MA 416: Mathematical Statistics – Spring 2019 – Living Syllabus
Section A: TR 2:45-4:00p in McGregory Hall 212

Professor
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Office Hours: M 12:30-1:30p, R 1:30-2:30p, and by scheduled appointment.

TLDR: This is where students finally find out "when they'll ever use calculus;" this is an applied calculus course where we employ probability and other areas of mathematics to describe the distributions of statistics and their varied use in estimating population values.

Mathematical Statistics: *"A mathematical statistician is someone that the mathematicians consider a statistician and that the statisticians consider a mathematician."*

Handbook Description: The further development of results in Probability (MATH 316) focusing on the derivation of results in mathematical statistics. Topics include estimation theory, confidence intervals, and tests of hypotheses (including an introduction to Bayesian and nonparametric estimation). More specifically, we explore sufficiency, minimum variance principles, and asymptotic evaluation, with the choice of topics determined by the instructor. Applications of these concepts are studied using software.

Purpose: To introduce students to the first principles of mathematical statistics. Students will use skills obtained in Calculus to learn and prove fundamental inference and hypothesis testing results, perhaps giving some students their first look into the mathematical rigor of topics from data analysis. The course will also have a programming element that will allow students the opportunity to see these theoretical results in action through graphical display and simulation results using `Cran R`.

Course Objectives:
At the completion of this course, students will be able to:

1. Solve for and interpret characteristics of statistics
2. Pinpoint the asymptotic distribution of statistics
3. Complete random sampling and discuss properties of a random sample
4. Work with and recognize data reduction in terms of sufficiency and likelihood
5. Determine point estimates for unknown quantities
6. Employs various techniques of interval estimation and hypothesis testing for unknown quantities
7. Articulate results of inference in a accurate and understandable manner
8. Additional topics: ANOVA, regression, logistic regression

In 20 years, I want students to remember the juice is worth the squeeze. If they struggle with a puzzle, they *can* solve it. We're working toward holistic understanding of thought and not mindless mimicking.

Productive Failure: I would like to recast failure as a learning tool. Realizing mistakes in practice provides a rich time for learning if we complete the hard work of helping each other to the point of epiphany. This requires us to signal our need for help to each other which necessitates an environment where it is save to take risks and connect. In class discussion, curious risk taking will be celebrated as much as the correct answer. An incorrect response provides the best place to grow. This is how we will *learn* to actively engage and discuss mathematics.

Rules of Engagement:

1. All humans are accepted members of our classroom.
2. Assume positive intent.
3. Share talking time.
4. Listen to understand.
5. Be present.
6. Critique ideas, not people.
7. Everyone has expertise. We can learn something from everyone.
8. Share a feeling of mutual responsibility for each other.
9. Encourage others to succeed.

Academic Honesty: Students are expected to follow Colgate's academic honor code. If a student feels stressed about exams or deadlines they should come see me as soon as possible so we can review their options to avoid any academic honesty issues.

Prerequisite: MATH 316 or permission of instructor.

Calculator: Each student may use a graphing or scientific calculator on in-class assessments, but nothing with a computer algebra system.

Outside Class Discussion: Students should use the discussion board in Moodle as a safe place to ask questions and be curious about the course material. I expect students to answer such questions and to feed the curiosity of their peers through furthering the discussion; I will monitor the discussion board and chime in from time to time. This is intended to foster students' creativity and curiosity, and prepare them to think critically, ask questions and gain a lifelong value out of their education.

Make-up Policy: Make ups and extensions will be considered on a case by case basis. Students who feel they are in an extreme circumstance must notify me **at least** two days before the regularly scheduled deadline or as soon as possible. Students should feel welcome to reach out to discuss any due dates or exam dates that conflict with their religious observations, or other issues which are not acknowledged by the university. All make up exams **must** be scheduled to be taken before or on the same day as the exam when possible.

Inclusion: It is my goal and responsibility to make this course and our classroom as accessible and inclusive as possible. I understand that students have different ways and paces of learning and accessing information, and that each student comes with their own, and sometimes difficult, experiences with learning. It is really important to me that I work to make the classroom environment as comfortable and respectful as possible. I acknowledge the persistence of discrimination and exclusion in mathematics based on race, gender, socio-economic status, and other factors. I take responsibility for the work of lowering barriers so that access is practical and equitable. I resolve to listen, learn and act in order to make this classroom proactively welcoming to all students. I encourage all students to see me if they want to discuss their learning process, experience or needs and to point out any blind spots.

Specific Learning Accommodations and Support: I hope that students will feel comfortable in notifying me at the start of the course if they require specific learning accommodations or support. I am here to help! This information will remain confidential. In many cases, students requesting accommodations will also need to contact the Director of Academic Support and Disability Services to receive help determining and coordinating a specific accommodation on the basis of disability/medical documentation. Contact info as follows: Lynn Waldman: lwaldman@colgate.edu, (315) 228-7375.

Technology: It is not assumed that students have much, or any, previous experience with statistical software and this course will introduce students to some of the most common `Cran R` procedures. `Cran R` is an extremely useful statistical programming language that has become widely used in recent years. Students shouldn't expect to learn how to code as in an introductory computer science course, but learn to be a consumer of statistical software. Students are expected to alter and create code similar to illustrations in class. Coding isn't easy, learning it or teaching it, but I believe that this skill will become more important over time. While teaching myself `Cran R`, whenever I was stuck with a particular problem I searched for a solution in the documentation and tried to understand the code and tweak it according to my requirements; this is the level of work students should expect – using the resources of the course, understanding the solutions and applying them to new problems.

Support for Technology: Devices, like laptops, are becoming increasingly important to success in college. I recognize that these digital devices can be expensive, and that students might not have the same access the latest technology. I also recognize that digital technology changes rapidly, and that students might rely on older, more problem-prone devices that breakdown or become unreliable to use. These technology issues can become a significant source of stress for students. Given these challenges, I encourage students to contact me if they experience a technology-related problem that interferes with their learning in this course. This will enable me to assist students in accessing one of many resources that Colgate University provides to students.

Attendance: Students are expected to attend all classes and to arrive on time. If a student should miss a class, they are responsible for all material and announcements covered in class on that day. That being said, there is no penalty for attendance as inflating grades with any percentage of a student's score coming from attendance would make a poor measure of an individual's competency in the course; students seeking high grades will quickly learn that they need to attend the course as often as possible.

Grading:

Homework (25%): The purpose of homework is to practice concepts introduced in lecture. Students can expect six assignments. These assignments will be posted throughout the semester and students will submit their answers in class on specified due dates, including weekly diagnostic check-points.

- **Completing Homework:** I encourage students to discuss the homework opportunities with each other and me. This can be done in a variety of ways – on the Moodle discussion board, in office hours, in active homework sessions.
- **Weekly Diagnostic Check-points:** Weekly, I will ask students to reflect on what we've discussed by seeing what they thought was important and if there are any unanswered questions. Each diagnostic will also have some questions aimed to help guide homework completion. Diagnostics will open Wednesday after class and must be submitted before midnight on Friday.
- **Late Homework:** I will not accept late homework. I will, however, happily discuss problematic deadlines to allow for thoughtful application of the course content and exploration of interesting theoretical ideas.

Standards (50%): We will cover roughly 18 standards which include probability concepts such enumerating a sample space. Students can expect three two-hour, cumulative exam periods where they will be evaluated on any of the 18 standards recently covered and, perhaps, be re-assessed on previous standards. These exams do not have a percentage score. Instead, questions are graded and tracked individually.

- **Why?:** This is to provide an iterative process of learning. Initial grades are meant to serve students by providing clear, specific, and actionable feedback on what they are doing well and what may need to be revisited.
- **How?:** Exams will be returned quickly and accompanied by detailed feedback on the progress made on each assessed standard.
- **What's the Benefit?:** This allows for the opportunity to *improve* work after receiving feedback. The aim is to more accurately measure learning, modeling the process more closely by allowing students to be evaluated after receiving feedback and revisiting material. Additionally, the topics of the course are implicitly cumulative and repeated retrieval leads to deeper learning.
- **Using Feedback:** Make attempts productive. Take a struggle with a particular topic as an invitation to try again – revisit the notes, past solutions, ask for help so that the second time is a success. Take successes as a chance to hone that knowledge on the subject by providing a highly formal solution the second time around.
- **Weighting:** The first and second attempts account for 25% and 75%, respectively.
- **When?:** The expected dates for the exam periods can be found in the schedule below, though they may change as our course progresses. **02/21, 03/21, 04/18**.

Final Exam (25%) A comprehensive final exam will be given according to the University's exam schedule. The exam will cover all information covered in the course.

- **When?:** The final exam is scheduled by the registrar as **Monday, May 21 9-11a**.

Scoring

Rubric: Each question asked on homework or during an exam period is scored on the following rubric:

- **A**: Mastery, the solution contains no non-trivial errors and clearly communicates understanding.
- **B**: Sufficient, the solution meets expectations and contains an easily correctable mistake like notational errors or a simple error in understanding or communication of the concept.
- **C**: Progressing, the solution contains correct work and a serious error in understanding or communication of the concept. Revision is needed.
- **D**: Developing, the solution does not contain the correct answer or doesn't fully answer the question and does show some reasoning in the correct direction. Revision is needed.
- **F**: Needs attention, the solution does not contain work in the correct direction and a reasonable attempt was made
- **Z**: No Response, there is no reasonable attempt to provide the correct solution. Not assessable.

By the nature of this retesting scheme the weight on the first attempt is chosen to be low thus putting more emphasis on the second attempt. This allows students to use previous attempts as *learning experiences* and to incentivize them to *revisit* materials they need to after receiving nuanced feedback. Students that do well on the first attempts are further incentivized to retain and revisit material which is important as this course is very cumulative.

After each assessment, students will receive individualized feedback outlining their progress on each topic. This list aims to create goals representing specific learning outcomes of the course. Students can track their progress on each topic over the semester to help self-diagnosis their understanding of the material. The grading scheme is directly aligned with these goals by providing intentional question-level feedback in place of one number measuring the whole. I understand that this might be different than most students' previous experiences. While I recognize that changing established practices can be difficult, I hope this constructive approach supports students' opportunities to learn.

Over the semester, students will see questions relating to the following topics.

ID	Standard/Objective	First Attempt	Most Recent Attempt
1	Covariance and Correlation		
2	Sums of Random Variables		
3	Order Statistics		
4	Convergence in Probability		
5	Convergence in Distribution		
6	Sufficient Statistics		
7	Ancillary Statistics		
8	Complete Statistics		
9	Point Estimation: Method of Moments		
10	Point Estimation: Maximum Likelihood		
11	Point Estimation: Best Unbiased Estimators		
12	Hypothesis Tests: Likelihood Ratio Tests		
13	Hypothesis Tests: Most Powerful Test		
14	Confidence Intervals: Inverting a Test Statistic		
15	Confidence Intervals: Pivotal Quantities and Pivoting		
16	Bayes Estimators*		
17	Bayesian Tests*		
18	Bayesian Intervals*		

Overall Grade: A student's overall grade will be a weighted average of their **percentage** scores on homework, standards, and the final exam. The overall grade that will be assigned to each student will align with the standard scale.

$$\text{Overall Grade} = 0.25(\text{HW}) + 0.50(\text{Standards}) + 0.25(\text{Final})$$

- **A** range represents above and beyond expectations, excellence with distinction. These are not impossible to achieve but are difficult to come by. While there is merit to hard work and long hours, it does not always guarantee success. Excellence refers to the combined results not just the effort.
- **B** range signifies that a student is meeting the expectations of the course. Good is more common than excellent and should be celebrated as a success.
- **C** range signifies adequate but at the level of expectation. Average is not usually an appealing categorization for those who strive for extraordinary. A grade of C, however, is a respectable point. If students don't want to be categorized as adequate, they must recognize what more is needed, make a plan to achieve that and execute it; I can help with a plan!
- **D** range represents less than adequately equipped to perform the basic functions of the course; just passable. Perhaps more adjustments to theoretical mathematics need to be established. I do recognize that a D may also mean that a student truly does not understand what is expected. Students, in this case, should make an appointment with me to discuss how they might make a plan and take action to achieve at the level they desire to. Course warnings are submitted to the appropriate Administrative Dean for students earning an D in this course at any point during the semester.
- **F** range represents a clear failure to meet the expectations of the class. F represents a lack of effort and interest in the course. This is a cause for deep concern; course warnings are submitted to the appropriate Administrative Dean for students earning an F in this course at any point during the semester.

A Pedagogical Note:

As a first generation student, I've come to realize that I have a point of view about education that differs with many students where I am perceived as a bit of an individualist. While many things affect performance and learning, our resolve to do well is most paramount to our success; my goal is to work with all students to where they are *earning* the grade that they want – *you all are capable of conquering difficult things.* Success is hard work, not innate talent.

A university level course should not be easy, no matter the level of the course. I think the best courses seem challenging but provide students with all the resources to succeed. Bjork(1994) coined this type of course as having "desirable difficulty," where the learning tasks require a "desirable" amount of effort which improves long-term performance. This class will be "desirably" challenging. Students should ask questions, read more sources, really dive into what they're learning. Students will become more effective thinkers and communicators through this process as they will retain the skills learned this semester.

Previous research (Hattie & Timperley 2007; Hattie 2009), suggest that a better understanding of essential principles is needed for grades to accurately reflect students' achievement. Providing feedback about how well a student has mastered each question on an assignment allows for more nuanced conversation with students about where they are strong and where they can make plans to improve their knowledge by using retesting as a diagnostic tool.

In this light, students will find that I will incessantly ask for feedback throughout the semester. The reason I survey students and rigorously review their comments about what could be changed models the behavior I expect from them. Having an accurate snapshot of what I am doing well and what I can work on, in terms of serving students, helps me become a better professor for current and future students. I take all feedback seriously and very often take constructive criticism as an invitation to make changes for the better.

Retesting is a tool for learning how to learn and conquering a challenging course that rewards long-term performance and discourages temporary memorization. Please ask for what you need. I want all of you to succeed this semester. Let's make the juice worth the squeeze.

Schedule:

Date	Event
01/21/19	First Day of Classes (Half-Day Schedule)
01/23/19	
01/28/19	
01/30/19	
02/04/19	
02/06/19	
02/11/19	
02/13/19	
02/18/19	
02/20/19	
02/21/19	**Exam 1***
02/25/19	
02/27/19	
03/04/19	
03/06/19	
03/09/19-03/17/19	**Mid-Term Recess**
03/18/19	
03/20/19	
02/21/19	**Exam 2***
03/25/19	
03/27/19	
03/27/19	Withdrawal Deadline (with a grade of W)
04/01/19	
04/03/19	
04/08/19	
04/10/19	
04/15/19	
04/17/19	
04/18/19	**Exam 3***
04/22/19	
04/24/19	
04/29/19	
05/01/19	
05/06/19	**Final Exam 9-11a**

* These exam periods will be held in McGregory Hall 212 from 5p-7p.
Note: Dates will likely change as I largely let the class dictate the speed of the course through asking questions and having extensive discussions in class. I will fill in the topics as we complete them and post updates to Moodle.

How to Succeed in this Class

1. Come to class prepared to discuss the material for that days lecture. Being prepared means: actively reading and thinking about past material by investigating the concepts on your own. Try practice problems, run the sample code on your own, try a problem from class without consulting the answer. When you come to class with questions based on the concepts from these activities we can strengthen and expand our knowledge in lecture.

2. For every hour in class, you are expected to spend 2-4 hours outside of class on reading, working on assignments, and studying for exams. Be sure this time is productive – seek advice if you find yourself 'spinning your wheels.'

3. Invest a small amount of time immediately after an assignment is given to make sure you understand it and dont have major questions. Then break down the assignment into manageable pieces and work on them over the course of the week. If you wait until the last minute, seemingly insurmountable problems will undoubtedly arise, and by then its too late to get assistance. Remember, it takes no more time to complete an assignment if you spread it out.

4. Come frequently to office hours.

5. Ask well-informed questions. Questions such as "I dont understand X; can you explain X to me?" are welcomed, but not well-informed and will almost certainly not get you the answer you are looking for. Instead, ask questions that reveal your current knowledge of the topic, similar to the following: "I understand how Y works, and I see that X is different from Y in way Z. What is it about X that causes this difference?" Answers to these questions will be much more informative and more likely to help us get closer to meeting our goals.