

APHY / ICSI / CINF 451/551

Bayesian Data Analysis

(3810, 3811, 3953, 3994, 3812, 3813)
(3 Credits)

Semester: Fall 2026

Day/Time: Tu/Th 10:30 PM - 11:50 PM

Location: Physics 225

Course Website:

<https://knuthlab.org/courses/2026/BayesianDataAnalysis/pmwiki.php/Main/HomePage>

Instructor: Prof. Kevin H. Knuth

Contact: kknuth@albany.edu

Office Location and Hours: Tue 2:00 - 3:00 PM 211;
Or by Arranged Appointment

Teaching Assistant:

Ning Wang Physics nwang3@albany.edu

Office Location and Hours:

Course Description:

This course will introduce both the principles and practice of Bayesian and maximum entropy methods for data analysis, signal processing, and machine learning. This is a hands-on course that will introduce MATLAB computing language for software development. Students will learn to write their own Bayesian computer programs to solve problems relevant to physics, chemistry, biology, earth science, and signal processing, as well as hypothesis testing and error analysis. Optimization techniques to be covered include gradient ascent, fixed-point methods, and Markov chain Monte Carlo sampling techniques. Prerequisites: CSI 201, MAT 214, or equivalents, or permission of instructor. PHY 509 or equivalent programming experience with permission of the instructor.

Basic Needs Statement

Our aim at the University at Albany is that every student succeeds in their academic and personal pursuits. Helping our students reach their goals means we are ready to assist with students' well-being, health, safety, issues related to basic living and emergencies that can arise. If you need help with these areas, let's work together to find solutions. Please seek assistance from Supplemental Support Services within the Dean of Students' Office at <https://www.albany.edu/dean-students>. You can also search for additional resources at <https://www.albany.edu/dean-students/supplemental-support-services>. We're here to help you!

Health and Mental Health Care

As a student there may be times when personal stressors interfere with your academic performance and/or negatively impact your daily life. The University at Albany Counseling and Psychological Services (CAPS) provides free, confidential services including individual and group psychological counseling and evaluation for emotional, social, and academic concerns. Given the COVID pandemic, students may consult with CAPS staff remotely by telephone, email or Zoom appointments regarding issues that impact them or someone they care about. For questions or to make an appointment, call (518) 442-5800 or email consultation@albany.edu. Visit www.albany.edu/caps/ for hours of operation and additional information **If your life or someone else's life is in danger, please call 911. If you are in a crisis and need help right away, please call the National Suicide Prevention Lifeline at 1-800-273-TALK (8255). Students dealing with heightened feelings of sadness or hopelessness, increased anxiety, or thoughts of suicide may also text "GOT5" to 741741 (Crisis Text Line).**

UAlbany students get free 24/7 medical and mental health support through TimelyCare.

TimelyCare is a telehealth platform that gives undergraduate and graduate students access to care anytime, anywhere—on phone, tablet, or computer. This supplements UAlbany's already comprehensive health and wellness services.

[Learn more about TimelyCare at UAlbany.](#)

Services include:

TalkNow: Immediate, on-demand mental health support (including students abroad)

Scheduled Counseling: Up to 12 virtual therapy sessions per year

Medical Visits: On-demand and scheduled care for common illnesses

Health Coaching: Support for nutrition, sleep, and stress management

Peer Community & Self-Care Tools: 24/7 wellness resources

Students register at TimelyCare.com/albany using their @albany.edu email.

Course Structure and Requirements:

Lectures will be conducted in person in PHYSICS 225.

EXERCISES

There will be a series of assigned Exercises.

Exercises will **NOT BE GRADED**. While completing them is optional, it is highly recommended as they are designed to prepare you for the homework assignments.

At the specified date, solutions to the exercise will be posted on our class website so that you can evaluate your work.

WRITTEN AND PROGRAMMING ASSIGNMENTS

There will be both Written and Programming Homework Assignments

Homework Assignments ARE GRADED

ALL homework is to be submitted to knuthclass@gmail.com

Each Homework assignment can be turned in by 11:59 pm of the Due Date for 100 points. An assignment can be turned in from 1-3 days after the Due Date for 90 points. An assignment can

be turned in from 4-7 days after the Due Date for 75 points. Assignments turned in more than 7 days after the Due Date will receive 0 points.

The Written HW assignment with the lowest score will be dropped.

The Programming HW assignment with the lowest score will be dropped.

This allows you to miss BOTH one Written AND one Programming HW assignment, if you wish.

Do not ask permission to turn HW assignments in late. You may do so with the penalties described above.

Written homework assignments will be assigned approximately once every three weeks.

Programming homework will be assigned approximately once every three weeks. Programs are to be written as Matlab m-file functions. In many cases, the instructor will provide the data to be analyzed, and the student is expected to turn in a computer-generated solution along with a zip file containing the software. The instructor/TA should be able to open the zip file, run the software successfully on his/her own machine, and obtain identical results. The assignments to be turned in must be written up and presented as an MS-Word or PDF-formatted report with appropriate explanation.

QUIZZES

Throughout the semester there will be several unannounced Quizzes.

Missed Quizzes cannot be made up.

The lowest two quiz scores will be dropped.

EXAMS

There will be one in-class MidTerm Exam on Oct 29.

There is **NO FINAL EXAM!**

FINAL PROJECTS

Graduate Students are required to complete a Final Project.

Ideally, such a project would be related to their M.S. or Ph.D. research. If a student cannot find an appropriate subject related to their research, then several projects will be provided that the student can choose from.

Undergraduate Students can CHOOSE to take on a Final Project.

Like the graduate students, such a project should be related to research that they are performing (possibly related to a Senior Thesis). If a student cannot find an appropriate subject related to their research, then several projects will be provided that the student can choose from.

Undergraduate Students who take on a Final Project will be graded according to the better outcome of the Undergraduate Scale and the Graduate Scale.

The Project will conclude with a Written Project Report, which follows the format of a short 4-to-8-page research paper including an abstract, introduction, method, results, conclusion, and references, along with the submission of a zip file containing the data and code.

Projects will be presented in a Final Poster Session on the last day of class, Dec 3.

Course Learning Objectives

Upon completion of the course, students should be able to accomplish the following activities:

- Use the sum and product rules of probability to compute probabilities in various situations.

- Measure: Students should be able to perform meaningful computations with probabilities
 - Assignments: Homework Assignments, Projects, Quizzes, and Exams
- Assign prior probabilities and likelihood functions based on the problem at hand.
 - Measure: Students should be able to assign probabilities to solve problems.
 - Assignments: Homework Assignments, Projects, Quizzes, and Exams
- Use Bayes theorem to solve inference-based data analysis problems.
 - Measure: Students should be able to solve word problems by hand and data analysis problems by writing code involving Bayes theorem
 - Assignments: Both Written and Programming Homework Assignments as well as Quizzes and Exams
- Assign prior probabilities and likelihood functions based on the problem at hand.
 - Measure: Students should be able to assign probabilities to solve problems.
 - Assignments: Homework Assignments, Projects, Quizzes, and Exams
- Use both analytic and numerical techniques for computing the mean and mode of a probability density function as well as the accompanying uncertainties and the Bayesian evidence.
 - Measure: Students should be able to solve basic data analysis problems by computing the means, variances, and modes of probability distributions
 - Assignments: Homework Assignments, Projects, Quizzes, and Exams
- Write computer programs to numerically solve data analysis problems.
 - Measure: Students should be able to write their own code to solve some data analysis problems numerically.
 - Assignments: Programming Homework Assignments, Projects.

Prerequisites:

CSI 201, MAT 214, or equivalents, or permission of instructor. PHY 509 or equivalent programming experience with permission of the instructor.

REQUIRED READINGS:

Data Analysis: A Bayesian Tutorial by Sivia and Skilling, 2nd Edition
<https://www.amazon.com/Data-Analysis-Bayesian-Devinderjit-Sivia/dp/0198568320>

What is your model?: A Bayesian tutorial by Romke Bontekoe, 2023
<https://www.amazon.com/What-your-model-Bayesian-tutorial/dp/B0BTNVR65>

Required Readings will be posted on the course website and schedule at:
<https://knuthlab.org/courses/2025/BayesianDataAnalysis/>

Software Packages:

MatLab Release 14 or Later: Student Edition
<https://www.mathworks.com/academia/tah-portal/the-university-at-albany-40540791.html>

Recommended Readings:

Bayesian Probability Theory: Applications in the Physical Sciences by Wolfgang Von der Linden, Volker Dose, and Udo von Toussaint, 2014
<https://www.amazon.com/Bayesian-Probability-Theory-Applications-Physical/dp/1107035902>

Recommended readings will be posted on the course website and schedule at:

<https://knuthlab.org/courses/2025/BayesianDataAnalysis/>

Course outline:

Details to be provided on the course website:

<https://knuthlab.org/courses/2026/BayesianDataAnalysis/>

GRADING:

This course is A-E graded and the grades are determined based on graded Written and Programming Homework Assignments, the Exam scores, and the Final Project grade (if applicable):

*Undergraduate Students are graded according to the Undergraduate Grading Scale.
Graduate Students are graded according to the Graduate Grading Scale.
Undergraduates who take on a Final Project are graded by the best result from the Undergraduate and Graduate Grading Schemes.*

Undergraduate Grading

Written HW	35%
Programming HW	35%
Quizzes	10%
Exam	20%

Graduate Grading

Written HW	25%
Programming HW	25%
Quizzes	10%
Exam	20%
Final Project	20%

The **Undergraduate Final Grade** will be based on a scale of 100 points:

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E
100-90	90-87	87-83	83-80	80-77	77-73	73-70	70-67	67-63	63-60	60-57	57-0

The **Graduate Final Grade** will be based on a scale of 100 points:

A	A-	B+	B	B-	C+	C	C-	D+	D	E
100-90	90-87	87-83	83-80	80-77	77-73	73-70	70-67	67-63	63-60	60-0

Policies:

Attendance Policy:

I will be taking attendance in this class (both in-person and online). Students with better than 80% attendance will have their letter grade increased to the next grade (with two exceptions). For example, a C+ would be upgraded to a B-, a B- would be upgraded to a B. However, an A being the maximum letter grade would have to remain an A. Similarly, an E will stay an E.

Missed Exams and Assignments:

It is expected that each student will submit homework in a timely manner, and perform their own work on homework. Homework submitted by 11:59pm on the Due Date will be graded for 100 points. An assignment can be turned in from 1-3 days after the Submission Date for 90 points. An assignment can be turned in from 4-7 days after the Submission Date for 75 points. Assignments turned in more than 7 days after the Submission Date will receive 0 points. Both the lowest Written Homework Assignment score and the lowest Programming Assignment score will be dropped meaning that one can miss one Written Homework Assignment and one Programming Assignment without consequence.

Missed Quizzes cannot be made up. With a written excuse, one missed quiz can be dropped.

If there is an emergency and MidTerm Exam is missed, the student should notify the instructor beforehand (an email is sufficient) along with DOCUMENTATION of the nature of the emergency (Doctor's letter etc.). If notified beforehand or with documentation, the instructor will arrange a make-up exam. Otherwise, a missed Exam counts for a ZERO.

Disability Policy: Reasonable accommodations will be provided for students with documented physical, sensory, systemic, medical, cognitive, learning and mental health (psychiatric) disabilities. If you believe you have a disability requiring accommodation in this class, please notify the Disability Access and Inclusion Student Services (<https://www.albany.edu/disability>, 518-442-5501; daiss@albany.edu). Upon verification and after the registration process is complete, DAISS will provide you with a letter that informs the course instructor that you are a student with a disability registered with the DAISS and list the recommended reasonable accommodations.

Extra Credit:

There are no Extra Credit opportunities for this course.

Instead Focus on Credit!

Withdrawal from the Course: The drop date for the Fall 2025 semester is **December 7**. That is the last date you can drop a course and receive a 'W'. It is your responsibility to take action by this date if you wish to drop the course. In particular, grades of "incomplete" will not be awarded to students because they missed the drop deadline.

Cell phones & laptops: Please make sure your electronic devices are turned off before entering the classroom unless we are doing a class exercise where they are helpful. Use of phones, tablets, computers, etc. for non-class purposes **during** class will count against you in your class attendance grade. While you may be using computers in class, texting, using Facebook, *etc.*, are not appropriate uses of class time and your instructor-evaluated grade will suffer for it.

I/Incomplete: No graduation credit. A temporary grade requested by the student and assigned by the instructor ONLY when the student has nearly completed the course requirements but because of circumstances beyond the student's control, the work is not completed. The incomplete should only be assigned on the basis of an agreement between the instructor and the student specifying the work to be completed and establishing a general timeline in which the work will be completed. Incompletes may NOT be resolved by auditing or registering again for a subsequent offering of the course. The date for the completion of the work may not be longer than one month before the end of the semester following that in which the incomplete is received. Once the work is completed, the instructor assigns the appropriate academic grade.

The instructor may extend an incomplete for a maximum of one semester beyond the original deadline providing that the student has made contact with the instructor to request the extension. Additional extensions are NOT permitted.

Any grade of I existing after the stated deadline shall be automatically changed to E or U according to whether or not the student is enrolled for A-E or S/U grading. Except for extenuating circumstances approved by the Office of the Vice Provost for Undergraduate Education, these converted grades may not be later changed.

Important: Incompletes will not be given to students who have not fulfilled their classwork obligations, and who, at the end of the semester, are looking to avoid failing the course. This is asking for special treatment.

Academic Integrity: It is every student's responsibility to become familiar with the standards of academic integrity at the University. Claims of ignorance, of unintentional error, or of academic or personal pressures are not sufficient reasons for violations of academic integrity. See http://www.albany.edu/undergraduate_bulletin/regulations.html

Course work and examinations are considered individual exercises. Copying the work of others is a violation of university rules on academic integrity. Individual course work is also key to your being prepared and performing well on tests and exams. Forming study groups and discussing assignments and techniques in general terms is encouraged, but the final work must be your own work. For example, two or more people may not create an assignment together and submit it for credit. If you have specific questions about this or any other policy, please ask.

The following is a list of the types of behaviors that are defined as examples of academic dishonesty and are therefore unacceptable. Attempts to commit such acts also fall under the term academic dishonesty and are subject to penalty. No set of guidelines can, of course, define all possible types or degrees of academic dishonesty; thus, the following descriptions should be understood as examples of infractions rather than an exhaustive list.

- Plagiarism
- Allowing other students to see or copy your assignments or exams
- Examining or copying another student's assignments or exams
- Lying to the professor about issues of academic integrity
- Submitting the same work for multiple assignments/classes without prior consent from the instructor(s)
- Getting answers or help from people, or other sources (*e.g.* research papers, web sites) without acknowledging them.
- Forgery
- Sabotage
- Unauthorized Collaboration (just check first!)
- Falsification
- Bribery
- Theft, Damage, or Misuse of Library or Computer Resources

Any incident of academic dishonesty in this course, no matter how "minor" will result in

- No credit for the affected assignment.
- A written report will be sent to the appropriate University authorities (*e.g.* the Dean of Undergraduate / Graduate Studies)
- One of -
 - A final mark reduction by *at least* one-half letter grade (*e.g.* B → B-, C- → D+),

- A Failing mark (E) in the course, and referral of the matter to the University Judicial System for disposition.

All course material and documents developed by the instructor are copyrighted and may not be reproduced or distributed without express written permission.

Responsible Use of Information Technology:

<https://wiki.albany.edu/display/public/askit/Responsible+Use+of+Information+Technology+Policy>

Style Manual and Guidelines: Written assignments should be word-processed and double-spaced. Students are required to cite sources, if any are used in their written work, according to the American Psychological Association (APA).

American Psychological Association. 2020. *Publication manual of the American Psychological Association*, 7th Edition. Washington, DC: American Psychological Association.

Style manuals are available in the reference sections of many mainstream bookstores and reference sections of all 3 of the University Libraries. (BF 76.7 P83 2020)

[Purdue OWL](https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/reference_list_books.html) provides guidance the construction of citations in APA style. It is based on the 7th edition of the Publication manual of the American Psychological Association. Individuals in the social science disciplines primarily use this style guide. https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/reference_list_books.html

Time Management:

For every credit hour that a course meets, students should expect to work 2 additional hours outside of class every week (3 x 2= 6). For a three-credit course you should expect to work 6 hours outside of class every week. Manage your time effectively to complete readings, assignments, and projects.

Instructor Availability: The instructor will be available for student consultation during office hours, and by appointment. Students are expected to check their university email account at least once every day to see whether the instructor is trying to reach them. Students should not assume that instructor is online 24 hours a day, 7 days a week, to answer your questions immediately (even though the instructor will try to do so as much as possible).

Courtesy In class (online) discussions the instructor and students are expected to demonstrate professional behavior. This means cooperating and interacting in a courteous, supportive, and tactful manner based on mutual respect for each other's ideas.

Students and professor should be professional at all time. Faculty should be addressed as Prof. XXX or Dr. XXX. Emails should be addressed “Dear...” and end with a “Thank you.” Disrespect in any form in any CEHC class will not be tolerated.