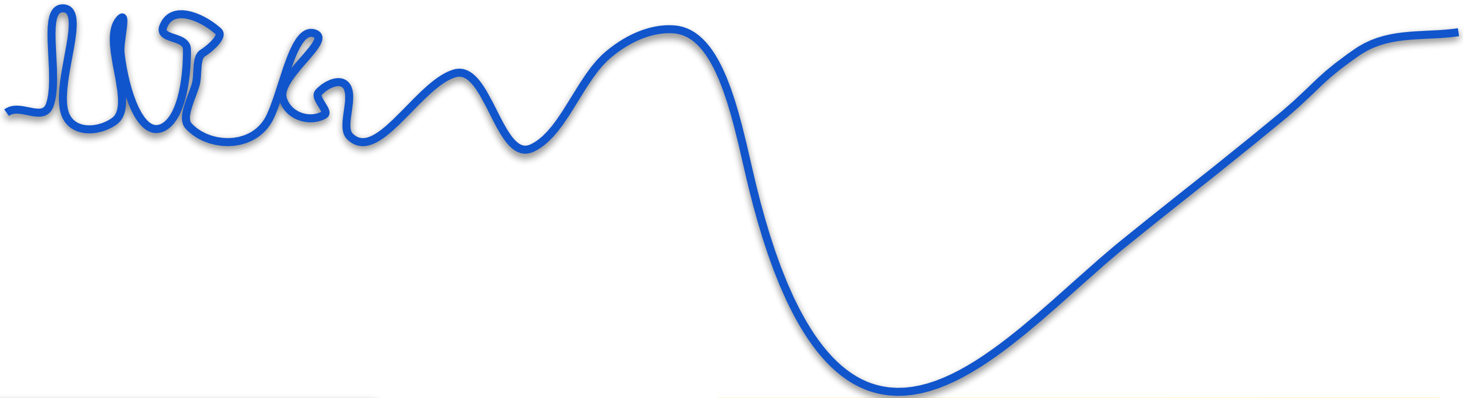
Computing with Signals



DA 623

Jan - May 2023

IIT Guwahati

Instructors: Neeraj Sharma

Lecture-19-[23-Feb]

Recap

- Continuous signals

Acknowledgement: Some figures in this presentation are borrowed from the book "The Fast Fourier Transform and its Applications", by E. Oran Brigham. These figures are used here only for educational purpose.

Recap

- Continuous signals
- Representations
  - Polynomial
  - Fourier series
  - Fourier Transform

Recap

- Continuous signals
- Representations
    - Polynomial
    - Fourier series
    - Fourier Transform
        - Convolution
        - Diracs, rect(), sinc(), train of Diracs
        - Frequency, Bandwidth

Recap

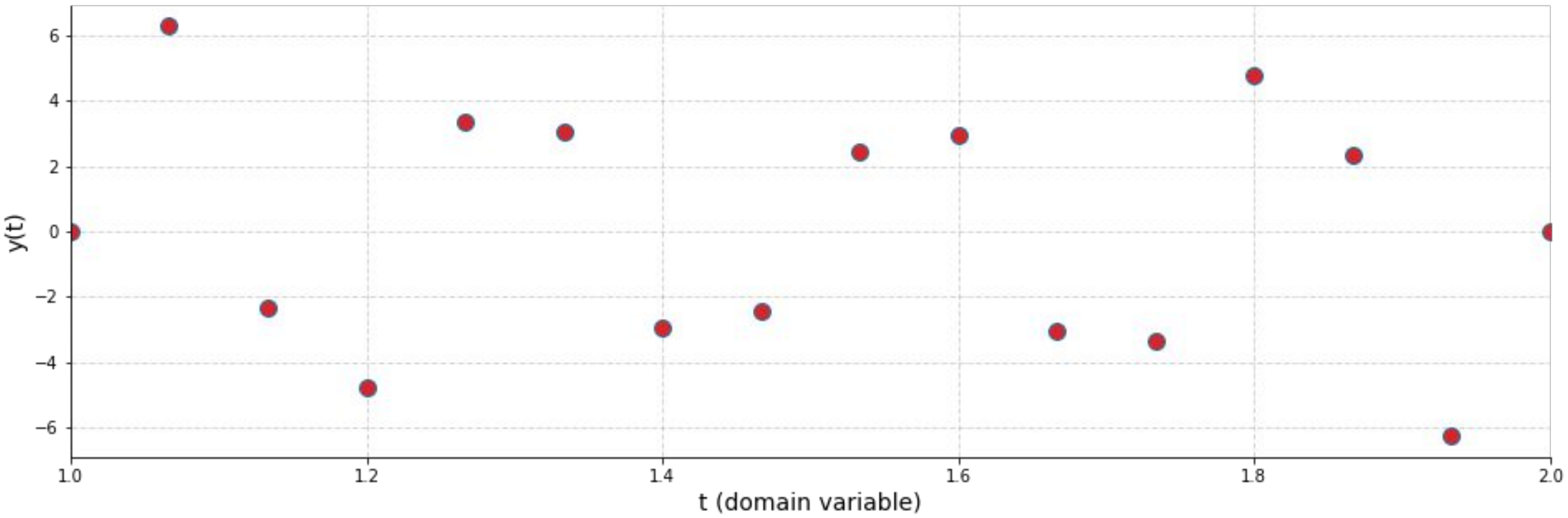
- Continuous signals
- Representations
  - Polynomial
  - Fourier series
  - Fourier Transform
    - Convolution
    - Diracs, rect(), sinc(), train of Diracs
    - Frequency, Bandwidth
- Sampling
  - Nyquist rate - intuition and theory

Recap

- Continuous signals
- Representations
  - Polynomial
  - Fourier series
  - Fourier Transform
    - Convolution
    - Diracs, rect(), sinc(), train of Diracs
    - Frequency, Bandwidth
- Sampling
- Interpolation or reconstruction
  - Aliasing, oversampling, undersampling

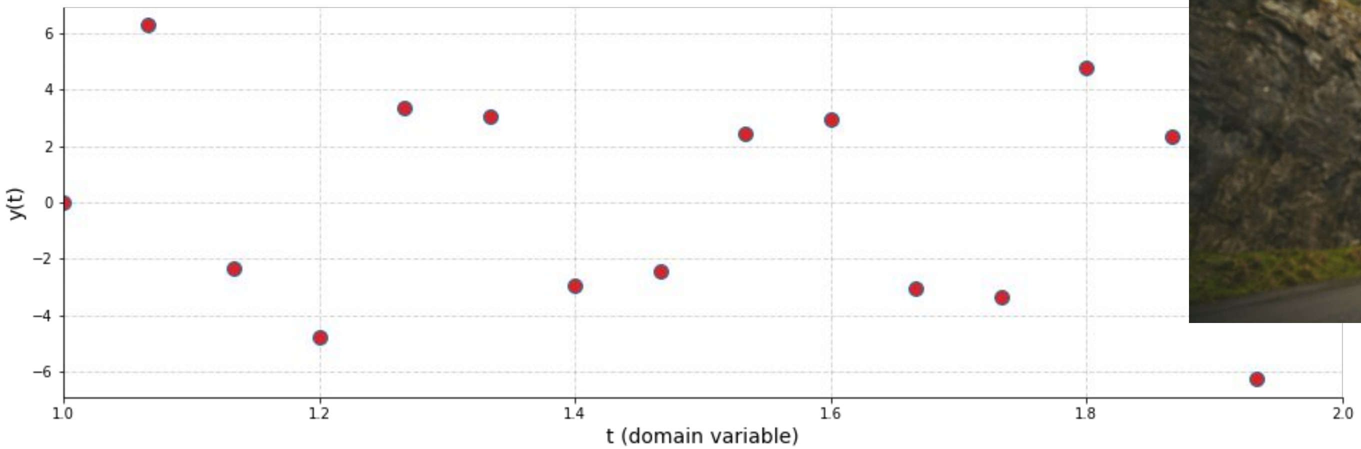
Processing discrete signals

Processing discrete signals



Processing discrete signals

- Can we take with us tools we developed in continuous domain to discrete domain?
  - Representations: polynomials, Fourier transform, …



Discrete Fourier Transform

- How do we proceed?

Can this be discretized?

$$\hat{f}(s) = \int_{-\infty}^{\infty} e^{-2\pi i s t} f(t)\, dt$$

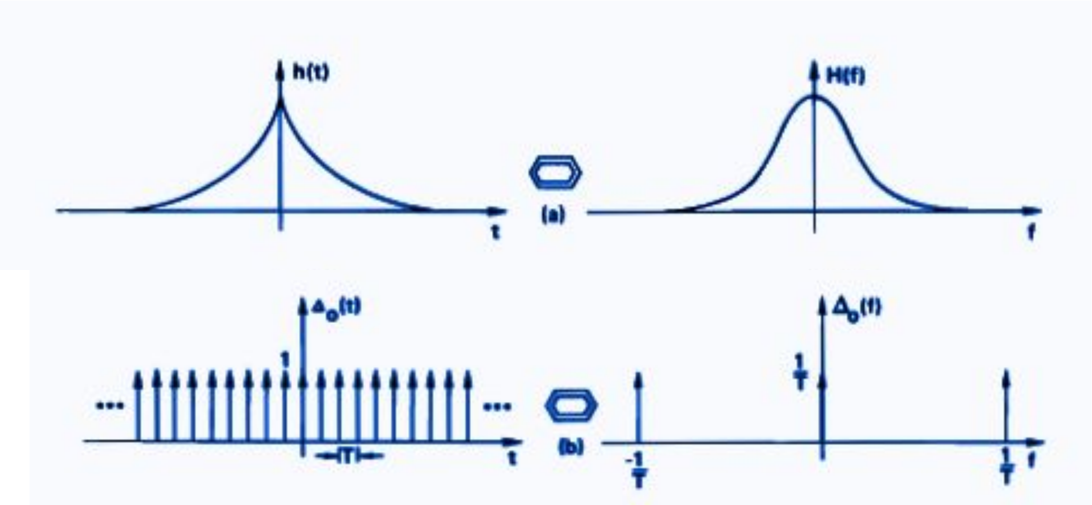
Can this be discretized?

Integral to summation?

Use Finite samples?

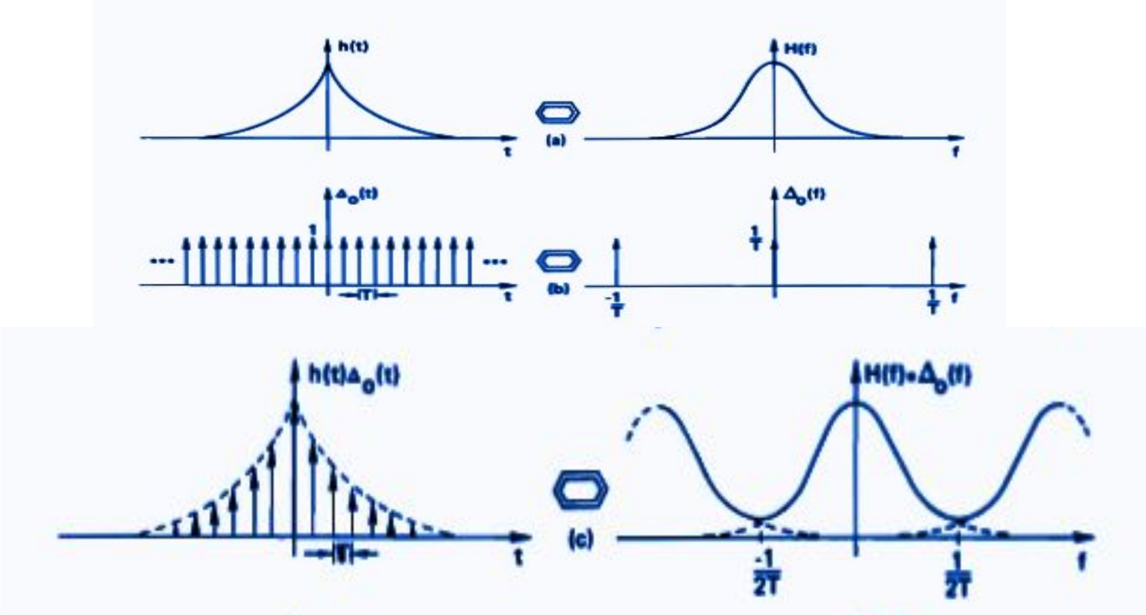
- Let's proceed through visualization.

- Continuous-time signal



- sampling
- truncation
- periodization

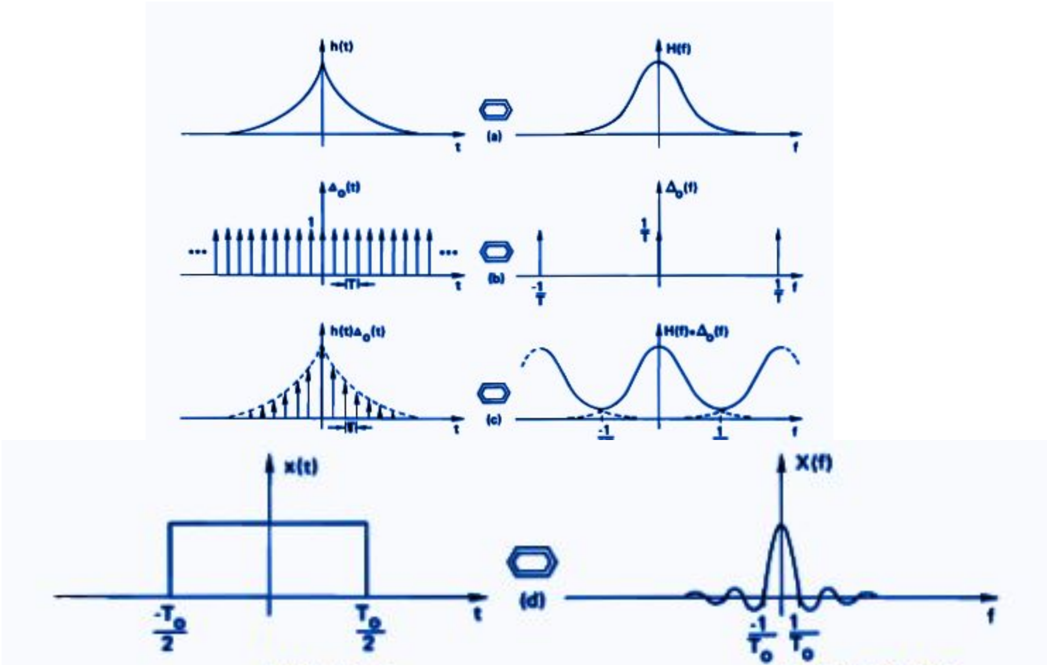
- sampling



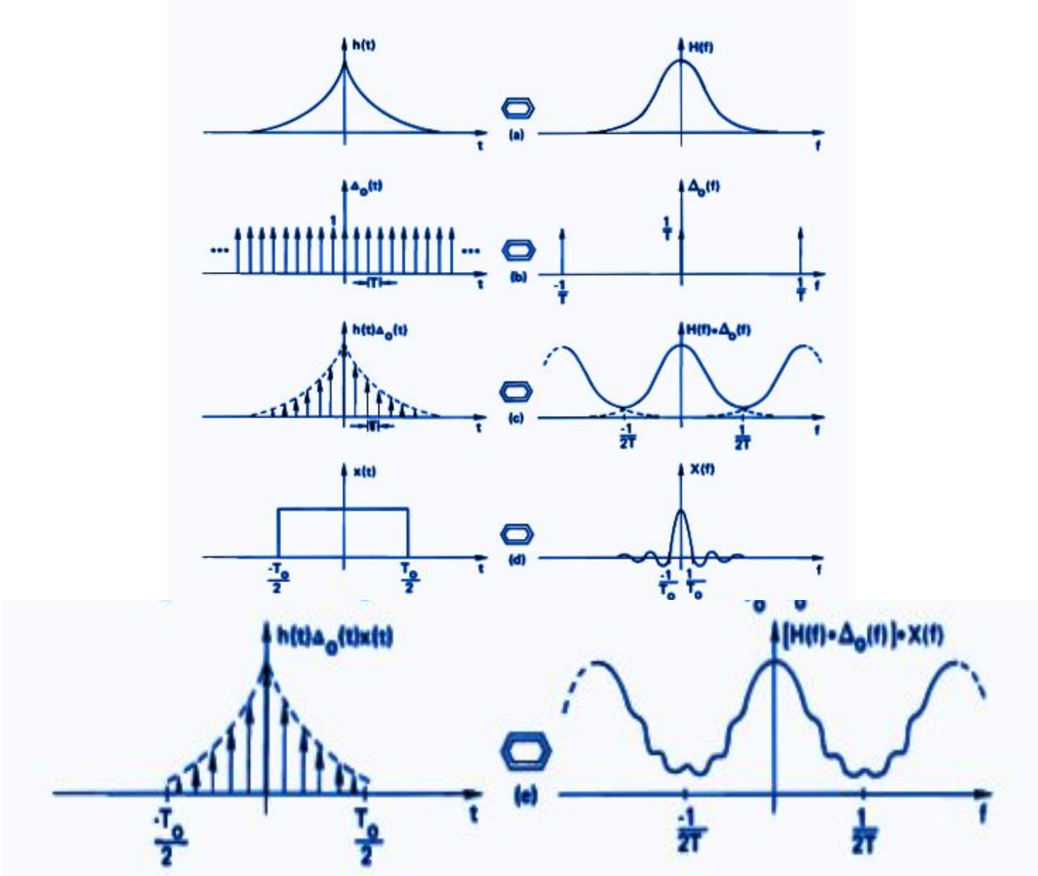
- truncation

- periodization

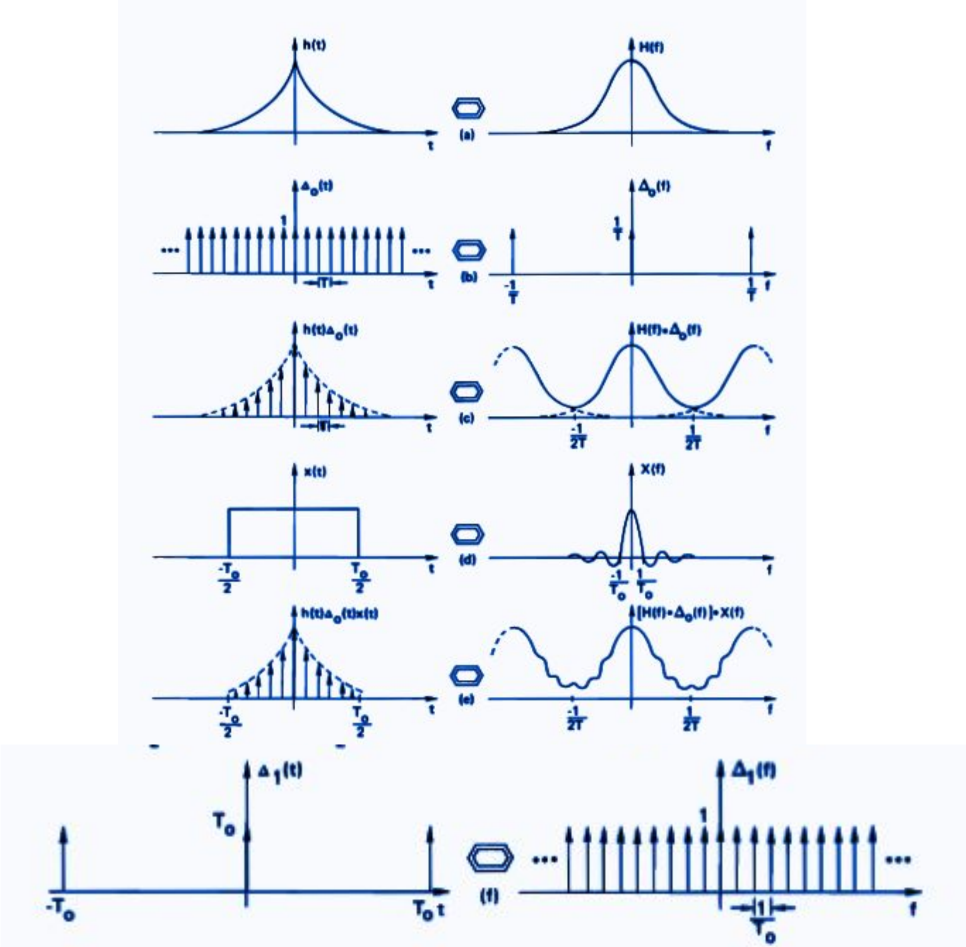
- sampling



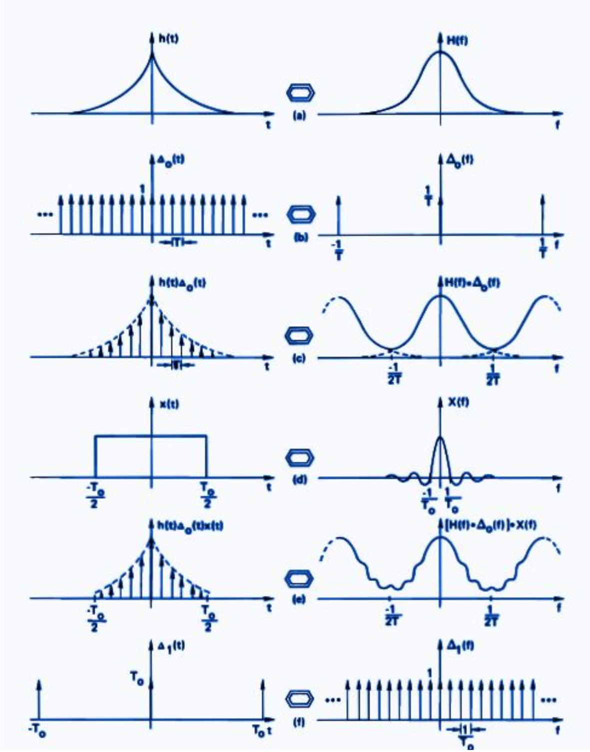
- truncation


h(t)
H(f)
t
f
(a)
Δo(t)
Δo(f)
1
T
1/T
-1/T
(b)
h(t)Δo(t)
H(f)*Δo(f)
-1/2T
1/2T
(c)
x(t)
X(f)
-To/2
To/2
-1/To
1/To
(d)
h(t)Δo(t)x(t)
[H(f)*Δo(f)]*X(f)
(e)

- sampling
- truncation
- periodization

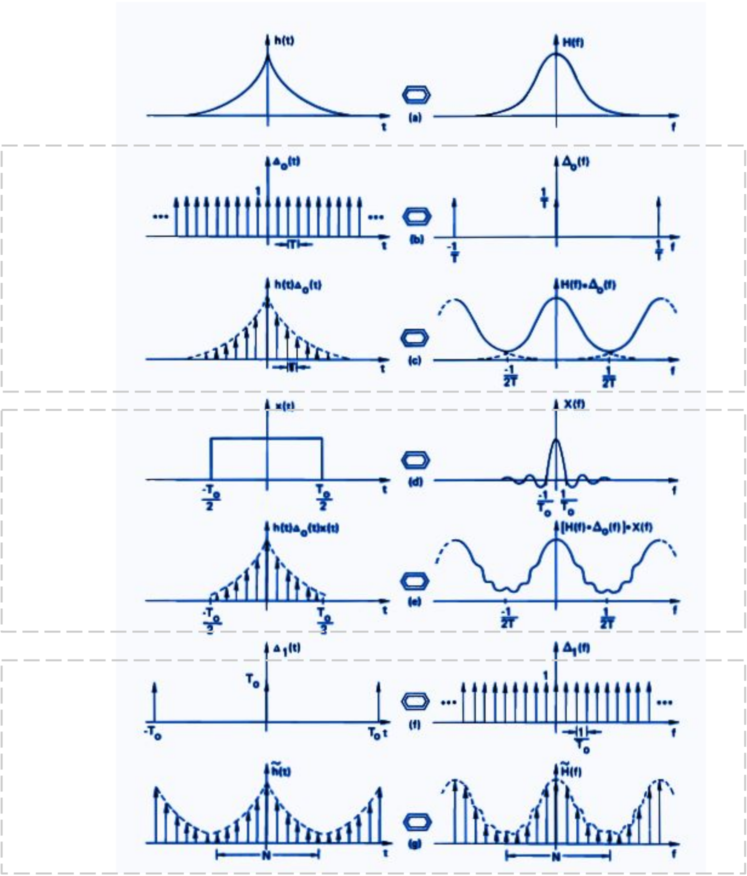


- sampling
- truncation
- periodization



Steps

- sampling
- truncation
- periodization



Result

- Discrete Fourier Transform (DFT)

Mathematical interpretation on blackboard

Summary

- A new representation for discrete-time signals
- Taking the learning of Fourier transform to discrete-time domain!
- Discrete Fourier Transform - vectors - multiplication - summation
- No integral - No infinite samples
- Remember the link using bandwidth (2B), duration (L) and N (number of samples)