

**Course Title:** *Advanced Bayesian Inference*

**Course Number:** *BIST 0721*

**Course Pre- and Co-requisite(s):** BIST 0610, BIST 0700

**Course Location:** online

**Course Date & Time:** asynchronous

**Course Instructor:** Jason Roy, PhD

Professor of Biostatistics

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**Office Hours:** *TBD*

**Course Assistant:** none

**Course Website:** [canvas.rutgers.edu](https://canvas.rutgers.edu)

**Software:** R (free): <https://www.rstudio.com/>

**Recommended Course Text:** *Bayesian Data Analysis*, 3rd Edition, Gelman, Carlin, Stern, Dunson, Vehtari and Rubin

**Additional/Supplemental Readings/Resources:** The primary course material will come from lecture notes and articles.

**Course Description:** This course will focus on modern Bayesian methods for analyzing biomedical and health-related data. The course will begin with a brief review of Bayesian principles, conjugate and non-conjugate priors, and computational algorithms (Gibbs; Metropolis Hastings; slice sampling). The majority of the semester will focus on Bayesian nonparametric (BNP) methods. This will include popular priors over distributions (Dirichlet process, dependent Dirichlet process, and variations) and priors over functions (BART; Gaussian processes). Homework assignments will involve implementation of various models and/or derivations of important results. There will be a final project that involves a more in depth exploration of a recently developed BNP method. This is a PhD-level course and is designed for students who have substantial background in statistical theory and methods.

**Selected Concentration Competencies Addressed:** Each Concentration identifies competencies for each degree offered. The competencies addressed in this course for the PhD in *Biostatistics* include:

- Integrate relevant scientific background to design experimental and observational studies in biomedical, clinical and public health research;
- Use statistical computer packages to organize, analyze and report collected data;
- Review and critique statistical methods and interpretations presented in published research studies, presentations or reports; and
- Communicate the results of statistical studies both in writing and orally to investigators and lay community members.

Please visit the Concentration webpages on the School of Public Health's website at [sph.rutgers.edu](http://sph.rutgers.edu) for additional competencies addressed by this course for other degrees and concentrations.

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

- Determine what type of prior distributions to use (non-informative, weakly informative, or informative)
- Be able to fit complex models by either writing their own Gibbs sampler, using available software, or some combination of the two
- Be able to implement non-parametric Bayesian methods for distributions and functions
- Understand the strengths and limitations of Bayesian inference
- Understand how Bayesian methods can be used to deal with common problems in biomedical data such as: missing data; censoring; confounding; sparse cells

**Course Requirements and Grading:**

- *Course evaluation:*

1. Homework (3 assignments)	60%
2. Project	40%
Total:	100%

Grading Policy: 94 – 100	A
90 – <94	A-
87 – <90	B+
84 – <87	B
80 – <84	B-
77 – <80	C+
70 – <77	C
<70	F

**Project:** The final project will involve selecting a recent paper (2018 or later) from the literature that developed a new Bayesian nonparametric approach. Each student will select a different paper. The paper needs to be approved by me. The first step is to read the paper and understand the motivation, models, priors, algorithm, and performance in detail. Then, create a ~20 minute video presenting the content as if you were teaching it to the class. The video should then be posted on canvas in module 15. All students are required to watch the videos posted by the other students. Grades will be based on how well the student demonstrated understanding of the paper in their own words.

**Course Schedule:**

<b>Week</b>	<b>Date</b>	<b>Course Topic</b>	<b>Assignments/ Assessments</b>	<b>Link To Competencies And Assessments</b>
1	Sept 6- Sept 10	Introduction to Bayesian modeling; conjugate priors	Optional reading: BDA Ch 1, 2	Integrate relevant scientific background to design experimental and observational studies in biomedical, clinical and public health research (assessed on HW 1)
2	Sept 12- Sept 16	Multiparameter models with some non-conjugate priors	Homework 1 distributed  Optional reading: Ch 2,3	Integrate relevant scientific background to design experimental and observational studies in biomedical, clinical and public health research (assessed on HW 1)
3	Sept 19- Sept 23	MCMC; Metropolis Hastings	Reading: An Introduction to MCMC for Machine Learning, sections 2.1, 3, 3.1  Optional reading: Ch 10, 11	Use statistical computer packages to organize, analyze and report collected data (assessed on HW 1)
4	Sept 26- Sept 30	Gibbs; Gibbs hybrid; slice sampling	Reading: An Introduction to MCMC for Machine Learning, section 3.6.2, 3.7, 4.2  Neal 2000  Optional reading: Ch 5, 6	Use statistical computer packages to organize, analyze and report collected data (assessed on HW 1)
5	Oct 3- Oct 7	Bayesian bootstrap	Homework 1 due	Use statistical computer packages to organize, analyze and report

			Reading: papers	collected data (assessed on HW 2)
6	Oct 10- Oct 15	CDF estimation - Dirichlet process priors	Homework 2 distributed  Reading: papers	Integrate relevant scientific background to design experimental and observational studies in biomedical, clinical and public health research (assessed on HW 2)
7	Oct 17- Oct 21	DP priors – sampling algorithms	Reading: papers	Integrate relevant scientific background to design experimental and observational studies in biomedical, clinical and public health research
8	Oct 24- Oct 28	Density estimation – DP mixtures	Reading: papers	Use statistical computer packages to organize, analyze and report collected data (assessed on HW 2)
9	Oct 31- Nov 4	Extensions: Enriched DP mixtures; Dependent DP	Reading: papers  Homework 2 due	Review and critique statistical methods and interpretations presented in published research studies, presentations or reports (assessed on HW 2)
10	Nov 7- Nov 11	Bayesian CART	Reading: papers  Homework 3 distributed	Review and critique statistical methods and interpretations presented in published research studies, presentations or reports (assessed on HW 2)
11	Nov 14- Nov 18	BART	Reading: papers	Review and critique statistical methods and interpretations presented in published research studies, presentations or reports (assessed on HW 3)
12	Nov 21- Nov 25	Gaussian process models	Reading: papers	Review and critique statistical methods and interpretations presented in published research studies, presentations or reports Use statistical computer packages to organize, analyze and report collected data (assessed on HW 3)

13	Dec 5- Dec 10	Causal inference using BNP; sensitivity analysis	Reading: papers	Review and critique statistical methods and interpretations presented in published research studies, presentations or reports  Use statistical computer packages to organize, analyze and report collected data (assessed on HW 3)
14	Dec 13- Dec 18	Missing data methods using BNP; sensitivity analysis	Homework 3 due  Reading: papers	Review and critique statistical methods and interpretations presented in published research studies, presentations or reports (assessed on homework 3)
15	Due by Dec 18	Presentation of projects		Communicate the results of statistical studies both in writing and orally to investigators and lay community members.  Review and critique statistical methods and interpretations presented in published research studies, presentations or reports.  (assessed on project)

**Special Circumstances During COVID-19 (For Fall 2020)**

The School of Public Health recognizes that students may experience challenges or be negatively impacted due to the COVID-19 pandemic, mental and emotional health toll from systemic racism, altered personal and professional obligations, and other crises existing at the moment in our local, national, and global communities. Students are encouraged to discuss these challenges and circumstances with their instructor, if they feel they may need additional support or temporary accommodations at the beginning or during this course. The course instructor may consider making reasonable temporary adjustments depending on the student's situation. If additional support is needed, students may reach out to the [Office of Student Affairs \(studentaffairs@sph.rutgers.edu\)](mailto:studentaffairs@sph.rutgers.edu) or any of the appropriate referral resources listed on the [Student Connect Canvas page](#).

**Learning Management System:** Canvas will be used extensively throughout the semester for course syllabus, assignments, announcements, communication and/or other course-related activities. It is the student's responsibility to familiarize themselves with Canvas and check it regularly. If you have difficulties accessing Canvas, please inform the instructor and Canvas Support ([help@canvas.rutgers.edu](mailto:help@canvas.rutgers.edu)). Canvas is accessible at [canvas.rutgers.edu](https://canvas.rutgers.edu).

**School of Public Health Honor Code:** The School of Public Health Honor Code is found in the School Catalog ([sph.rutgers.edu/academics/catalog.html](https://sph.rutgers.edu/academics/catalog.html)). Each student bears a fundamental responsibility for maintaining academic integrity and intellectual honesty in his or her graduate work. For example, all students are expected to observe the generally accepted principles of scholarly work, to submit their own rather than another's work, to refrain from falsifying data, and to refrain from receiving and/or giving aid on examinations or other assigned work requiring independent effort. In submitting written material, the writer takes full responsibility for the work as a whole and implies that, except as properly noted by use of quotation marks, footnotes, etc., both the ideas and the works used are his or her own. In addition to maintaining personal academic integrity, each student is expected to contribute to the academic integrity of the School community by not facilitating inappropriate use of her/his own work by others and by reporting acts of academic dishonesty by others to an appropriate school authority. It should be clearly understood that plagiarism, cheating, or other forms of academic dishonesty will not be tolerated and can lead to sanctions up to and including separation from the Rutgers School of Public Health.

**Students with Disabilities:** Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student must apply for Services by first completing a Registration Form with the Rutgers Office of Disability Services (ODS) at [ods.rutgers.edu](https://ods.rutgers.edu). The student will also be required to participate in an ODS intake interview and provide documentation. If reasonable accommodations are granted, ODS will provide you with a Letter of Accommodations which should be shared with your instructors as early in your courses as possible.

**Commitment to Safe Learning Environment:** The Rutgers School of Public Health is committed to helping create a safe learning environment for all students and for the School as a whole. Free expression in an academic community is essential to the mission of providing the highest caliber of education possible. The School encourages civil discourse, reasoned thought, sustained discussion, and constructive engagement. Provocative ideas respectfully presented are an expected result. An enlightened academic community, however, connects freedom with responsibility. The School encourages all students to disclose any situations where you may feel unsafe, discriminated against, or harassed. Harassment or discrimination of any kind will be not tolerated and violations may lead to disciplinary actions.

**Reporting Discrimination or Harassment:** If you experience any form of gender or sex-based discrimination or harassment, including sexual assault, sexual harassment, relationship violence, or stalking, know that help and support are available. You may report such incidents to the [RBHS Title IX Office](#) or to the School of Public Health's [Office of Student Affairs](#). Rutgers University has staff members trained to support survivors in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, and more. If you experience any other form of discrimination or harassment, including racial, ethnic, religious, political, or academic, please report any such incidents to the School's [Office of Student Affairs](#). The School strongly encourages all students to report any incidents of discrimination or harassment to the School. Please be aware that all Rutgers employees (other than those designated as confidential resources such as advocates, counselors, clergy and healthcare providers as listed in Appendix A to [Policy 10.3.12](#)) are required to report information about such discrimination and harassment to the School and potentially the University. For example, if you tell a faculty or staff member about a situation of sexual harassment or sexual violence, or other related misconduct, the faculty or staff member must share that information with the [RBHS Title IX Coordinator](#). If you wish to speak to a confidential employee who does not have this reporting responsibility, you can find a list of resources in Appendix A to University [Policy 10.3.12](#). For more

information about your options at Rutgers, please visit [Rutgers Violence Prevention and Victim Assistance](#).

**Graduate Student Computer Policy:** Students are required to possess a personal laptop, no older than approximately two years, that must meet minimum requirements which may be found online at: [sph.rutgers.edu/student-life/computer-support.html](http://sph.rutgers.edu/student-life/computer-support.html)

**Policy Concerning Use of Recording Devices and Other Electronic Communications Systems:**

When personally owned communication/recording devices are used by students to record lectures and/or classroom lessons, such use must be authorized by the faculty member or instructor who must give either oral or written permission prior to the start of the semester and identify restrictions, if any, on the use of mobile communications or recording devices.

**Policy Concerning Use of Turnitin:** Students agree that by taking this course all required papers may be subject to submission for textual similarity review to Turnitin.com (directly or via learning management system, i.e. Canvas) for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the Usage Policy posted on the Turnitin.com site. Students who do not agree should contact the course instructor immediately.

**Withdrawal/Refund Schedule:** Students who stop attending their course(s) without submitting a completed [Add/Drop Course](#) form will receive a failing grade. Furthermore, students dropping to zero credits for the semester are considered withdrawn and must submit a completed [Leave of Absence](#) form from the School of Public Health's Office of Student Affairs. The School of Public Health refunds tuition only. Administrative and technology fees are non-refundable. You may find the Withdrawal/Refund Schedule on the School of Public Health website at: [sph.rutgers.edu/academics/academic-calendar.html](http://sph.rutgers.edu/academics/academic-calendar.html)