Fall 2021   EE 313 Linear Systems and Signals   Prof. Evans

Homework #3 Fourier Series and Sampling

Assigned on Tuesday, September 21, 2021
Due on Friday, September 21, 2021, by 11:59 pm via Canvas submission

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

Reading: McClellan, Schafer and Yoder, *Signal Processing First*, 2003, Ch. 3. Errata.
Companion Web site with demos and other supplemental information.
Web site contains solutions to selected homework problems from *DSP First*.

E-mail address for Mr. Faris Tabbara (TA) is firas.tabbara@utexas.edu. Lecture hours and office hours for Mr. Tabbara and Prof. Evans on Zoom (see links on the Canvas calendar) follow:

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)		

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

In your solutions, please put all work for problem 1 together, then all work for problem 2 together, etc. Please see the guidelines for writing your solutions on the homework page.
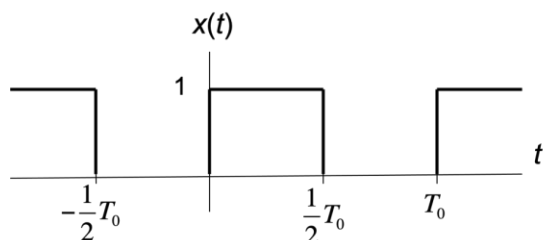
Because of the amount time needed on Mini-Project #1, this assignment has been reduced from four problems to two problems.

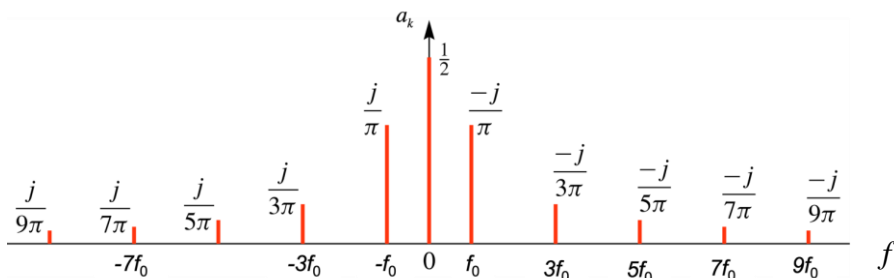## 1. Fourier Analysis and Synthesis. 50 points.

Signal Processing First, problem P-3.14, page 67. In addition, please do to following parts:

(c) Below, the square wave $x(t)$ from lecture slide 3-10 and *SP First* Sec. 3-6.1

$$x(t) = \begin{cases} 1 & \text{for } 0 \le t < \frac{1}{2}T_0 \\ 0 & \text{for } \frac{1}{2}T_0 \le t < T_0 \end{cases}$$

has the following Fourier series coefficients per lecture slides 3-10 and 3-11: $\quad x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j2\pi k f_0 t}$

$$a_k = \begin{cases} \dfrac{1}{2} & \text{for } k = 0 \\ 0 & \text{for } k \text{ even but not zero} \\ -\dfrac{j}{\pi k} & \text{for } k \text{ odd} \end{cases}$$

Give a formula for the Fourier series coefficients b_k for $y(t) = 2\, x\left(t - \frac{1}{4}T_0\right)$ by using your results from in parts (a) and (b).

(d) Validate your solution in part (c) by plotting the approximation of $y(t)$ given by b_k for $k \in [-10, 10]$ with $T_0 = 1$ s. Translate your answer for b_k for $k = 0$ as well as k positive and k negative into the MATLAB script FourierSynthesisSquareWave.m. Please note that this MATLAB script will animate the contribution of each term in the Fourier series for $y(t)$ from $-\frac{1}{2}T_0 \le t < \frac{1}{2}T_0$.

2. Sampling. 50 points.

Signal Processing First, problem P-4.2, page 96. In addition, please complete the following part:

(d) What is the continuous-time period of $x(t)$? What is the discrete-time period after $x(t)$ has been sampled at $f_s = 15$ samples/s? The course handout on *Discrete-Time Periodicity* might help.

A similar problem was assigned on homework #3 in fall 2018.