

Outline of Topics:

1. Review
 - a. Basics of Mathematical Deduction
 1. Necessary, Sufficient Conditions
 2. Proofs via contradiction, contraposition
 - b. Basics of Linear Algebra
 1. Linear independence of vectors (points in linear space)
 2. Range and Null space of the combination process
 3. Projection to Range/Null Space (orthogonality principle)
 4. Positive Definite Matrices
 - c. Basics of Probability
 1. Probability as a mapping, axioms, conditional probability
 2. Expectation, law of large numbers
 3. Moments, moment generating function

2. Random Processes
 1. Random variables, random vectors (or a sequence of random variables), moment descriptions (mean, variance, correlation), decorrelating transforms
 2. Random processes, stationarity, wide Sense Stationarity (WSS), power spectral density, spectral factorization, linear time invariant processing of WSS random processes, ergodicity

Ref: Therrien, Hayes, Papoulis, Ross

3. Signal Modeling
 0. LS methods, Pade, Prony (Deterministic methods)
 1. AR, MA, ARMA Processes (Stochastic approach), Yule-Walker Equations, Non-linear set of equations for MA system fit
 2. Harmonic Processes

Ref: Hayes, Papoulis

4. Estimation Theory Topics
 0. Random parameter estimation
 1. Cost function, loss function, square error, absolute error
 2. Conditional mean (regression line) as the minimum mean square error (MSE) estimator, orthogonality properties
 3. Linear minimum mean square error (LMMSE) estimators, orthogonality principle
 4. Regression line, orthogonality
 5. FIR, IIR, Causal-IIR Wiener filters
 6. Linear Prediction, backward prediction
 7. Random vector LMMSE estimation (multiple parameter)
 1. Non-random parameter estimation
 1. Maximum likelihood method
 2. Best Linear Unbiased Estimator (BLUE)
 3. Discussion of linear estimators for the linear observation model $y=Ax+n$
 2. Karhunen – Loeve Transform

Ref: Therrien, Hayes

References:

[Hayes]: M. H. Hayes, Statistical Signal Processing and Modeling, Wiley, New York, NY, 1996.

[Therrien]: C. W. Therrien, Discrete random signals and statistical signal processing, Prentice Hall, c1992.

[Papoulis]: A. Papoulis, Probability, Random Variables, and Stochastic Processes, 3rd edition, McGraw Hill, 1991.

[Ross]: S. M. Ross, Introduction to probability models, 7th ed. Harcourt Academic Press, 2000.