ECE 3210 Midterm 2

Week of: November 6, 2019

Student's name and section: ______________________________

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You have 120 minutes for 5 problems.

- Show enough (neat) work in the clear spaces on this exam to convince us that you derived, not guessed, your answers.
- Put your final answers in the boxes at the bottom of the page.

You can use two pages of notes and a calculator.

Problem	Score	Possible Points
1		20
2		20
3		20
4		20
5		20
Total score		100

1 Short answer

(a) Signal $f_1(t)$ has a bandwidth of $B_1 = 500\text{Hz}$. Signal $f_2(t)$ has a bandwidth of $B_2 = 1\text{kHz}$. What is the Nyquist sampling rate of $f_1(t)f_2(t)$ and $f_1(t)f_2^2(t)$?

$f_1(t)f_2(t)$:	$f_1(t)f_2^2(t)$:

(b) If a system has a transfer function $H(s) = \frac{5s^2+1}{s^3+5s^2+2s}$ is it stable?

Circle your choice: stable	unstable	marginally stable

(c) Given a second order transfer function

$$H(s) = \frac{9}{s^2 + 12s + 9}$$

is this system overdamped, critically damped, or underdamped?

Circle your choice: overdamped critically damped underdamped

(d) What is your preference, the Laplace or Fourier tranform? (No wrong answer here, just curious what people prefer.)

Circle your choice: Fourier Laplace

2 Solving differential equations

Given the differential equation

$$(D^2+7D+12)y(t)=(3D+9)f(t)$$

where $y(0^-)=1$, $y'(0^-)=2$, and $f(t)=e^{-3t}u(t)$, answer the following questions.

(a) Find the zero-input response.

$y_{\text{zi}}(t)=$

(b) Find the zero-state response.

$y_{\text{zs}}(t) =$

(c) Find the total system response. (*Hint:* use your answers from the previous two parts rather than deriving the total response from scratch.)

$y(t) =$

3 Block diagrams

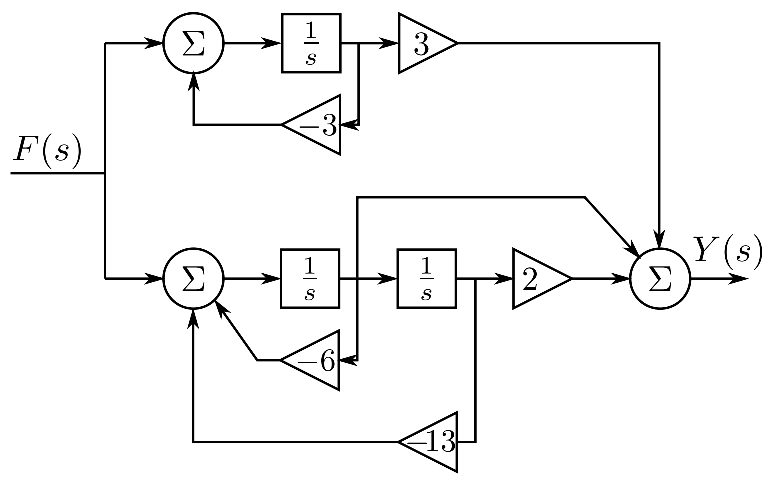
Please answer the following.

(a) Given the system

$$(D^3 - 3D)y(t) = (5D^2 + D + 2)f(t)$$

Please draw the *canonical* block diagram system realization.

(b) Given the parallel system realization below, find the system's impulse response $h(t)$.



$h(t) =$

4 Sampling

A zero-order hold system can be used to reconstruct a signal $f(t)$ from its samples. The impulse response of this system is

$$h(t) = \mathrm{rect}\left(\frac{t}{T}\right)$$

where T is the sampling interval. Please answer the following questions about this system H.

(a) This system, being noncausal, is unrealizable. By delaying its impulse response, the sysrtem can be made realizable. What is the minimum delay (t_d) required to make this system (H_d) realizable?

$t_d =$

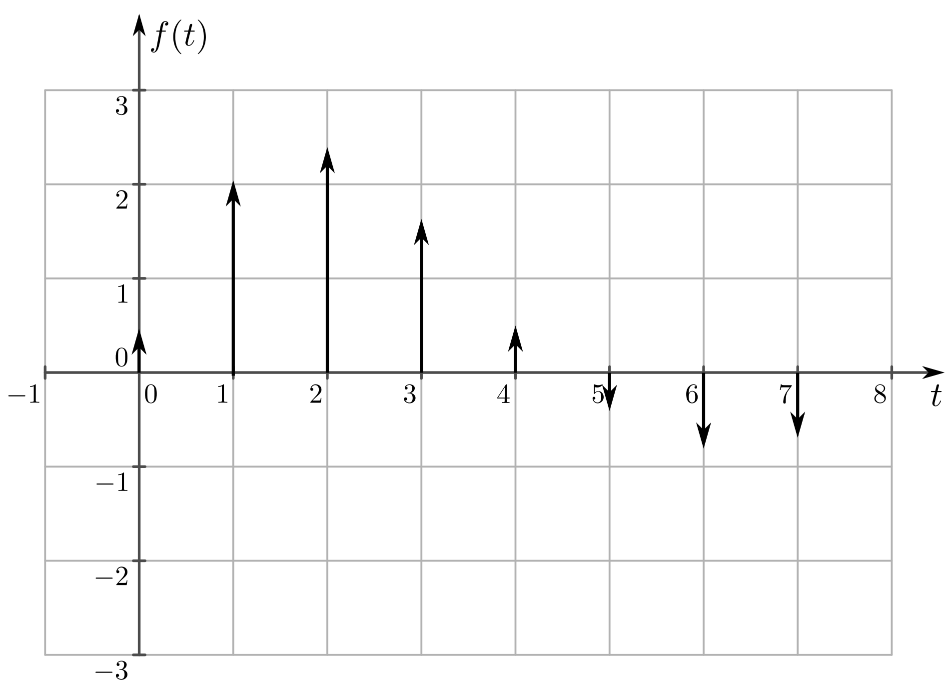
(b) If $h_d(t)$ is the delayed impulse response found in the previous part, what is the transfer function $H_d(s)$ (it will probably be easiest consider $h_d(t)$ in terms of step functions than a rect function)?

$H_d(s) =$

(c) Give a simplified expression (i.e., do not include a convolution in the final expression) for $f_r(t)$, which is the reconstructed signal for any given sampled signal $\bar{f}(t)$ by system H_d (and its impulse response function $h_d(t)$). In this scenario, we assume ideal sampling such that $\bar{f}(t) = f(t) \cdot \delta_T(t)$.

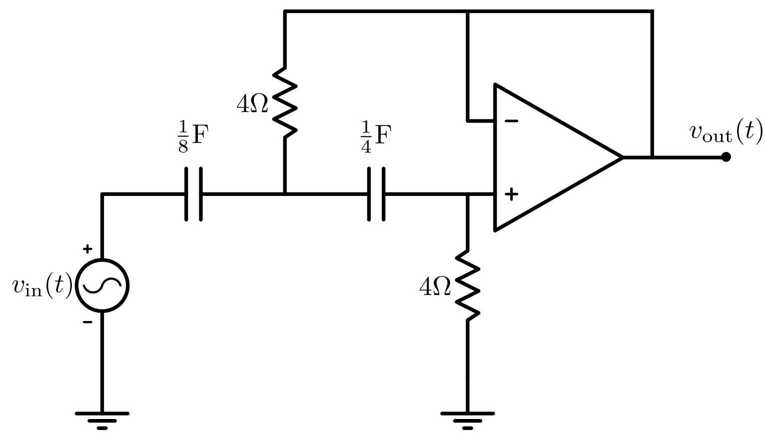
$h_r(t) =$

(d) If a signal $f(t)$ is sampled to be $\bar{f}(t)$ and subsequently reconstructed using the system H_d, sketch the output $f_r(t)$.



5 Sallen-Key Filters

In lab we analyzed and built a 2nd order Butterworth low-pass filter using the Sallen-Key circuit topology. Here, we will do something similar, but we will analyzing a 2nd order high-pass filter using the Sallen-Key topology. Given the circuit below, please answer the following questions.



(a) Redraw the circuit in the s-domain. Assume all initial conditions are zero.

(b) The transfer function for this circuit will take the form

$$H(s) = \frac{s^2}{s^2 + 2\zeta\omega_0 s + \omega_0^2}.$$

For this circuit, please find ω_0 and ζ (i.e., first find $H(s)$ from the circuit, then from the coefficients in $H(s)$, find the parameters ζ and ω_0).

$\omega_0 =$	$\zeta =$

(c) What is the impulse response for this system?

$h(t) =$