GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL of ELECTRICAL & COMPUTER ENGINEERING

QUIZ #2

DATE: 14-Oct-11 COURSE: ECE-2025

NAME: ______________________________ GT username: ______________
LAST, FIRST (ex: gpburdell3)

3 points 3 points 3 points

Recitation Section: Circle the date & time when your **Recitation Section** meets (not Lab):

	L05:Tues-9:30am (Richards)		L06:Thur-9:30am (Casinovi)
	L07:Tues-Noon (Richards)		L08:Thur-Noon (Casinovi)
	L09:Tues-1:30pm (Chang)		L10:Thur-1:30pm (Coyle)
L01:M-3pm (Barry)	L11:Tues-3pm (Chang)	L02:W-3pm (Clements)	L12:Thur-3pm (Baxley)
L03:M-4:30pm (Barry)		L04:W-4:30pm (Clements)	L14:Thur-4:30pm (Baxley)

- Write your name on the front page ONLY. **DO NOT** unstaple the test.
- Closed book, but a calculator is permitted.
- One page ($8\frac{1}{2}'' \times 11''$) of **HAND-WRITTEN** notes permitted. OK to write on both sides.
- JUSTIFY your reasoning CLEARLY to receive partial credit.
- You must write your answer in the space provided on the exam paper itself.
  Only these answers will be graded. Circle your answers, or write them in the boxes provided.
  If more space is needed for scratch work, use the backs of previous pages.

Problem	*Value*	*Score*
1	25	
2	25	
3	25	
4	25	
No/Wrong Rec	-3	

PROBLEM Fall-11-Q.2.1:

Shown below are spectrograms (labeled as **S1** – **S6**) for six signals. The (vertical) frequency axis for each plot has units of Hz; the horizontal axis is time, $0 \le t \le 14$ s. For each signal description below, identify the corresponding spectrogram. ***Write each answer in the box provided.***

(a) $x(t) = \cos(-1700\cos(2\pi t/42))$

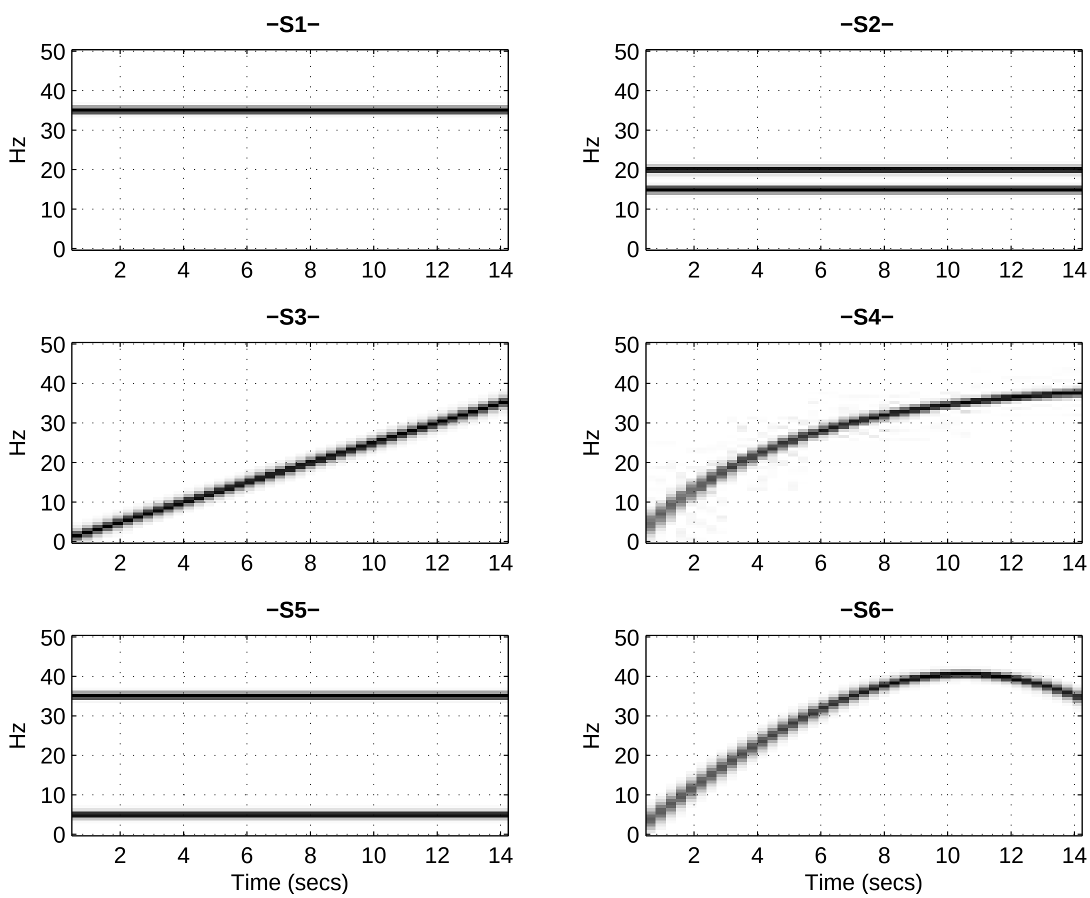
(b) $x(t) = \cos(2\pi 40t + 400\pi \exp(-t/5))$

(c) $x(t) = \cos(2\pi 15t)\cos(2\pi 20t)$

(d) $x(t) = \cos(2\pi 5t + \pi/4) + \cos(2\pi 35t) + \cos(2\pi 5t - 3\pi/4)$

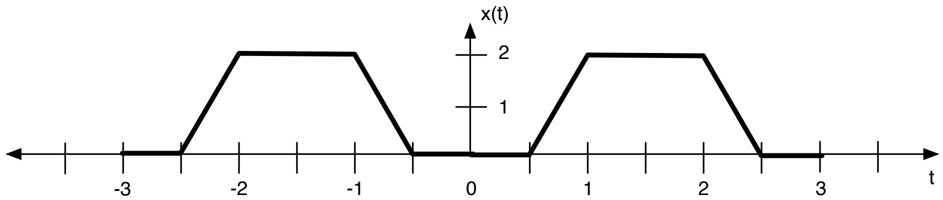
(e) $x(t) = \cos(2.5\pi t^2)$

(f) $x(t) = \cos(2\pi 20t) + \cos(2\pi 15t)$



PROBLEM Fall-11-Q.2.2:

Suppose that a periodic signal $x(t)$ is defined by the plot below (only the section $-3 \le t \le 3$ is shown).



(a) Determine the fundamental frequency of $x(t)$ in radians/second.

$\omega_0 =$ ☐

(b) Since $x(t)$ is periodic, it has a Fourier series given by $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j\omega_0 kt}$. Determine the numerical value of a_0.

$a_0 =$ ☐

(c) Define a new signal $y(t)$ that is related to the signal above by the following formula:

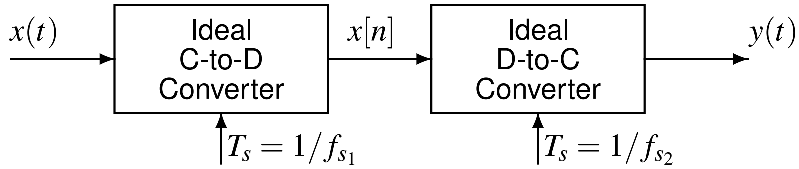
$$y(t) = 4\cos(4\pi t/3 + \pi/4) + 2x(t) - 1.$$

This new signal is also periodic with the same period as $x(t)$, having a Fourier series $y(t) = \sum_{k=-\infty}^{\infty} b_k e^{j\omega_0 kt}$. Fill in the table below with appropriate expressions for b_k. Do **not** try to calculate numeric answers here. **Each b_k should be written in terms of the coefficients a_k for the signal $x(t)$ described above.**

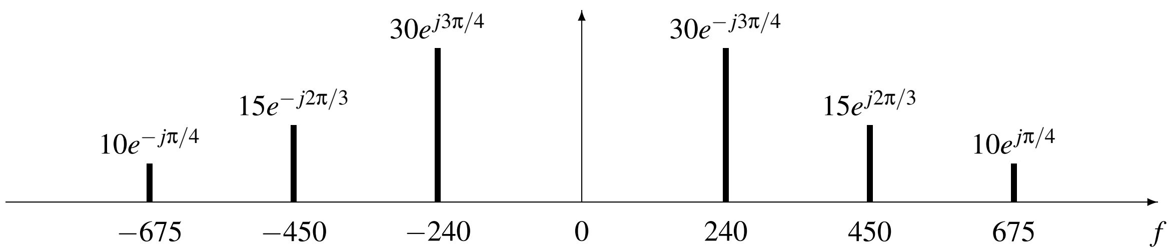
Signal: $z(t)$

b_k	Value
b_3	
b_2	
b_1	
b_0	
b_{-1}	
b_{-2}	
b_{-3}	

PROBLEM Fall-11-Q.2.3:



For parts (a) and (b) below, the input to the C/D converter is a signal $x(t)$ whose spectrum is shown here. The frequency f is in hertz.



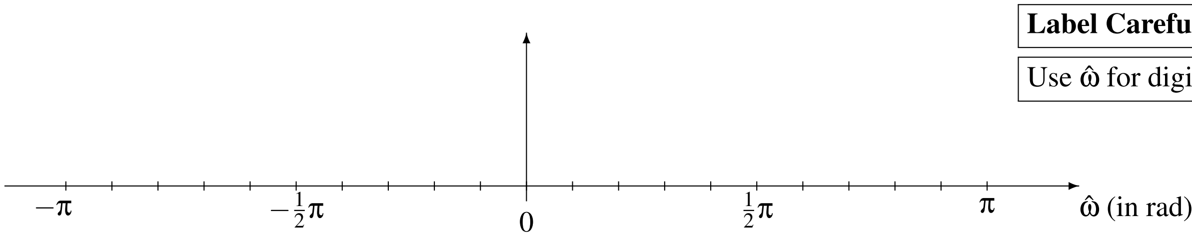
(a) Determine the Nyquist rate (in hertz) for sampling the signal $x(t)$.

$f_{\text{Nyquist}} =$ ☐ Hz

(b) If the sampling rate is $f_{s_1} = 600$ samples/sec., plot ***all of the spectrum components*** of the discrete-time signal $x[n]$ over the range of frequencies $-\pi \le \hat{\omega} \le \pi$. Make sure to label the frequency, amplitude and phase of each spectral component.

Label Carefully

Use $\hat{\omega}$ for digital freq.



(c) Note that in the diagram above, f_{s_1} may not be equal to f_{s_2}. We consider such a situation in this part of the problem. Suppose that a student writes the following MATLAB code to generate a sine wave, where the variable assignment `ff` has been left for you to fill in:

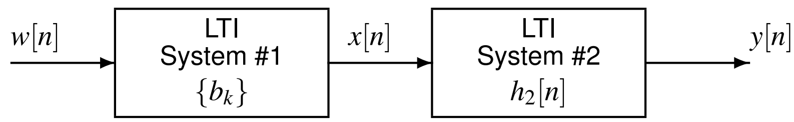
```
ff = ?;
tt = 0:1/2400:10000;
xx = sqrt(pi) * sin(2*pi*ff*tt-pi/4);
soundsc(xx,1600);
```

Determine the value of `ff` that should be used to play the vector `xx` as a 400 Hz sinusoid.

`ff` = ☐

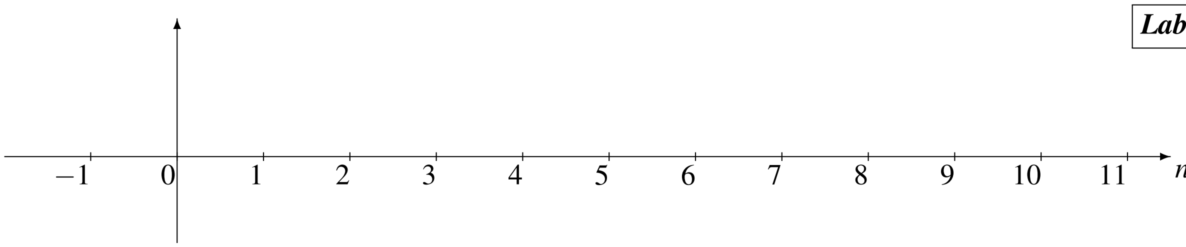
PROBLEM Fall-11-Q.2.4:

The diagram in the figure below depicts a *cascade connection* of two linear time-invariant systems, i.e., the output of the first system is the input to the second system, and the overall output is the output of the second system.



(a) Suppose that System #1 is an FIR filter whose filter coefficients are $\{b_k\} = \{0, 0, -0.4, 0, 0.2\}$. Determine the impulse response, $h_1[n]$, of the first system. Give your answer as a ***stem plot.***

Label Carefully



(b) Suppose that System #2 is defined by the MATLAB code below, where the variable `xx` is the signal $x(t)$ and the variable `yy` is the signal $y(t)$:

```
yy = conv([1 0 -1],xx);
```

Write the difference equation that relates the output $y[n]$ of this second system to its input $x[n]$.

(c) Using the descriptions of System #1 and System #2 in parts (a) and (b) above, determine the impulse response $h[n]$ of the overall cascaded system. Give your answer as a ***sum of shifted deltas.***

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(a) **S6** $x(t) = \cos(-1700\cos(2\pi t/42))$

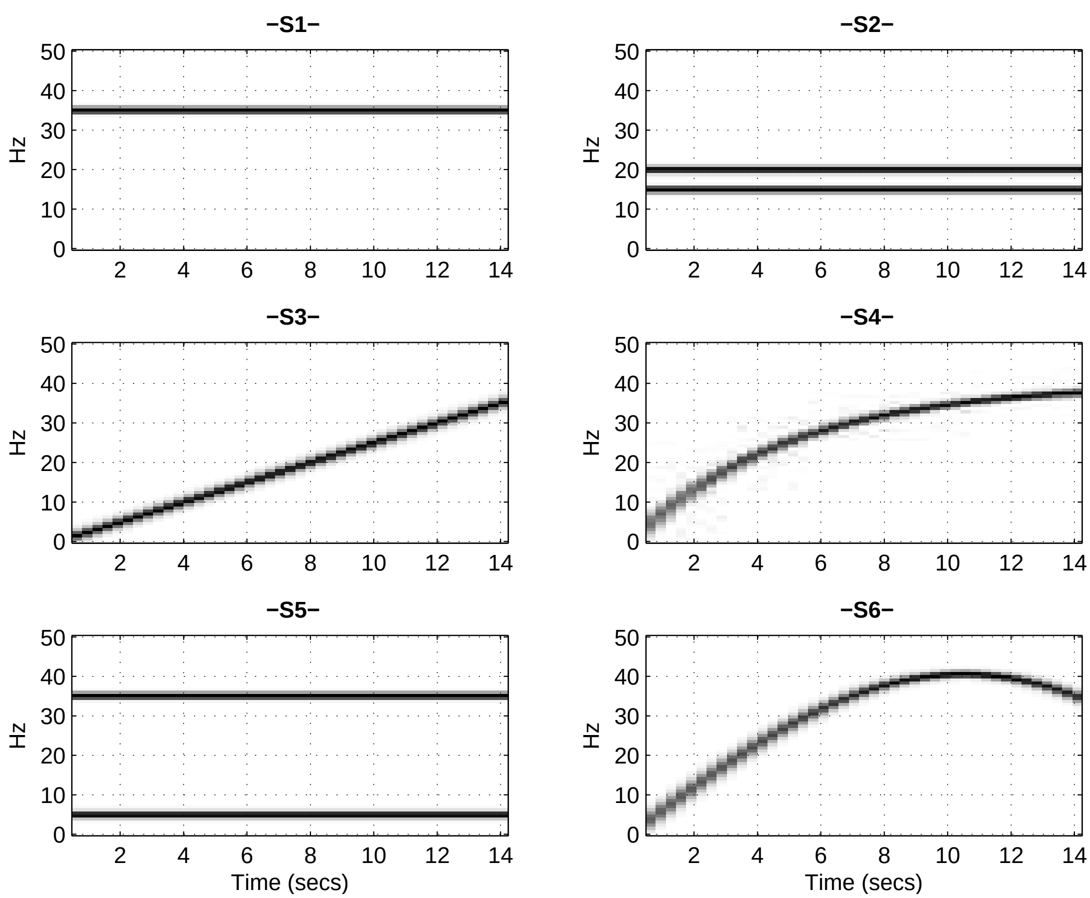
(b) **S4** $x(t) = \cos(2\pi 40t + 400\pi \exp(-t/5))$

(c) **S5** $x(t) = \cos(2\pi 15t)\cos(2\pi 20t)$

(d) **S1** $x(t) = \cos(2\pi 5t + \pi/4) + \cos(2\pi 35t) + \cos(2\pi 5t - 3\pi/4)$

(e) **S3** $x(t) = \cos(2.5\pi t^2)$

(f) **S2** $x(t) = \cos(2\pi 20t) + \cos(2\pi 15t)$



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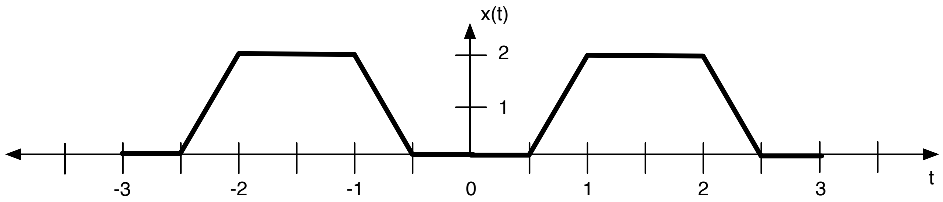


(a) Determine the fundamental frequency of $x(t)$ in radians/second.

$\omega_0 = \boxed{2\pi/3}$

(b) Since $x(t)$ is periodic, it has a Fourier series given by $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j\omega_0 kt}$. Determine the numerical value of a_0.

$a_0 = \boxed{1}$

(c) Define a new signal $y(t)$ that is related to the signal above by the following formula:

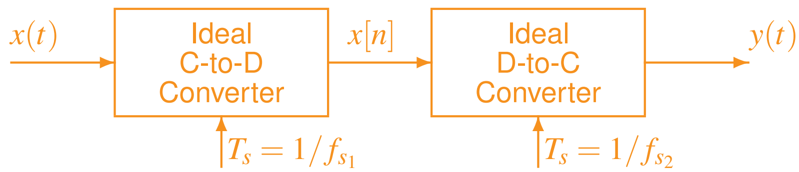
$$y(t) = 4\cos(4\pi t/3 + \pi/4) + 2x(t) - 1.$$

This new signal is also periodic with the same period as $x(t)$, having a Fourier series $y(t) = \sum_{k=-\infty}^{\infty} b_k e^{j\omega_0 kt}$. Fill in the table below with appropriate expressions for b_k. Do **not** try to calculate numeric answers here. **Each b_k should be written in terms of the coefficients a_k for the signal $x(t)$ described above.**

Signal: $z(t)$

b_k	Value
b_3	$2a_3$
b_2	$2a_2 + 2e^{j\pi/4}$
b_1	$2a_1$
b_0	$2a_0 - 1$
b_{-1}	$2a_{-1}$
b_{-2}	$2a_{-2} + 2e^{-j\pi/4}$
b_{-3}	$2a_{-3}$

PROBLEM Fall-11-Q.2.3:



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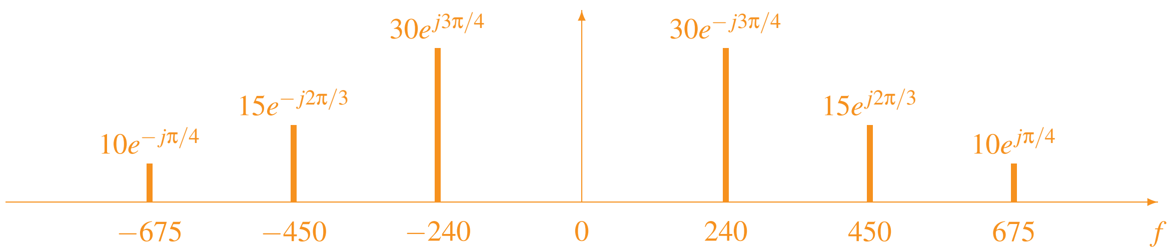
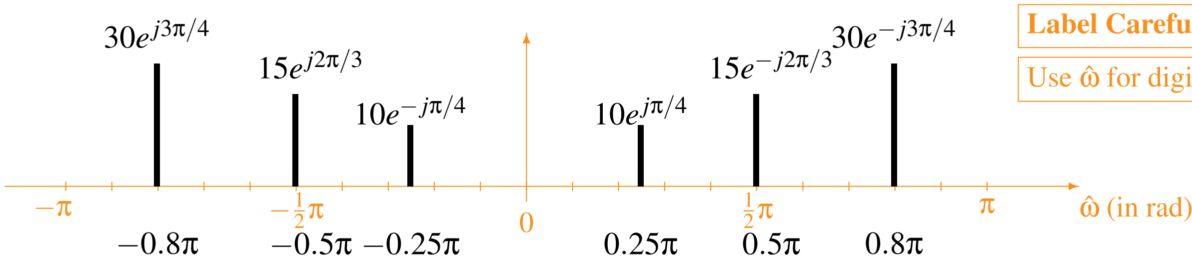


(a) Determine the Nyquist rate (in hertz) for sampling the signal $x(t)$.

$f_{\text{Nyquist}} = \boxed{1350}$ Hz

(b) If the sampling rate is $f_{s_1} = 600$ samples/sec., plot ***all of the spectrum components*** of the discrete-time signal $x[n]$ over the range of frequencies $-\pi \le \hat{\omega} \le \pi$. Make sure to label the frequency, amplitude and phase of each spectral component.



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(c) Note that in the diagram above, f_{s_1} may not be equal to f_{s_2}. We consider such a situation in this part of the problem. Suppose that a student writes the following MATLAB code to generate a sine wave, where the variable assignment `ff` has been left for you to fill in:

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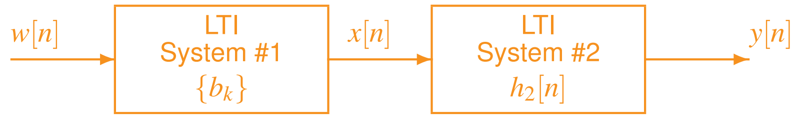
xx = sqrt(pi) * sin(2*pi*ff*tt-pi/4);
soundsc(xx,1600);
```

Determine the value of `ff` that should be used to play the vector `xx` as a 400 Hz sinusoid.

`ff` $= \boxed{600}$

PROBLEM Fall-11-Q.2.4:

The diagram in the figure below depicts a *cascade connection* of two linear time-invariant systems, i.e., the output of the first system is the input to the second system, and the overall output is the output of the second system.



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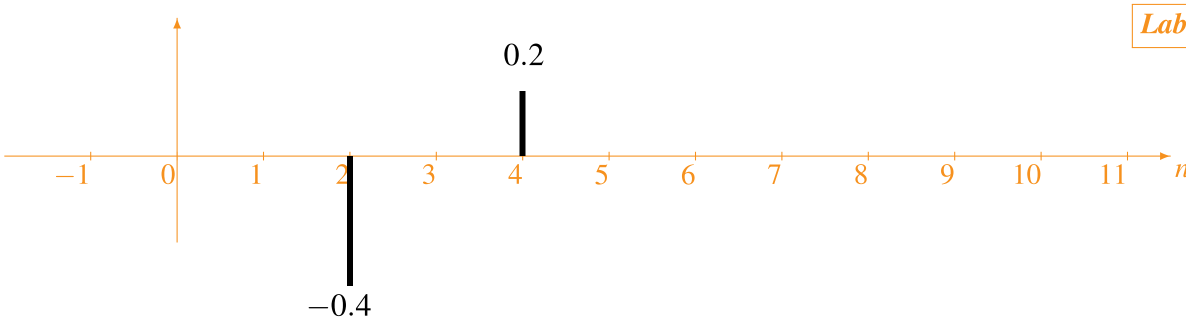

Plot is of $h_1[n] = -0.4\delta[n-2] + 0.2\delta[n-4]$

(b) Suppose that System #2 is defined by the MATLAB code below, where the variable `xx` is the signal $x(t)$ and the variable `yy` is the signal $y(t)$:

```
yy = conv([1 0 -1],xx);
```

Write the difference equation that relates the output $y[n]$ of this second system to its input $x[n]$.

$y[n] = x[n] - x[n-2]$

(c) Using the descriptions of System #1 and System #2 in parts (a) and (b) above, determine the impulse response $h[n]$ of the overall cascaded system. Give your answer as a ***sum of shifted deltas.***

$h[n] = -0.4\delta[n-2] + 0.6\delta[n-4] - 0.2\delta[n-6]$