Random Signals and Noise: Syllabus

Part A: Random Variables

- **Probability and Random Variables (two weeks)**
  - Review of basic definitions: probability space, axioms, engineering motivation
  - Review of basic properties for a single random variable
  - Characteristic function, moments
  - Law of large numbers
  - Functions of random variables
- **Random Vectors (two weeks)**
  - Bivariate random variables: joint, conditional and marginal distribution
  - Random vectors
  - Gaussian random vectors
- **Estimation (two weeks)**
  - Optimal estimation, error criteria
  - Minimum mean square error (MMSE) estimation
  - Linear MMSE (LMMSE) estimation

Part B: Random Processes

- **Definitions, Properties, Basic Discrete- and Continuous-Time Processes (one week)**
  - Introduction and basic definitions
  - Generating a random process (random parameter, i.i.d. process, recursive definition)
  - Joint distribution, autocorrelation function
  - Strict-sense and wide-sense stationary (SSS and WSS, respectively) processes
  - Gaussian processes
  - Examples: moving-average (MA), random-walk and autoregressive (AR) processes
- **Joint stationarity, Ergodicity (one week)**
  - Joint SSS (JSSS) and WSS (JWSS) processes
  - Ergodicity definitions
  - Mean-ergodicity and Slutsky's theorem
  - Ergodicity in autocorrelation
  - Examples of ergodic and non-ergodic processes
- **Power Spectral Density, Wiener Filtering, Power and WSS Process Passing Through Linear Time-Invariant Systems (one–two week)**
  - Definitions of power spectral density (PSD), and continuous- and discrete-time white noises
  - Joint stationarity of random processes
  - Random process passing through linear time-variant and linear time-invariant (LTI) systems
  - Linear MMSE estimation (Weiner filter)
  - Parallel processing of disjoint frequency bands
- **Processes with Independent Increments (one–two weeks)**
  - Random walk and first-order AR processes
  - Levy processes
    - Poisson process
    - Wiener process
- **Markov Chains (one week)**
  - Transition matrix, stationary distribution
  - Characterizing chains by state diagrams
- ***Time permitting:*** **Kalman filter (one week)**
  - MSE optimal linear estimation of vector first-order AR processes (Kalman filter)