Fall 2021 EE 313 Linear Systems and Signals Prof. Evans

Homework #9

# Fourier and Laplace Transforms

Assigned on Sunday, November 28, 2021

Due on Friday, December 3, 2021, by 11:59 pm via Canvas submission

*Late homework is subject to a penalty of two points per minute late*.

***Reading***: McClellan, Schafer & Yoder, *Signal Processing First*, 2003, Ch. 11 and  
Supplemental Chapter on [The Laplace Transform](https://utexas.instructure.com/files/60800285/download?download_frd=1).

Companion Web site with demos and other supplemental information: <http://dspfirst.gatech.edu/>

Web site contains solutions to selected homework problems from *DSP First*.

Office hours for Mr. Tabbara and Prof. Evans follow:

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| --- | --- | --- | --- | --- | --- |
| ***Time Slot*** | ***Monday*** | ***Tuesday*** | ***Wednesday*** | ***Thursday*** | ***Friday*** |
| **9:30 am** |  |  |  | Evans  (Zoom) |  |
| **10:00 am** |  |  |  | Evans  (Zoom) |  |
| **10:30 am** |  |  |  |  |  |
| **11:00 am** |  | Evans (EER 1.516) |  | Evans (EER 1.516) |  |
| **11:30 am** |  | Evans (EER 1.516) |  | Evans (EER 1.516) |  |
| **12:00 pm** |  | Evans (EER 1.516) |  | Evans (EER 1.516) | \*\* |
| **12:30 pm** |  | Evans  (Zoom) |  |  | \*\* |
| **1:00 pm** |  | Evans (Zoom) |  |  | **\*\*** |
| **1:30 pm** |  |  |  |  | **\*\*** |
| **2:00 pm** |  |  |  |  | Evans (Zoom) |
| **2:30 pm** |  |  |  |  | Evans (Zoom) |
| **3:00 pm** |  |  |  |  | Tabbara (Zoom) |
| **3:30 pm** |  |  | Tabbara (Zoom) |  | Tabbara (Zoom) |
| **4:00 pm** |  |  | Tabbara (Zoom) |  | Tabbara (Zoom) |
| **4:30 pm** |  |  | Tabbara (Zoom) |  |  |

\*\* Prof. Evans holds coffee/advising hours on Fridays 12:00-2:00pm in the EER café.

[EE 313 tutoring](http://www.ece.utexas.edu/academics/tutoring) is available 7-10pm on Sundays through Thursdays online.

1. **Continuous-Time Fourier Transforms Using Transform Properties and Pairs. *18 points.***

*Signal Processing First*, problem P-11.8, page 343.

1. **Transfer Functions in the Laplace Domain. *27 points*.**

Plot each signal in the time domain for -1 < *t* < 1, compute the Laplace transform including the region of convergence, and sketch the pole-zero plot and region of convergence for the following signals:

1. . *6 points*.
2. . *6 points*.
3. . *6 points*.

*Same as Homework Problem 10.2 from Fall 2018.*

For each part, what is the frequency selectivity— lowpass, highpass, bandpass, bandstop, allpass or notch? *3 points for each part.*

1. **Transfer Function in the Laplace Domain. *55 points.***

A continuous-time system with input *x*(*t*) and output *y*(*t*) is described by the following linear constant coefficient differential equation for *t* > 0-:

Initial conditions are set to zero, i.e. *y*(0-) = 0 and *x*(0-) = 0, so the system will have linearity and time-invariant properties. (Notice the two different uses of “linear”. In the case of linear constant different equation, “linear” refers to “affine” which is a line that does not necessarily go through the origin.)

1. What is the transfer function *H*(*s*) of the system in the Laplace domain including the region of convergence? *9 points.*
2. What is the impulse response *h*(*t*) of the system? *9 points.*
3. Find the frequency response *H*(*j*) of the system from the transfer function. Why is the substitution *s* = *j* valid? *9 points.*
4. From part (c), plot the magnitude response. What is the frequency selectivity— lowpass, highpass, bandpass, bandstop, allpass or notch? *9 points.*
5. For *x*(*t*) = *u*(*t*), find *X*(*s*) and *Y*(*s*). *9 points.*
6. From part (e), find *y*(*t*) by taking the inverse Laplace transform of *Y*(*s*). *10 points.*

*Same as Homework Problem 10.3 from Fall 2018.*

As stated on the course descriptor, “Discussion of homework questions is encouraged. Please be sure to submit your own independent homework solution.”