# *Tentative List of Topics* - EE623 Detection and Estimation Theory

1. Basics of Random Signals and Probability Analysis
2. Introduction to Signal Estimation
    a. *Parameterized Likelihood Formulation*
    b. *Optimal Estimation*
    c. *Mean and Variance Characterization*
3. Scalar Parameter Cramer-Rao Lower Bound
    a. *CRLB Derivation*
    b. *CRLB for Gaussian Estimation*
    c. *Practical Example: Communication Synchronization, CRLB*
4. Vector Parameter Cramer-Rao Lower Bound
    a. *Vector parameter estimation formulation*
    b. *Brief introduction to properties of positive definite and semi definite matrices*
    c. *Vector parameter CRLB derivation*
    d. *CRLB for Linear estimation in White Gaussian Noise*
    e. *Practical Example: Image Filtering*
5. Maximum-Likelihood Estimation
    a. *Optimal estimators for White and Colored Noise*
    b. *Examples and Applications*
    c. *MLE for parameter functions*
    d. *Sequential Least Squares*
    e. *Expectation-Maximization Algorithm and Examples*
6. Bayesian Estimation
    a. *Minimum Mean Squared Estimation*
    b. *Linear MMSE Approximation*
    c. *Wiener and Optimal MMSE filtering*
    d. *Bayesian Cramer-Rao Lower Bounds*
    e. *Maximum Aposteriori Estimation*
7. Kalman Filtering
    a. *Introduction to State-Space Modeling*
    b. *Introduction to Kalman estimation and tracking*
    c. *Derivation of the Forward and Backward Scalar Kalman Filter*
    d. *Extension to vector Kalman filter.*
    e. *Practical examples from Computer vision, robotics and Wireless Communications*
8. Introduction to Signal Detection

a. *Formulation of the binary hypothesis testing problem*
b. *Maximum Likelihood based Optimal Detection*
c. *Likelihood Ratio Test and Performance*
d. *Neyman Pearson Criterion for optimal detection*
e. *Minimum probability of error detector*
f. *Bayesian minimum risk detector*

9. Detection of Deterministic Signals
    a. *Matched Filter Detector*
    b. *Development of the optimal detector in white and colored Noise*
    c. *Performance of MF detection*
    d. *Multiple Hypothesis testing and asymptotic performance*
    e. *Practical examples: Synchronization, Face detection, Wireless Sensor Networks etc.*
10. Detection of Random Signals
    a. *Introduction of Random Signal Detection*
    b. *Derivation of the energy detector*
    c. *Estimator Correlator for Arbitrary covariance based optimal detection*
    d. *Performance analysis of Random signal detection*
    e. *Practical examples: Cognitive radio scenarios*
11. Signals with unknown Parameters
    a. *Deterministic Signals with unknown parameters*
    b. *Generalized Loglikelihood Ratio Test (GLRT)*
    c. *Bayesian Approach*
    d. *Practical Examples: Sinusoidal Detection*
    e. *GLRT for the Linear Model*
    f. *Asymptotic Performance of Energy Detection*
    g. *Asymptotic performance of GLRT for Linear Model*
    h. *Incompletely known Signal covariance based detection*
    i. *Weak signal detection*
12. Sequential and Model Change Detection
    a. *Sequential Likelihood Ratio Test*
    b. *Average number of Required Observations for Sequential Testing*
    c. *Introduction to Model Change detection*
    d. *Multiple Change time detection*
    e. *Time varying statistics based process detection*