DSAA Mid 1

- ✓ Basics
- ✓ Operations on Signals
- ✓ Characteristics of Signals
- ✓ Properties of a System
- ✓ Convolution
- ✓ Vector Algebra

Mid 1

- **Signal :** Function that conveys information about behaviour and attributes of some phenomenon.
- **Sampling -** While storing an analogue signal in digital media, it's sampled at fixed intervals are stored, the process is called ***sampling.***
  Discretisation of time-space — Sampling.
- Interval at which samples are recorded is called **sampling rate.**
- **Nyquist's Theorem :** A signal with maximum frequency **F** can be recovered accurately if it's **sampling frequency >= 2F**.
- **Quantisation :** The amplitude space is also discretised for storage, process called quantisation.
  Quantisation is a lossy process.
- Analogue to digital because-
  - Cheaper.
  - Allows for more sophisticated algorithms.
  - Easy storage, reproduction.
  - Modular and flexible.
  - Easy offline and remote processing.
- *Digital signals are slower than analogue to transmit though.*
- **Interpolation** : Digital to analogue conversion.
- **Aliasing :** A false signal, close enough to the real one.

- Reconstruction from quantised sample (Interpolation):
  Zero Order Hold : Keeping the original signal's value until a new value is reached.
  Nearest Neighbour : Value equal to the nearest neighbour, not

for realtime data. Delay with realtime.
Linear : Linear between points.
Sync : Some weird function.

- **Operations on Signals :**
  Shifting : x (n-2)
  Flipping : x (-n)
  *Scaling : x (b*n)*
  To be done precisely in this order Shift — Flip — Scale
- Scaling causes loss of info, to avoid this loss, while sampling, take a greater sampling frequency than 2F.

- **Characteristics of Signals :**
  Odd Even *— x (-n) = - x (n) , x (-n) = x (n)*
  Periodic *— x (N + n) = x (n)*
  Energy *— E = ∑ (-∞, ∞) | x(t) |^2*
  Power *— lim N —> ∞, ∑ (-N, N) 1/(2N + 1) * Energy*
  Unit *— x(n) = 1 for all n ≠ 0*
  ∂ (Delta) *— opposite of Unit*
  r (n) *— n for all n, 0 for 0*
  e (n) *— |a|^n * u (n)*

- **Properties of a Systems:** *(Averaging Filter given as example)*
  Causal vs Non-Casual
  Static vs Dynamic
  Linear (Must satisfy Additivity and Homogeneity)
  Time Invariance

- **Linear Time Invariant Systems -** Linear and Time invariant.
- **Impulse Response -** Characterises the system, can predict output for any given input to the system.

- **Convolution**
  - Derivation of convolution equation, and the equation itself. — **BLUE DENOTES NOTEBOOK**
  - That one convolution example in the notebook, for understanding how to convolve graphically.
  - Flipping and sliding for convolution — **zeroth value at overlap of centres.**
  - Matrix form for convolution.
  - **Algorithm for convolution in 2D.**

- **Properties of Convolution**
  - Commutative.
  - Distributive.
  - Associative

- Representing functions as flow diagram. *(Z^x) for delay.*
- Averaging Filter, equations and convolution.
- Gaussian averaging filter FORMULA for 1D and 2D.
- Moving average filter.
- Recursive moving average, equations and flow diagram.
- Recursive mean.
- Recursive Variance.
- **Linear Regression,** derivation + Polynomial regression.
- Proof that the line passes through means of x and y.

- **Sinusoids and Exponentials**
- Finding whether an expression is periodic, using **(*omega_not*)N = 2πk**
  N must be integral for integral K for periodicity.
- Complex Exponential generating machine.
- **Wagon Wheel Effect.**

- **Vector Spaces :** two rules for qualification. (*Additive Closure, and constant multiplicative Closure*)
- **Spanning Set** *of a Vector Space* **:** Any element defined as linear combination of other elements.
- **Linear Independence :** Statement expression.
- **Basis :** A linearly independent set which spans V is called the basis of V.
  Revisit Crammer's Rules
- **Inner Product:** Formula. **∑(i,N-1) u(i)v(i)** Vectors multiplied position by position then added.
- **Orthogonal :** If inner product of 2 vectors is 0, they are orthogonal.
- **Norm :** Inner product with itself.
- **Orthonormal :** If orthogonal, and vectors are unit vectors.
- **Theorem :** If a subset S of V, of non-zero vectors is orthogonal, then S is linearly independent. - **PRACTICE PROOF AGAIN**
- **Theorem of Orthogonal Decomposition -** See notes for expression and proof.