MTH/SDS 320: Mathematical Statistics

Class Location: Sabin-Reed 301
Class Time: Wednesday/Friday, 2:45 PM - 4:00 PM
Instructor: Rebecca Kurtz-Garcia
Email: rkurtzgarcia@smith.edu
Office location: Burton 314
Office Hours: Monday 3:00 pm - 4:30 pm; Wednesday, 10:30 am - Noon; By Appointment

Course Description: An introduction to the mathematical theory of statistics and to the application of that theory to the real world. Topics include functions of random variables, estimation, likelihood and Bayesian methods, hypothesis testing and linear models.

Course Prerequisites: an introductory statistics course, MTH 212, and MTH 246.

Textbooks: The first textbook will be our main text. The last two textbooks are supplementary.

- [DS] *Probability and Statistics*, Fourth Edition Morris H. DeGroot and Mark J. Schervish. Pearson, 2011
- [JOD] *Bayes Rules*! An Introduction to Applied Bayesian Modeling. Alicia A. Johnson, Miles Q. Ott, and Mine Dogucu. Chapman & Hall/CRC, 2022. https://www.bayesrulesbook.com
- [CH] *Mathematical Statistics with Resampling and R*, Third Edition. Laura M. Chihara and Tim C. Hesterberg. Wiley & Sons, 2022

Course Communication: All course materials—including lecture slides and handouts, assignments, and other course resources—will be posted on the class Moodle, and all grades will be recorded there.

During the week, I will try my best to answer all messages and emails within 24 hours of receiving them. If you contact me over the weekend, however, I may not respond to your message until Monday in an effort to maintain my own work-life balance. Please plan accordingly.

Computing: We will be using R and RStudio throughout this course.

- You may access both of these resources on the Smith College server: https://rstudio.smith.edu. Please contact me if you have any issues logging in.
- Alternatively, R is available for free desktop download at https://www.r-project.org and RStudio is available for free download at https://www.rstudio.com.

Homework: Homeworks will be assigned approximately weekly and typically be due at 11:55 pm on Tuesdays. You will have an opportunity to work on homework in class in small groups, and ask questions to the instructor. You will turn all of your assignments electronically on Moodle. You may either typeset your problem sets using LATEX or complete them by hand and then scan them. Your lowest homework grade will be dropped.

Homeworks will be graded out of 10 points:

- 3 points for completing all the problems
- 1 point for being well formatted and clear. All pages are oriented in the correct way, problems are in order, and writing is overall legible.
- 6 points will be allotted for a subset of problems selected for grading.

Homework Extensions: There are a lot of homework assignments, and it is important to turn them in on time because they are a pivotal part of the course. However, if for some reason you need more time you can submit due date extension requests on homework by using this form: https://forms.gle/LRKeU43n4XeN9vFaA. A late work request must be submitted before the assignment due date. Below are the requirements based on the different extension requests:

- *24 hrs or less*: Almost always be approved. You can assume it has been approved even if you do not get an email from me.
- *Between 24-48 hrs*: Requests should be due to a more serious reason. If there have been a lot of extension requests in this bracket we may ask for documentation. These requests are not automatically approved, you will get a follow up email regarding your request.
- *Above 48 hrs*: Should be a college approved excuse. Documentation is often asked for. You will get a follow up email regarding your request.

You do not need to provide extensive details for the reason for your request, just a general idea. Late assignments will be penalized at the rate of 2 points per day.

Reading Checks: There are assigned readings with corresponding reading checks on Moodle that are due immediately before the class period meets. You will have unlimited attempts on the reading checks, access to them at least one week in advance, and the lowest three reading checks will be dropped. There may be multiple reading checks due on the same day. Reading checks will be graded out of 5 points. There are no late submissions or extensions.

Exams: There will be two self-scheduled midterm exams over the course of the semester.

Final Project: The American Statistician (TAS) is a quarterly publication from the American Statistical Association that features general interest articles on statistical methods development, lessons and issues in the practice of statistics, the history of probability and statistics, and many other topics. You will select an article from TAS to read, review, and contextualize/discuss in light of the content in MTH/SDS 320. You will give a short presentation on your article review during the last week of class and will submit a written report by the end of the finals period. More details will be provided as the semester progresses.

Evaluation: Final grades will be weighted as follows:

- 10% - Reading Checks
- 10% - Engagement
- 20% - Midterm 1
- 20% - Midterm 2
- 20% - Homework
- 20% - Project

I may curve final grades up at the end of the semester, but I will never curve grades down.

Class Policies and Expectations: This is a 4 credit course, meaning that by federal guidelines, it should consume about 12 hours per week of your time. We meet for 2.5 hours per week. That means you should be spending about 9.5 hours per week on this course outside of class, or roughly 4.75 hours per each class period outside of the regular class meeting time.

We are implementing a modified flipped-classroom approach, requiring you to review the material and grasp its content before attending class. Our class meetings will have minimal lecturing, with a significant portion of the time dedicated to collaborative completion of homework in small groups and addressing your queries. It is advised to invest several hours before class in reading upcoming material, completing the reading check, and starting the homework. Ideally, homework corresponding to the class period should be initiated before class and finished during the class session.

Collaboration/External Resources: I strongly encourage you to form study groups and to work together to complete your homework assignments and prepare for exams. You can also use external resources! When collaborating or using external resources, here are a few general principles to keep in mind.

- *Reliable Information Sourcing*: Rely on credible sources for information. If consulting unverified sources like ChatGPT, Wikipedia, or StackOverflow, a good rule of thumb is to cross-check the information with at least two credible sources to mitigate confirmation bias.
- *Aim for genuine comprehension*: Avoid directly copying and pasting prompts into search engines or seeking specific answers from peers like, "How did you solve question 7.2.2?". Instead, concentrate on grasping the underlying concepts, such as “What is a likelihood function?”.
- *Maintain Academic Integrity*: While collaboration and external resources are permitted, your submissions must reflect your understanding and be expressed in your own words. Do not directly copy others' work. If uncertain, acknowledge your sources through citations.

Academic Honesty: Every student in this class is expected to abide by the Academic Honor Code:

> *Students and faculty at Smith are part of an academic community defined by its commitment to scholarship, which depends on scrupulous and attentive acknowledgement of all sources of information and honest and respectful use of college resources.*
> *Smith College expects all students to be honest and committed to the principles of academic and intellectual integrity in their preparation and submission of course work and examinations. All submitted work of any kind must be the original work of the student who must cite all the sources used in its preparation.*

All violations of the Academic Honor Code will be reported to the Academic Honor Board.

Accessibility: This course is for all Smith and Five Colleges students, no matter your background, identity, disability, or life/financial circumstances. If you have personal circumstances that may impact your experience in this class, I encourage you to contact the Office of Disability Services in College Hall 104 or at ods@smith.edu to obtain an accommodation letter. Once you have this letter, you are welcome to set up an appointment with me to discuss how we can tailor this course accordingly. Whether or not you have a letter from ODS, please feel free to contact me if you would like to discuss how we can maximize your learning potential in the course.

Student Well-being: College life is stressful and life outside of college can be overwhelming. I firmly believe that your physical and mental health should be a top priority and that they are far more important than any particular class. Please let me know if you are struggling with this course or having trouble meeting course expectations (for any reason), or if there is anything else that I can do to make this course work better with your needs this semester. If you or someone you know is experiencing distress, there are numerous campus resources that can provide support via the Schacht Center. In particular, the Smith College Counseling Services provide free, confidential mental health services on campus. They are reachable at 413-585-2840 or on their website. Help is always available.

Discrimination and Harassment: Discrimination and harassment will not be tolerated. If you feel uncomfortable or unwelcome in this course because of the actions of anyone else (in this class or otherwise), please consult with me, your class dean, the associate provost, or the vice president for inclusion, diversity, and equity. You may also report violations of Smith's Code of Conduct as well as Title IX violations (such as sexual assault, sexual harassment, relationship abuse, gender-based violence, and stalking) using the confidential reporting system EthicsPoint.

Please note that I am a responsible reporter, meaning that I must notify the Title IX Coordinator of all disclosures of sexual or gender-based misconduct and domestic violence. If you would like to speak to someone confidentially, you may contact:

- Smith College Counseling Services, for free-of-charge counseling services: 413-585-2840
- Campus health service providers, for medical assistance and referrals: 413-585-2811

- The Director of Religious Life: 413-585-2750
- The Assistant Director of Student Affairs: 413-585-4908

Approximate Schedule: More details will be posted on Moodle.

Week	Date	Learning Objectives	Book Section(s)
1	F - 1/26	Statistical inference, and probability review	DS 7.1
2	W - 1/31	Prior and Posterior Distributions	DS 7.2
	F - 2/2	Conjugate Prior Distributions	DS 7.3
3	W - 2/7	Bayes Estimators	DS 7.4
	F - 2/9	Maximum Likelihood Estimators	DS 7.5
4	W - 2/14	Properties of Maximum Likelihood Estimators	DS 7.6
	F - 2/16	Sufficient Statistics	DS 7.7 - 7.9
5	W - 2/21	Law of Large Numbers and Central Limit Theorem	DS 6.1-6.3
	F - 2/23	Sampling Distributions of Statistics	DS 8.1 - 8.4
6	W - 2/28	The Bootstrap Distribution	DS 12.6
	F - 3/1	Review for Exam 1; Exam 2 period starts this weekend.	
7	W - 3/6	Confidence Intervals	DS 8.5
	F - 3/8	Bayesian Analysis from a Normal Distribution	DS 8.6
8	W - 3/14	Unbiased Estimators	DS 8.7
	F - 3/15	Fisher Information	DS 8.8
9	W - 3/20	Spring Recess - Class will not be meeting	
	F - 3/22	Spring Recess - Class will not be meeting	
10	W - 3/27	Problems of Testing Hypotheses (Part 1)	DS 9.1
	F - 3/29	Problems of Testing Hypotheses (Part 1)	DS 9.1
11	W - 4/3	Testing Simple Hypotheses	DS 9.2
	F - 4/5	Uniformly Most Powerful Tests	DS 9.3
12	W - 4/10	Two-Sided Alternatives	DS 9.4
	F - 4/12	The t-test, Comparing two Means	DS 9.5, 9.6

13	W - 4/17	Bayes Testing Procedures, Foundational Issues	DS 9.8, 9.9
	F - 4/19	Celebrating Collaborations - Virtual asynchronous class	
14	W - 4/24	Review For Exam 2	
	F - 4/26	Project Day; Exam 2 period starts this weekend.	
15	W - 5/1	Project Day	
Final Examinations Tuesday, May 7–Friday, May 10			