Fall 2024 EE 313 Linear Systems and Signals Prof. Evans

Homework #3 Fourier Series and Sampling

Assigned on Friday, September 20, 2024
Due on Friday, September 27, 2024, 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 Ed Discussion., which can be answered by anyone in the class. You can post anonymously. Lecture and office hours follow:

Time Slot	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*
11:00 am		**Evans (ECJ 1.204)**		**Evans (ECJ 1.204)**	
11:30 am		**Evans (ECJ 1.204)**		**Evans (ECJ 1.204)**	
12:00 pm		**Evans (ECJ 1.204)**		**Evans (ECJ 1.204)**	
12:30 pm					
1:00 pm			**Balti (EER 5.652)**		
1:30 pm			**Balti (EER 5.652)**		
2:00 pm	**Evans (EER 6.882; Zoom)**		**Balti (EER 5.652)**		**Balti (EER 4.650)**
2:30 pm	**Evans (EER 6.882; Zoom)**		**Balti (EER 5.652)**		**Balti (EER 4.650)**
3:00 pm	**Evans (EER 6.882; Zoom)**				**Balti (EER 4.650)**
3:30 pm			**Evans (EER 6.882; Zoom)**		**Balti (EER 4.650)**
4:00 pm			**Evans (EER 6.882; Zoom)**		
4:30 pm			**Evans (EER 6.882; Zoom)**		
5:00 pm				**Balti (EER 4.702)**	
5:30 pm				**Balti (EER 4.702)**	
6:00 pm				**Balti (EER 4.702)**	
6:30 pm				**Balti (EER 4.702)**	

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.

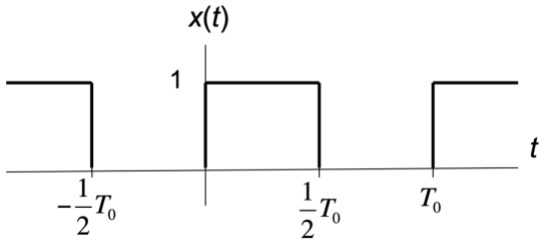
ECE 313 tutoring is available Sundays through Thursdays from 7:00pm to 10:00pm online.

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.

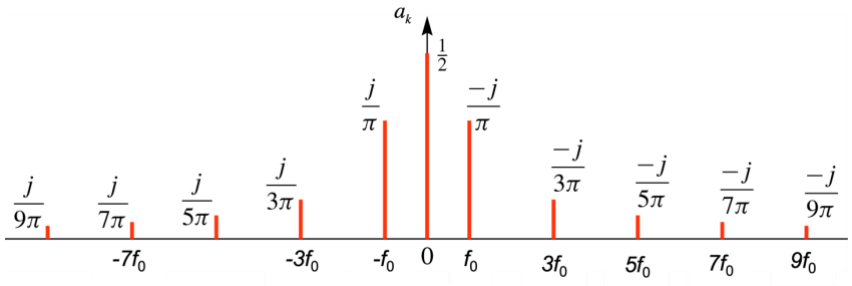
Signal Processing First, problem P-3.14, page 67. In addition, please do to following parts:

(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.