Fall 2023 EE 313 Linear Systems and Signals Prof. Evans

Homework #3 Fourier Series and Sampling

Assigned on Wednesday, September 20, 2023
Due on Saturday, September 23, 2023, 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. 4. 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. Elyes Balti (TA) is ebalti@utexas.edu. Please consider posting questions on the class Ed Discussion site, which can be answered by anyone in the class. You can post anonymously to the other students and the instructors would still be able to see your name.

Lecture and office hours for Mr. Balti and Prof. Evans follow:

Time Slot	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*
11:00 am		**Evans (ECJ 2.104)**		**Evans (ECJ 2.104)**	
11:30 am		**Evans (ECJ 2.104)**		**Evans (ECJ 2.104)**	
12:00 pm		**Evans (ECJ 2.104)**		**Evans (ECJ 2.104)**	
12:30 pm					
1:00 pm					
1:30 pm					
2:00 pm			**Evans (EER 6.882 and Zoom)**	**Evans (EER 6.882 and Zoom)**	**Balti (EER 3.648)**
2:30 pm			**Evans (EER 6.882 and Zoom)**	**Evans (EER 6.882 and Zoom)**	**Balti (EER 3.648)**
3:00 pm			**Evans (EER 6.882 and Zoom)**	**Evans (EER 6.882 and Zoom)**	**Balti (EER 3.648)**
3:30 pm		**Balti (EER 3.648)**			
4:00 pm		**Balti (EER 3.648)**			
4:30 pm		**Balti (EER 3.648)**			
5:00 pm				**Balti (EER 3.648)**	
5:30 pm				**Balti (EER 3.648)**	
6:00 pm				**Balti (EER 3.648)**	

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.

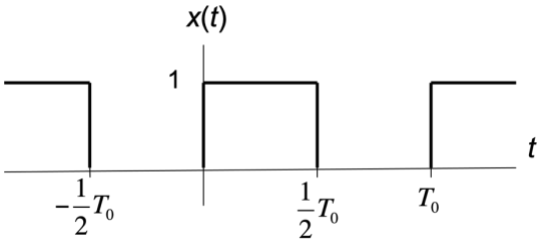
ECE 313 tutoring is available Sundays through Thursdays from 7:00pm to 10:00pm online.

Because of the amount time needed on Mini-Project #1, this assignment has been reduced from four problems to two problems. *These problems were also assigned on homework #3 in fall 2021*.

1. Fourier Analysis and Synthesis. 50 points.

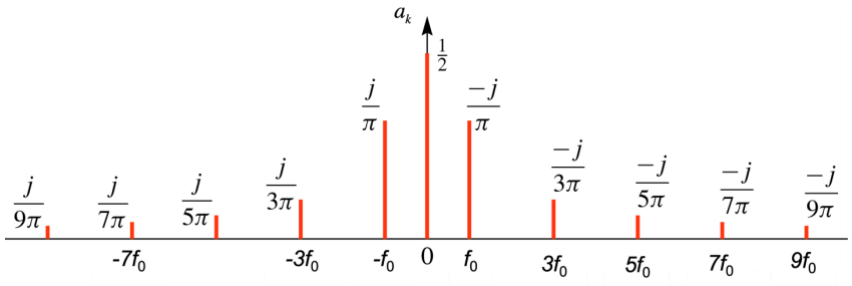
Signal Processing First, problem P-3.14, page 67. In addition, please do to following parts:

(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: $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j2\pi k f_0 t}$



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

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.