Homework for Module 5

Quiz, 19 questions

Try again once you are ready.

Required to pass: 80% or higher

You can retake this quiz up to 3 times every 8 hours.

Back to Week 7

Retake

1 / 1 points

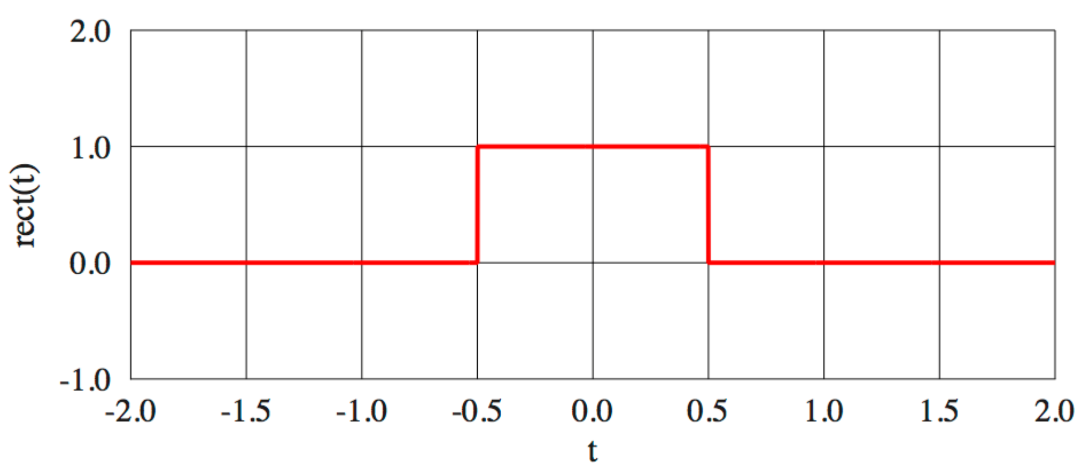
1.
(Difficulty: ⋆) Select the correct statement among the ones below:

1 / 1 points

2.
(Difficulty: ⋆) A piecewise constant function in continuous time can always be expressed as a linear combination of scaled and translated unit step functions. Recall the definition of the unit step is:

$$u(t) = \begin{cases} 1 & \text{for } t > 0 \\ 0 & \text{otherwise} \end{cases}$$

Consider the function shown in the figure below:

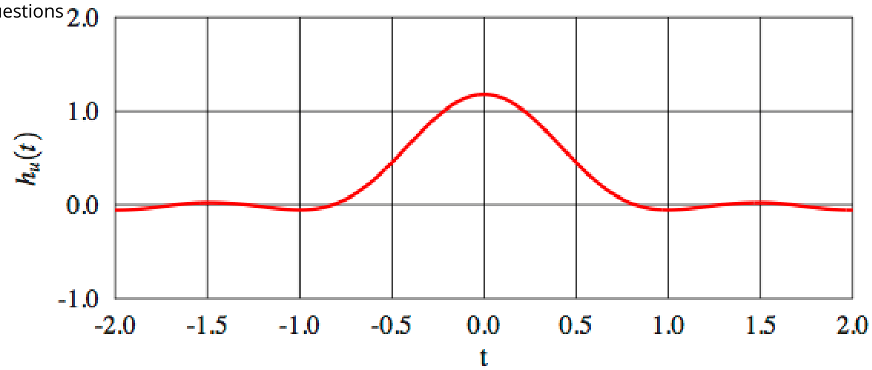


Which is the correct expression for the function in terms of units steps?

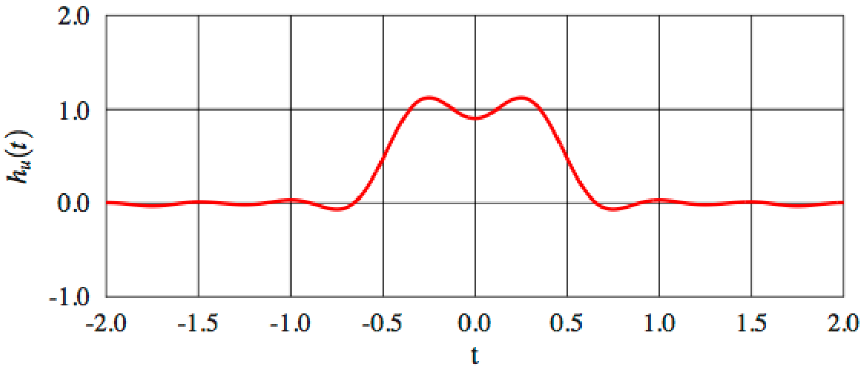
1 / 1 points

3.

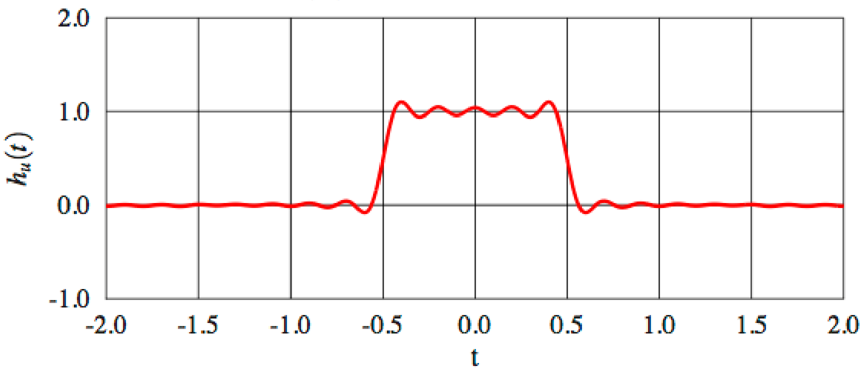
(Difficulty: ⋆) The figures below show the result of filtering the signal $x(t) = \mathrm{rect}(t)$ with four ideal lowpass filters with different cutoff frequencies Ω_{c_i}, $i = 0, 1, 2, 3$.



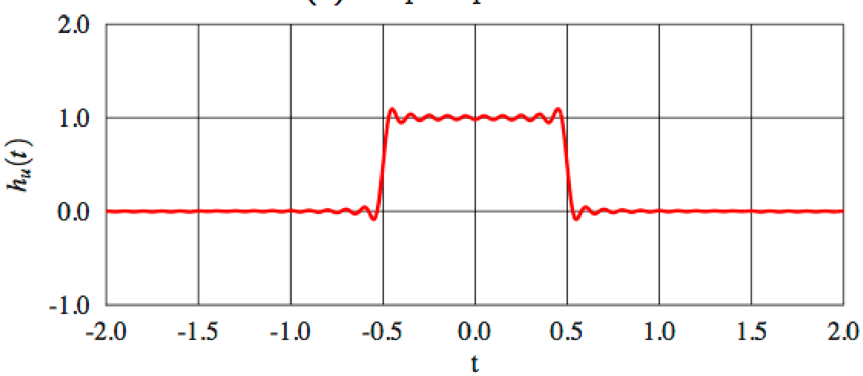
(a) Step response.



(b) Step response.



(c) Step response.



(d) Step response.

Check the correct statements below.

1 / 1 points

Homework for Module 5

Quiz, 10 questions

4.
(Difficulty: ⋆⋆) Consider the interpolator

$$I(t) = \begin{cases} 1 - 2|t| & \text{for } |t| \le \dfrac{1}{2} \\ 0 & \text{otherwise} \end{cases}$$

The interpolator has a triangular shape in the time domain. Select the correct expression for $I(j\Omega)$, the Fourier transform of the interpolator. (Hint: a triangle can be obtained by convolving two rectangles).

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0 / 1 points

5.
(Difficulty: ⋆⋆⋆) Consider a discrete-time signal $x[n]$ whose spectrum between $-\pi$ and π is

$$X(e^{j\omega}) = \begin{cases} 1 & \text{for } |\omega| \le \frac{2\pi}{3} \\ 0 & \text{otherwise} \end{cases}$$

with 2π-periodicity over the entire frequency axis.

$x[n]$ is interpolated to a continuous-time signal $x(t) = \sum_{n=-\infty}^{\infty} x[n] I\left(\frac{t-nT_s}{T_s}\right)$ ~~using the interpolator $I(t)$~~ defined in the previous question:

$$I(t) = \begin{cases} 1 - 2|t| & \text{for } |t| \le \dfrac{1}{2} \\ 0 & \text{otherwise} \end{cases}$$

Which graph represents the resulting spectrum of $x(t)$?

0.50 / 1 points

6.
(Difficulty: ⋆⋆) When using a first-order interpolator (such as the one described in the previous question) to interpolate a **finite-support** sequence, which of the following statements are true?

0.67 / 1 points

7.
(Difficulty: ⋆) Select the correct statement(s).

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0 / 1 points

8.

(Difficulty: ⋆) Consider a real-valued, continuous-time signal $x(t)$. All you know about the signal is that $x(t) = 0$ for $|t| > t_0$. Can you determine a sampling frequency F_S so that when you sample $x(t)$, there is no aliasing?

Select the correct statement(s).

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0 / 1
points

9.
(Difficulty: ⋆⋆) Listen to the sound of a triangle (the percussive musical instrument):

Below you are given 4 processed version of the original sound. In which one can you hear aliasing artifacts due to downsampling?

Try to find the answer just by listening. If you are stuck, you may use a numerical package to study the spectrum.

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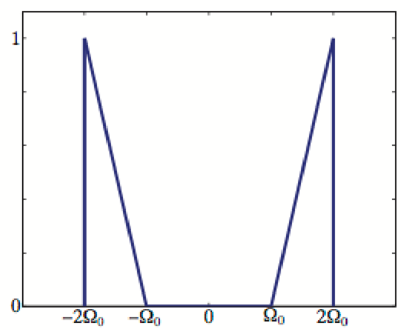
1 / 1
points

10.
(Difficulty: ⋆) Consider a real-valued, continuous-time signal $x_c(t)$ with the following spectrum:



What is the maximum sampling period T_s that we can use to sample $x_c(t)$ so that the spectral copies caused by sampling do not overlap?

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0 / 1
points

11.
(Difficulty: ⋆) Assume $x(t)$ is a continuous-time pure sinusoid at 10 kHz. The signal is raw-sampled at 8 kHz and then interpolated back to a continuous-time signal with an interpolator at 8 kHz. What is the perceived frequency in kHz of the interpolated sinusoid?

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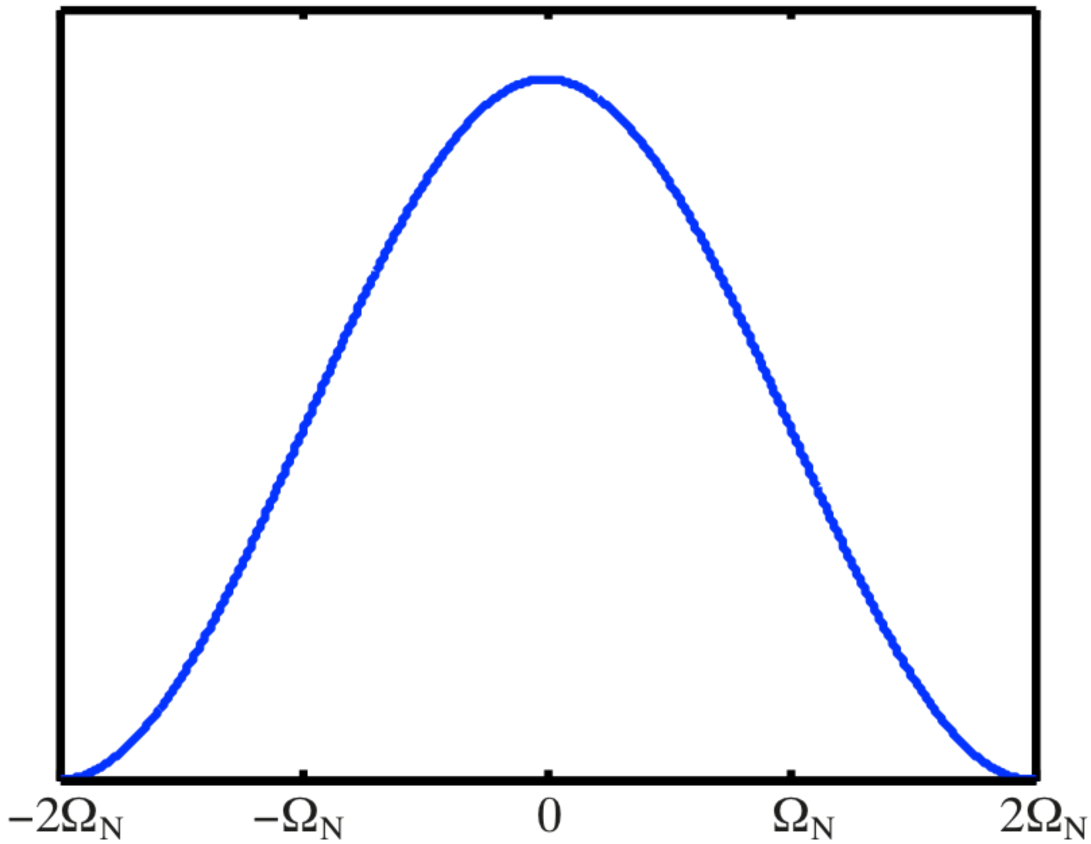
0 / 1
points

12.

(Difficulty: ⋆⋆⋆) Consider a real-valued continuous-time signal $x_c(t)$ whose bandlimited Fourier transform is

$$X_c(j\Omega) = \begin{cases} \cos^2(\frac{\pi}{4}\frac{\Omega}{\Omega_N}) & \text{for } |\Omega| < 2\Omega_N \\ 0 & \text{otherwise} \end{cases}$$

$X_c(j\Omega)$ is shown here between $-2\Omega_N$ and $2\Omega_N$:



The signal $x(t)$ is now sampled with $T_s = \pi/\Omega_N$; this defines the periodized spectrum

$\tilde{X}_c(j\Omega) = \sum_k X_c(j(\Omega - 2k\Omega_N))$

Which of the following pictures depicts $\tilde{X}_c(j\Omega)$?

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0 / 1
points

13.

(Difficulty: ⋆) A chirp is a sinusoidal signal whose frequency increases over time. Consider the linear chirp defined as

$$x(t) = \cos(2\pi f_0 t + \alpha \pi t^2).$$

By setting $\alpha = \frac{f_1 - f_0}{t_1}$, then f_0 is the inital frequency of the chirp at time $t = 0$, and $\frac{f_0 + f_1}{2}$ is the instantaneous frequency at time $t = t_1$ and the frequency increases linearly with time.

Write a program in your favorite programming language that computes a discrete-time version of the chirp at a sampling frequency $F_s = 8000\text{Hz}$ for $0 \leq t \leq 2$ seconds. Set $f_0 = 0\text{Hz}$ and $f_1 = 10\text{Hz}$ and $t_1 = 2$ seconds.

Use the program to count how many times the signal crosses the abscissa. How many zero-crossings can you count in the generated chirp?

Enter the number of zero-crossings as an integer.

0.25 / 1
points

14.
(Difficulty: ⋆⋆) Consider the same chirp signal as in the previous question. Which of the following statements are true for the signal?

Tick all the correct statements.

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0 / 1
points

15.
(Difficulty: ⋆) Consider the stochastic process defined as

$$Y[n] = X[n] + \beta X[n-1]$$

where $\beta \in \mathbb{R}$ and $X[n]$ is a zero-mean wide-sense stationary process with autocorrelation

$$R_X[k] = \sigma^2 \alpha^{|k|}, \qquad |\alpha| \leq 1$$

$Y[n]$ can also be expressed as filtered version of $X[n]$ where the filter's impulse response $h[n]$ is:

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0 / 1
points

16.
(Difficulty: ⋆ ⋆ ⋆) Using the same setup as in the previous question, select the correct expression for the power spectral density $P_Y(e^{j\omega})$.

0.33 / 1
points

17.
(Difficulty: ⋆⋆) Using the same setup as in the previous question, assume that the output $Y[n]$ turns out to be a white noise sequence. Which of the following statements are necessarily true ?

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0 / 1 points

Homework for Module 5

Quiz, 19 questions

18.

(Difficulty: $\star$) What is the minimum number of bits per sample you must use in order to sample and uniformly-quantize an analog signal with at least 80 dB of SNR?

Hint : you can use the "rule of thumb" from the lecture notes.

0 / 1 points

19.

(Difficulty: $\star\star\star$) A uniformly-distributed, zero mean stochastic signal with power spectral density $P_x(e^{j\omega}) = \sigma_x^2$ is quantized by means of a uniform linear quantizer with input range from $-2\sqrt{3}\sigma_x$ to $+2\sqrt{3}\sigma_x$ and resolution of R bits per sample.

What is the SNR at the output of the quantizer?