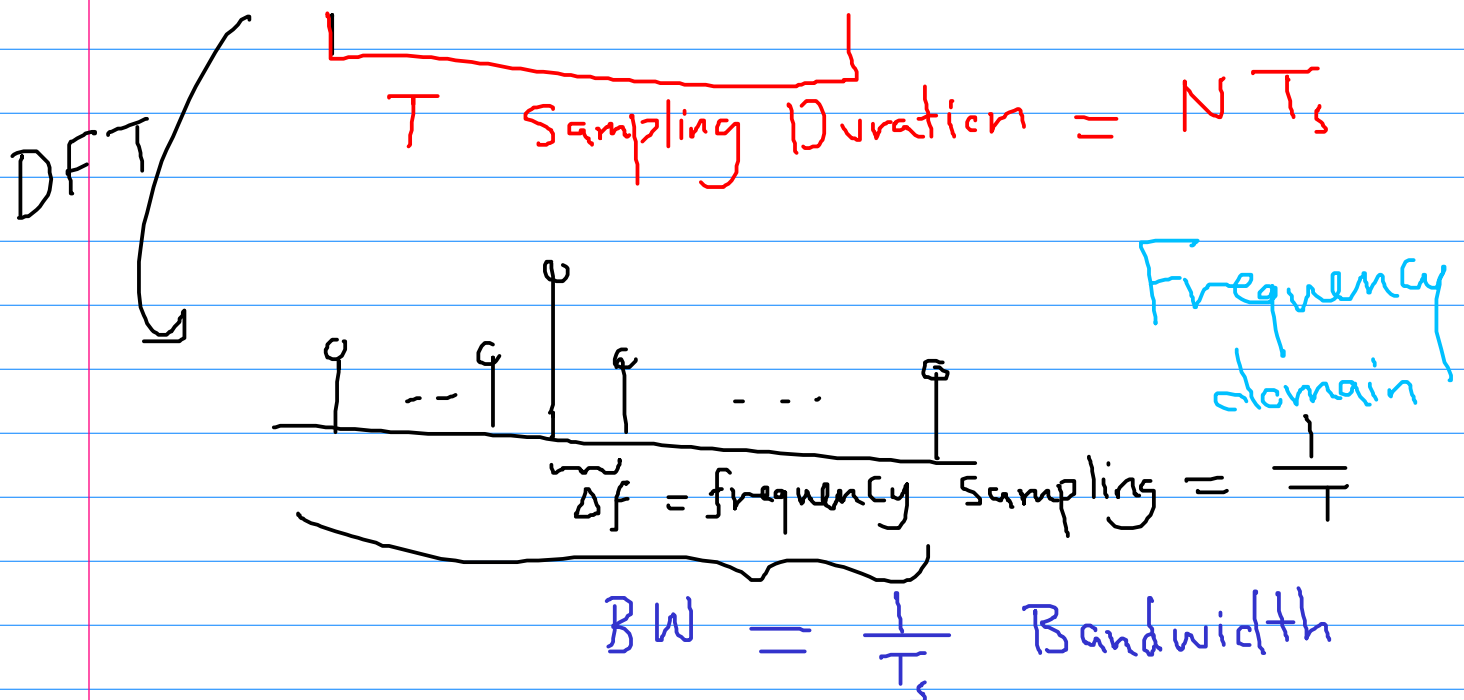
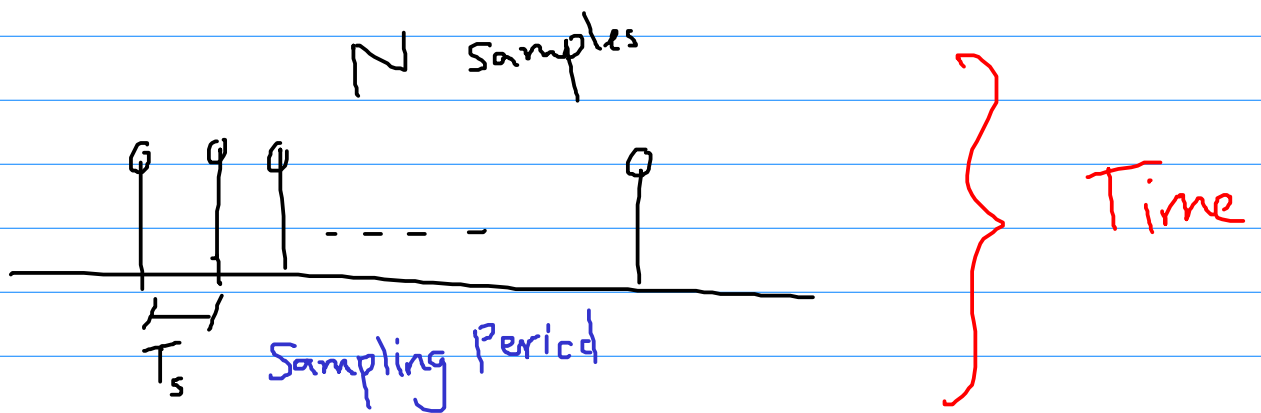
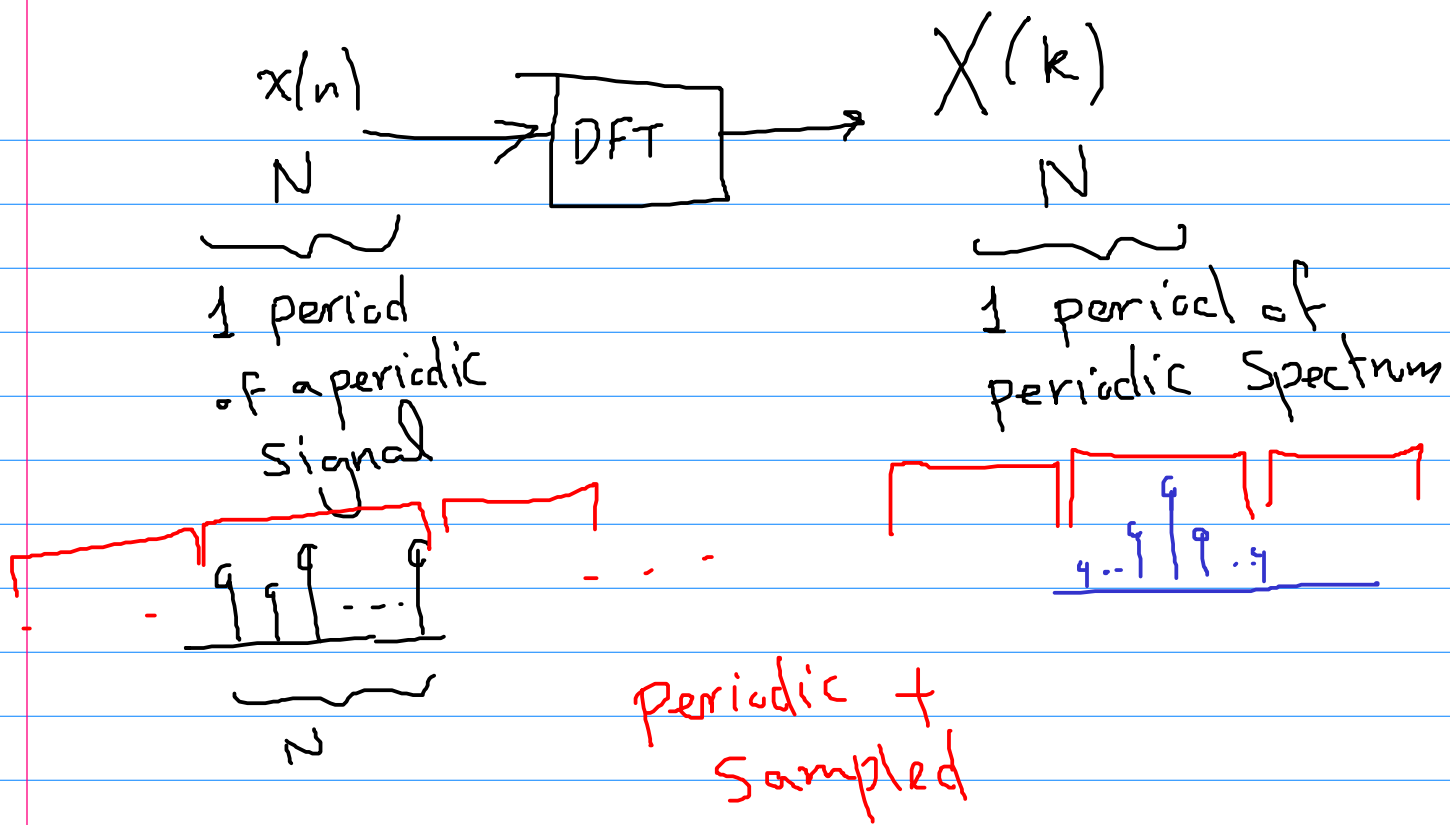
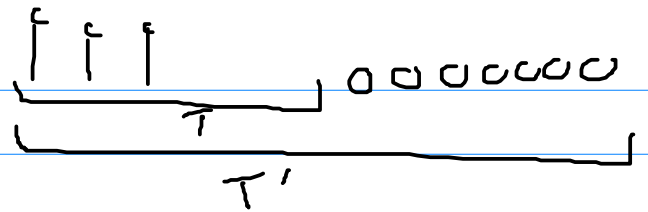




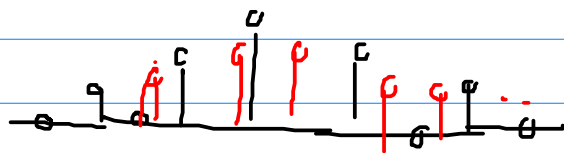
$$\Delta f \downarrow$$

$$= \frac{1}{T}$$

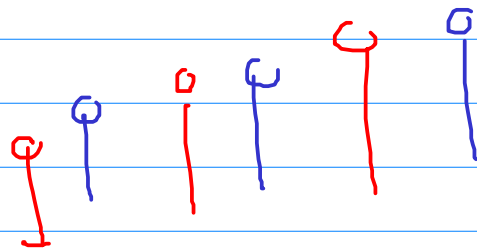


$\Delta f = \frac{1}{T'}$ $\Rightarrow$ higher resolution

Zero Padding $\rightarrow \uparrow T \rightarrow \downarrow \Delta f$



Interpolation

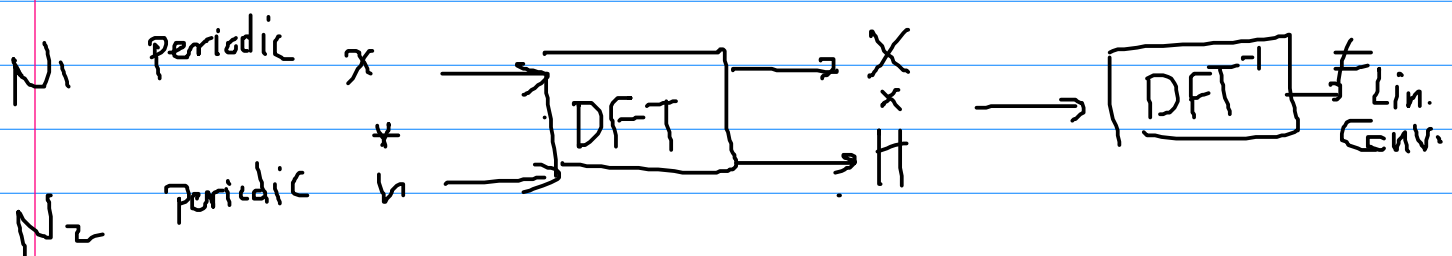
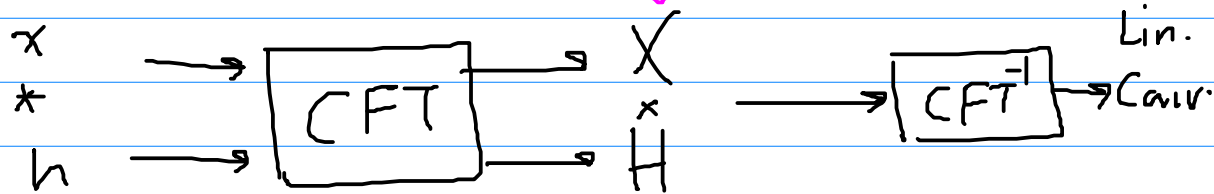
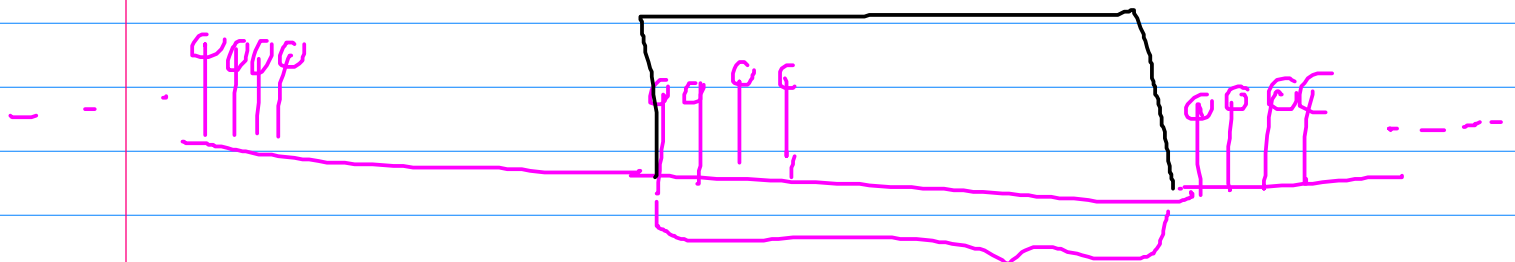
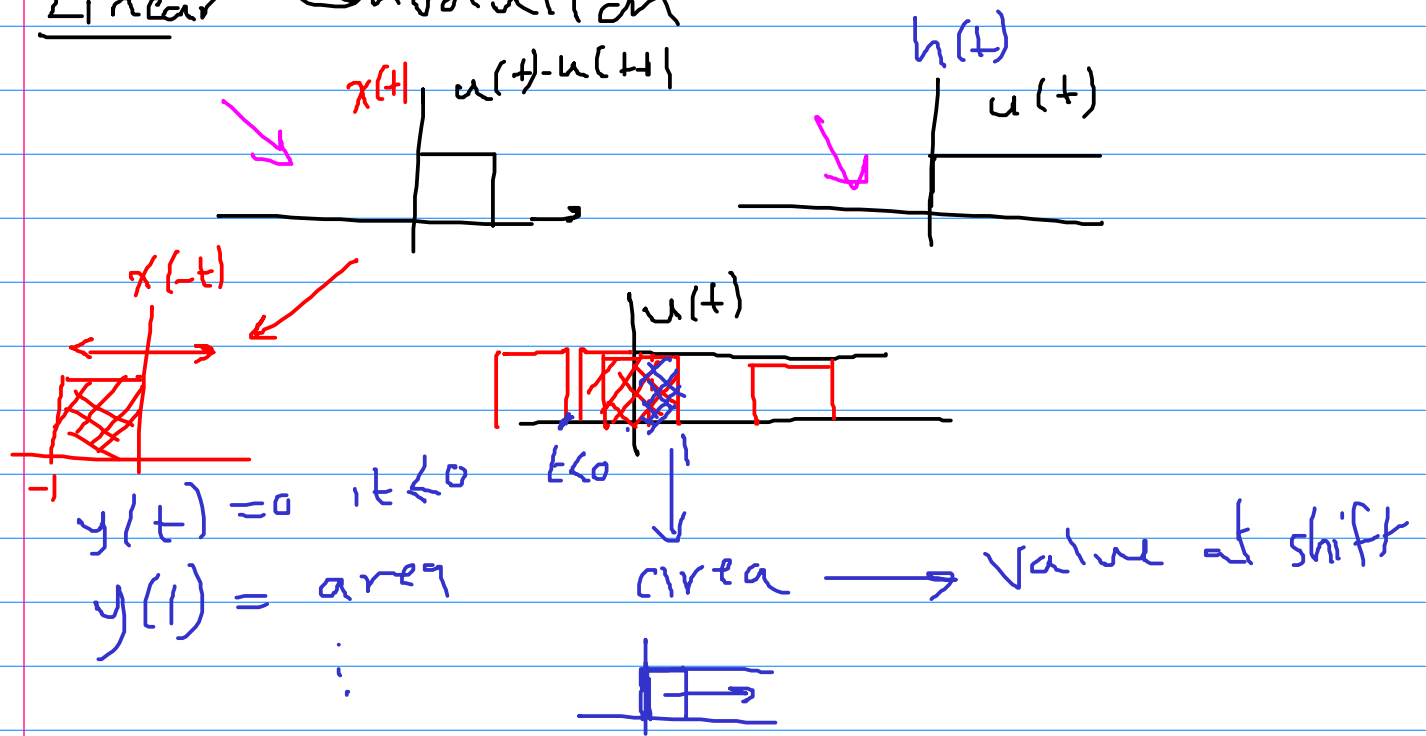


$2N$

$BW \uparrow \rightarrow \downarrow T_s \rightarrow$ higher time resolution

$$y(t) = x(t) * h(t)$$

Linear Convolution



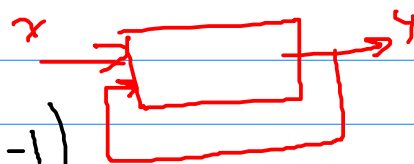
DFT
 zero padding
 $\geq N_1 + N_2 - 1$

$\rightarrow \checkmark$

Filter Concept

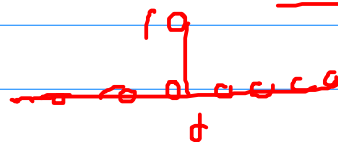


$$y_1(n) = 3x(n) + 1x(n-1)$$



$$y_2(n) = 1x(n) + 2x(n-1) + y(n-1)$$

$$x(n) = \delta(n)$$



$$y(-1) = 0$$

	non-recursive	recursive
n	y_1	y_2
0	3	1
1	2	2
2	0	2
3	0	2
	$\vdots$	$\vdots$
	0	$\vdots$

Finite impulse response

FIR

infinite impulse response
IIR

Z-Trans form

Laplace

$$\frac{d^2 y}{dt^2} + 2 \frac{dy}{dt} + y = \frac{dx}{dt} + x$$

$$Y(s) [s^2 + 2s + 1] = X(s) [s + 1]$$

$$H(s) \quad \checkmark$$

$$Y(s) \quad \text{For } X(s) = \frac{1}{s} \quad \checkmark$$

$$\begin{array}{ccc} x(n-n_0) & \xleftarrow{\mathcal{Z}} & z^{-n_0} X(z) \\ \frac{d^n y}{dt^n} & \xrightarrow{\mathcal{L}} & s^n Y(s) \end{array}$$

$$y(n) = 3x(n) - 2x(n-1) - y(n-1)$$

$$\downarrow \mathcal{Z}$$

$$Y(z) = 3X(z) - 2z^{-1}X(z) - z^{-1}Y(z)$$

$$Y(z) [1 + z^{-1}] = X(z) [3 - 2z^{-1}]$$

$$H(z) = \frac{3 - 2z^{-1}}{1 + z^{-1}}$$

recursive

$$\underbrace{3 - 2z^{-1}}_{\text{non-recursive}}$$

Example

$$H(z) = \frac{1 + 2z^{-1} + 3z^{-2}}{1 - z^{-1}}$$
$$\frac{Y(z)}{X(z)} = \dots$$

$$y(n) - y(n-1] = x(n) + 2x(n-1) + 3x(n-2)$$

