Course Syllabus

Course Number: DS 400

Course Title: Bayesian Statistics

Department Name: Data Science

College/School/Division Name: School of Natural Sciences and Mathematics

Term: Spring 2023

Course Credits: 3

Class Meeting Days: Tuesdays and Thursdays

Class Meeting Hours: 2:30 – 3:50pm

Class Location: Tredtin Hall, Room DSC

Instructor Name: Laura Tipton, PhD

Email: laura.tipton@chaminade.edu

Phone: 808-735-4804

Office Location: Tredtin DSC 3

Office Hours: M,W 9-11am or by appointment

Instructor Website:

Other Professional Contact Information:

1. University Course Catalog Description

This course will introduce the Bayesian approach to data analysis (including choice of prior distributions and calculation of posterior distributions) with an emphasis on practical applications. Topics to be discussed include: Bayes' Theorem; prior distributions; inferences for discrete random variables and binomial proportion; inferences for continuous random variable and normal means; linear regression; analysis of variance; MCMC/Gibbs sampler; and model evaluation/comparison.

2. Course Overview

In this course we will cover the use of Bayesian statistics for data analysis in an applied fashion. While we will cover some theory for motivation, the majority of the course will focus on practical applications and real world datasets, including programming in R, leading up to a project in which the students apply a Bayesian framework to analyze their own data.

3. Program Learning Outcomes

Upon completing the B.S. degree program in Data Science Analytics and Visualization the student will demonstrate the following:

1. Source, describe and curate large data sets ('Big Data') that may not be amenable to traditional hardware and software, and conventional statistical analysis including domain and file specific metadata and the tools built around alternatives to tabular relations that allow the use of multimodal data;
2. Identify, describe and apply foundational mathematical and statistical concepts and operations, including the application of tools such as R, SQL and Python languages, that underlie data sourcing, management, analysis and interpretation;
3. Develop and implement approaches for effective data translation, dissemination and communication between domains, stakeholders and the public;
4. Identify and apply basic data modeling, predictive models and visualizations to support decision-making;
5. Integrate an awareness of ethical issues and collective standards to positively influence the application of data science to service, justice and peace in working towards solutions for societal problems;
6. Explain, plan and execute data science tasks within multidisciplinary teams;
7. Execute a domain-specific capstone project addressing a stakeholder-generated use case.

4. Course Learning Outcomes and Linkage to Program Learning Outcomes

At the conclusion of DS 400, students will:

Course Learning Outcomes	**PLO 1**	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**	**PLO 7**

1. Explain prior and posterior probabilities and how they relate to each other		X					
2. Describe differences between Bayesian and frequentist approaches		X					
3. Identify scenarios when Bayesian data analysis will be appropriate			X				
4. Implement and explain an MCMC/Gibbs sampler		X		X			
5. Explain hierarchical models and their uses				X			
6. Effectively communicate the outcomes of Bayesian data analysis			X			X	
7. Describe and use container computing		X					

5. Course Prerequisites

CS 201 OR CS 202, AND MA 331

6. Required Learning Materials

Doing Bayesian Data Analysis; A Tutorial with R, JAGS, and Stan by John K. Kruschke, 2nd Edition
https://sites.google.com/site/doingbayesiandataanalysis/ (available in the bookstore)
Doing Bayesian Data Analysis in brms and the tidyverse by Soloman Kurtz
https://bookdown.org/content/3686/ (free)
Any additional necessary material will be posted to Canvas.

6.1 Recommended Supplemental Materials

Bayesian Statistics the Fun Way: Understanding Statistics and Probability with Star Wars, LEGO, and Rubber Ducks by Will Kurtz

7. Course Website:

8. Technical Assistance for Canvas Users:

Search for help on specific topics at help.instructure.com. Chat live with Canvas Support 24/7/365. Watch this video to get you started with online guides and tutorials. Contact the Chaminade IT Helpdesk for technical issues: helpdesk@chaminade.edu, or call (808) 735-4855

9. Assessment.

Attendance/Communication	5 points
Homework Assignments (9X)	45 points
Project Proposal	15 points
Project Presentation	15 points
Project Write-up	20 points
Total	**100 points**

Grading will be based on student points earned from attendance/communication, homework, and project development milestones. Homework and projects will be required to be in R. Projects will be developed based on material and sources discussed in class.

10. Grading Scale

Letter grades are given in all courses except those conducted on a credit/no credit basis. They are interpreted as follows:

A 90-100% 90 points or more: Outstanding scholarship and an unusual degree of intellectual initiative

B 80-89% 80-89 points: Superior work done in a consistent and intellectual manner

C 70-79% 70-79 points: Average grade indicating a competent grasp of subject matter

D 60-69% 60-69 points: Inferior work of the lowest passing grade, not satisfactory for fulfillment of prerequisite course work.

F <60% 59 points or less: Failed to grasp the minimum subject matter; no credit given

11. Course Schedule

Blue background indicates these classes are scheduled to be online, see Canvas and your email for a link and further instructions.

Week	Date	Lesson	Chapter	Assignment
1	1/10-12	• Introduce syllabus. • Everyone introduces themselves. • Historical motivation and context.		

2	1/17-19	• Docker/Container Computing		Install Docker, Rocker, and appropriate container
3	1/24-26	• Concept intuition • Bayes Rule	2, 5	Homework Assignment 1
4	1/31-2/2	• Binomial probability • Beta distribution	6	Homework Assignment 2
5	2/7-9	• Markov Chain Monte Carlo/Gibbs sampler	7	Homework Assignment 3
6	2/14-16	• Hierarchical models	9	Homework Assignment 4
7	2/21-23	• Hierarchical models		Project proposal due
8	2/28-3/2	• Comparing Models	10	Homework Assignment 5
9	3/7-9	• Null hypothesis significance testing • Problems with p-values	11	Homework Assignment 6
10	3/14-16	• Bayesian approaches to hypothesis testing	12	Homework Assignment 7
11	3/22-23	• SPRING BREAK		
12	3/28-30	• Power and sample size calculations	13	
13	4/4-6	• Reporting results	25	Homework Assignment 8
14	4/11-13	• Special topics – ANOVA/variants, ordinal variables, historical examples, recent developments, etc		Homework Assignment 9
15	4/18-20	• Project meetings		
16	4/25-27	• Project presentations		Project Presentation due.
17	5/2-4	• Exams (no class)		Project Write Up due.

This schedule is presented as a guideline and is subject to change at the instructor's discretion. The student will be notified of any major deviations from this schedule.

12. Alignment of Natural Sciences Courses with Marianist and Hawaiian values of the University.

The School of Natural Sciences and Mathematics provides an *integral, quality education:* sophisticated integrative course content taught by experienced, dedicated, and well-educated instructors.

- We *educate in family spirit* – every classroom is an *Ohana* and you can expect to be respected yet challenged in an environment that is supportive, inclusively by instructors who take the time to personally get to know and care for you.
- We *educate for service, justice and peace*, since many of the most pressing global issues (climate change, health inequity, poverty, justice) are those which science and technology investigate, establish ethical parameters for, and offer solutions to.
- We *educate for adaptation and change*. In science and technology, the only constant is change. Data, techniques, technologies, questions, interpretations and ethical landscapes are constantly evolving, and we teach students to thrive on this dynamic uncertainty.

The study of science and technology can be formative, exploring human creativity and potential in the development of technologies and scientific solutions, the opportunity to engage in the stewardship of the natural world, and the opportunity to promote social justice. We provide opportunities to engage with the problems that face Hawai‘i and the Pacific region through the Natural Sciences curriculum, in particular, those centered around severe challenges in health, poverty, environmental resilience, and erosion of traditional culture. The Marianist Educational Values relate to Native Hawaiian ideas of *mana, na'auao, ohana*, *aloha* and *aina*. We intend for our Natural Sciences programs to be culturally-sustaining, rooted in our Hawaiian place, and centered on core values of *Maiau,* be neat, prepared, careful in all we do; *Makawalu*, demonstrate foresight and planning; *`Ai,* sustain mind and body; *Pa`a Na`au*, learn deeply.

13. Additional departmental and university policies

13.1. Late Work Policy

Requests for extensions due to extenuating circumstances (medical problems, for example) will be considered but in general work received after the deadline will not be graded. Computer problems and poor time management are not an excuse for late work.

13.2. Grades of "Incomplete"

Students and instructors may negotiate an incomplete grade when there are specific justifying circumstances. An Incomplete Contract (available from the School Secretary and the Portal) must be completed. When submitting a grade, the “I” will be accompanied by the alternative grade that will automatically be assigned after 90 days. These include IB, IC, ID, and IF. If only an “I” is submitted the default grade is F. The completion of the work, evaluation, and reporting of the final grade is due within 90 days after the end of the semester or term. This limit may not be extended.

13.3. Writing Policy

Paper requirements and formatting will be discussed during the course when the assignment is given

13.4. Instructor and Student Communication

Questions for this course can be emailed to the instructor at laura.tipton@chaminade.edu. Online, in-person, and phone conferences can be arranged. Response time will take place within 3 days.

The University provides a Chaminade email address for all students. Official Chaminade communications will be sent to the students' Chaminade email address and instructors will use only this email to communicate with students. It is the responsibility of the student to check their email frequently. Report email-related problems to the Helpdesk at 808-735-4855 or helpdesk@chaminade.edu

13.5. Cell phones, tablets, and laptops

Music Devices and Cellular Phones: Unless specifically permitted by your instructor, use of music devices and cell phones is prohibited during all Natural Science and Mathematics classes, as it is discourteous and may lead to suspicion of academic misconduct. Students unable to comply will be asked to leave class. Out of consideration for your classmates, please set your cell phone to silent mode during class. Students are encouraged to bring laptops or tablets to class as the instructor will assign online activities and readings that will require the use of a laptop or tablet. Laptops and tablets should not be misused, such as checking distracting websites. Use your best judgment and respect your classmates and instructor.

13.6. Disability Access

If you need individual accommodations to meet course outcomes because of a documented disability, please speak with me to discuss your needs as soon as possible so that we can ensure your full participation in class and fair assessment of your work. Students with special needs who meet criteria for the Americans with Disabilities Act (ADA) provisions must provide written documentation of the need for accommodations from the Counseling Center by the end of week three of the class, in order for instructors to plan accordingly. If a student would like to determine if they meet the criteria for accommodations, they should contact the Kokua Ike Coordinator at (808) 739-8305 for further information (ada@chaminade.edu).

13.7. Title IX Compliance

Chaminade University of Honolulu recognizes the inherent dignity of all individuals and promotes respect for all people. Sexual misconduct, physical and/or psychological abuse will NOT be tolerated at CUH. If you have been the victim of sexual misconduct, physical and/or psychological abuse, we encourage you to report this matter promptly. As a faculty member, I am interested in promoting a safe and healthy environment, and should I learn of any sexual misconduct, physical and/or psychological abuse, I must report the matter to the Title IX Coordinator. If you or someone you know has been harassed or assaulted, you can find the appropriate resources by visiting Campus Ministry, the Dean of Students Office, the Counseling Center, or the Office for Compliance and Personnel Services. Should you want to speak to a confidential source you may contact the following:

• Chaminade Counseling Center| 808 735-4845.

• Any priest serving as a sacramental confessor or any ordained religious leader serving in the sacred confidence role

13.8. Attendance Policy

If you are not feeling well, please do not come to campus! Please email Dr. Tipton to let her know that you will not be attending. All lectures will be posted online and participation in online components will be considered attendance. Repeated unexcused absences without email notification may lead to a grade reduction for the course.

13.9. Academic Conduct Policy

See the current Undergraduate Academic Catalog and the Student Handbook available from Student Affairs.

14. Dr. Tipton's policies

14.1 Inclusion Statement

I recognize that I cannot fully understand the lived experience of many minoritized individuals. However, I am dedicated to increasing excellence through inclusion. That includes recognizing as assets the different perspectives students and scholars from diverse backgrounds bring to the classroom and to science. It includes a drive to have the readings and examples used in the classroom be as inclusive and diverse as possible. Furthermore, it is an awareness that biases, both conscious and unconscious, exist in academia, science, and the world, and an aim to reduce the influence of those biases in my decisions and in those around me. Actions that seek to limit the potential of others or perpetuate biases or anti-inclusive sentimentality will not be tolerated.

14.2 Safe Space

To the extent possible, I hope you will consider my office a safe, non-judgmental space; a place where you can bring your whole self and all your emotions. As stated above, I am obligated by law to report Title IX violations and any reports of abuse. Beyond that, I will do my best to listen, help, and direct you to campus and community resources when appropriate.

14.3 Syllabus Changes

This syllabus is a guide to the class and will be adhered to as much as possible; however, I reserve the right to make changes as I see fit, so long as they do not create an additional undue burden on the student.

14.4 Miscellaneous

Congratulations on reading all the way to the end of the syllabus. For an extra credit point, please email a picture of your favorite fruit to me.