

Memorandum

To: The Faculty of the College of Engineering
From: The School of Aeronautics and Astronautics
Date: January 29, 2025
Re: New Graduate Course, **AAE 56200 Aerospace Eng Probability and Estimation**

The faculty of the School of Aeronautics and Astronautics have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Course no. **AAE 56200 Aerospace Eng Probability and Estimation**
Fall, Lecture, Cr. 3

Description: The objective of this course is to introduce students to probability and estimation theory with a special emphasis on estimation of Gaussian random variables. An introduction to probability is presented which covers all the standard distributions, studies expectation and conditional expectation. The Google PageRank algorithm with some applications to data science is also presented. The course develops the mathematical background via the projection theorem in Hilbert space to study estimation theory. This provides the students with the background to study estimation problems in data science, robotics and GPS applications. This also sets the stage for developing the Kalman, Wiener and Levinson filter.

Reason: Probability and estimation theory plays a fundamental role in data science, robotics and GPS applications. This introductory course provides engineering students with the mathematical background to apply estimation theory to a variety of engineering applications. The course also develops the Google PageRank algorithm which plays a fundamental role in data science. The course provides the mathematical background necessary to derive and modify the Kalman filter, Wiener and Levinson filter which is widely used in engineering. The course provides complementary material for AAE 56000, AAE 56700, AAE 56800 AAE 66800 and AAE 57500.

William A. Crossley

J. William Uhrig and Anastasia Vournas Head of Aeronautics and Astronautics,
and Professor of Aeronautics and Astronautics

Enrollment History – Previously taught as AAE 590 Aerospace Eng Probability and Estimation

	Enrollment		Fall 2021	2022 Fall	2023 Fall	2024 Fall
AAE59000 - Aerospace Eng Probability & Est PWL Enrollment	GR - Graduate School	IESE - Int Ecog Sci & Eng	1			
		AAEN - Aeronautics & Astronautics	14	19	22	33
		ENMG - Engineering Management				1
		CIVL - Civil Engineering			1	
	AE - School of Aero and Astro Engr Undergraduates	AAE - Aero & Astro Engineering	11	12	14	6
	Totals		26	31	37	40

	Fall 2021	2022 Fall	2023 Fall	2024 Fall	Totals
Undergraduate	11	12	14	6	43
Graduate	15	19	23	34	91
Grand Total	26	31	37	40	134

AAE 56200 Syllabus
Probability and Estimation
Theory for Aerospace Engineering

A.E. Frazho
Armstrong 3333
frazho@purdue.edu

1 Credit Hours: 3.00

This course presents an introduction to probability and estimation theory. The course also pays special attention to the topics necessary for studying Kalman filtering.

Topics include:

- Probability measure, conditional probability, and Bayes rule
- The gamblers ruin problem
- Pagerank and Google's search algorithm
- Random variables, distribution, and density functions
- The exponential, uniform and Gaussian random variables
- The binomial, Poisson random variables.
- Functions of a random variable
- Joint densities and distributions
- The Raleigh density
- The Box-Muller transformation
- Expectation, mean, variance standard deviation, and median
- Applications to Gaussian, exponential, binomial etc.
- Dream and cheating in Minecraft.
- The projection theorem and applications to least squares estimation
- Condition expectation
- Condition expectation of Gaussian random vectors and the orthogonal projection
- The central limit theorem
- Maximal likelihood estimation

2 Course Outcomes

On completing this course, the student shall be able to:

- Demonstrate a knowledge of probability measure and distributions.
- Know how to apply the classical distribution functions.
- Know how to apply the Google PageRank algorithm.
- Have a good understanding of mean variance and median in applications.
- Have a deep understanding of conditional expectation.
- Use the projection theorem to solve both linear and “nonlinear” estimation problem.

3 Class notes on Brightspace:

4 Course structure

- Class meets Tuesday and Thursday 1:30 pm - 2:45 pm ARMS 1103.
- Students are expected to show up for class.
- In general, I do not answer homework questions over e-mail. Please ask questions during class or office hours.
- Office hours Tuesday and Thursday before and after class, or by appointment.
- TA: Nathaniel P. Sailor
- Email: nsailor@purdue.edu
- TA office hours: ARMS B098.2
Monday: 12:30pm - 3:00pm
Friday: 12:00pm - 1:20pm

5 Grading

- Grades are A, B, C, D, F and no \pm grades.
- Grades are based on homework, exams and a final. The final is take home.
- The homework counts for 25% to 35% of the final grade depending upon the number of exams and projects. The lowest 2 homeworks will be dropped.
- The homework will be handed in by gradescope.
- Late homework will be accepted up to 48 hours after the due date and time, but a 10% penalty will incur for every 12 hours it is late. In other words:
0-12 hours late = 10% deduction
12-24 hours late = 20% deduction
24-36 hours late = 30% deduction
36-48 hours late = 40% deduction
After 48 hours, no late homework will be accepted unless there is a medical

reason; the late due date may be adjusted in such a case.

- The grading and distribution of grades in this course are done totally blind. I have no idea what student is associated with any score when assigning grades.

6 Academic Dishonesty

- Students can work together on solving homework problems.

However, each student must write up their homework solutions and Mat-lab code individually and cannot directly copy another student's work.

- **Students caught cheating on an exam or special take home exam will fail the course.**

Purdue's Academic Dishonesty Policy: Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, Student Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]

7 Grief Absence Policy for Students

Below is the University's Grief Absence Policy for Students:

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for misses assignments or assessments in the event of the death of a member of the student's family.

See the University's website for additional information:

http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

8 Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates

creativity, promotes the exchange of ideas, and enriches campus life. More details are available on our course Brightspace table of contents, under University Policies. The School of Aeronautics and Astronautics is also committed to a climate of inclusion; if you need to report an issue of hate or bias, you may use the link at the top right of our page here:

https://engineering.purdue.edu/AAE/aboutus/Diversity/index_html.

9 Students with Disabilities

The Disability Resource Center (DRC) is a resource for students and instructors.

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Purdue has assistance available to help you make learning materials accessible. Some examples include:

- Information on Universal Design for Learning.
- Guidance on creating accessible documents.

10 Emergency Preparation

Guidelines regarding ensuring access to emergency information:

- Keep your cell phone on to receive a Purdue ALERT text message.
- Log into a Purdue computer connected to the network to receive any Desktop Popup Alerts.
- If you have a “no cell phone” in class policy allow one or two students who have signed up for Purdue ALERT to keep their phones on to receive any alerts.

11 Mental Health Statement

On the recommendation of the University Senate, CAPS and the Dean of Students:

- If you find yourself beginning to feel some stress, anxiety and/or feeling slightly over-whelmed, try [WellTrack](#). Sign in and find information and tools at your fingertips, available to you at any time.
- If you need support and information about options and resources, please see the Office of the Dean of Students for drop-in hours (M-F, 8 am- 5 pm).
- If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support,

services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

12 Disclaimer

This syllabus is subject to change.