Department of Electrical Engineering and Computer Science
The University of Kansas

EECS 861- Signal and System Analysis

Fall 2024

Catalog Data: EECS 861 (3) Random Signals and Noise: Fundamental concepts in random variables, random process models, power spectral density. Application of random process models in the analysis and design of signal processing systems, communication systems and networks. Emphasis on signal detection, estimation, and analysis of queues. This course is a prerequisite for most of the graduate level courses in radar signal processing, communication systems and networks. Prerequisite: An undergraduate course in probability and statistics, and signal processing.

Prerequisites by Topics:

1. Probability and statistics.
2. Fourier Analysis
3. Signals and Systems
4. Signal Processing

Instructional Mode: In person class, 3153 LEA, TR 11:00-12:15 PM

Optional Discussion Sessions:

Usually scheduled for Monday 5:00-6:50 PM in 1136 Lea. Normally the session will be used for test reviews, make up classes, and as needed homework reviews. Will not meet every week; check class web site to find out if discussion session is meeting.

Textbook: Random Signals: Detection, Estimation and Data Analysis by K,S., Shanmugan and A. Breiphol, ISBN: 978-0-471-81555-6, January 1991

References: Probability, Statistics, and Random Processes for Electrical Engineering 3rd Edition by Alberto Leon-Garcia, 2008.
Probability, Random Variables and Stochastic Processes 4th Edition, by Athanasios Papoulis, 2002.
Harry L. Van Trees
Detection, Estimation, and Modulation Theory, Part I. New York: John Wiley and Sons, 1968.
Detection, Estimation, and Modulation Theory, Part II. New York: John Wiley and Sons, 1971.
Detection, Estimation, and Modulation Theory, Part III. New York: John Wiley and Sons, 1971.

Tools Used for Class Assignments:

Some homework assignments will require plotting, you can use MATLAB or another software tool for your choice

MATLAB: For plotting in MATLAB see Plotting Functions using fplot
https://www.youtube.com/watch?v=Xaos1ALprCQ
Creating stem plots in MATLAB https://www.youtube.com/watch?v=bWIzuYwwAbk
Excel
WolframAlpha https://www.wolframalpha.com
Any other plotting tool is acceptable, e.g., see Graphing Function
https://mathstat.slu.edu/~may/ExcelCalculus/sec-1-4-GraphingFunctionsExcel.html and
Online Graph Plotter
The demos plotter https://www.desmos.com/calculator

Wolfram CDF Player

Interactive documents
Installed on all EECS Windows computers
Free download available at http://www.wolfram.com/products/player/

Some homework assignments will require processing of .xls or .csv ("comma-separated values") files. You can use any tool for homework, e.g., MALAB, Excel, C, java, C++, other.

Class web page: http://www.ittc.ku.edu/~frost/EECS_861/index_EECS_861_Fall_2024.html

Course Objectives: Students will be able to:

1. Apply the foundations of Probability, with focus on
    a. Covariance and correlation
    b. Characteristic and Moment Generating Functions
    c. Multivariate random vectors
    d. Multivariate Gaussian random vectors
    e. Transformations of random variables
    f. Central Limit Theorem
    g. Bounds
2. Define and analyze Random Processes
3. Characterize Random Processes with
    a. Autocorrelation functions
    b. Power spectral densities
4. Determine the properties of Random Processes, including
    a. Stationarity (SSS and WSS)
    b. Ergodicity
5. Perform operations on Random Processes, including
    a. Integration
    b. Time Averaging
    c. Sampling
    d. Quantizing
    e. Decomposition
    f. Filtering
6. Understand the nature of common Random Processes, including
    a. Markov
    b. Poisson
    c. ARMA
    d. Gaussian white noise
7. Apply the concepts of Random Processes to
    a. Detection
    b. Estimation

Instructor: Victor S. Frost

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864-1028
vsfrost@ku.edu (e-mail is the best ways to contact me)
More information about me can be found at http://www.ittc.ku.edu/~frost/

Office Hours: 9:00 - 10:30 TR
1:00 - 2:00 TR
I am available outside of office hours: e-mail to confirm day/time

Computer Usage: Plotting. Interacting with CDF files for interactive content

Grading: The following percentages will be used to arrive at the final grade scores

Test 1	22.5%
Test 2	22.5%
Final Exam	35%
Homework	15%
Class Participation	5%

In class tests and the final will be open book and notes.

Final letter grades are determined from the final grade scores using

90 – 100%	A
80 – 89%	B
70 – 79%	C
60 - 69 %	D
0 – 59%	F

Lower limit on these ranges maybe reduced as a function of the distribution of the final scores. This class will **not** use +/- grading.

Homework:

1. Homework is intended to illustrate and reinforce concepts covered in class.
2. There is a strong correlation between the course grade and understanding concepts demonstrated in homework problems.
3. Homework assignments are posted on the class web site.
4. There will be approximately one homework assignment per week.
5. Collaboration with classmates is permitted. Copying is not permitted.
6. Each homework problem is counted as 10 points, e.g., an assignment with 6 problems will be 60 points.
7. Plots and graphs on homework should be generated by a computer tool, e.g., MATLAB.
8. Homework **must** be submitted in the specified format given at Homework Format
9. Homework is to be submitted on paper at the beginning of the class period.
10. Electronic submission of assignments is not permitted.
11. Solution will not be posted; any problem will be worked in class or during office hours upon request.

Quizzes: Quizzes maybe given at random and unannounced. Quiz scores will be counted as homework.

Make-ups: Make-up exams are given rarely, and only if:

1. I am informed IN ADVANCE, and
2. I deem the reason to be sufficiently meritorious (job interviews and pleasure trips are not). If the reason is illness, I REQUIRE documentation of the illness from a health-care professional.

Class decorum: The School of Engineering is a professional school, and the decorum in this class will reflect that. You are expected to arrive on time, leave on time, and act professionally in class. This includes being intellectually and physically involved in the class. Cell phones are **not** to be used in class. Use of tablets, and laptops during class is discouraged; tablets. Tablets and laptops may **only** be used in direct support of class activities. Texting, general web browsing, checking of e-mail is NOT permitted during class.

Video and audio recording of the EECS 861 class lectures is strictly prohibited.

Attendance Policy: Attendance at all class meetings is expected. Anything presented in class is considered required material. Academic success in this class requires: regular class attendance, doing the homework, and class participation. There is a strong correlation between attendance and the course grade.

Academic Misconduct: Instances of cheating will be referral to the Dean. Cheating includes, but is not limited to: copying another exam, copying of hardcopy or online solutions or previously worked homework or exam solutions, having another person do your work, use of "tutoring" websites like chegg.com.

Course Evaluation: A course evaluation will be available to students at the end of the semester.

Special Needs: Any student who has a disability that demands special accommodations should contact the Student Access Center at https://access.ku.edu/ in order to make arrangements. Also, members of KU sanctioned organizations (band, athletic teams, etc.) that have special needs should also contact the instructor as the need arises.

Course Schedule (subject to change)

No class October 3, 2024
No class November 5, 2024
Make classes TBD

Topic/Chapter

1. Probability (Chapter 2) ~ 4 weeks
    a. Axioms
    b. Random Variables
        i. Discrete
        ii. Continuous
    c. Distributions
        i. Marginal

        ii. Joint
        iii. Conditional
    d. Expect Value
    e. Characteristic and moment generating functions
    f. Random vectors and Multivariate Gaussian RVs
    g. Transformations of RVs
    h. Bounds and Approximations
2. Random Processes (Chapter 3) ~ 5.5 weeks
    a. Definition
    b. Example RPs

---------Likely time for Test 1

    c. Stationarity
    d. Autocorrelation function
    e. Power Spectral Density
    f. Ergodicity
    g. Decomposition of RPs
    h. Major classes of RP (Sections 5.2, 5.3, 5.4.1-5.4.2, 5.5)
3. Response of Systems to Random Inputs (Sections 4.1, 4.2 4.3.1-4.3.3) 2.5 weeks
    a. Discrete time systems

---------Likely time for Test 2

    b. Continuous time systems
4. Application of Random Process Theory ~ 3 weeks
    a. Detection (Chapter 6)
    b. Estimation (Sections 7.1, 7.2, 7.7, 8.4.1, 8.4.2, 8.4.5, 8.4.6, 8.4.7, 8.5.1)

Comprehensive Final Exam: December 16, 2024 10:30 a.m. - 1:00 p.m.

Late work: Assignments should be submitted on the indicated due date. I acknowledge that life happens, and sometimes a deadline cannot be met because of illness, caregiving responsibilities, work demands, mental health struggles, and emergencies. In these cases, I request that you contact me via email as soon as possible to arrange an alternative due date. I believe the material in this course is valuable, and I want to work with you so you can successfully complete the assignments. If I do not receive any communication from you before the assignment is due you will receive a 0 for late assignments.

Changes: Changes announced in class and on the class web page will supersede these written instructions.

IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

I. To uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities.

1. to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment;

2. to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems;

3. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;

4. to avoid unlawful conduct in professional activities, and to reject bribery in all its forms;

5. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, to be honest and realistic in stating claims or estimates based on available data, and to credit properly the contributions of others;

6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;

II. To treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others.

7. to treat all persons fairly and with respect, and to not engage in discrimination based on characteristics such as race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;

8. to not engage in harassment of any kind, including sexual harassment or bullying behavior;

9. to avoid injuring others, their property, reputation, or employment by false or malicious actions, rumors or any other verbal or physical abuses;

III. To strive to ensure this code is upheld by colleagues and co-workers.

10. to support colleagues and co-workers in following this code of ethics, to strive to ensure the code is upheld, and to not retaliate against individuals reporting a violation.

Important Resource and Policy Information

- Explanation of instructional time expected for out-of-class student work per credit:

see https://policy.ku.edu/registrar/credit-hour .

- Accommodations and/or information for students with disabilities:

see https://access.ku.edu/syllabus-statement .

- Sexual Harrassment Policy:

see https://policy.ku.edu/civil-rights/sexual-harassment .

- Nondiscrimination, Equal Opportunity, and Affirmative Action Policy:

see https://policy.ku.edu/IOA/nondiscrimination .

- KU Statement on Diversity and Inclusion: see https://policy.ku.edu/provost/diversity-inclusion .
- Academic Misconduct (USRR 2.7.1):

see https://policy.ku.edu/governance/USRR#art2sect6 .

- Change of Grade:

see https://policy.ku.edu/registrar/grade-change and

https://policy.ku.edu/governance/USRR#art2sect3 .

- Code of Student Rights and Responsibilities:

see https://policy.ku.edu/student-affairs/student-code .

- Commercial Note-Taking:

see https://policy.ku.edu/provost/commercial-note-taking .

- Mandatory Reporting:

see https://policy.ku.edu/civil-rights/mandatory-reporting .

- Racial and Ethnic Harassment Policy:

see https://policy.ku.edu/civil-rights/racial-ethnic-harassment-policy .