

EE 102: Signal Processing and Linear Systems

Instructor: Ayush Pandey

Homework #6: Fourier Series

Name: _____

Submission Date: _____

Problem 1 Consider the RC circuit example in previous problem sets and use its impulse response for this problem. For each of the input signals below, find the Fourier series representation of the output signal:

(a) [20 points] A train of impulses:

$$x(t) = \sum_{n=-\infty}^{\infty} \delta(t - n)$$

(b) [20 points] A square wave of amplitude 1 sketched below in Figure 1.

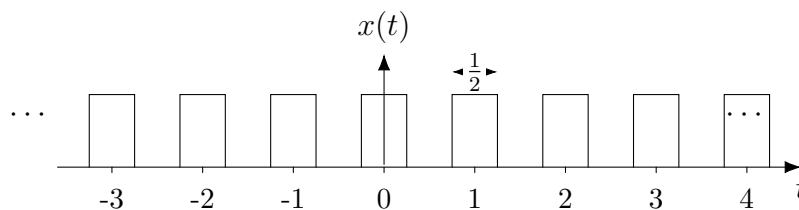


Figure 1: A square wave of amplitude A and period $T = 1$.

(c) [20 points] The $x(t)$ above in part (b) models a PWM signal that drives a motor at a fixed duty cycle. As you engineer your system dynamics, you decided to increase the speed of the motor by twice. For this new PWM signal, sketch the signal and use the answer from the previous part along with properties of LTI systems to find the Fourier series representation of the output signal.

(d) [10 points] Write Python/MATLAB code to implement the signals in (b) and (c). Compute the outputs, the Fourier series representations, and plot the magnitude spectra of the outputs. Validate your results using these simulations.

Problem 2 Compute the Fourier series representation of the following signals. For each part, if you consider only the first N terms of the Fourier series, compute the error energy in the representation for $N = 1, 2, 3, 4$. You are allowed to use computer programs for computations, if it helps.

(a) [15 points] A triangular signal sketched below in Figure 2A.

(b) [15 points] A rectangular signal sketched below in Figure 2B.

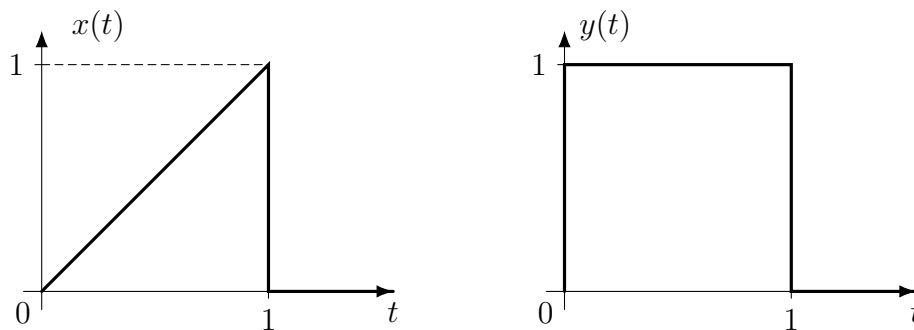


Figure 2: (a) A triangular signal $x(t)$ and (b) a rectangular signal $y(t)$.