Quantitative Techniques in Public Policy and Political Science I

Mathematics and Statistics for Political Science

PLS 801, Michigan State University

Fall 2017

Instructor: Constanza F. Schibber

Lecture Time and Location: Tuesday and Thursday 10:20 AM - 11:40 PM, S104 South Kedzie

Office Hours: Thursday 11:40 AM - 1:00 PM, and by appointment, 344 South Kedzie

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Teaching Assistant: Seo Youn Choi

Lab & Recitation Time and Location: Thursday 2:00 PM - 4:00 PM, College of Natural Science 205

Office Hours: Monday 12:00 PM to 1:00 PM and 4:00 PM to 5:00 PM, on Piazza

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Overview and Objectives

This course is designed to provide mathematical tools useful for the statistical methods sequence, as well as for other courses in formal theory or mathematical modeling. Throughout the course, the mathematical tools will be motivated by applications to the general problem of how politics can be modeled for purposes of statistical analysis, deductive reasoning, or conceptual theorizing. Mathematical topics covered include: linear algebra; differential calculus and optimization; and probability. By learning to solve problems covering these mathematical topics, students will learn to represent political phenomena symbolically and to reason about social inquiry formally. Furthermore, this course will provide an introduction to statistical concepts including hypothesis testing.

Classes

Lectures: There class will meet twice a week. Students who use laptops in lectures must do so exclusively for the purpose of note taking. To prepare for the lectures you should review material covered in previous lectures and also complete the reading assignments. You can find the topics and reading list for each lecture in the schedule below.

Lab Session: There will be weekly one-hour lab sessions in which you will learn the statistical software `R` and also do practice exercises. Students should bring their own laptops to

the lab sessions and use them exclusively for `R` or note taking.

Recitation Session: Right at the end of the lab session there will be a one-hour recitation class in which the teaching assistant will receive questions from students regarding how to solve exercises from previous assignments or from the current assignment. The teaching assistant can also guide students through the material covered during the lectures or the `R` portion of the lab. If any topic of the lecture was challenging, the teaching assistant will prepare additional practice exercises to be solved on the blackboard. Students can also submit questions through **Piazza** during the week so that the teaching assistant and/or the instructor can prepare any additional material if necessary. Students can also work on their assignment during the recitation session.

Piazza: We will use Piazza to connect online outside of the class. Students can post questions about the material and the assignments (with the exception of exams!) and other students can (and should try to) reply. Students should also answer their own questions if they realized the answer later. The teaching assistant and the instructor will also reply to questions on Piazza. *Students should do their best to ask questions and provide answers in a concise manner and in a way that does not give away the complete answer to an exercise.*

If a student e-mails the teaching assistant or the instructor a question about an assignment that could have been asked on Piazza, the student will be asked to post the question on Piazza. Questions about assignments that should be sent directly to the teaching assistant or instructor include questions that would give away the solution to an exercise if posted on Piazza.

Student should not post on Piazza during take-home exams.

Evaluation

Attendance: I expect students to attend *all* lectures and labs, and to arrive to class on time. Although attendance to recitation classes is not required, I encourage you to stay after the lab and take full advantage of them.

Participation: Forms of participation may include asking questions, answering questions from the instructor, the teaching assistant, or from other classmates, participating in in-class group activities and class discussion, among others. Participation is encouraged both in lectures, labs, and recitation classes. Using **Piazza** to ask and answer questions is strongly encouraged and it will contribute to your participation evaluation as well.

Assignments: Most weeks you will have readings and problem sets. Unless otherwise noted, submission is due on Tuesday at the start of class and you should give me a hard copy of your solution. Late assignments will not be accepted. If for any reason you do not attend class, it is your responsibility to provide me with a copy of your assignment before it is due. Assignments should be written in an organized and professional fashion. If your work is not clear, you will receive no credit. If you have difficulties in this area, you can use the document preparation system LaTeX(there are plenty of online resources on LaTeX). Moreover,

in order to receive credit for a question on a problem set, you must show your own work. Correct answers with no work will receive no credit.
I strongly encourage you to work together on the problem sets, but each keystroke of your solution set must be your own (cut-and-paste solutions are not acceptable nor are solutions transcribed for other resources). I also encourage you to use Piazza and office hours to discuss any specific assignments, difficulties, or questions about the course.

Midterm Exams: There will be two take-home midterm exams. The exams will be open book. No make-up exams are allowed unless a dire emergency arises and is documented. The first midterm exam will take place between September 28 and October 3, 2017. The second midterm exam will take place between October 26 and October 31, 2017. Midterm exams are due at the beginning of class.

Final Exam: There will be a take-home final exam. The exam will be open book. No make-up exam is allowed unless a dire emergency arises and is documented. The final exam is due Thursday, December 14, 2017 at 12 PM via Piazza.

Grading

Your grade will be structured as follows:

- Participation and attendance: 5%
- Assignments: 5% each; total of 45% (Out of 10 homeworks, the lowest grade will be dropped when computing each student's score)
- Midterm Exam 1: 10%
- Midterm Exam 2: 15%
- Final Exam: 25%

Late assignments will not be accepted and no incompletes will be given for assignments, exams, or the course. Exceptions will be granted only under truly extraordinary circumstances.

If you experience a dire emergency or a university addressed absence that preempted the handing-in of any of the assignments in time, you must notify the instructior on or before the due date or exam date by email and provide a well-documented explanation (e.g., doctor's note, etc.).

The procedure to have any grade revised is as follows. Please write up a short description of your argument as to why your grade should be changed and hand it in, along with your initial assignment, within one week of receiving your grade. The instructor will respond in writing. The instructor's decisions regarding grades are final.

Academic Honesty & Integrity

We will abide by MSU's statements and policies regarding academic honesty, as detailed at the ombudsman's website at https://ombud.msu.edu/academic-integrity/index.html. No cheating will be tolerated, and this includes handing in a homework that is the same as someone else's homework or using computer software to automatically calculate solutions to an assignment that you are supposed to solve yourself without any assistance.

Required Texts

Jeff Gill. 2006. *Essential Mathematics for Political and Social Research,* Cambridge University Press: New York.

James E. Monogan III. 2015. *Political Analysis Using R*, Springer.

Morris H. DeGroot and Schervish, Mark J. *Probability and Statistics*, Addison-Wesley.†

† You will need this book by October 31. There are multiple editions. To buy it, look for the paperback 2016 edition which is roughly $20.

Additional Texts

Selected chapters of the following books are assigned.

Garrett Grolemund. 2014. *Hands-On Programming with* R*: Write Your Own Functions and Simulations*, O'Reilly Media.

María L. Rizzo. 2007. *Statistical Computing with* R, Chapman & Hall/CRC The R Series.

Installing R

All students will need to download and install the latest R software. R is a free statistical programming language that we will use to do calculations, simulation, computing probabilities, creating graphics, *etc.* You will be using R in other courses of the statistical methods sequence as well so this course will serve as an introduction. It may be obtained at the CRAN website. Go to http://lib.stat.cmu.edu/R/CRAN and click your choice of platform (Linux, MacOS X or Windows) for the precompiled binary distribution. Note the FAQs link to the left for additional information.

Lecture Schedule

Tueday	Thursday
Aug 29th	31st **1** 1. The Basics: Notation, Sets, Functions, Logarithm, and Exponents
Sep 5th **2** 2. The Basics: Summation & Product	7th **3** 3. Linear Algebra: Vectors, Matrices, and Operations
12th **4** **HW #1 Due** 4. Linear Algebra: Rank, Trace, Determinant	14th **5** 5. Linear Algebra: Matrix Inversion
19th **6** **HW #2 Due** 6. Linear Algebra: Linear Systems of Equation	21st **7** 7. Linear Algebra: Linear Systems of Equation
26th **8** **HW # 3 Due** 8. Elementary Calculus: Limits: Definitions, Properties, Continuity.	28th **9** **Midterm #1 Out** 9. Elementary Calculus: Secants, Tangents, Derivatives
Oct 3rd **10** **Midterm # 1 Due** 10. Elementary Calculus: Derivatives Rules for Common Functions	5th **11** 11. Elementary Calculus: L'Hopital Rule, Mean Value Theorem

Tueday	Thursday
10th **12** **HW # 4 Due** 13. Elementary Calculus: Implicit, Logarithmic, Parametric, and Partial Differentiation	12th **13** 14. Combining Summation/Product and Derivatives
17th **14** **HW # 5 Due** 15. Elementary Calculus: Maxima, Minima, and Root Finding	19th **15** 16. Scalar and Vector Calculus: Constrained Optimization
24th **16** **HW # 6 Due** 17. Scalar and Vector Calculus: Integration by Substitution, Integration by Parts	26th **17** **Midterm #2 Out** 18. Review
31st **18** **Midterm #2 Due** 19. Probability Theory: Counting Rules and Permutations	Nov 2nd **19** 20. Probability Theory: Calculations with Probabilities
7th **20** **HW#7 Due** 21. Probability Theory: Conditional Probability and Bayes Law	9th **21** 22. Random Variables: Measurement, Distribution Functions
14th **22** **HW#8 Due** Random Variables: Measures of Central Tendency, Measures of Dispersion, Correlation and Covariance	16th **23** 24. Random Variables: Expected Value, Moments of a Distribution

Tueday	Thursday
21st **24** **HW#9 Due** 25. The Normal Distribution (and Other Special Distributions)	23rd **Thanksgiving Day**
28th **25** 26. Law of Large Numbers, Central Limit Theorem, The Sampling Distribution of a Statistic	30th **26** 27. Confidence Intervals
Dec 5th **27** **HW #10 Due** 27. Hypothesis Testing	7th **28** 27. Hypothesis Testing

Reading List Organized by Lecture Number

1. Class 1: Read the Syllabus!
2. Class 2: Gill, chapter 1, *The Basics*
3. Gill, chapter 3
4. Gill, chapter 4, sections 4.1-4.5
5. Gill, chapter 4, section 4.6
6. Gill, chapter 4, section 4.7
7. Gill, chapter 4, sections 4.8-4.10
8. Gill, chapter 5, sections 5.1 and 5.2
9. Gill, chapter 5, sections 5.3
10. Gill, chapter 5, section 5.4.1 and 5.4.2
11. Gill, chapter 5, sections 5.4.3 and 5.4.4, and section 5.7.1
12. Gill, chapter 6, sections 6.1-6.3
13. No reading.
14. Gill, chapter 6, section 6.4

15. Gill, chapter 6, sections 6.7 and 6.8
16. Gill, chapter 6, section 5.6, and chapter 6, section 6.5
17. No reading.
18. Gill, chapter 7, sections 7.1-7.4; DeGroot & Schervish, chapter 1, sections 1.1-1.8
19. Gill, chapter 7, section 7.5; DeGroot & Schervish, chapter 1, sections 1.10
20. Gill, chapter 7, sections 7.6-7.9; DeGroot & Schervish, chapter 2
21. Gill, chapter 8, sections 8.1-8.3, DeGroot & Schervish, chapter 3, sections 3.1-3.9
22. Gill, chapter 8, sections 8.4-8.6
23. Gill, chapter 8, sections 8.7-8.11; DeGroot & Schervish, chapter 4
24. DeGroot & Schervish, chapter 5
25. DeGroot & Schervish, chapter 6, sections 6.1-6.3, and chapter 8, section 8.1 and 8.2
26. DeGroot & Schervish, chapter 8, sections 8.3-8.5 and section 8.7
27. DeGroot & Schervish, chapter 9
28. TBD

Lab Session Schedule

8/31 Lab 1: Introduction to `R`. Introduction to LaTeX.

- Monogan, chapter 1.
- Tobias Oetiker, Hubert Partl, Irene Hyna and Elisabeth Schlegl. 2016. *The Not So Short Introduction to* LaTeX2ϵ, which is available here https://tobi.oetiker.ch/lshort/lshort.pdf

9/07 Lab 2: Introduction to `RStudio` and `knitr`. Reading Data and Basic Data Visualization in `R`.

- Karl Broman. `knitr` *in a knutshell – a minimal tutorial*, which is available here http://kbroman.org/knitr_knutshell/.
- Monogan, chapters 2 and 3.

9/14 Lab 3: Vectors and Matrices in `R`.

- Monogan, sections 10.1 and 10.2.

9/21 Lab 4: Linear Systems of Equations in R.

9/28 Midterm Exam Out. Optional recitation session if there are questions about topics covered by the exam or the solution to HW#3.

10/05 Lab 5: Derivatives. Practice Exercises.

10/12 Lab 6: Functions, Loops, and If Statements in R.

- Monogan, section 11.2 on *Functions* and section 11.3 on *Loops*.

10/19 Lab 7: Maxima, Minima, and Root Finding in R.

- Rizzo, sections 11.1, 11.4, 11.5, 11.6, on *Numerical Methods*.

10/26 Midterm Exam Out. Optional recitation session if there are questions about topics covered by the exam or the solution to HW#6.

11/02 Lab 8: Monte Carlo Integration in R. Programming Probability Problems in R.†

- Rizzo sections 5.1, 5.2.1, and 5.2.2 on *Monte Carlo Integration*.
- Grolemund, selected sections TBD.

† This Lab might run longer and use part of the recitation class. Please, plan accordingly.

11/09 Lab 9: Random Variables in R, Part I.

- Monogan, chapter 11 (only 11.1).

11/16 Lab 10: Random Variables in R, Part II.

- Monogan, chapter 4.

11/23 Thanksgiving Break

11/30 Lab 11: Central Limit Theorem, Law of Large Numbers, and Monte Carlo Methods for Estimation in R.

- Rizzo, chapter 6 on *Monte Carlo Methods in Inference*

12/07 Lab 12: Hypothesis Testing. The R Basics.

- Monogan, chapter 5.