Midterm Topics

1) Discrete-Time Signals: Sequence
    - Memoryless, LTI, Causality, BIBO Stability
    - Properties of LTI
    - Linear difference equations
    - Eigenfunctions for LTI Systems
    - Transform domain representation: DTFT
    - Properties of the DTFT: linearity, Time/Frequency shifting, time reversal, differentiation in frequency, Parseval's theorem, convolution theorem, modulation/windowing theorem
    - Symmetry properties of DTFT
    - Common DTFT pairs
2) z-Transform
    - Region of convergence
    - Common z-transform pairs
    - Properties of ROC for the z-transform
    - Pole location and time-domain behavior for causal signals
    - Inverse z-transform
        - table lookup or inspection
        - partial fraction expansion
        - power series expansion
    - z-transform properties: linearity, time shifting, multiplication by an exponential sequence, differentiation, conjugation of a complex sequence, time reversal, convolution, initial value theorem, final value theorem
    - Solving linear difference equations
3) Sampling of Continuous-Time Signals
    - Periodic sampling
    - Frequency-domain representation of sampling
        - Nyquist sampling theorem: $\Omega_s \geq 2\Omega_N$
    - Reconstruction of bandlimited signal from its samples
    - Discrete-time processing of continuous-time signals
    - Continuous-time processing of discrete-time signals
    - Change of sampling rate using discrete-time processing
        - Integer factor
        - Non-integer factor
    - Digital processing of analog signal
4) Transform Analysis of LTI Systems
    - Frequency response LTI systems
        - Magnitude, phase, and group delay
    - System functions for systems characterized by linear constant-coefficient difference equations
    - Frequency response for rational system functions
        - single zero or pole
        - second-order IIR
        - second-order FIR
    - Relationship between magnitude and phase
        - If $H(z)$ is causal and stable, then all its poles are inside the unit circle
    - Allpass systems
        - phase of allpass systems is non-positive for $0 \leq \omega < \pi$

- Poles and zeros form conjugate reciprocal pair

- Minimum phase system
  - system factorization: $H(z) = H_{min}(z)H_{ap}(z)$
  - stable and causal inverse systems
  - minimum phase lag, minimum group delay, minimum energy-delay properties
  - maximum phase system - all zeros outside the unit circle
- Generalized linear phase
  - symmetry: even and odd order
  - antisymmetry: even and odd order
- Causal generalized linear phase FIR systems
  - even order: $H\left(e^{j\omega}\right) = A_e\left(e^{j\omega}\right)e^{\frac{-j\omega M}{2}}$, $A_e\left(e^{j\omega}\right)$ is even and real
  - odd order: $H\left(e^{j\omega}\right) = A_o\left(e^{j\omega}\right)e^{\frac{-j\omega M + j\pi}{2}}$, $A_o\left(e^{j\omega}\right)$ is odd and real
  - Type I - IV systems
  - zeros form reciprocal pair: $z_0 = re^{j\theta} \Longrightarrow z_0^{-1} = r^{-1}e^{-j\theta}$
  - for real $h[n]$, zeros come in as conjugate pairs: $z_0^* = re^{-j\theta} \Longrightarrow (z_0^*)^{-1} = r^{-1}e^{j\theta}$
- Linear system factorization: $H_{linp}(z) = H_{min}(z)H_{uc}(z)H_{max}(z)$