SSY080

Transformer, Signaler och System

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Date: 05/01/21, Time: 4 h (14.00-18.00)

Grading system

10 Quest A	**1 point each**	**10 points in total**	**5/10 necessary to pass**
3 Quest B	**5 points each**	**15 points in total**	**7/15 necessary to pass**

Note: only a **complete answer** results in the **full point** (A) / **points** (B).

Points	**[12,16)**	**[16-21)**	**[21-25]**
Final grade	**3**	**4**	**5**

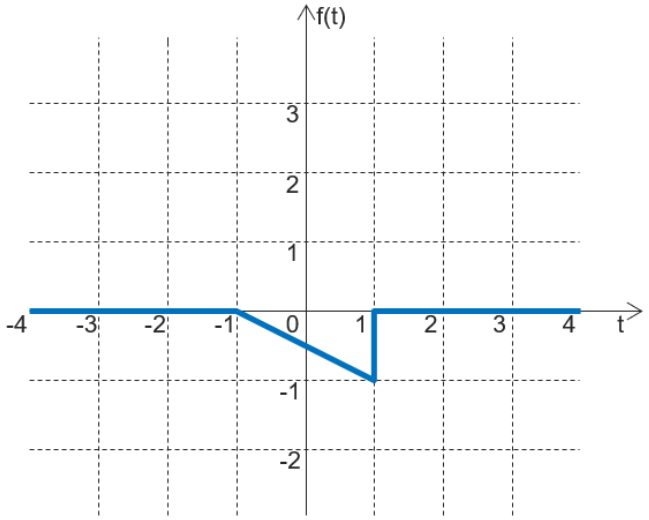
At the top of the first page, report **which questions you have answered** (e.g. A1, A3, A10, B2).

All answers must be written in **English**.

The solutions must be complete and easy to follow.

You can either write by hand or on a computer.

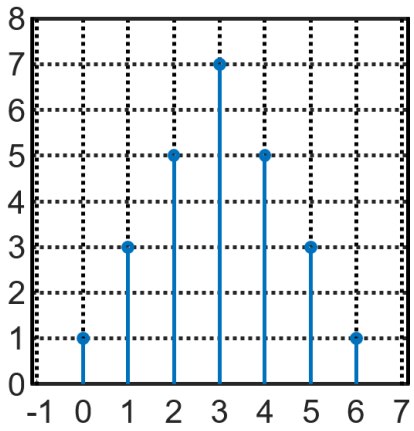
A1. Given the signal f(t) in the figure



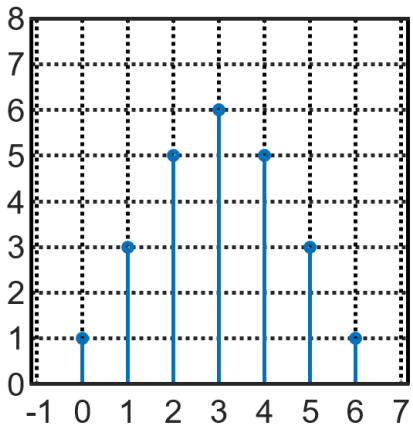
Plot the signal y(t) = 1 - f(t). Motivate your answer.

A2. Given the two sequences $x_1[n] = u[n] - u[n-4]$ and $x_2[n] = \delta[n] + 2\,\delta[n-1] + 2\delta[n-2] + \delta[n-3]$, determine the convolution x[n]= x_1[n] * x_2[n]. One of the 4 options (A, B, C, D) is correct. Motivate your answer.

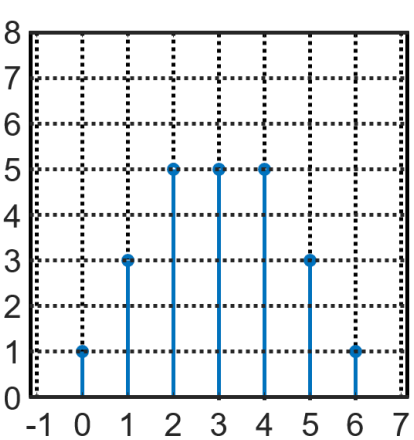
A



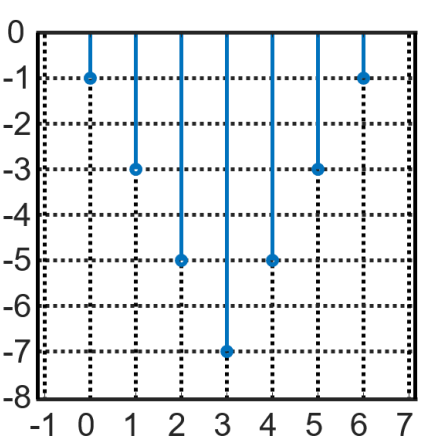
B



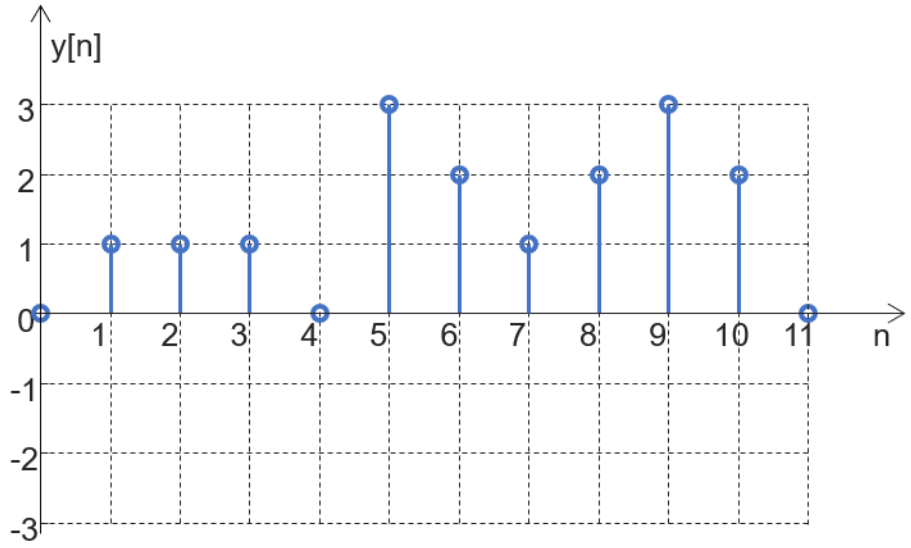
C



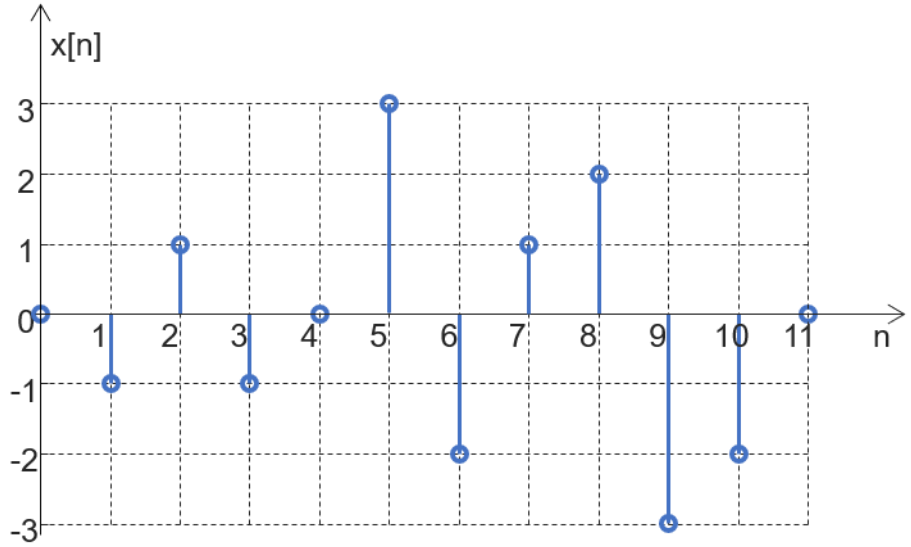
D



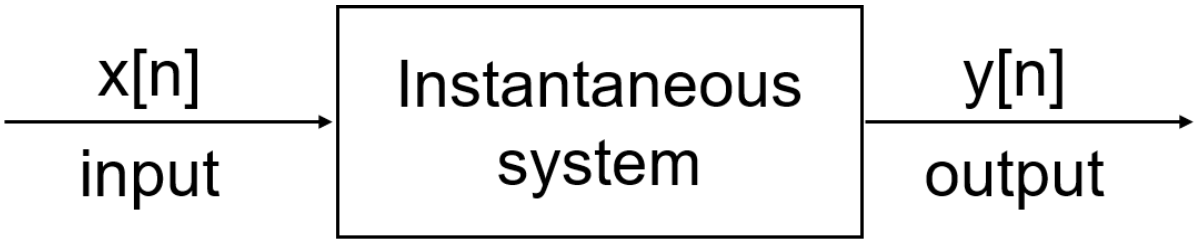
A3. Given an instantaneous system that provides as output the sequence y[n] represented below



when fed with the sequence x[n] as input,



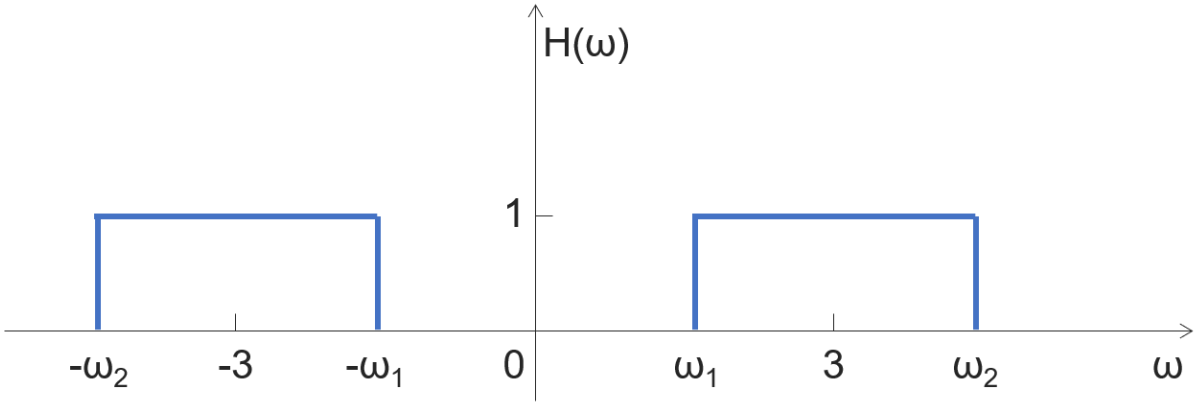
determine the mathematical function that relates the input x[n] to the output y[n] (i.e. y[n] = …). Motivate your answer.



Is the system invertible? Motivate your answer.

A4. Given a LTI system with

- input x(t)=sin(t)+cos(3t)
- and impulse response h(t) with Fourier transform $H(\omega)$ represented in the figure



Determine the values of ω_1 and ω_2 so that the resulting system output y(t) is equal to

$$y(t) = \alpha \cos(3t)$$

with α constant and ≠ 0. Motivate your answer.

A5. Given the periodic signal $x(t) = cos(3t) + 2\sin(9t)$, compute the coefficient c_0 of the complex Fourier series

$$x(t) = \sum_{k=-\infty}^{+\infty} c_k e^{jk\omega_0 t}.$$

Motivate your answer.

A6. Determine the inverse Laplace transform $f(t)$ of the function

$$F(s) = \frac{1}{s} - \frac{3}{2}\frac{1}{s+2}$$

Motivate your answer.

A7. Consider the LTI system described by the following differential equation

$$\frac{d^2y(t)}{dt^2} + 10\frac{dy(t)}{dt} + 16\,y(t) = x(t),$$

where x(t) is the system input and y(t) the system output. Determine the system transfer function in the Laplace domain. Motivate your answer.

A8. Given a system with transfer function

$$H(s) = \frac{1}{s^2 + 2s + 5}$$

determine if the system is stable. Motivate your answer.

A9. Compute the following summation using the z-transform $\sum_{n=0}^{+\infty}(0.4)^n$.

A10. Determine the inverse z transform $f[k]$ of the function

$$F[z] = \frac{4}{z-3} + \frac{5}{z-2}$$

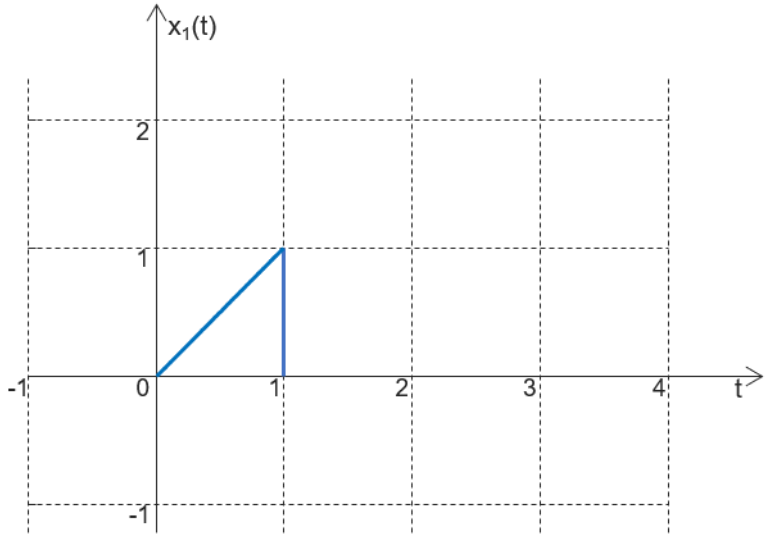
Motivate your answer.

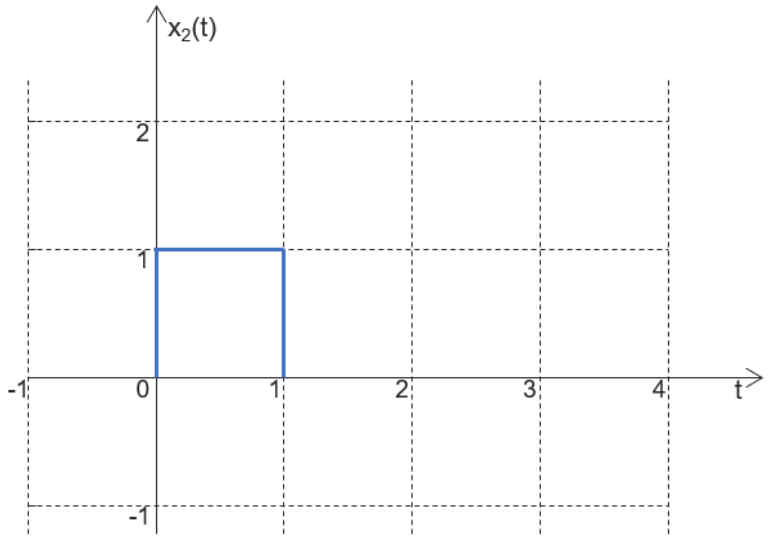
B1. Given the signal $x(t) = 7 + sin(2t) + 5\cos\left(4t + \frac{\pi}{3}\right)$,

a. Determine the fundamental frequency ω_0
b. Determine the coefficients c_k of the complex Fourier series

$$x(t) = \sum_{k=-\infty}^{+\infty} c_k e^{jk\omega_0 t}.$$

B2. a. Compute the convolution between $x_1(t)$ and $x_2(t)$.





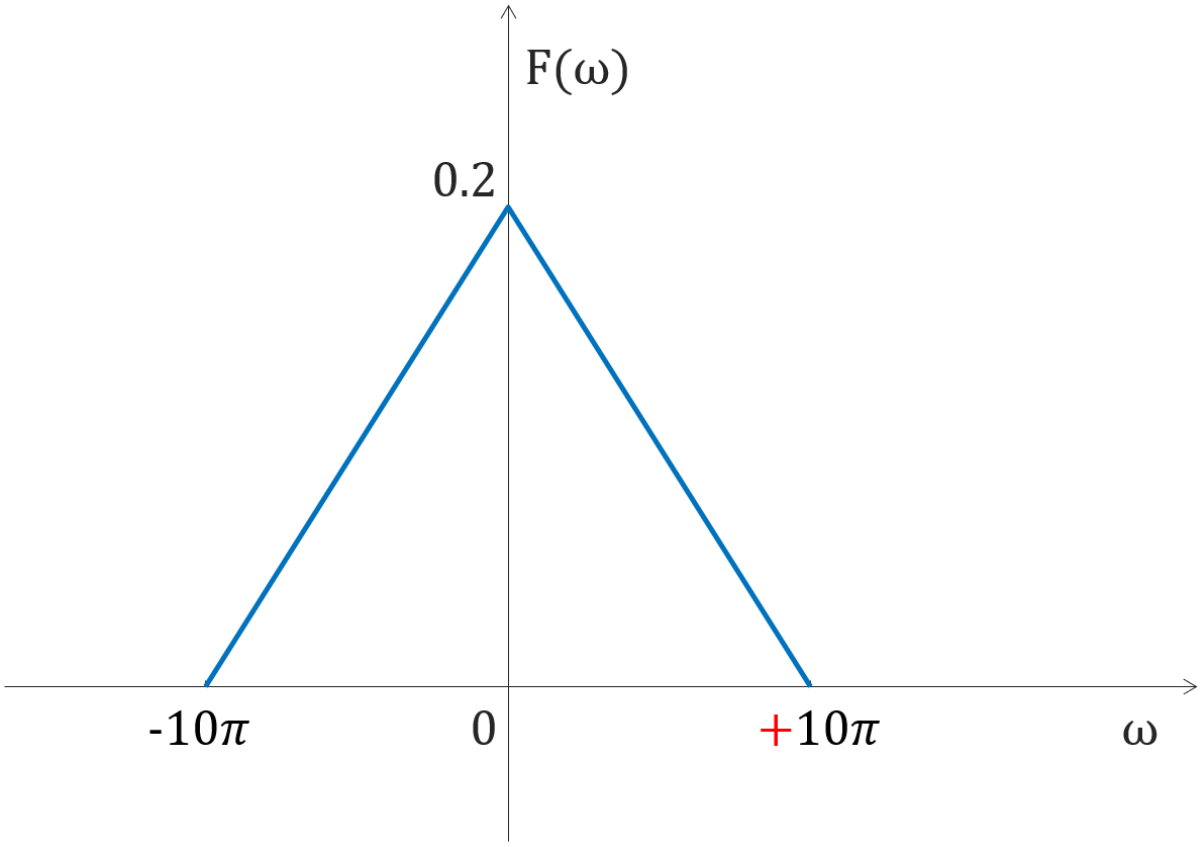
b. Show that the commutative property of the convolution holds true by computing the convolution between $x_2(t)$ and $x_1(t)$.

NOTE: If you use a software to calculate the integrals, you need to indicate which software you used. Even if you solved the integrals with a software, you need to indicate the mathematical expression of the integrals.

I report a random example to clarify what I mean:

- $\int_a^b x(\tau)d\tau = \frac{b^2-a^2}{2}$ will NOT be considered correct, because the mathematical expression of $x(\tau)$ is not specified
- $\int_a^b x(\tau)d\tau = \int_a^b \tau\, d\tau = \frac{\tau^2}{2}\Big|_a^b = \frac{b^2-a^2}{2}$ will be considered correct
- In case you use a software to calculate the integrals, $\int_a^b x(\tau)d\tau = \int_a^b \tau\, d\tau = \frac{b^2-a^2}{2}$ will also be considered correct because the expression of $x(\tau)$ has been explicitly reported (provided that you indicate which software you used to calculate the integral).

B3. Given a signal $f(t)$ with Fourier transform $F(\omega)$ sketched in the following figure



with ω expressed in radians / second, plot the Fourier spectrum $\bar{F}(\omega)$ of the signal $\bar{f}(t)$ obtained by sampling the signal $f(t)$ at a rate of $\mathcal{F}_s = \frac{1}{T}$ in the following two cases

a. $T = 0.4\ seconds$
b. $T = 0.05\ seconds$

Explain the procedure you followed.

Based on the two plots (a and b), discuss which of the two sampling intervals T (a or b) is suitable in order to be able to recover $f(t)$ from its samples. Motivate your answer.