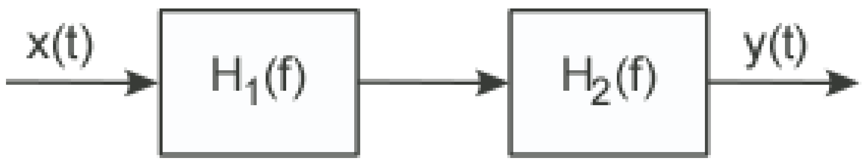
Frequency Domain Exercises

The **due date** for this homework is **Sun 14 Apr 2013 8:00 PM EDT**.

Question 1

What is the overall transfer function between $x(t)$ and $y(t)$? Here $H_1(f)$ and $H_2(f)$ represent the transfer functions of linear, time-invariant systems in a **cascade** configuration.

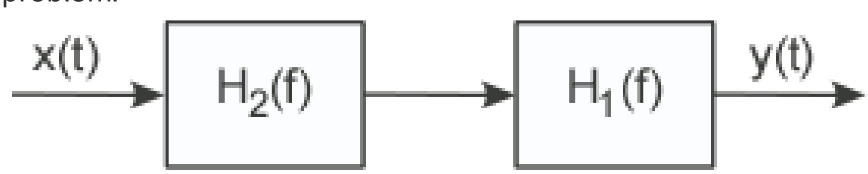


Type your answer as an expression, with `H1` representing $H_1(f)$ and `H2` representing $H_2(f)$.

Preview

Question 2

What is the overall transfer function between $x(t)$ and $y(t)$? Here $H_1(f)$ and $H_2(f)$ represent the transfer functions of linear, time-invariant systems in a cascade configuration. Note that the systems are in a different order than in the previous problem.

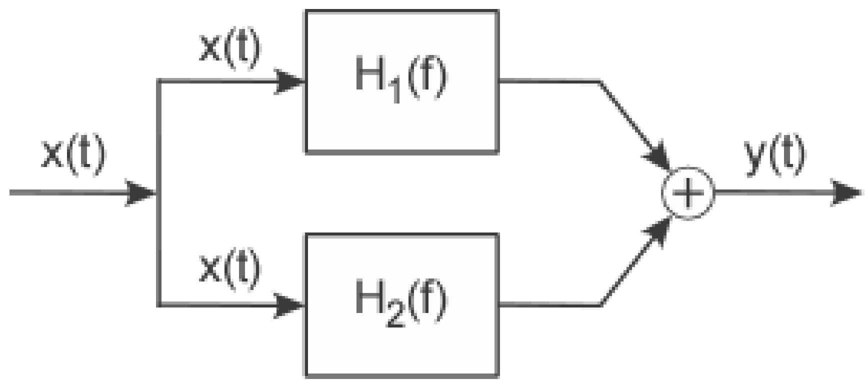


Type your answer as an expression, with `H1` representing $H_1(f)$ and `H2` representing $H_2(f)$.

Preview

Question 3

What is the overall transfer function between $x(t)$ and $y(t)$? Here $H_1(f)$ and $H_2(f)$ represent the transfer functions of linear, time-invariant systems in what is known as a **parallel** configuration.

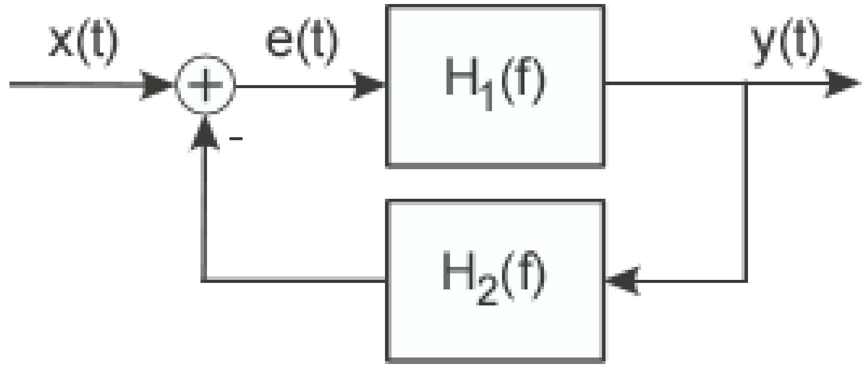


Type your answer as an expression, with `H1` representing $H_1(f)$ and `H2` representing $H_2(f)$.

Preview

Question 4

What is the overall transfer function between the input $x(t)$ and the output $y(t)$? Here $H_1(f)$ and $H_2(f)$ represent the transfer functions of linear, time-invariant systems in what is known as a **feedback** configuration.



Here, the signal $e(t)$ equals the input $x(t)$ minus the output of the lower system. The small minus sign near the lower system's output going into the adder indicates whether that signal is added or subtracted.

Type your answer as an expression, with `H1` representing $H_1(f)$ and `H2` representing $H_2(f)$.

Preview

Question 5

In some cases, simple mathematical operations on a signal can be implementing by passing the signal through a linear, time-invariant (LTI) system. Suppose we wanted to produce a signal that equalled the *derivative* of some signal. What is the transfer function of a system that accomplishes this operation?

- Can't be implemented with an LTI system.
- $j2\pi f$
- $\frac{1}{j2\pi f}$

Question 6

Suppose we wanted to produce a signal that equalled the *second* derivative of some signal. What is the transfer function of a system that accomplishes this operation?

- $-4\pi^2 f^2$
- $2 \cdot j2\pi f$
- Can't be done.

Question 7

Reverberation (producing simple echoes) corresponds to adding a signal to its delayed version: $x(t) + x(t - \tau)$.

What is the input-output relationship of a reverberation system? In other words, what is the transfer function, if it exists (reverberation may not correspond to a linear, time-invariant operation)?

Type `tau` to represent τ. If the transfer function does not exist, type `nan`.

Preview

Question 8

Reverberation corresponds to some kind of filter; what kind?

- Lowpass
- Bandpass
- Highpass
- Something else

Question 9

The music group FEE is having trouble selling its recordings. The record company's engineer gets the idea of applying different delays to low and high frequencies, then adding the results to create a novel listening experience that will sell **lots** of records. Thus, FEE's audio would be separated into two parts, lowpass filtered to f_0 with an LTI system having transfer function $H(f)$ and highpass filtered to f_0 with a system having transfer function $\left(1 - H(f)\right)$. The lowpass part would then be delayed by τ_l, and the highpass part delayed by τ_h. What is the transfer function of this music system?

Denote $H(f)$ by `H`, τ_l by `tau_l`, and τ_h by tau_h.

Preview

In accordance with the Honor Code, I certify that my answers here are my own work.

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