Signals and Systems

Assignment 5

Fall 2020

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Question1

Let $x(t)$ be a signal with Nyquist rate ω_n. Determine the Nyquist rate for the following signals:

(a) $\int_{-\infty}^{t} x(t)dt$

(b) $x(2t)$

(c) $x^2(t)$

(d) $x(t)cos(2\pi t)$

(e) $e^{jw_0t}x(t)$

Question2

Determine whether or not each of the following signals is band-limited and if it is, determine its Nyquist rate.

(a) $x(t) = e^{j\omega_1 t}\dfrac{sin(\omega_2 t)}{\pi t}$

(b) $x(t) = 3te^{-3t}u(t)$

(c) $x(t) = sin^2(\frac{2\pi}{3}t) + cos(\pi t)sin(\frac{\pi}{4}t)$

(d) $x(t) = \delta(t) + 2$

(e) $x(t) = \dfrac{sin^2(\pi t)}{\pi t^2}$

Question3

Consider a band-limited signal $x(t)$ for which $X(j\omega)$ is zero for $|\omega| > \omega_M$. $x(t)$ is modulated using a modulation scheme in which the modulated signal $g(t)$ is obtained as follows:

$$g(t) = x(t)cos(\omega_c t) - x(t)cos(\omega_c t) * \left(\frac{sin(\omega_c t)}{\pi t}\right)$$

(a) What should be the relation between ω_c and ω_M so that $x(t)$ is recoverable from $g(t)$?

(b) Determine the value of A such that $g(t)$ is demodulated as follows:

$$x(t) = (g(t)cost(\omega_c t)) * \frac{Asin(\omega_M t)}{\pi t}$$

Question4

Let $x[n]$ be a periodic signal with fundamental period N and Fourier series coefficients a_k. Determine the Fourier series coefficients for the following signals:

(a) $x[3-n]$

(b) $x^2[n]$

(c) $\sum_{r=<N>} x[r]x[n+2-r]$

(d) $e^{j\frac{6\pi}{N}n}x[n]$

(e) $x[n]-x[n-2]$

(f) $x^*[-n]$

Question5

Determine the Fourier series coefficients for the following signals:

(a) $sin\left(\frac{2\pi}{N}n\right) + cos\left(\frac{2\pi}{N}n + \frac{\pi}{4}\right)$

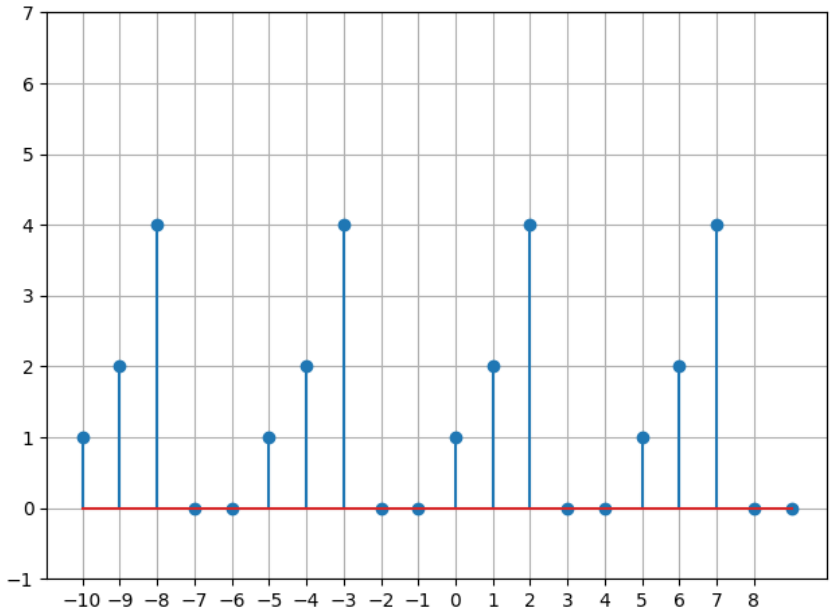
(b) $2 + 3cos\left(\frac{2\pi}{3}n\right) + sin\left(\frac{\pi}{3}n\right)$

(c) $(-1)^n + cos^2\left(\frac{\pi}{5}n + \frac{\pi}{4}\right)$

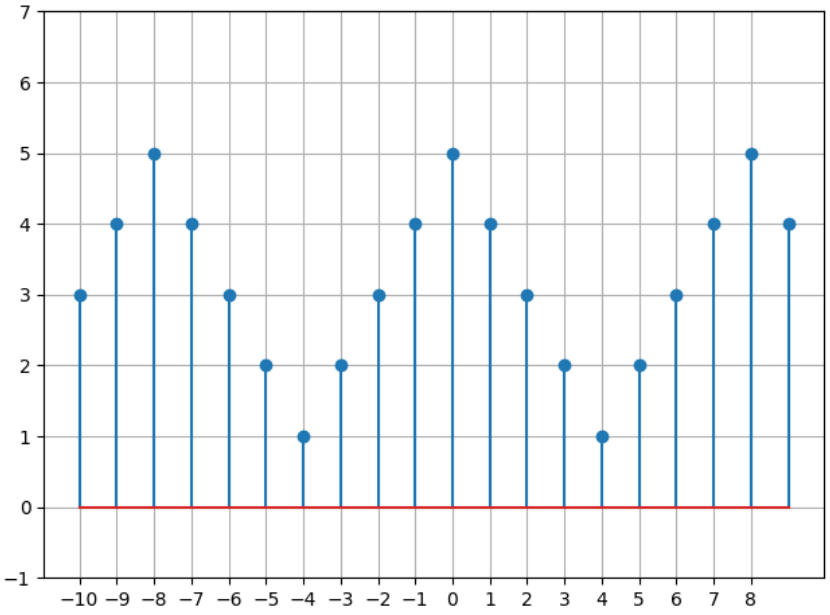
(d) $\sum_{k=-\infty}^{\infty} \delta[n - 3k]$

(e) $\hat{x}[n] = \begin{cases} 1, & |n| \leq N_1 \\ 0, & N_1 < |n| \leq \frac{N}{2} \end{cases}$

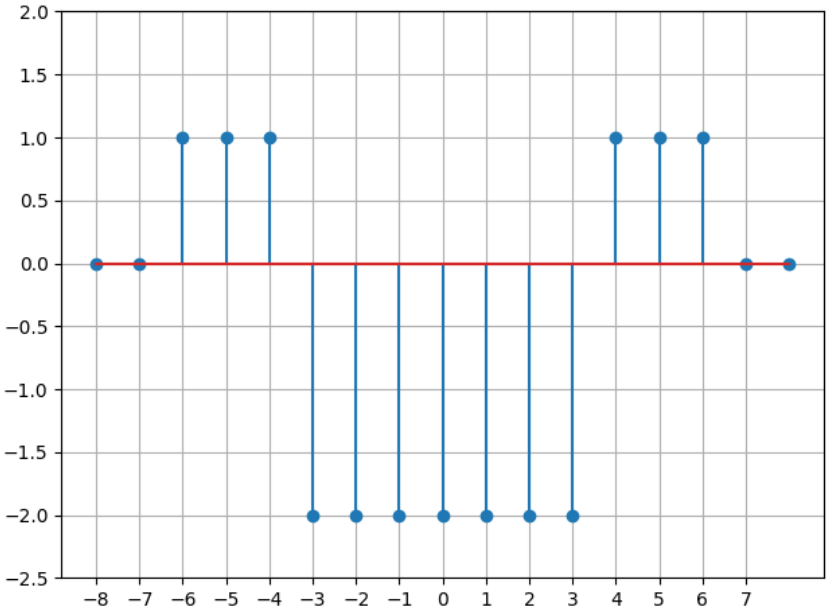
(f)



(g)



(h) Use the result from part *e*. (N = 10)



Question6

Let $x[n]$ be a real and odd periodic signal with period $N = 7$ and Fourier coefficients a_k. Given that

$$a_{15} = j, a_{16} = 2j, a_{17} = 3j,$$

determine the values of a_0, a_{-1}, a_{-2}, and a_{-3}.