ECE 604 : Stochastic Processes
Fall 2024

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Lecture Schedule: Mondays and Wednesdays from 10.00-11.20 in EIT 3141

There will be no lectures on Nov 28 and Nov 30. Make-up lectures will be scheduled after consultation with the class.

Midterm date: October 21, 2024.

Class website: Waterloo LEARN

Office hours: When not busy in my office or by appointment (please send me an e-mail to set up an appointment).

Pre-requisite: ECE316 or an undergrad probability course

Aims: Stochastic processes is a core course for graduate studies in electrical engineering and a must for those who wish to specialize in communications, controls, signal processing, and networking. The subject matter is also very useful for other fields such as machine learning, financial engineering, operations research, and algorithm design.

The principal aim of this course is to introduce the students to a rigorous and fairly comprehensive view of probability, random variables and random signals (or stochastic processes). The first part of the course will begin with a comprehensive view of probability and random variables. The notions of conditional probabilities and expectations will be studied. Once the basics have been seen we will then study important results needed in the study of random phenomena as they present themselves in the modeling of signals and noise namely the notions of independence, normality etc. Based on these we will then study key results such as the Central Limit Theorem, Laws of Large Numbers and convergence concepts. The latter third of the course will be devoted to the study of important signal models especially the so-called theory of wide sense stationary processes. The course will conclude with an introduction to Markov chains that are very versatile processes for modeling and algorithmic development.

The overall aim is to provide the student with a good understanding of the underlying structure associated with stochastic processes particularly as models of signals and systems, and learn the principal tools to work in applications involving stochastic phenomena.

COURSE OUTLINE

1. Review of Probability: Distributions, Expectations, Conditioning, Bayes' Theorem, Independence, Random Variables, Bounds: Markov, Chebychev, Chernov. Borel-Cantelli Lemmas.

2. Discrete-probability– counting arguments, branching processes.

3. Gaussian Random Variables, Conditioning, Conditional Expectation

4. Stochastic Processes : Classification: Gaussian, Poisson, Markov, structure of Gauss-Markov processes. Stationarity- Weak and strong laws. CLT, Convergence, Ergodic Theorems.
5. Wide sense stationary processes- L2- Theory of Stochastic Processes: AR and MA Approximations. Wold decomposition and prediction of 2nd. order stationary processes. Bochner's Theorem, Spectral Theory, Shannon sampling, Karhunen-Loeve Expansions.
6. Independent increment processes: Wiener process, Poisson Processes.
7. Discrete Markov chains: Classification, invariant distributions, ergodicity. Applications.

TEXT AND REFERENCES

There is no text for this course. Typed class notes will be available on the course website . The notes are fairly detailed.The following references are useful to expand on the notes

References:

There are a number of books that cover the material but with variable treatment of the topics. The following are two very good books that may serve as useful references:

1. P. Bremaud, Probability Theory and Stochastic Processes, Universitext Series, Springer-Verlag, 2020 (This is an excellent and very recent book. My notes are very similar to the content of this book. Highly recommended as a reference.)

2. G. Grimmett and D. R. Stirzaker: Probability and random Processes, 3rd. Edition, Cambridge University Press, 2002. (Also an excellent book but a bit advanced and not enough on wide-sense theory)

Course Evaluation

Bi-weekly problem sets will be posted on the website. The solutions will be posted before the midterm and final, and discussed during problem solving sessions. It is in your interest to solve the problems given at the end of each chapter of the notes. The emphasis will be on understanding rather than formulae.

Marks distribution: Midterm= 40%, Final Exam = 60%

Auditors will be required to take the midterm exam and score around the mean for the class.

Additional remarks

- All exams will be open notes.
- If you miss the midterm exam no make-up exam will be given. If you have a valid reason then your final marks will be based on your performance in the rest of the course.
- Students are advised to be regular and attempt to solve the problem sets on their own.
- Dishonesty will be dealt with harshly according to the rules of the university.