EECS 360 Signal and System Analysis
Lab 9. Sampling and Signal Reconstruction

1. Consider the system below:

![Diagram](image.png)

a. Describe what is taking place in this block diagram.
b. Blocks “A” and “B” represent signals, what is the relationship between these two signals?
c. “T_s” is the sampling period. In order for the system to function without aliasing, what relationship must exist between signal “A” and T_s?

2. Consider an analog signal \( x_a(t) = \cos(20\pi t), \) \( 0 \leq t \leq 1 \). Sample this signal at \( T_s = 0.01, 0.05, 0.1 \) second intervals.
   a. What is the frequency of \( x_a(t) \)?
   b. Produce a stem plot of all three sampled sequences. Use 3 subplots contained in a single figure.
   c. From the stem plots, comment on which sequences are over sampled, under sampled, or ideally sampled.

3. Reconstruct the analog signal \( y_a(t) \) using the following techniques. Use the following time vector for all the reconstruction plots, \( t_a = [0 : 0.001 : 1] \).
   a. Reconstruct the signal using rectangular pulses.
   \textit{Hint:} use “rectpuls” function.
   b. Reconstruct the signal using triangle pulses.
   \textit{Hint:} use “tripuls” function.
   c. Reconstruct the signal using \( \text{sinc} \) interpolation (see example on next page).
   d. Reconstruct the signal using \( \text{spline} \) interpolation
   e. Plot the three rectangular pulse reconstructed signal (3 subplot, 1 figure)
   f. Plot the three triangular pulse reconstructed signal (3 subplot, 1 figure)
   g. Plot the three \( \text{sinc} \) interpolation reconstructed signal (3 subplot, 1 figure)
   h. Plot the three \( \text{spline} \) interpolation reconstructed signal (3 subplot, 1 figure)
   i. Comment on the results, which interpolation works the best? Why?
   j. What sampling frequencies reconstructed better than others?

\textit{Sinc} interpolation example:
Formula: \( y_a(t) = \sum_{n=-\infty}^{\infty} x_a(nT_s) \sin \left( \frac{\pi (t - nT_s)}{T_s} \right) = \sum_{n=-\infty}^{\infty} x_a(nT_s) \sin \left( \frac{F_s (t - nT_s)}{T_s} \right) \)

4. Calculate the mean squared error of all 12 reconstructed signals
   a. Construct a “bar” graph using the given function “mseplot.m” 
      Note: reshape the mse vector into a 3x4 matrix before apply.
   b. Comment on which reconstruction technique produced the lease MSE.