Lab 3

School of Architecture, Civil and Environmental Engineering

EPFL, SS 2022-2023

http://disal.epfl.ch/teaching/signals_instruments_systems/

Lab 3 outline

- Concept:
  - Responses (Step and impulse response)
  - Continuous-Time Transforms (LT, CTFT)
  - Discrete-Time Transforms (ZT, DTFT, DFT)
- Tools:
  - Matlab

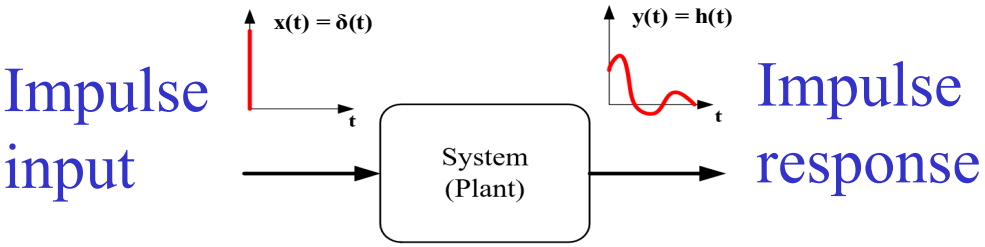
Reminder: Symbolic Toolbox in MATLAB

- `syms x,y,z` → Define symbolic variables
- `z = x + y` → Define functions
- `assume(x>0)` → Assumption on variables
- `sympref('HeavisideAtOrigin',1)` → Symbolic preferences
- `fplot()` → Plot symbolic functions
- `Heaviside()` → Step function
- `tf()` → Define transfer function
- `step()` → Plot step response
- `int()` → Symbolic integration

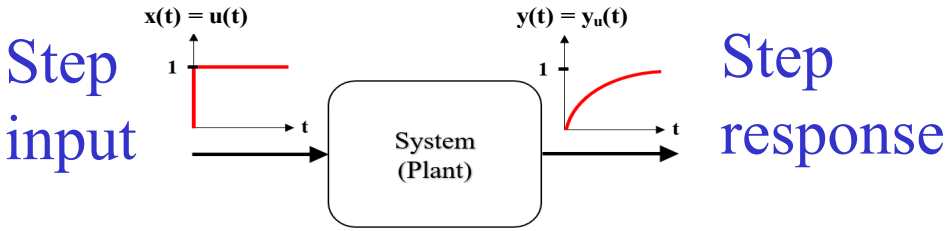
*** Check MATLAB help to learn how to use it

Reminder: Impulse and Step Response

- **Impulse response:** Time evolution of its output when input is impulse function



- **Step response:** Time evolution of its output when input is step function



Reminder: Fourier Transform

$$\hat{f}(\xi) = \int_{-\infty}^{\infty} f(t) \cdot e^{-i2\pi\xi t} dt$$

$$f(t) = \int_{-\infty}^{\infty} \hat{f}(\xi) \cdot e^{i2\pi t\xi} d\xi$$

The Fourier Transform is a special case of the Laplace Transform

`fourier()` → Symbolic CT Fourier Transform
`ifourier()` → Symbolic Inverse CT Fourier Transform

Reminder: Laplace Transform

$$F(s) = \mathcal{L}\{f(t)\} = \int_{-\infty}^{\infty} e^{-st} f(t) dt$$

$$s = \sigma + i\omega$$

*The Laplace transform is an extension of Fourier transform to allow analysis of broader class of signals and systems

*Check transform tables in appendix

`laplace()` → Symbolic Laplace Transform

`ilaplace()` → Symbolic Inverse Laplace Transform

Reminder: Z Transform

$$X(z) = \mathsf{Z}\ \{x[n]\} = \sum_{n=-\infty}^{\infty} x[n] z^{-n}$$

$$z = Ae^{j\varphi} \text{ or } z = A(\cos\varphi + j\sin\varphi)$$

*Similar to Laplace transform but for discrete signal and systems
*Check transform tables in appendix

```
ztrans() → Symbolic Z-Transform
iztrans() → Symbolic Inverse Z-Transform
```

Reminder: Discrete Time Fourier Transform

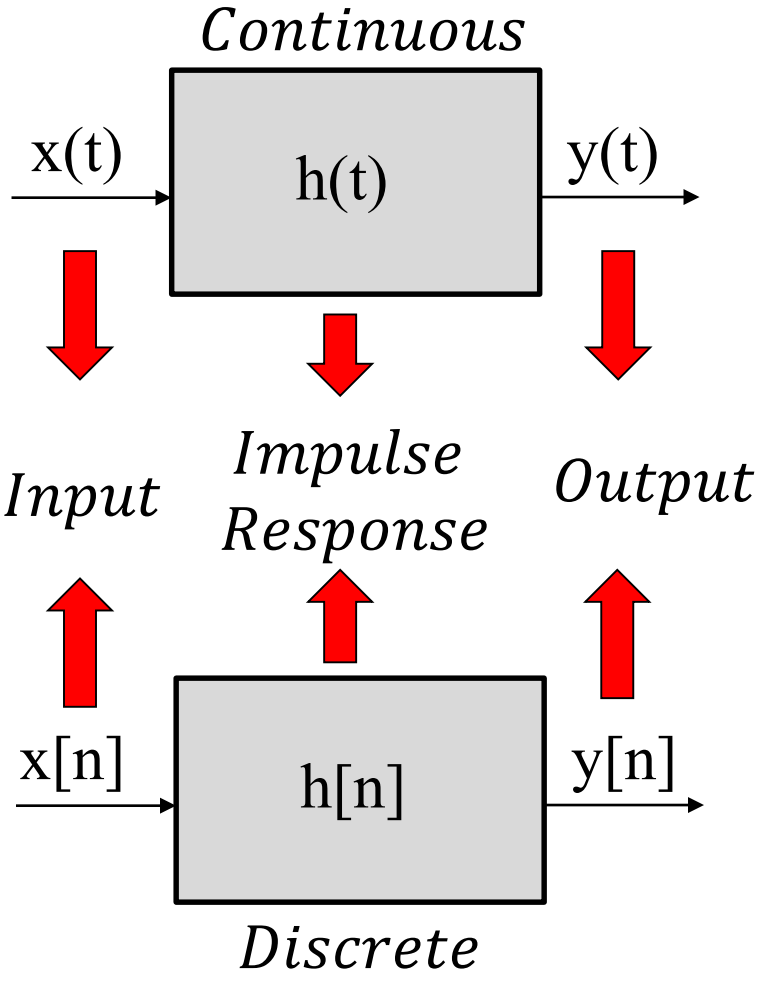
$$X(\omega) = \sum_{n=-\infty}^{\infty} x[n] \cdot e^{-i\omega n}$$

The Discrete-Time Fourier Transform is a special case of the Z Transform

Transform discrete-time signals from time-domain to frequency domain (continuous spectrum)

```
No direct symbolic tool
fft() → Numerical DF Transform
ifft() → Numerical Inverse DF Transform
```

Reminder: System Analysis with Transforms



- $y(t) = x(t) * h(t)$
- $Y(s) = X(s)H(s)$
- $Y(s) = \mathcal{L}(X(t))$

Cont. Transfer function

- $y[n] = x[n] * h[n]$
- $Y(z) = X(z)H(z)$
- $Y(z) = Z(y[n])$

Disctrete Transfer function

Finding step response

Continuous-time

- Solving differential equation
- Applying Laplace transform and use transfer functions
- Theoretical, numerical or analytical

Discrete-time

- Solving difference equations
- Applying Z-transform and use discrete transfer function
- Theoretical, numerical or analytical

Main ideas behind the quesitons

Question No.	Main Idea
1 (Q)	Finding the step response by using the definition of convolution theoretically
2 (S)	Finding the impulse response from the step response
3 (S)	Finding the step response by using the definition of convolution programmatically
4 (I)	Applying Fourier transform to an arbitrary function to observe the freq. content
5 (B)	Finding the step response by using Laplace transform theoretically
6 (S)	Finding the step response by using Laplace transform programmatically
7 (I)	Finding the step response by using Matlab's built-in functions
8 (B)	Finding the transfer function by using Z-transform theoretically (Discrete time)
9 (I)	Finding the step response by using Matlab's built-in functions (Discrete time)
10 (I)	Finding the step response by using Z-transform programmatically (Discrete time)
11 (B)	Applying DTFT to arbitrary function to observe the freq. content (Discrete time)

General Remarks

- Check type of questions **(Q,S,I,B)*****
- Questions for which you need to use Laplace and Z-Transform tables are Bonus
- Check **MATLAB help** to learn how to use functions***
- Check given material, carefully read explanations and templates
- Pay attention to Hints and Notes
- It is about 3h, assistance will be given.

Feedback form

Please fill the feedback form for Lab 3!