COURSE SYLLABUS

1 ECE 8072 - Statatistical Signal Processing

2 Meeting Information

3 credits, 3 contact hours Two 75-minute lectures

a. **Section 001:**
Lecture: Tuesday 06:10 pm to 08:50 pm, **CEER 212**
https://villanova.zoom.us/j/96862483018

b. **Section DL1:**
Lecture: Tuesday 06:10 pm to 08:50 pm, **CEER 212**
https://villanova.zoom.us/j/96862483018

3 Course Instructor(s), TA(s)

a. **Section 001:**

Class Instructor:	Dr. Mojtaba Vaezi
Office Hours:	Tuesday 5 pm to 6 pm, or by appt.
TA:	None

b. **Section DL1:**

Class Instructor:	Dr. Mojtaba Vaezi
Office Hours:	Tuesday 5 pm to 6 pm, or by appt.
TA:	None

4 Textbook

A. Papoulis and S. U. Pillai, *1. Probability, Random Variables, and Random Signal Principles, 4th ed.* , McGraw Hill, 2002. OPTIONAL.

a. **Other Supplemental Materials:**
Lecture Notes and Handouts
H. Hsu, Schaum's Outline of Probability, Random Variables, and Random Processes, McGraw Hill, 1997.

5 Specific Course Information

a. **Catalog Description**
This is an advanced course on probability, random variables, estimation theory, and stochastic process, and will cover

- **Probability and random variables:** review of the probability theory, discrete and continuous random variables, functions and transformations of random variables, conditional and joint distributions, continuous and discrete distributions, mean, variance and higher order moments, and order statistics.

- **Estimation and prediction:** linear estimation, minimum mean square estimation (MMSE), parameter estimation, Baysian estimation, and maximum-likelihood estimation.
- **Convergence and limit theorems:** convergence in probability, convergence in mean square sense, convergence in distribution, laws of large numbers, and central limit theorem.
- **Random processes:** discrete-time random process, continuous-time random process correlation, stationary, non-stationary, and ergodic processes, independent and identically distributed (i.i.d.) processes, Poisson process, Markov chain, random walk, Wiener process, Brownian motion, spectral analysis, Gaussian process and response of linear systems to random processes.

b. **Prerequisites:** An undergradute course on probability; **Co-requisites:** None

c. Required for MS/PhD in Signal Processing and Communications (SPC)

6 Course-specific Goals

a. At the end of the course, the students will be able to:

- Understand the basic principles of probability, probability axioms, independence, conditional probability, Bayes theorem and use these principles in solving problems.
- Characterize probability distributions of different functions of random variables and find their expected value, variance, and moments.
- Explain the difference between deterministic and stochastic signals providing examples in the context of signal processing and communications.
- Understand and reflect on the implications of the laws of large numbers and the central limit theorem in the context of signal acquisition and analysis.
- Apply the linear, maximum likelihood and Bayesian estimations methods to solve problems concerning the estimation of signal parameters.
- Understand and explain the use of Markov chains and process in signal processing, communication and machine learning.

7 List of Covered Topics

1. Introduction to probability and random variables
2. Functions of random variables, multivariate random variables
3. Expectation, moments, correlation and covariance
4. Continuous and discrete distributions, Gaussian distribution
5. Random vectors, random sequences, order statistics
6. Mean square estimation, parameter estimation, and maximum likelihood estimation
7. Convergence, laws of large numbers, and central limit theorem
8. Stochastic processes (Poisson process, random walk, ...)
9. Stationary processes, ergodic process, white noise process
10. Markov processes and Markov chains

8 Tentative Schedule

Tentative schedules for all sections follow. Be sure to refer to the schedule for your specific section, if more than one is provided.

Tentative Schedule for **All Sections**

Week	Date	Topics and Reading	Due
1	8/24	Lecture 1: Introduction to Probability Theory	
2	8/31	Lecture 2: Random Variables	HW1
3	9/7	Lecture 3: Functions of One Random Variable	
4	9/14	Lecture 3: Functions of Two Random Variables	HW2
5	9/21	Lecture 5: Vector Random Variables/Order Statistics	
6	9/28	Lecture 6: Conditional Statistic	HW3
7	10/5	Lecture 7: Covariance and Correlation	Midterm Exam
8	10/12	Fall break	
9	10/19	Lecture 8: MMSE Estimation	Paper title
10	10/26	Lecture 9: Parameter Estimation	
11	11/2	Lecture 10: Convergence and Limit Theorems	HW4
12	11/9	Lecture 11: Random Processes	
13	11/16	Lecture 12: Stationary Random Processes	HW5
14	11/23	Lecture 13: Markov Processes and Chains	
15	11/30	Course Review/Students' Presentations	Presentations
16	12/7	Final Exam	HW6/Final Exam

9 Grading Policy

Homework 30%, Midterm Exam 20%, Final Exam 30%, Presentation 20%
Letter grade scale:

$A(94-100), A^-(90-93), B^+(87-89), B(83-86), B^-(78-82), C^+(74-77), C(70-73), F(<70)$

10 HW Assignment and Laboratory Report Submission Policy

- Assigned on Tuesday, due the following Tuesday at 5pm.
- Make sure that the answers are in order and the solutions are neat and readable (if handwritten). Please submit your work in one pdf file.

11 Attendance Policy

Whenever possible, students should inform the instructor if they plan to be late or absent from class. In all cases, documentation is required to petition for *excused* absences to the Associate Dean for Student and Strategic Programs, Dr. Stephen Jones. The excused absence form is posted at: https://www1.villanova.edu/villanova/engineering/resources/undergraduates.html.

Excused absences do not count towards a failure in the course for first year students. Absence from class does not release the student from assigned work. Students who miss an in-class obligation such as an exam, a presentation, etc., due to an excused absence will not be penalized - the instructor may offer a make-up test, arrange an alternative time for a presentation, exempt a student from the assignment, or provide another arrangement. In the case of illness or injury, the form must be submitted within 24 hours of missing a class. The University's list of excused absences for all students includes the following:

1. Participation in NCAA athletic competitions
2. Participation in special academic events such as: conferences, field trips, project competitions, etc., and in official university business such as student representatives attending meetings related to university governance
3. Attendance at significant events of the immediate family such as: funerals, weddings, etc.
4. Religious holidays - see the University's policy on Religious Holidays
5. College-approved participation in placement activities such as: job interviews, graduate school interviews, job fairs
6. Legally required absence such as: jury duty, court appearance, short-term military service
7. Documented serious illness or disability

12 Examination Policy

The College of Engineering has adopted the following general examination guidelines:

1. Students must arrive before the start of the examination. Under exceptional circumstances a student may need to arrive late, but he/she can enter the examination room no later than five (5) minutes after the start of the exam.
2. Cell phones must be turned off until the student exits the examination room.
3. The official Villanova class attendance policy must be followed when requesting excuses for absences or lateness to an examination.
4. Each student must write and sign the following statement, "I have neither given nor received any unauthorized assistance in the completion of this examination."
5. For online examinations, the instructor may implement video proctoring or other measures to ensure academic integrity. For consent purposes, the instructor will inform students in advance if (s)he plans to use any form of video-proctoring and whether the examination will be recorded.

13 Academic Integrity Policy

The College of Engineering is committed to creating an environment of academic integrity and ethical decision-making that we hope is reflected in the actions of our students and graduates. As Villanova students, integrity is central to the University mission. As engineers, our code of conduct requires us to place honor and integrity at the forefront of everything we do. As engineering

students, it is expected that you will begin to adopt these values and instill them into your work habits. Students violating the academic integrity policy will receive a zero on that assignment or exam and the violation will be reported to the Associate Dean for Academic Affairs. The University's academic integrity policy can be found on the following web page:
https://www1.villanova.edu/villanova/provost/resources/student/policies/integrity.html.

14 Adherence to the Student Code of Conduct

Students are expected to act in a professional and respectful manner to their fellow students, faculty, and staff. Students should become acquainted with and understand the responsibilities set forth in the Student Handbook, especially those in the sections on Policy and Regulations. Adherence to university regulations is expected and required for successful completion of the program of studies. Enforcement within the classroom of policies regarding classroom behavior is the responsibility of the faculty member. All other discipline problems are to be referred to the Dean of Students.

15 Online Expectations

To foster a professional environment, please wear appropriate clothes, mute if you are not talking to cut down on background noise, refrain from eating, and select an appropriate setting when we are meeting online.

16 Inclusive Classroom

This classroom is a place where you will be treated with respect; we welcome individuals of all ages, backgrounds, beliefs, ethnicities, gender, gender identities and expressions, sexual orientation, and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment to allow all among us to learn and flourish.

17 Students with Disabilities

It is the policy of the university to make reasonable academic accommodations for qualified individuals with disabilities. If you are a person with a disability (non-physical) please register with the office of Learning Support Services (LSS) by emailing Learning.support.services@villanova.edu or by phoning 610-519-5176 as soon as possible. Registration is *required* in order to receive accommodations.

The Office of Disability Services (ODS) collaborates with students, faculty, staff, and community members to create diverse learning environments that are usable, equitable, inclusive and sustainable. The ODS provides Villanova University students with physical disabilities the necessary support to successfully complete their education and participate in activities available to all students. If you have a diagnosed disability and plan to utilize academic accommodations, please contact and register with Gregory Hannah, advisor to students with disabilities at 610-519-3209 or visit the office on the second floor of the Connelly Center.

18 Tutoring Services

Villanova's tutoring services include The Writing Center, The Learner's Studio, and The Center for Speaking and Presentation. These services are offered free of charge to students. Drop in as-needed or book a regular weekly session to supercharge your academic success. Sessions can be 30 or 60 minutes in length.

Register for an account and book sessions in advance at villanova.mywconline.com. If you don't see your class listed, request a tutor for a missing subject at: tutorrequest.villanova.edu For more information, contact Juliana Struder at juliana.studer@villanova.edu or at 610-519-5862.

19 Electronics Policy

The use of electronic devices, such as phones, laptops, tablets, calculators, etc., during class is generally allowed, unless their use causes a disturbance to others. During examinations, the use of any electronic device is prohibited, unless it is expressly authorized by the instructor.

Students are prohibited from making any audio or visual recordings (including taking photographs) of lectures, discussions, or other classroom activities, unless a student (1) has written permission in advance from the instructor, or (2) is permitted to record under terms and conditions as approved by the University's Office of Disability Services or Learning Support Services. Students who have received approval to record classes as an academic accommodation must provide supporting documentation from the Office of Disability Services or Learning Support Services in advance of any recording. Students may use authorized recordings only for the purposes of individual study in the course, and may not disseminate or share them with a wider audience without explicit permission.

20 Copyright Policy

The materials used in Villanova University courses ("Course Materials") generally represent the intellectual property of course instructors, third parties and/or the university which may not be disseminated or reproduced in any form for public distribution (e.g., sale, exchange, etc.) without the written permission of the course instructor. Course materials include all written or electronic documents and materials, including syllabi, current and past examination questions/answers, and presentations such as lectures, videos, slides, etc., provided by a course instructor. Course materials may only be used by students enrolled in the course for academic (course-related) purposes.

Published course readings (book chapters, articles, reports, etc.) available in "Blackboard" are copyrighted materials. These works are made available to students through licensed databases or fair use. They are protected by copyright law, and may not be further disseminated or reproduced in any form for distribution (e.g. uploading to websites, sale, exchange, etc.) without the permission of the copyright owner.

Follow these links for more information on Intellectual Property, Copyright, and Computer Acceptable Use.

21 Professorial Duties

It is important to note that teaching is one of the many duties that professors perform as part of their job responsibilities. In addition to teaching, professors perform research, advise graduate students, edit journals and review journal articles, serve on committees for the university and professional societies, travel to conferences to remain abreast of current developments and to present their results... to name just a few commitments.