

## Lecture Notes 0

### Course Introduction

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- EE 278 in EE Curriculum
- Statistical Signal Processing
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- Lecture Notes

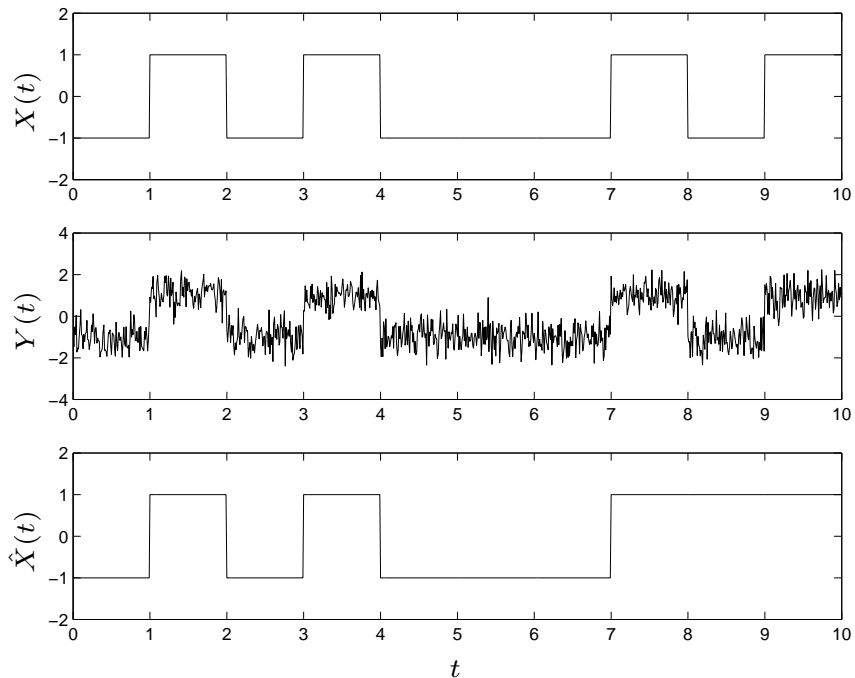
### EE 278 in EE Curriculum

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- EE at Stanford: five laboratories in two general areas:
  - Systems: emphasis on applications of *mathematics* to EE
    - Computer Systems Lab (CSL)
    - Information Systems Lab (ISL)
    - Space, Telecommunications, and Radioscience Lab (STAR)
  - Devices: emphasis on applications of *physics* to EE
    - Solid State and Photonics Labs (SSPL)
    - Integrated Circuits Lab (ICL)
- EE 278 is one of three *core* ISL graduate courses
  - EE 261 and EE 263 deal with *deterministic* (linear) systems
  - EE 278 deals with *statistical* systems
- EE 278 is also prerequisite to many STAR lab courses and provides good background for other areas (e.g., study of noise in circuits)



- Very simple case:  $h(t) = \delta(t)$ ,  $X(t)$  binary waveform



## Course Goal

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- To provide the probability and statistical signal processing background for many ISL and STAR lab courses:
  - provide relevant probability and random processes background
  - introduce basic channel models
  - introduce basic detection and estimation
  - have fun with lots of *neat* probability and statistical signal processing problems (and tricks!)
- Courses that require EE278 as prerequisite include:
  - communications courses: EE276, EE279, EE376A,B and EE379A,B,C,
  - signal and image processing and estimation courses: EE378, EE355, EE359, EE363, EE368
- EE 278 may not provide sufficient background for research in communication or signal processing; more advanced and mathematical courses, e.g., Stats 217, 218, 310A,B,C may be needed

## Course Topics

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- **Basic probability and random variables:** Lectures Notes 1–5, lectures 1–7. Axioms, basic laws, conditional probability, Bayes rule, and independence. Random variables; probability mass function, cumulative distribution function, probability density function, joint, marginal and conditional distributions. Expectation; mean, variance, covariance and correlation. Inequalities; Markov and Chebyshev. Functions of random variables. Applications: Generation of random variables. Basic detection; MAP rule, minimum probability of error. Mean square error estimation. Linear estimation.
- **Random vectors:** Lecture Notes 6,7, lectures 8–11. Extending cdf, pdf, and pmf to more than two random variables. Independence and conditional independence. Covariance matrix. Gaussian random vectors. Convergence and laws of large numbers. Applications: Linear estimation—the vector case.
- **Random processes:** Lecture Notes 8,9, lectures 12–18. Definition and examples of discrete and continuous random processes: IID, random walk, independent increment processes, Gaussian random processes. Stationarity, autocorrelation function and power spectral density. White noise, bandlimited processes. Applications: Response of linear systems to random inputs. Noise analysis in circuits. Linear estimation; infinite smoothing.

## Lecture Notes

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- Help to organize and reduce note taking in lectures
- You will need to take some notes, e.g., clarifications, missing steps in derivations, solutions to additional examples
- Slide title indicates a topic that often continues over several consecutive slides
- Lecture notes + your notes + review sessions should be sufficient. (You may want to refer to textbooks for more explanations or different approaches)

## References

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The following books should be on reserve at Terman Library:

- Gray and Davisson, *An Introduction to Statistical Signal Processing*, Cambridge Press. Available through Prof. Robert Gray's webpage and EE 278 webpage.
- Leon-Garcia, *Probability and Random Processes for Electrical Engineers*
- Papoulis, *Probability, Random Variables and Stochastic Processes*. A great classical book but a bit too terse to use as a text. Some definitions are not consistent with modern probability and random processes and some proofs contain errors.
- Bertsekas and Tsitsiklis, Second Edition, *Introduction to Probability*. Text used in EE 178. Excellent for basic probability.