreciate it if you let me know in advance. You **must** get approval before missing any exam.

Accommodations policy:

Students with disabilities who believe they may need accommodations in this class are encouraged to contact the Office of Services for Students with Disabilities at 333-6275 as soon as possible to better ensure that such accommodations are implemented in a timely fashion.

Academic integrity policy:

I encourage you to collaborate when studying or completing assignments, activities, homework, or projects. **You must work alone on exams!**

Review the SAU policy at http://web.sau.edu/Registration/documents/AcademicIntegrityPolicy.pdf

Policy on the use of electronic equipment:

Calculators and computers will be used extensively in this course. Out of courtesy to other students, please turn off the volume on any device you have.

Do I need to buy a textbook?

I've reviewed dozens of books and truly believe these are the most helpful in learning the content. I strongly recommend you buy a book for review and practice. You do not need to purchase this book to be successful in the course, though. On our course website, I provide online sources and free homework exercises/solutions.

If you're interested, I can point you to a free online textbook that will cover most (but not all) of the content in this course. I will also keep a copy of the textbook in my office in case you want to review it during my office hours.

Do I need to do the homework?

I purposefully selected homework exercises to help you practice the content we will cover in class. I strongly recommend you work through the exercises to assess your understanding. You do not need to complete the homework exercises to succeed in this course, though. If you choose not to complete homework exercises, your exam scores will count for more of your grade. In recent semesters, students completing homework exercises have outperformed other students.

What grade should I expect?

Here's the distribution of grades from students who have taken this course over the past 10 years:

26% = A
32% = B
21% = C
5% = D
13% = F
3% = WF

Assessment and Grading:

Your grade in this class will reflect the degree to which you master the course outcomes by the end of the semester. To evaluate your performance, I will use evidence from exams, assignments, and homework exercises you complete.

We will separate this course into three (overlapping) units:

(1) Probability Basics
(2) Applied Probability Models/Distributions
(3) Statistical inference and Hypothesis Testing.

Throughout each unit, you will be given opportunities to complete **assignments** I designed to help you evaluate your understanding. Because of this purpose, I will not grade these assignments for correctness. Instead, upon turning-in an assignment, I will award you credit for completion and will email you fully worked-out solutions. I expect you to review these solutions to assess your understanding (and to ask me any questions if you do not understand the solutions).

Another way to check your understanding throughout each unit is by completing **homework exercises**. The schedule identifies recommended homework problems from your textbook and from the course website. Because solutions are provided (in the textbook or online), we may not spend any time in class reviewing homework exercises. Instead, you will be expected to check your work and seek assistance outside of class if needed.

A third way I will evaluate your performance is through **unit exams**. Exams will assess your statistical literacy, reasoning, thinking, computation, and communication skills in relation to content covered in class. Typically, I give unit exams with both in-class and take-home components

While I strongly recommend you complete assignments and homework exercises, you are only required to complete the unit exams. If you choose not to complete assignments or homework exercises, your grade will not be penalized. Instead, your unit exam scores will count for a greater percentage of your overall grades.

Depending on the work you decide to do, I will calculate your unit scores with the following weights:

	Complete Everything	No Homework	No homework/assignments
Unit Exam	75%	85%	100%
Assignments*	15%	15%	-----
Homework	10%	-----	-----

* Assignments may include in-class quizzes or take-home projects

To calculate your final grade, I will average your unit scores and use the following grading scale:

A (100-90%) B (90-80%) C (80-70%) D (70-60%) F (60-0%)

Extra Credit & Reassessment:

As we work through the in-class activities, I may think of novel mini-projects to extend your learning. Any extra credit opportunities you complete will reduce the weight of the exam on your unit grade.

The easiest way for you to succeed in this course is to successfully pass the unit exams. If you are not satisfied with your score on any exam, you can do the following to improve (or lower) your score:

1) Identify 1-2 student learning outcomes you have yet to master (based on your test score)

2) Solve **all** the problems on the test related to those outcomes. Show all your work. Briefly explain why you missed each problem (identify your misconceptions or explain why your approach did not work).

3) **Demonstrate that you have put significant effort into mastering those outcomes**. Significant effort must include reading about the topic (textbook or online), completing practice problems (10+ problems from homework or online sources), and writing/solving 3+ original problems.

4) Identify how you would like to demonstrate your learning. You could take a short test on the topic (without notes), complete a project, teach a short lesson to me, or identify another way to demonstrate your learning

Completing **all** the above tasks will update your grade to reflect your mastery of course outcomes. Evaluating problems, creating tests, and reviewing projects are all time consuming, so the opportunity to retry any outcomes is subject to my availability. **Make sure you have mastered the outcomes before attempting to retry!**

Other helpful materials:

Our course website – **http://www.bradthiessen.com/html5/M300.html** – contains in-class activities, assignments, supplements (online readings, calculators, and applets), related readings, and Khan Academy videos that may help you master the course outcomes.

In addition to the textbook I recommend for this course, you could learn the course content from:

Mathematical Statistics with Applications (7th edition) by Wackerly, M. et al. (ISBN: 978-0-49511081-1)
A Modern Introduction to Probability & Statistics by Dekking, F.M. (ISBN: 978-1-8523-3896-1)
OpenIntro Statistics (a free, online textbook available at http://www.openintro.org/stat/textbook.php)

While we will use computers in this class, I recommend bringing a calculator to class. TI-83 or higher models will be able to perform many of the statistical functions we will need in this class.

If you're going to get serious about statistics, I'd recommend taking the time to learn some statistical applications. I recommend:

Stata (available for $49/year or $179 lifetime at http://www.stata.com/coursegp.html)
R (available for free at http://cran.r-project.org/) with RStudio (available for free at http://www.rstudio.com)

Week	Topics/Activities	Online (Devore) homework	ACTEX book exercises
8/23	Course overview and introductions Activity 1: Intro to statistical inference via randomization	2.1: 2, 9 2.2: 11, 12, 13, 15, 17, 21, 25	Read Preface 1.1: 1-3
8/28 8/30	Activity 2: Basic probability theory Activity 3: Counting rules	**Assign: Tricky Problems** 2.3: 29, 30, 31, 33, 39, 41	**Assign: Tricky Problems** 1.2: 5-7, 9-11, 14, 17, 20, 23, 25 1.5: 1-9, 12-16 2.2: 2, 5, 7, 19-22 2.7: 1, 3-4, 6, 8-10, 12, 14-17
9/4 9/6	Activity 3a: Permutation tests Activity 4: Conditional probability	**School bus inspector** **Permutation tests** **Randomizations** 2.4: 45, 47, 49, 50, 53, 55, 59 **Practice probability problems**	**School bus inspector** **Permutation tests** **Randomizations** 2.3: 27-28, 30, 34 2.4: 39, 47, 48-49 2.5: 56 2.7: 20-25 **Practice probability problems**
9/11 9/13	Activity 5: Independence Activity 6: Discrete random variables Activity 7: Binomial Distribution (chance for 1,000,000 points)	2.5: 71, 80, 83, 108 **Georgia Shipyard Cancer Rates** 3.1: 1, 7 3.2: 11, 13, 17 **Presidential Election** 3.2: 11, 13, 17 3.3: 29, 31, 44	**Georgia Shipyard Cancer Rates** **Presidential Election** 3.1: 1, 3 3.3: 11-13, 17 3.4: 26, 27, 29 3.8: 1, 4, 5, 8
9/18 9/20	Activity 7a: Binomial test; Sign test Review for exam (7b: dog resemblance activity)	3.4: 46, 47, 49, 50, 55, 57 **Supreme Court**	4.2: 14-15, 17, 21, 22 **Supreme Court**
9/25 9/27	**Exam #1: Probability** Activity 8: Discrete Distributions Activity 9: Continuous Random Variables	3.5: 69, 71, 73 3.6: 79, 81, 83 **Base Coach, Quiz, Practice** 4.1: 1, 3, 5 4.2: 11, 15 **Industrial Robot; Battery Prob.**	4.3: 30, 39 4.4: 44, 45 4.5: 51, 52 4.6: 56, 58, 61, 65a 4.8: 2, 5, 7, 9, 11 **Base Coach, Quiz, Practice** **Industrial Robot; Battery Prob.**
10/2 10/4	Activity 10: Exponential Distribution Activity 11: Normal Distribution	4.4: 59, 61 4.3: 28, 31, 33, 35, 37, 47 **Fishing Problem; Normal Pract.**	5.2: 1, 3 5.3: 8, 11 5.7: 1, 2, 6, 10 6.2: 10, 17 6.3: 25, 26 6.8: 3 **Fishing Problem; Normal Pract.**
10/9 10/11	Activity 12: Central Tendency Activity 13: Exploratory Data Analysis (intro to Tableau?) Activity 14: Point estimates	Extra credit: Sections 4.5-4.6 1.3: 33, 37, 39 1.4: 47, 49, 51	9.1: 1-4
10/16 10/18	Activity 15: Maximum Likelihood (optional) Activity 16: Sampling Distributions Activity 17: Central Limit Theorem	6.1: 1, 3, 5 6.2: 20 (optional) 5.3: 37 5.4: 46, 47, 49, 53	6.4: 45, 47, 48 6.7: 7, 8
10/23 10/25	Activity 17b: Central Limit Theorem Bootstrap Method Demonstration (via Stata) **Exam #2: Applied Probability**	5.5: 59, 65 **Practice Exam**	**Practice Exam**
10/30 11/1	Activity 18: Confidence Intervals Activity 19: Student's t-distribution	7.1: 1, 3, 5 7.2: 13, 17, 19, 23 7.3: 29, 30, 33, 35, 37	9.3: 11, 12 9.8: 1, 2, 4, 5, 11
11/6 11/8	Activity 20: Hypothesis Testing Activity 21: t-tests	8.1: 1, 3, 5, 7 8.2: 17, 19, 21, 23, 25 **t-test exercises, practice, quiz**	**t-test exercises, practice, quiz** 10.1: 1, 2, 4 10.2: 5, 6, 7, 8, 9
11/13 11/15	Activity 22b: Test for proportions Activity 23: Independent samples t-test theory	8.4: 45, 47, 51, 53 9.1: 1 8.3: 35, 37, 39	9.5: 19, 20 10.4: 12, 13 10.5: 15, 16 10.7: 6, 8, 11
11/20-22	Thanksgiving Break - No classes		
11/27 11/29	Activity 24: Independent samples t-test Activity 25: Dependent samples t-test	**Darwin Problem** **Practice Problems** 9.2: 21, 23c, 25, 27 9.3: 39, 41 **2-group randomization test**	**Darwin Problem** **Practice Problems** 9.6: 23, 24 9.7: 25, 26 **2-group randomization test**
12/4-6	Review for final exam		
Final Exam			

Note: If you choose to complete the ACTEX problems, you can either complete the exercises or sample examinations

Week	Topics/Activities	Wackerly homework	Albright homework
8/23	Course overview and introductions Activity 1: Intro to statistical inference via randomization	Read sections 1.1, 1.4, 1.5 2.1-2.5: 1, 2, 3, 8, 13, 14, 33	Read section 1.1
8/28 8/30	Activity 2: Basic probability theory Activity 3: Counting rules	**Assign: Tricky Problems** 2.6: 37, 38, 41, 43, 49, 51, 55	**Assign: Tricky Problems** 1.2: 1, 3, 9 1.3: 1, 3, 5, 7, 9, 17 1.4: 3, 7, 9, 17
9/4 9/6	Activity 3a: Permutation tests Activity 4: Conditional probability	**School bus inspector** **Permutation tests** **Randomizations** 2.7: 71, 74, 77 2.8: 93, 95, 101 **Practice probability problems**	**School bus inspector** **Permutation tests** **Randomizations** 1.5: 1, 3, 7 1.6: 3, 7, 9, 13 **Practice probability problems**
9/11 9/13	Activity 5: Independence Activity 6: Discrete random variables Activity 7: Binomial Distribution (chance for 1,000,000 points)	2.9-2.10: 110, 115, 121, 124, 125, 129, 133 **Georgia Shipyard Cancer Rates** 3.1-3.3: 1, 5, 14, 19 **Presidential Election** 3.4: 41, 43, 45, 53	1.7: 3, 5, 7 **Georgia Shipyard Cancer Rates** 2.2: 3, 19 2.3: 1, 3, 5, 7, 9, 11, 13 **Presidential Election** 2.5: 1, 9, 11, 13
9/18 9/20	Activity 7a: Binomial test; Sign test Review for exam (7b: dog resemblance activity)	Page 748: Problem 15.3 **Supreme Court**	7.2: 1, 3 **Supreme Court**
9/25 9/27	**Exam #1: Probability** Activity 8: Discrete Distributions Activity 9: Continuous Random Variables	3.5-3.8: 67, 73, 79, 90, 97, 105, 113, 127, 135 **Base Coach, Quiz, Practice** 4.1-4.3: 11, 17, 31 **Industrial Robot; Battery Prob.**	2.4: 3, 5, 7, 9 **Base Coach, Quiz, Practice** 3.2: 1, 3, 5, 9 **Industrial Robot; Battery Prob.**
10/2 10/4	Activity 10: Exponential Distribution Activity 11: Normal Distribution	4.5: 59, 63, 66, 73, 77 **Fishing Problem; Normal Pract.**	3.3: 9, 11, 19 3.4: 1, 3, 9, 13, 17 **Fishing Problem; Normal Pract.**
10/9 10/11	Activity 12: Central Tendency Activity 13: Exploratory Data Analysis (intro to Tableau?) Activity 14: Point estimates	1.2: 3, 5, 7 1.3: 1, 3 (mean & std. deviation) 8.1-8.3: 3, 21	4.1: 1, 5, 7, 9 4.2: 3, 5, 6, 9, 13, 17
10/16 10/18	Activity 15: Maximum Likelihood (optional) Activity 16: Sampling Distributions Activity 17: Central Limit Theorem	Read 9.1 9.7: 83 (optional) 7.1-7.4: 1, 5, 11, 13, 41, 43, 45	2.7: 1, 3, 11 (optional) 4.3: 1, 5 (optional) 4.4: 4
10/23 10/25	Activity 17b: Central Limit Theorem Bootstrap Method Demonstration (via Stata) **Exam #2: Applied Probability**	 **Practice Exam**	3.8: 1, 3, 5, 7 **Practice Exam**
10/30 11/1	Activity 18: Confidence Intervals Activity 19: Student's t-distribution	8.5: 58, 60 8.8: 81, 82, 85	4.6: 1, 3, 5, 7
11/6 11/8	Activity 20: Hypothesis Testing Activity 21: t-tests	10.1-10.7: 1, 2, 17, 21, 43, 45, 51, 53 10.8: 65, 67, 72, 75 **t-test exercises, practice, quiz**	**t-test exercises, practice, quiz** 5.2: 1, 3 5.3: 3, 5, 9, 11
11/13 11/15	Activity 22b: Test for proportions Activity 23: Independent samples t-test theory	8.6: 57, 59	4.5: 3, 5, 9, 11 4.8: 1, 3 5.4: 1, 3, 5 5.6: 3, 5, 9, 11, 15
11/20-22	Thanksgiving Break - No classes		
11/27 11/29	Activity 24: Independent samples t-test Activity 25: Dependent samples t-test	**Darwin Problem** **Practice Problems** 12.3: 10, 15 **2-group randomization test**	**Darwin Problem** **Practice Problems** 4.8: 7, 9, 15 **2-group randomization test**
12/4-6	Review for final exam		
Final Exam			