Noise in Devices and Communication Systems
EEL 4516, Sections CAMP
Class Periods: Monday/Wednesday/Friday 11:45 AM - 12:35 PM
Location: NEB 201
Academic Term: Fall 2022

Instructor:

Dr. John M. Shea
Email: jshea@ece.ufl.edu
Phone: (352)575-0740 (Text messaging is encouraged for short questions or to schedule an appointment)
Office hours: Monday 1:30 PM – 3:00 PM, Thursday 10:00 AM – 11:30 AM, or by appointment.
Office: 439 New Engineering Building

Supervised Teaching Students:

Please contact through the Canvas website

- Caleb Bowyer, c.bowyer@ufl.edu, Office: NEB 401, Office hours: Wed 4-5PM in NEB 409

- Guangyu Zhu, gzhu@ufl.edu, Office: NEB 446, Office hours: Wed 3-5PM in NEB 409

Course Description

(3 credits) Origin, characterization and measurement of random noise. Calculation of signal-to-noise ratios and probability of errors in communication systems.

Pre-requisites:

Course Objectives:

Upon completion of this course, the student should be able to

- Apply the axioms and corrolaries of probabilities to solve problems and ensure that answers are reasonable

- Understand apply combinatorics for experiments with equally likely outcomes

- Use random variables to model numerically valued random phenomena and use the probability-mass, density, distribution functions to calculate probabilities

- Know and apply common random variables to model random phenomena

- Understand and use conditional probability to model dependent phenomena, to break problems down into simpler parts, and to make optimal decisions, using tools such as total probability, Bayes' law, MAP and ML detection, and MMSE estimation

- Understand how a function of a random variable transforms the probability to create a new random variable, and be able to determine the density, distribution, and expected value of functions of one or more random variables

- Determine the expected values, moments, variances, and covariances of random variables

- Use inequalities and bounds for probabilities that cannot be solved in closed form

- Use transform methods to simplify solving some problems that would otherwise be difficult

- Use the Karhunen-Loève transform to decorrelate random variables and use PCA for dimensionality reduction

- Build Monte Carlo simulations of random phenomena and understand how to choose the number of samples to make the estimates reasonable

- Understand stationarity and evaluate whether random processes are wide-sense stationary, covariance-sense stationary, strict-sense stationary, or none of these

- Characterize wide-sense stationary random processes using the mean, autocovariance, and autocorrelation functions

- Evaluate the power spectral density for wide-sense stationary random processes

- Analyze wide-sense stationary random processes in linear systems

- Give the matched filter solution for a simple signal transmitted in additive white Gaussian noise

Material and Supply Fees

Students pay a fee for taking a course that is offered on EDGE.

Relation to Program Outcomes

Not applicable

Required Textbooks and Software

- Course notes developed by the instructor will be provided in PDF form.

- Alberto Leon-Garcia, *Probability, Statistics, and Random Processes for Electrical Engineering*, Pearson Prentice Hall, 3rd ed., 2008 (ISBN 0131471228).

- John M. Shea, *Foundations of Data Science with Python*, online: https://jmshea.github.io/Foundations-of-Data-Science-with-Python (free)

- Python 3+ and Jupyter, Anaconda distribution strongly recommended (free)

- Wolfram CDF player (free)

- Both on-campus and off-campus students will need to use Learning Catalytics to complete interactive activities during the class. However, off-campus students must enroll in the off-campus section of Learning Catalytics. The cost is $12 per semester. Sign up here: https://learningcatalytics.com/

Recommended Materials:

- If you feel like you are having a hard time with basic probability, I suggest:

  - D. P. Bertsekas and J. N. Tsitsiklis, *Introduction to Probability*, 2nd ed., 2008 (ISBN 978-1-886529-23-6).
  - Sheldon Ross, *A First Course in Probability*, Prentice Hall, 8th ed., 2009 (ISBN 978-0136033134).

- For more depth on filtering of random processes:

  - Bruce Hajek, *Random Processes for Engineers*, Cambridge University Press, 2015 (ISBN 1107100127)
  - Michael B. Pursley, *Random Processes in Linear Systems*, Prentice Hall, 2002 (ISBN 0-13-067391-9)

- Additional Reference:

  - Athanasios Papoulis and S. Unnikrishna Pillai, *Probability, Random Variables and Stochastic Processes*, McGraw Hill, 4th ed., 2002 (ISBN 0-07-112256-7)

Course Shedule

(As time allows:)

- **Week 1**

  - Introduction to probability models & philosophies
  - Random experiments
  - Samples spaces and set operations
  - Combinatorial (counting) analysis

- **Week 2**

- Probability spaces and axioms of probability

- Statistical independence

- Mutually exclusive events

- Conditional probability

- Chain rule

- *Assignments:* Homework 1 Preparation Assessment, Homework 1

- **Week 3**

  - Total probability

  - Bayes' rule

  - Maximum likelihood and maximum *a posteriori* decision rules

  - Sequential experiments

  - The Poisson law

  - Single random variables and types of random variables

  - *Assignments:* Homework 2 Preparation Assessments, Homework 2

- **Week 4**

  - Distribution and density functions

  - Important random variables

  - Computing probabilities for Gaussian random variables

  - Point conditioning, total probability, Bayes' rule for continuous random variables

  - *Assignments:* Homework 3 Preparation Assessment, Homework 3

- **Week 5**

  - Multiple random variables

  - Joint and marginal distribution and density functions

  - *Assignment:* Homework 4 Preparation Assessment, Homework 4

- **Week 6**

  - Computing probabilities using joint distributions and densities
  - Conditioning with multiple random variables

  - *Assignment:* Homework 5

- **Week 7**

  - Functions of one random variable
  - One function of multiple random variables
  - Order statistics

  - *Exam 1*

- **Week 8**

  - Functions of several random variables
  - Generating random variables
  - Expected value of a random variable
  - Expected value of a function of a random variable
  - Moments of a single random variable: mean, variance, standard deviation, Nth moment, Nth central moment

  - *Assignment:* Homework 6

- **Week 9**

  - Poisson points
  - Expected value of function of multiple RVs: sum or RVs, product of RVs
  - Joint moments
  - Covariance and correlation coefficient
  - Bivariate jointly Gaussian random variables
  - Cauchy-Schwartz Inequality
  - Conditional expected value
  - Minimum mean-square error estimation

  - *Assignment:* Homework 7

- **Week 10**

  – Complex random variables
  – Transform methods: Characteristic and moment-generating functions, Laplace transform and probability generating functions
  – Applications of transform methods: determining moments, characterizing functions of random variables, sums of independent random variables
  – Markov and Chebyshev inequalities, Chernoff bound

  – *Assignment:* Homework 8

- **Week 11**

  – Laws of Large Numbers
  – The Central Limit Theorem
  – Random Vectors
  – Jointly Gaussian random vectors
  – Covariance matrices and properties
  – Decorrelating/whitening random variables and application to principal components analysis

- **Week 12**

  – Random processes
  – Moving average and autoregressive processes
  – Mean, autocorrelation, and autocovariance functions
  – Power at the output of a filtered random process

  – *Exam 2*

- **Week 13**

  – Properties of autocorrelation and autocovariance functions
  – Stationarity
  – Gaussian random processes
  – Multiple random processes

  – *Assignment:* Homework 9

- **Week 14**

  - Time-invariant filtering of random processes
  - Important classes of random processes
  - Power spectral density

  - *Assignment:* Homework 10

- **Week 15:**

  - Matched filters
  - Sampling random processes
  - Markov chains

- **Exam 3**: 12/13/2022 @ 3:00 PM - 5:00 PM

Attendance Policy, Class Expectations, and Make-Up Policy

Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Evaluation of Grades:

Grading will be based on three exams (25% each), Learning Catalytics (10%), selected homework problems (10%), and participation (5%). Participation includes all class-related interaction with the instructor (such as in class, in office hours, via email), as well as contributing to discussions on Canvas.

EEL 4516 students will have reduced problem sets on some homeworks and exams.

Homework sets will be graded on a spot-check basis: if I give ten problems, we may only grade two of them. Homework will be accepted late once, with an automatic 25% reduction in grade.

No formal project is required, but, as mention above, students will be required to use Python in solving some homework problems.

When students request that a submission (test or homework) be regraded, I reserve the right to regrade the entire submission rather than just a single problem.

Honor statements on tests must be signed in order to receive any credit for that test.

I understand that many of you will have access to at least some of the homework solutions. Time constraints prohibit me from developing completely new sets of homework problems each semester. Therefore, I can only tell you that homework problems exist for your benefit. It is dishonest to turn in work that is not your own. In creating your homework solution, you should not use the homework solution that I created in a previous year or someone else's homework solution. If I suspect that too many people are turning in work that is not their own, then I will completely remove homework from the course grade.

Collaboration on homework is permitted **and encouraged** unless explicitly prohibited, provided that:

1. Collaboration is restricted to students currently in this course.

2. Collaboration must be a shared effort.

3. Each student must write up his/her homework independently.

4. On problems involving programming, each student should write his or her own program. Students may discuss the implementations of the program, but students should not work as a group in writing the programs.

⚠ I have a zero-tolerance policy for cheating in this class.

If you talk to anyone other than me during an exam, I will give you a zero. If you plagiarize (copy someone else's words) or otherwise copy someone else's work, I will give you a failing grade for the class. Furthermore, I will be forced to bring academic dishonesty charges against anyone who violates the Honor Code.

Grading Policy:

Percent	Grade	Grade Points
90.0 - 100	A	4.00
87.0 - 89.9	B+	3.33
80.0 - 87.0	B	3.00
76.7 - 79.9	C+	2.33
70.0 - 76.6	C	2.00
60.0 - 69.9	D	1.00
0 - 59.9	E	0.00

Grades will be curved.

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at `https://gatorevals.aa.ufl.edu/students/`. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via `https://ufl.bluera.com/ufl/`. Summaries of course evaluation results are available to students at `https://gatorevals.aa.ufl.edu/public-results/`.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code." On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (`https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/`) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator

- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu

- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu

- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources

Health and Wellness

U Matter, We Care: Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the Office of Title IX Compliance, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus:
https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints:
http://www.distance.ufl.edu/student-complaint-process.