Homework 1

Profs. Snyder, Shomorony   **Due: Friday, Jan 30, 11:59pm on Gradescope**

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1. Plot each of the following discrete-time signals for $-5 \leq n \leq 5$. Recall that $\delta[n]$ is the unit impulse or Kronecker delta and $u[n]$ is the unit step signal.

   (a) $\delta[n+4] - \delta[n+1] + 3\delta[n] + 2\delta[n-2]$

   (b) $\left(\frac{2}{3}\right)^n (u[n+2] - u[n-3])$

   (c) $\cos\left(\frac{3\pi}{4}n - \frac{\pi}{4}\right)$

2. Let $x[n]$ be a length–8 discrete-time signal as given below.

$$x[n] = \{2, 1, \underset{\uparrow}{-3}, 4, 0, -2, 3, -1\}$$

   (a) Sketch the signal $y[n]$ where $y[n] = x[2-n]$. **Please carefully label your plots!**

   (b) Sketch the signal $z[n]$ where $z[n] = x[2n+3]$.

3. For each of the following plots of a discrete-time signal, express the signal in terms of **(i)** the Kronecker delta $\delta[n]$ and **(ii)** the unit-step signal $u[n]$. All samples not shown may be assumed to be zero.

(a)   (b)
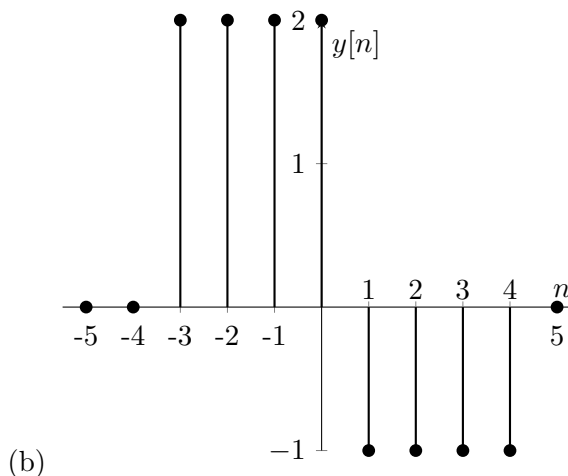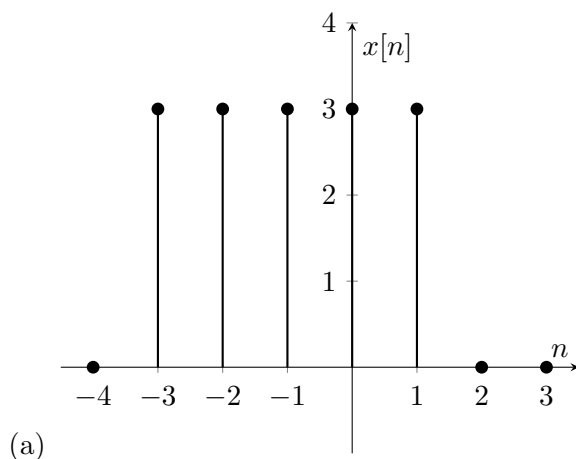
4. For each of the following parts, **(i)** determine the values of z that satisfy the equation and **(ii)** plot these values of z on the complex plane. **Hint:** recall that complex numbers in exponential form may be written as $Re^{j\theta} = Re^{j(\theta_p + 2\pi k)}$ where $\theta_p \in [-\pi, \pi]$ is the *principal angle* and k is some integer.

   (a) $z^4 - 1 = 0$

   (b) $z^4 + 1 = 0$

5. A clipping system is a common block included in larger digital systems. For constants a and b where $a < b$, the clipping system with input $x[n]$ produces output $y[n]$ as follows.

$$y[n] = \begin{cases} b, & x[n] \geq b \\ x[n], & a < x[n] < b \\ a, & x[n] \leq a \end{cases}$$

(a) Let $x[n] = \{-4, -3, -2, -1, \underset{\uparrow}{0}, 1, 2, 3, 4\}$, $a = 0$, and $b = 3$. Sketch $y[n]$.

(b) Determine if the system is linear or non-linear. Please provide justification, e.g. proof or counter-example.

(c) Determine if the system is time-invariant or time-varying. Please provide justification.