Final Exam

Due: Saturday, April 22, 2023 10:00 pm (Eastern Daylight Saving Time)

Thanks for your submission!

Your assignment has been received and is waiting to be graded.

Review your submission

Q1 (10 points)

1 page submitted

Consider the following signal that was created in an amplitude-modulation type communication system using a carrier wave with angular frequency ω_c and an information-bearing signal that was a sinusoid with angular frequency ω_m :

$s(t) = cos(2000\pi t) + 4cos(2400\pi t) + cos(2800\pi t)$

What are the values of ω_c and ω_m ? (provide a brief explanation; include a diagram if needed)

Q1 $s(t) = \cos(2000\pi t) + 4\cos(2400\pi t) + \cos(2800\pi t)$

Standard form of A.M: $s(t) = (A_c + x(t))\cos(w_c t)$

$s(t) = A_c \cos(w_c t) + x(t)\cos(w_c t)$

$= A_c \cos(w_c t) + A_m \cos(w_m t)\cos(w_c t)$

$= A_c \cos(w_c t) + \frac{A_m}{2}\cos[(w_c - w_m)t] + \frac{A_m}{2}\cos[(w_c + w_m)t]$

taking out given equation,

$A_c \cos(w_c t) = 4\cos(2400\pi t)$

$A_c = 4000$

$w_c = 2400\pi$

$\frac{A_m}{2}\cos((w_c - w_m)t) = \cos(2000\pi t)$

$\frac{A_m}{2} = 1$, $A_m = 2$

$w_c - w_m = 2000$

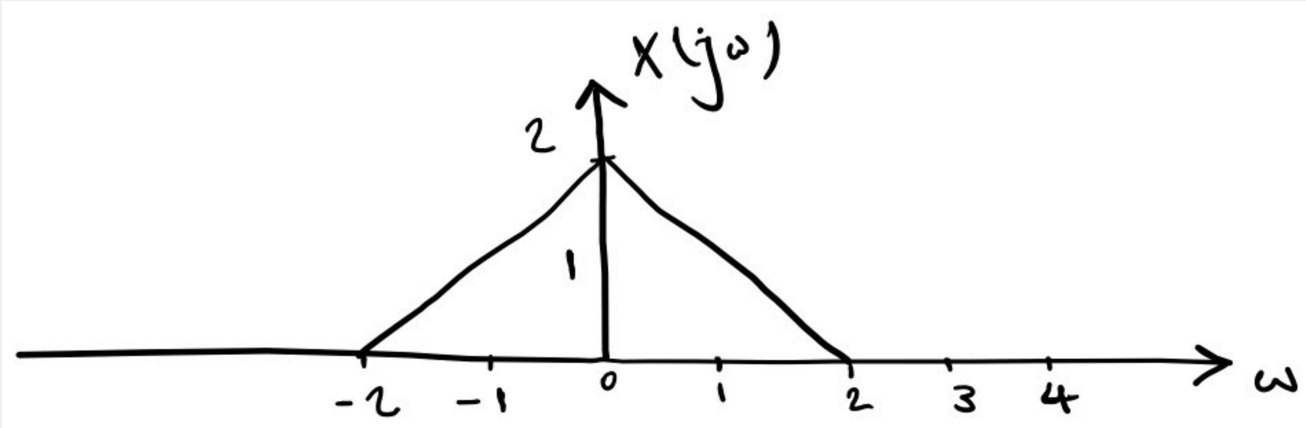
$2400 - w_m = 2000$

$w_m = 400$

Q2 (10 points)

Submitted

The impulse train $p(t) = \sum_{n=-\infty}^{+\infty} \delta(t - nT)$ can be used for sampling continuous-time signals. T would then refer to the sampling period and the sampling process is done by multiplying the signal of interest with the impulse train. Consider the message signal $x(t)$ with Fourier transform $X(j\omega)$ sketched in the figure below. We can sample this signal with two different sampling periods: $T_1 = \frac{\pi}{3}$ and $T_2 = \frac{2\pi}{3}$.



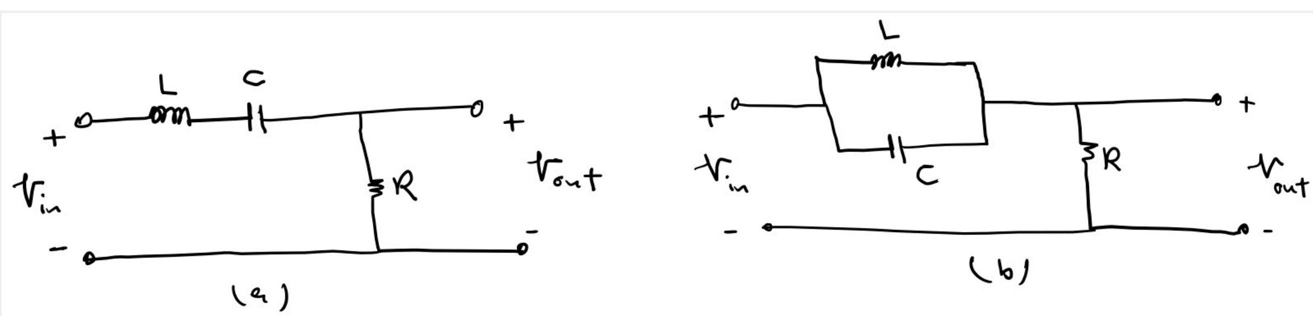
Which sampling period will allow us to restore the message signal completely from the discrete samples?

- Both sampling periods will allow us to restore the signal completely.
- Only T_1 will allow us to restore the signal completely.
- Only T_2 will allow us to restore the signal completely.
- Neither T_1 nor T_2 will allow us to restore the signal completely.

Q3 (10 points)

Submitted

Consider an LTI system implemented as the RLC circuit in part (a) of the figure below, where $v_{in}(t)$ is the input signal and $v_{out}(t)$ is the output signal. Now, let's say the circuit was rebuild and it in now looks like the circuit in part (b) of the figure (the components remained the same).



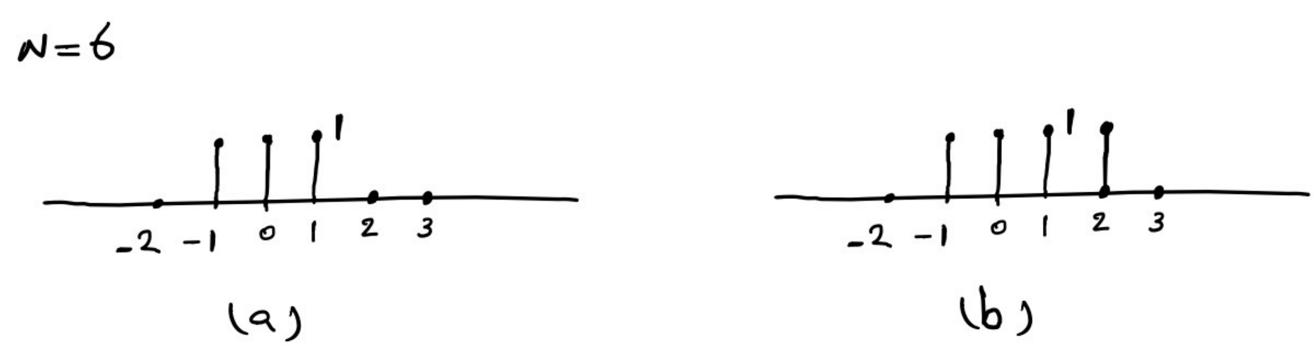
Select the correct statement from the provided options:

- Both circuits will function as a band-pass filter.
- Both circuits will function as a band-stop filter.
- Circuit (a) functions as band-pass filter and circuit (b) functions as band-stop filter
- Circuit (a) functions as band-stop filter and circuit (b) functions a band-pass filter
- Circuit (a) functions as a low-pass filter and circuit (b) will function as band-pass filter

Q4 (10 points)

Submitted

Consider a discrete-time signal $x[n]$ with period $N = 6$ in part (a) of the figure below. If that signal changes to the signal in part (b) of the figure (the period stays the same), how will the Fourier series coefficients of $x[n]$ need to be revised?



- None of the Fourier coefficients will change
- Only a_2 will need to be changed to a new value
- Only a_2 and a_{-2} will need to be changed to new values
- The phase and magnitude of all of the Fourier series coefficients will change to new values
- Just the magnitude of all of the Fourier series coefficients will change to new value

Q5 (10 points)

Submitted

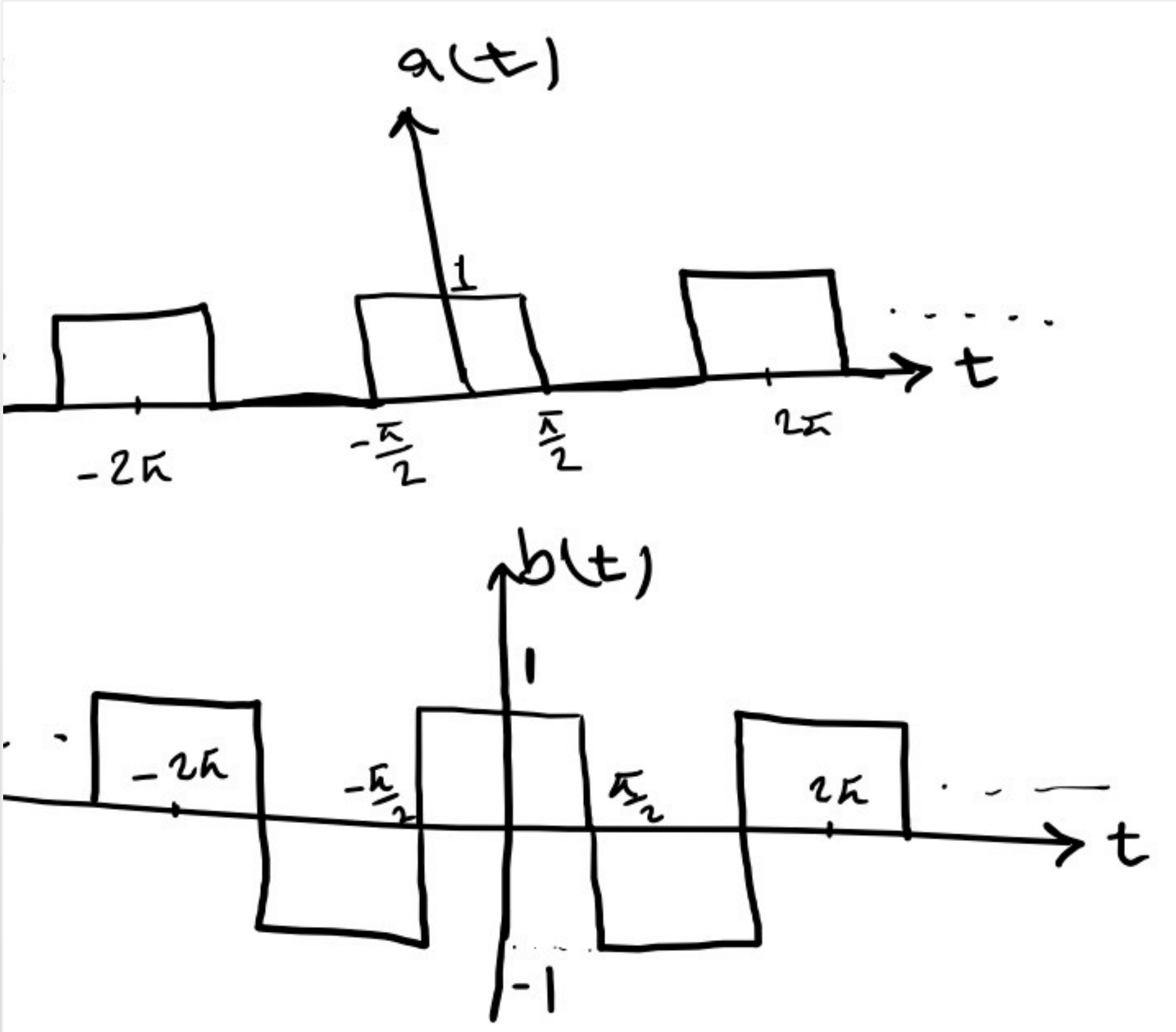
Consider a continuous-time signal $x(t)$ that can be (on a final interval with length $T = \frac{2\pi}{\omega_0}$) represented with a Fourier series with coefficients a_k and a signal $y(t) = \frac{d^2 x}{dt^2}$.
If we represent $y(t)$ on that interval with a Fourier series with coefficients b_k, what will be the value of b_2 ?

- ( ) $\omega_0^2 a_2$
- ( ) $-2\omega_0^2 a_2$
- (•) $-4\omega_0^2 a_2$
- ( ) $-4\omega_0^2 a_{-2}$
- ( ) $4\omega_0^2 a_2$

Q6 (10 points)

Submitted

Consider two periodic signals, $a(t)$ and $b(t)$, plotted below and their real sinusoidal Fourier series.



Which one of the following statements is true?

- The value of the DC coefficient of both signals is non-zero.
- The sin coefficients of signal $a(t)$ and cos coefficients of signal $b(t)$ are zero.
- The cos coefficients of signal $a(t)$ and sin coefficients of signal $b(t)$ are zero.
- The sin coefficients of both signals and DC coefficient of $b(t)$ are zero.
- The cos coefficients of both signals and DC coefficient of $b(t)$ are zero.

Q7 (10 points)

Submitted

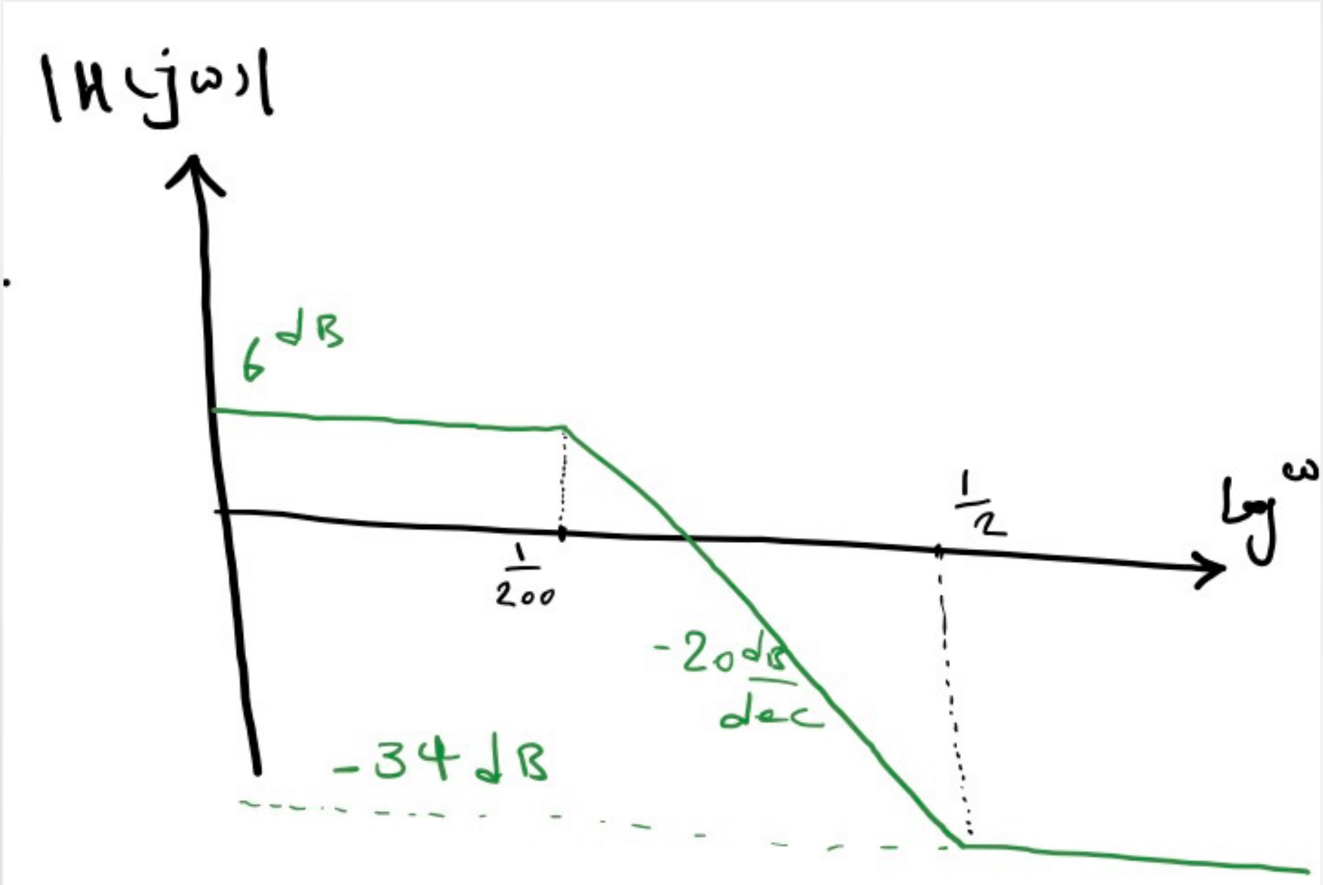
Consider a signal $x(t)$ that can be (on a final interval with length $T = \frac{2\pi}{\omega_0}$) represented with a Fourier series with coefficients a_k and a signal $y(t) = x(t - t_0) + x(t + t_0)$.
If we represent $y(t)$ on that interval with a Fourier series with coefficients b_k, which one of the statements below is correct?

- $b_2 = 2a_2 sin(2\omega_0 t_0)$
- $b_2 = 2a_1 sin(2\omega_0 t_0)$
- $b_2 = 2a_2 cos(\omega_0 t_0)$
- $b_2 = 2a_1 cos(\omega_0 t_0)$
- $b_2 = 2a_2 cos(2\omega_0 t_0)$

Q8 (10 points)

Submitted

Consider the transfer function $H(j\omega)$ plotted in the figure below.

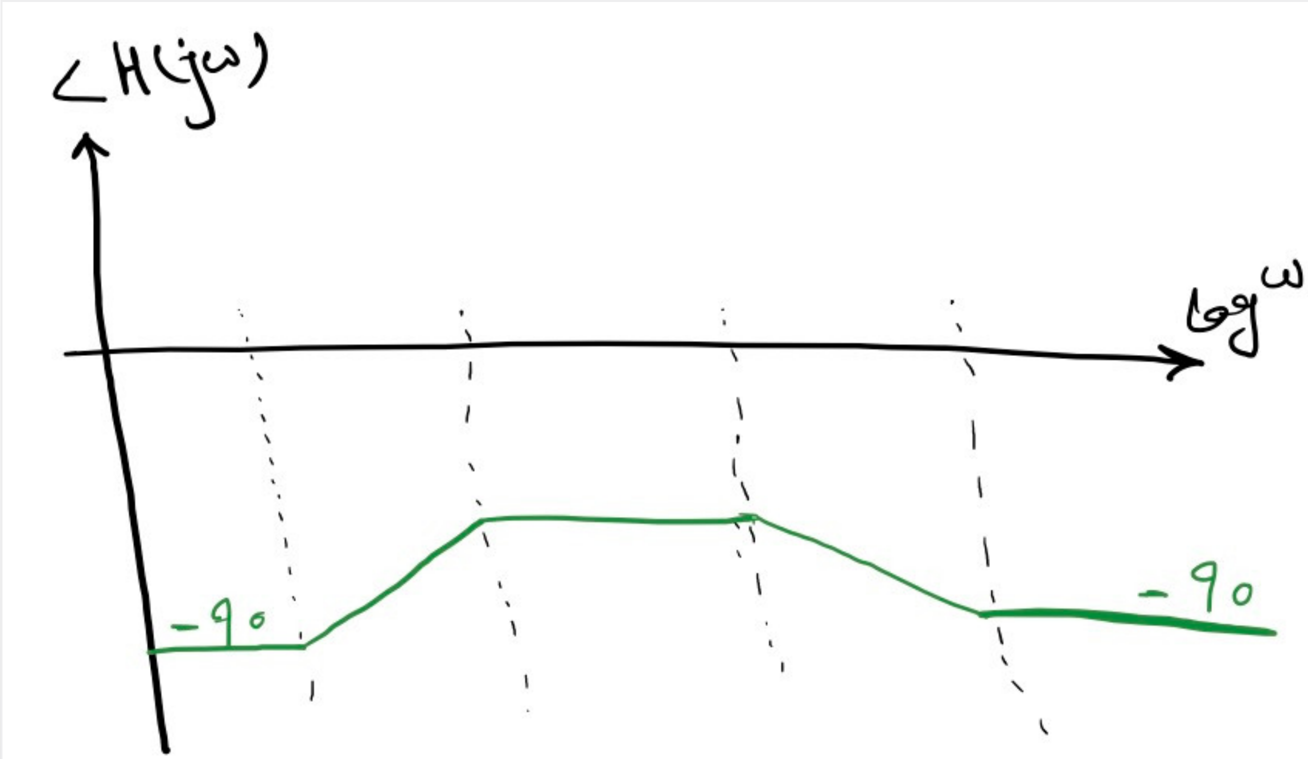


Which statement about $H(j\omega)$ is correct?

- Real part of the numerator of $H(j\omega)$ is equal to 1
- $H(j\omega)$ has one pole
- $H(j\omega)$ has at least two poles
- $H(j\omega)$ does not have a zero
- none of the above

Q9 (10 points)

Submitted



Which one of the statements about a transfer function $H(j\omega)$ is true, given the provided plot?

- [ ] $H(j\omega)$ has one zero at the origin
- [ ] $H(j\omega)$ has two simple zeros
- [x] $H(j\omega)$ has one pole at the origin
- [ ] $H(j\omega)$ has two simple poles
- [ ] none of the above

Q10 (10 points)

Submitted

Consider a continuous-time LTI system with a transfer function
$H(s) = \frac{10}{s^2+21s+20}$.
What will be the value of the numerator of the transfer function if/when this system is approximated as a standard first-order system?

- 0.5
- 1
- 5
- 10
- 20

Q11 (10 points)

Submitted

Which one of the transfer functions below will result in a SISO LTI system that is BIBO stable?

- $H(s) = \frac{s+2}{(s+3)(s+2)(s-1)}$
- $H(s) = \frac{s^2}{s+5}$
- $H(s) = \frac{(s-1)(s+1)}{(s+3)(s^2+2s+5)}$
- $H(s) = \frac{s^3}{s^2+s-2}$
- $H(s) = \frac{s+2}{s(s+3)(s+5)}$

Q12 (10 points)

Submitted

Consider a system with the following transfer function:

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

What are the values of this system's time constant and dc gain?

- Time constant is 1 and dc gain is 2
- Time constant is 1 and dc gain is 5

- Time constant is 0.5 and dc gain is 2.5
- Time constant is 2.5 and dc gain is 0.5
- Time constant is 2 and dc gain is 5

Q13 (10 points)

Submitted

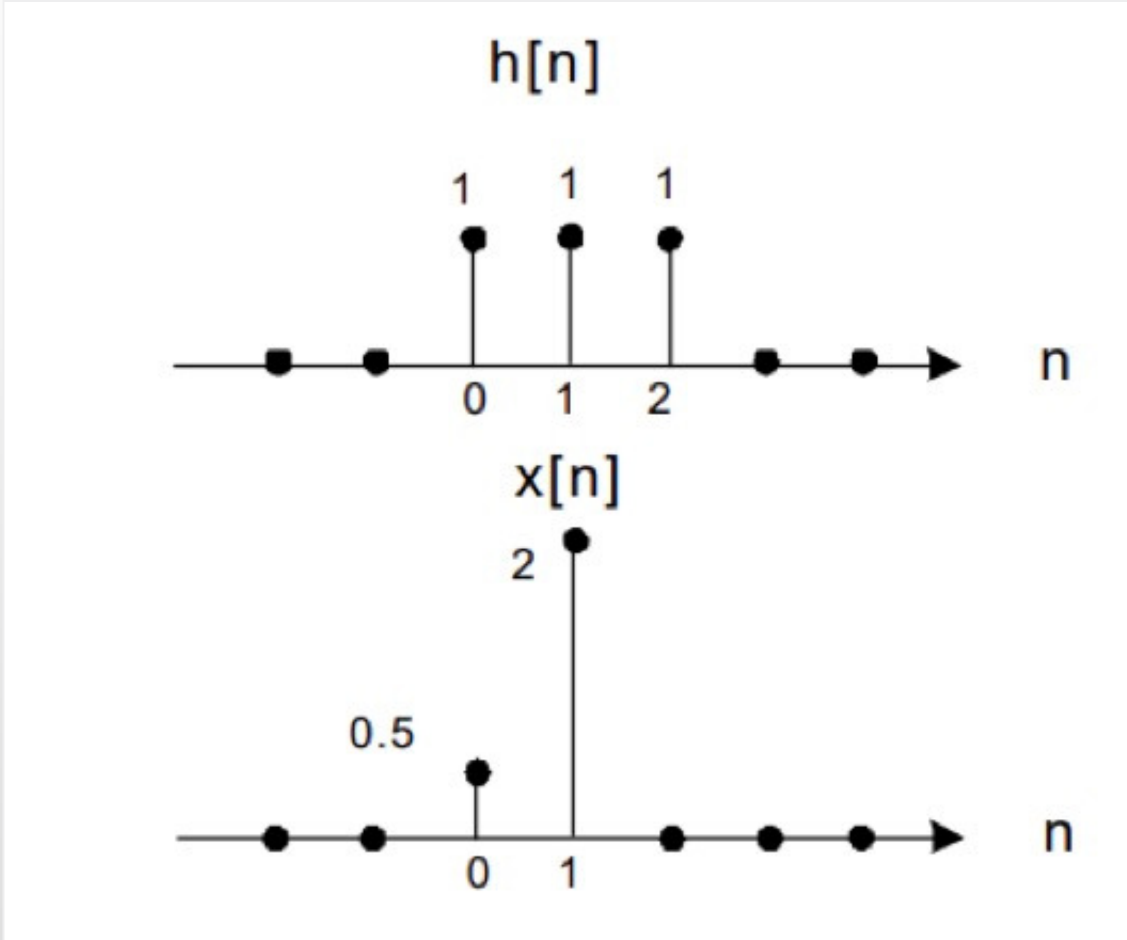
Consider a LTI system with impulse response $h(t) = u_{-1}(t)$.
A signal $x(t) = e^{-at}u_{-1}(t-b)$ is sent into this system as input. Under what conditions will the output of this system be not equal to zero?

- The value of the output will always be zero for this input.
- When $t < b$, the output is not zero.
- When $a = b$, the output is not zero.
- When $t > b$, the output is not zero.
- When $b > 0$, the output is not zero.

Q14 (10 points)

Submitted

Consider a discrete-time LTI system with impulse response $h[n]$ and input signal $x[n]$ shown in the figure.



Which one of the statements below would be correct if $x[1]$ had a value of 0 instead of 2?

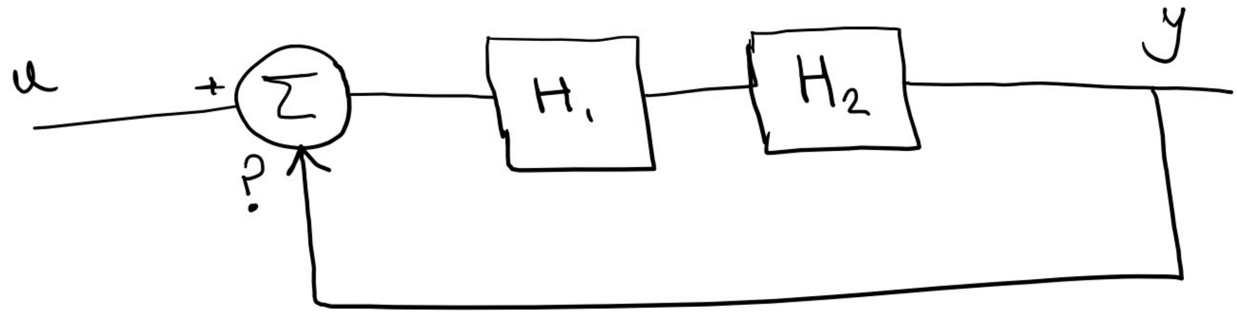
- $y[3]$ would have a value of 1 instead of 0.5
- $y[3]$ would have a value of 0 instead of 1
- $y[2]$ would have a value of 2 instead of 1
- $y[2]$ would have a value of 1 instead of 2.5
- $y[3]$ would have a value of 0 instead of 2

Q15 (10 points)

Submitted

Which one of the provided statements is correct?

(the question mark could be a '+' or a '-'; $H(s)$ is the overall transfer function of the system)



A. If ? is negative, H(s) = $H_1(s) * H_2(s)$

B. If ? is positive, H(s) = $H_1(s) * H_2(s)$

C. H(s) never could be $H_1(s) * H_2(s)$

D. ? does not effect on H(s)

- A
- B
- C
- D

Q16 (10 points)

Submitted

$$f(x) = \begin{cases} 1 & \cdots\cdots \\ 0 & \text{others} \end{cases}$$

$$\Rightarrow F(s) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{jsx} f(x)\, dx \cdots\cdots$$

$$\vdots$$

$$= \frac{1}{\sqrt{2\pi}} \int_{?}^{?} (\cos xs + j \sin xs)\, dx = \frac{1}{\sqrt{2\pi}} \int_{?}^{?} \cos xs\, dx = \cdots$$

$$\vdots$$

The pieces of calculation pictured above were recovered (with some damage and missing info) from a trash can. What could be the boundaries of the integral marked by question marks (notice that some details of $f(x)$ are also missing)?

- from 1 to 2
- from 0 to 10
- from -1 to 2
- from -1 to 1

- cannot be determined without the specifics of $f(x)$

Q17 (10 points)

Submitted

The Fourier transform of the impulse response $h(t)$ of a causal LTI system is found to be $H(j\omega) = \frac{1}{4+j\omega}$. We observe an output signal $y(t) = e^{-4t}u_{-1}(t) - e^{-5t}u_{-1}(t)$, where $u_{-1}(t)$ is the unit step function, that results from an input signal $x(t)$. What is $x(t)$?

- (selected) $e^{-5t}u_{-1}(t)$
- $e^{-4t}u_{-1}(t)$
- $e^{-4t}u_{-1}(t) - e^{-5t}u_{-1}(t)$
- $e^{-3t}u_{-1}(t)$
- e^{-4t}

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