MATH 3340 -- Probability Modeling  
Fall 2021

Name: Greg Miller, PhD  
Department: Mathematics and Statistics  
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Office: 312 – Math & Nursing

Course Times: Monday & Wednesday, 10:00-10:50 AM, Tuesday 5:00-5:50 PM

Office Hours: Monday and Wednesday, 12:00 – 2:00 PM  
Tuesday: 4:00 – 5:00 PM & 6:00 – 7:00 PM

Please be aware that I will have very limited availability on Thursday and Friday and I do not expect to be in the office at consistent times on those days.

Text and Materials:  
Supplemental: Your Calculus Textbook

Course Objectives: To familiarize the student with the basics of probability theory, while retaining a focus on probability as a tool for modeling real world phenomena. This includes mastery of elementary probability laws, conditional probability, the concept of random variables and their features & distribution theory (both discrete and continuous). Further, a main objective of the course is to expose students to applications of the theory with a heavy emphasis on applied stochastic processes. These include the study of the Poisson Process and ideas from Markov Chains, as well as other selected areas. Examples are provided from the sciences of Engineering, Medicine, Physics, Chemistry and others.

Daily Work: First and foremost, you will always be expected to read in the textbook. Each day in class there will be a few homework problems from the book given out that are for your practice. The total number of problems assigned works out to about one per calendar day (seven per week). You should keep all of the homework organized in one place and separate from the place where you keep notes from class. Each problem must be started on a separate piece of paper. Do not work two or more problems on the same page. Be prepared to turn in any the assigned problems at any point one week after they are assigned.

How Daily Work is Assessed: Each Monday & Wednesday of the semester (after the first day) you will turn in one or two homework problems (usually one, but sometimes two). The homework MUST be turned in when asked at the beginning of the class period. NO EXCEPTIONS. Homework is NOT accepted at the end of class or later in the day. Do not ask to turn in homework at that time. There will not be a homework pick up the Monday after an exam.
This means you will have approximately 24 daily grades. Once homework problems have been assigned for a week, they can be called for at any time – even much later in the semester. That is, a problem assigned on September 13 could be asked to be turned in on September 20 or October 20, etc.

The homework assignments are EXTREMELY IMPORTANT in this class.

Exams: All exams in MATH 3340 are closed and are taken out of class at a time you sign up for on the following dates:

- Exam 1: Thursday, September 23
- Exam 2: Friday, October 15
- Exam 3: Friday, November 12
- Final: Monday, December 6

The exams typically take between three and four hours to complete. Feel free to bring a water bottle and snacks. The earliest you may start the exam is 8:15 AM. The latest you may begin the exam is 3:30 PM. It would be wise to choose your block of time at the beginning of the semester for these exams and go ahead and schedule them in your day planner or electronic calendar. Plan ahead.

The exams are thorough. You will need to have a very strong command of class notes and homework in order to do well on the exams. The second and third exams are technically not cumulative, but it is certainly true that knowledge from prior exams is expected to be applied on future exams.

Format of Final Exam: Unlike the three “midterm” exams, the final exam is comprised exclusively of problems from assigned homework and previous exams, except with numbers, symbols and names changed. That is, the “spirit” of the problem will be retained, but a “2” may become a “3” and a "θ" may become a "θ^2", etc. The final generally works out well for students who have a complete set of worked homework problems and have reviewed them. It generally works out poor for those who don’t.

Course Calendar: See Attached

Grading:
Everything counts 20%: Exam 1, Exam 2, Exam 3, Final Exam, Homework Average.

Letter Grades:
- Class Average at or above 89.5: You are guaranteed an A
- Class Average at or above 79.5: You are guaranteed a B
- Class Average at or above 69.5: You are guaranteed a C
- Class Average at or above 59.5: You are guaranteed a D

You must earn an A, B or C to proceed to MATH 3345. This is departmental policy and is not a large consideration when assigning final grades. You get what you earn.
**Attendance Policy:** I probably won’t like you if you don’t come to class.

**COVID Policy:** None, formally.
Mask shaming (for either wearing or not) and Vaccine shaming (for either being so or not) is not tolerated and I will address you about it if you are a jerk. Be nice.
Formalities:

Academic Integrity (A-9.1)

The penalty for violating Academic Integrity policy A-9.1 at any time during this semester is failure of the course. No exceptions. No grade will be calculated for a student who violates the policy. They will be asked to sign an academic dishonesty form after evidence of their violation has been provided to them and they will receive an F in the course no matter what grades have been accumulated to that point in the semester.

Academic integrity is a responsibility of all university faculty and students. Faculty members promote academic integrity in multiple ways including instruction on the components of academic honesty, as well as abiding by university policy on penalties for cheating and plagiarism.

Definition of Academic Dishonesty

Academic dishonesty includes both cheating and plagiarism. Cheating includes but is not limited to (1) using or attempting to use unauthorized materials to aid in achieving a better grade on a component of a class; (2) the falsification or invention of any information, including citations, on an assigned exercise; and/or (3) helping or attempting to help another in an act of cheating or plagiarism. Plagiarism is presenting the words or ideas of another person as if they were your own. Examples of plagiarism are (1) submitting an assignment as if it were one's own work when, in fact, it is at least partly the work of another; (2) submitting a work that has been purchased or otherwise obtained from an Internet source or another source; and (3) incorporating the words or ideas of an author into one's paper without giving the author due credit.

Please read the complete policy at http://www.sfasu.edu/policies/academic_integrity.asp

Withheld Grades Semester Grades Policy (A-54)

Ordinarily, at the discretion of the instructor of record and with the approval of the academic chair/director, a grade of WH will be assigned only if the student cannot complete the course work because of unavoidable circumstances. Students must complete the work within one calendar year from the end of the semester in which they receive a WH, or the grade automatically becomes an F. If students register for the same course in future terms the WH will automatically become an F and will be counted as a repeated course for the purpose of computing the grade point average.

The circumstances precipitating the request must have occurred after the last day in which a student could withdraw from a course. Students requesting a WH must be passing the course with a minimum projected grade of C.

Students with Disabilities

To obtain disability related accommodations, alternate formats and/or auxiliary aids, students with disabilities must contact the Office of Disability Services (ODS), Human Services Building, and Room 325, 468-3004 / 468-1004 (TDD) as early as possible in the semester. Once verified, ODS will notify the course instructor and outline the accommodation and/or auxiliary aids to be provided. Failure to request services in a timely manner may delay your accommodations. For additional information, go to http://www.sfasu.edu/disabilityservices/.

Mental Health Statement

SFASU values students’ mental health and the role it plays in academic and overall student success. SFA provides a variety of resources to support students mental health and wellness. Many of these resources are free, and all of them are confidential.

On-campus Resources:
SFASU Counseling Services
www.sfasu.edu/counselingservices
3rd Floor Rusk Building
936-468-2401

SFASU Human Services Counseling Clinic
www.sfasu.edu/humanservices/139.asp
Human Services Room 202
936-468-1041

Crisis Resources:
Burke 24-hour crisis line 1(800) 392-8343
Suicide Prevention Lifeline 1(800) 273-TALK (8255)
Crisis Text Line: Text HELLO to 741-741
MATH 3340 – Detailed List of Topics Covered

- Introduction to Modeling [read by students during Week 1]
  - the modeling process
  - probability models vs. other models
  - a first model: the random walk
  - applications of random walks in science

- Sets and Functions [≈2 weeks]
  - Elementary set operations and theory
  - Definition of function and set function
  - Probability function and the axioms of probability
  - Equally likely sample spaces and the need for counting rules

- Probability Laws Based on the Axioms [≈1 week]
  - The Complement Rule
  - The Addition Rule
  - The Inclusion-Exclusion Principle and extensions to the Addition rule

- Conditioning [≈2 weeks]
  - Conditional Probability definition and the Multiplication Rule
  - Independent Events
  - The Theorem of Total Probabilities and Bayes' Rule
  - Extensions of the Multiplication Rule
  - Introduction to Markov Chains

- Language of Random Variables and Stochastic Processes [≈2 weeks]
  - Definition of random variable
  - Discrete v. Continuous random variables
  - Mass and density functions
  - Expected Value (Mean and Variance) of random variables
  - Moment Generating Functions
  - Introduction to multiple random variables and independence
  - Roles, types and characteristics of stochastic processes
  - More on the random walk and more on Markov chains

- Modeling with discrete distributions [≈4 weeks]
  - Bernoulli and Binomial models
    - with application to random walks
  - Hypergeometric models
  - Poisson models
    - with application to the Poisson process
  - Geometric and Negative Binomial Models
    - with application to queueing and birth & death processes
• Modeling with continuous distributions [≈ 4 weeks]
  o continuous uniform models
    • with application to simulation
    • with application to the Poisson process
  o Exponential models
    • with application to the Poisson process
    • with application to renewal processes and recurrence times
  o Gamma models
    • with applications to queueing
    • chi-square as a special case, with application to goodness-of-fit
  o Normal models
    • with discussion of limit theorems including CLT
    • with applications to Brownian motion

Note: one topic that many cover in a probability class is the idea of "transformation theory". While I usually don't lecture over transformation of random variables, I do assign problems that take students through the CDF method, the MGF method and the theorems that allow one to obtain the distribution of \( Y = g(X) \) if \( X \sim f \) when \( g \) monotone.

For all of the distributions listed above, we discuss
  • when the model should be used
  • how it relates to other probability models
  • how to use the mass or density function to compute probabilities
  • properties such as expected value, variance, and moment generating functions (if helpful)

• More than a dozen other distributions are explored in exercises

• I (very briefly) introduce the class to need for estimating parameters in statistical settings. They read about the method of moments and maximum likelihood estimation and obtain a few estimators in some simple cases.

• the class is very heavy on modeling, distribution theory and a very large set of examples in stochastic processes

• the class makes particularly intense use of integral calculus in the back half the semester (MATH 2314)

See [http://www3.sfasu.edu/math/docs/syllabi/MATH3340Syllabus.pdf](http://www3.sfasu.edu/math/docs/syllabi/MATH3340Syllabus.pdf) for elements common to all sections.
MATH 3340 – Probability Modeling
Course Syllabus

Course description: Elementary probability laws, conditional probability, the language of random variables and stochastic processes, modeling with discrete and continuous probability distributions, applications among various stochastic processes, methods of estimating parameters.

Credit hours: 3

The following is an excerpt from SFA Policy 5.4:

The federal definition of a credit hour is an amount of work represented in intended learning outcomes and verified by evidence of student achievement that is an institutionally established equivalency that reasonably approximates:

1. Not less than one hour of classroom or direct faculty instruction and a minimum of two hours out-of-class student work each week for approximately fifteen weeks for one semester or trimester hour of credit, or 10 to 12 weeks for one quarter hour of credit, or the equivalent amount of work over a different amount of time, or;

2. At least an equivalent amount of work as outlined in item 1 above for other academic activities as established by the institution including laboratory work, internships, practica, studio work, and other academic work leading to the award of credit hours.

To this end, all students in courses offered by the Department of Mathematics and Statistics that wish to be successful should plan to spend a minimum of two hours outside of class for every credit hour associated with this course. Expected activities to be completed in the time outside of class include reviewing notes from previous class meetings, reading assigned course resources, completing all assigned exercises and projects, and performing periodic assessment preparation.

Course Prerequisites and Corequisites: MATH 2314.

Course outline:

<table>
<thead>
<tr>
<th>Course outline</th>
<th>Approximate time spent</th>
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<tbody>
<tr>
<td><strong>Introduction to Modeling</strong></td>
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Mass and density functions
Expected Value (Mean and Variance) of random variables
Moment Generating Functions
Roles, types and characteristics of stochastic processes
More on the random walk and more on Markov chains

- **Modeling with discrete distributions**
  - Survey of popular models: Bernoulli, binomial, hypergeometric, Poisson, geometric, negative binomial
  - Relationships between discrete probability models
  - Investigation of settings in which each model is appropriate for use
  - Applications involving various stochastic processes
  - Estimating Parameters in Discrete Distributions: Method of Moments, MLE, bias, mean squared error

- **Modeling with continuous distributions**
  - Survey of popular continuous distributions: uniform, exponential, gamma, normal
  - Using graphical methods to identify proper continuous models
  - Investigation of settings in which each model is appropriate for use
  - Applications involving various stochastic processes
  - Estimating Parameters in Continuous Distributions: Method of Moments, MLE, bias, mean squared error

**Student Learning Outcomes (SLO):** At the end of MATH 3340, a student who has studied and learned the material should be able to:

1. Discriminate between mathematical, statistical and probabilistic models. [PLO: 1, 2, 3]
2. Explain and apply the axioms and major laws associated with the probability function. [PLO: 1, 2, 3]
3. Explain the difference between unconditional and conditional probabilities and how to compute each in physical settings. [PLO: 1, 2, 3]
4. Model physical systems using popular discrete random variables. [PLO: 1, 2, 3]
5. Discriminate between popular discrete probability models based on physical scenarios that generate discrete data. [PLO: 1, 2, 3]
6. Apply various stochastic models that are associated with discrete random variables to physical settings. [PLO: 1, 2, 3]
7. Model physical systems using popular continuous random variables. [PLO: 1, 2, 3]
8. Apply various stochastic models that are associated with continuous random variables to physical settings. [PLO: 1, 2, 3]
9. Discriminate between key features seen in data that lead to the choice of a particular continuous probability model. [PLO: 1, 2, 3]
10. Estimate unknown parameters in order to complete the process of probability modeling. [PLO: 1, 2, 3]
11. Compare and contrast methods of estimating parameters. [PLO: 1, 2, 3]
12. Compare and contrast basic stochastic processes and provide illustrations of when they occur in nature. [PLO: 1, 2, 3]

**Program Learning Outcomes (PLO):** Students graduating from SFA with a B.S. Degree and a major in mathematics will:

1. Written Communication - SFA Mathematics majors communicate mathematical ideas effectively in written form, integrating mathematical notation correctly and consistently.
2. Verbal Communication - SFA Mathematics majors communicate mathematics effectively to diverse audiences.
3. Mathematical Maturation - SFA Mathematics majors grow from a computational understanding of mathematics to an integrated approach which includes critical thinking proficiency, computational facility, conceptual understanding, and problem-solving persistence.
This course meets educator preparation standards for one or more certification programs; a complete listing of all the educator preparation standards this course meets can be found at: https://sfasu.edu/docs/jacksteach/jacksteach-standards-alignment-chart.xlsx.

Academic Integrity
Academic integrity is a responsibility of all university faculty and students. Faculty members promote academic integrity in multiple ways including instruction on the components of academic honesty, as well as abiding by university policy on penalties for cheating and plagiarism.

The penalty for a student found cheating on any part of an assignment, quiz, or exam in this class will range from a grade of zero on the work to a grade of F in the course, and may result in additional, more severe disciplinary measures. A student who allows another to copy his work and the student copying the work are both guilty of cheating. Do your own work. Do not show your completed work to others. Do not allow others to copy your work.

Definition of Academic Dishonesty (SFA policy 4.1):
Academic dishonesty includes both cheating and plagiarism. Cheating includes, but is not limited to:
- using or attempting to use unauthorized materials on any class assignment or exam;
- falsifying or inventing of any information, including citations, on an assignment;
- helping or attempting to help other student(s) in an act of cheating or plagiarism.

Plagiarism is presenting the words or ideas of another person as if they were one’s own. Examples of plagiarism include, but are not limited to:
- submitting an assignment as one’s own work when it is at least partly the work of another person;
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SFASU Human Services Counseling Clinic
Crisis Resources:
Burke 24-hour crisis line 1(800) 392-8343
Suicide Prevention Lifeline 1(800) 273-TALK (8255)
Crisis Text Line: Text HELLO to 741-741

Acceptable Student Behavior
Classroom behavior should not interfere with the instructor’s ability to conduct the class or the ability of other students to learn from the instructional program (see the Student Conduct Code, policy 10.4). Unacceptable or disruptive behavior will not be tolerated. Students who disrupt the learning environment may be asked to leave class and may be subject to judicial, academic or other penalties. This prohibition applies to all instructional forums, including electronic, classroom, labs, discussion groups, field trips, etc. The instructor shall have full discretion over what behavior is appropriate/inappropriate in the classroom. Students who do not attend class regularly or who perform poorly on class projects/exams may be referred to the Early Alert Program. This program provides students with recommendations for resources or other assistance that is available to help SFA students succeed.

Date of document: 08/17/2021