Lab 1

Chengxuan Li
1631060
Section 801
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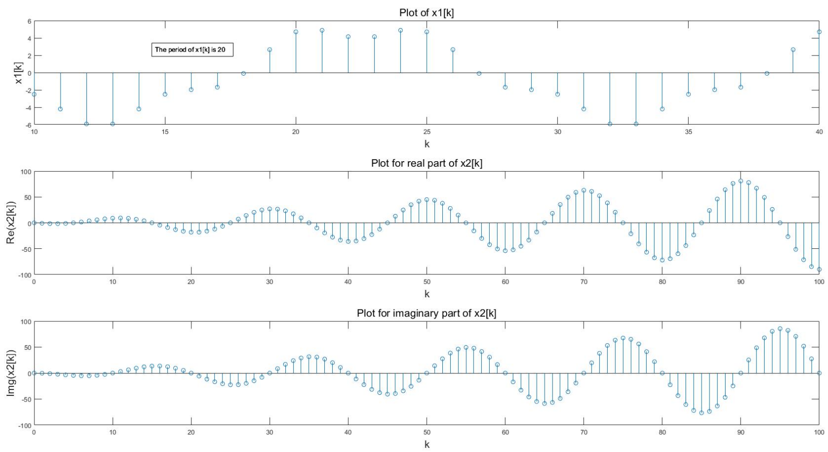
Q.1 Signal Generation and Plotting

a) Plot for discrete function $x_1[k]$ and $x_2[k]$:



Associate code for generating the discrete function and plots:

```
% initialize input vector for k1 and k2
k1 = (10:40);
k2 = (0:100);

% output vector x1 and x2 with input k1 and k2 respectively
x1 = -5.1 * sin(0.1 * pi * k1 - 3 * pi / 4) + 1.1 * cos(0.4 *
    pi * k1);
x2 = (-0.9 .* k2) .* exp(1j * pi * k2 / 10);

realX2 = real(x2);  % real part of x2[k]
imagX2 = imag(x2);  % imaginary part of x2[k]

% Set the plot layout. Placing 3 different graph separately in
% a vertical manner
tiledlayout(3,1);

% plot of x1[k]
ax1 = nexttile;
stem(ax1, k1, x1);
title('Plot of x1[k]', 'Fontsize', 16);
xlabel('k', 'Fontsize', 16);
ylabel('x1[k]', 'Fontsize', 16);
dim = [.2 .78 .1 .1];
text = {'The period of x1[k] is 20'};
annotation('textbox', dim, 'String', text);

% plot of real part of x2[k]
ax2 = nexttile;
stem(ax2, k2, realX2);
title('Plot for real part of x2[k]', 'Fontsize', 16);
xlabel('k', 'Fontsize', 16);
ylabel('Re(x2[k])', 'Fontsize', 16);
```

```
% plot of imaginary part of x2[k]
ax3 = nexttile;
stem(ax3, k2, imagX2);
title('Plot for imaginary part of x2[k]', 'Fontsize', 16);
xlabel('k', 'Fontsize', 16);
ylabel('Img(x2[k])', 'Fontsize', 16);
```

b) $x_1[k]$ is a periodic sequence, and period is 20. $x_2[k]$ is not a periodic sequence.

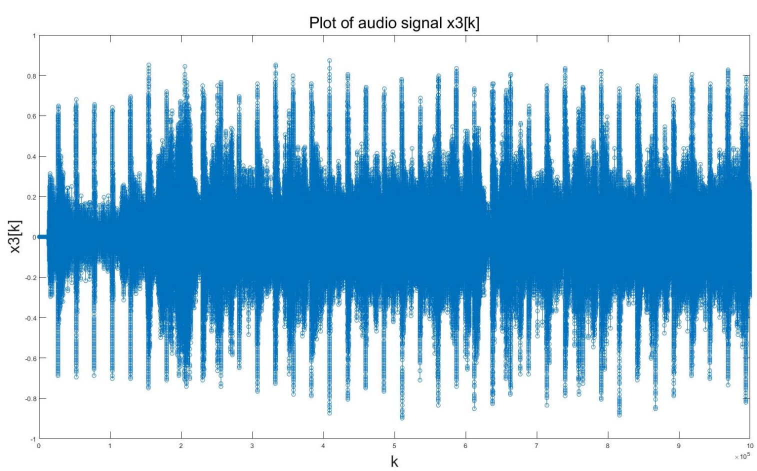
c) The total energy of $x_1[k]$ is 426.3335. The total energy of $x_2[k]$ is 274063.5.

Q.2 Digital Audio

b) Code to generate matrix x3:

```
% Read the audio signal and store it into matrix x3. Fs is the
% sample rate, which is necessary for write the audio signal
% into .wav file after processing.
[x3, Fs] = audioread("baila.wav");

% A matrix represent the index of each sample.
k = (1:length(x3));
sampleSize = length(x3);  % Size and No. of sample of x3
```

c) The size of x_3 matrix is 1000000 x 1.The number of samples is 1000000.



d) The energy of x_3 is 20422.7731323242.

e) Code to generated matrix x3s[k]:

```
% Generate matrix x3s[k] by keeping the first half of x3
x3Half = x3(1:sampleSize/2);
```

f) Code for **baila_half** file:

```
% Write x3s[k] into an output audio file.
audiowrite("baila_half.wav", x3Half, Fs);
```

Q.3 Digital Image

b) No. of both rows and columns are 512. The maximum pixel value is 165.

Code to store matrix lena:

```
lena = imread("lena.jpg"); % Read .jpg file into a matrix
[row, column] = size(lena); % Return the number of row and
    column
maxPixel = max(max(lena)); % Find the maximum pixel
```

c) Code for creating **lena_bright**:

```
% Create a brighter version of the .jpg file
lena_bright = lena + 30;
```

d) Coe for written **lean_bright.jpg** file:

```
% Write the matrix into a .jpg file
imwrite(lena_bright,'lena_bright.jpg','jpg','Quality', 100);
```

Q.4 System response

a) The difference equation is $y[k] - ay[k-1] = x[k]$

b)
- Hand Calculation of y[k] for $0 \leq k < 5$ and $x[k] = u[k]$
  - $a = 0.5$

$$
\begin{aligned}
y[k] &= u[k] + ay[k-1] \\
&k = 0, y[0] = 1 + 0.5y[-1] = 1 + 0 = 1 \\
&k = 1, y[0] = 1 + 0.5y[0] = 1 + 0.5 = 1.5 \\
&k = 2, y[0] = 1 + 0.5y[1] = 1 + 0.75 = 1.75 \\
&k = 3, y[0] = 1 + 0.5y[2] = 1 + 0.875 = 1.875 \\
&k = 4, y[0] = 1 + 0.5y[3] = 1 + 0.9375 = 1.9375
\end{aligned}
$$

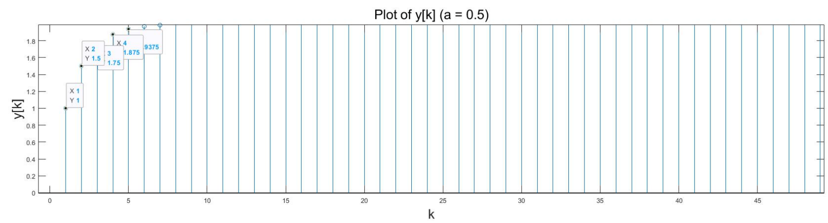
- $a = 2$

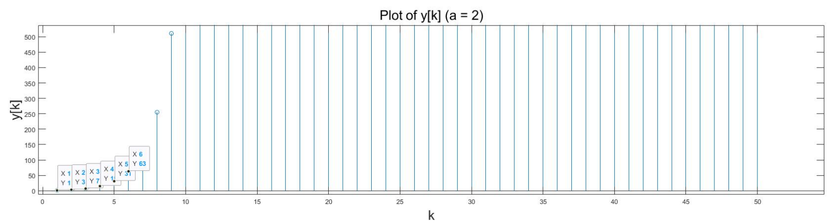
$$
\begin{aligned}
y[k] &= u[k] + ay[k-1] \\
&\quad k = 0, y[0] = 1 + 0.5y[-1] = 1 + 0 = 1 \\
&\quad k = 1, y[0] = 1 + 0.5y[0] = 1 + 2 = 3 \\
&\quad k = 2, y[0] = 1 + 0.5y[1] = 1 + 6 = 7 \\
&\quad k = 3, y[0] = 1 + 0.5y[2] = 1 + 14 = 15 \\
&\quad k = 4, y[0] = 1 + 0.5y[3] = 1 + 30 = 31
\end{aligned}
$$

- Code Sysresp.m function:

```
function y=sysresp(x, a)
% computes the output in response to an arbitrary input
% x[n], n=0,...N-1
% assume that the system has 0 initial conditions
% input:
% x: the input signal,
% a: the system parameter
% output:
% y: the output signal

% Return the length input signal / input matrix x
n = length(x);

% Initialize the output signal / output matrix y
y = zeros(n, 1);

% The first sample is always 1 due to given initial
% condition
y(1) = x(1);

% Generate each sample from k = 1 to n - 1
for i = 2:n
  y(i) = x(i) + a * y(i-1);
end

return
```

- When $a = 0.5$, the DT system is BIBO stable. When $a = 2$, the DT system is not BIBO stable because the output signal is not bounded.
- The plot result matches the hand calculation from $0 \leq k < 5$. Plot for $y[k]$ when $a = 0.5$ and $a = 2$:





c) When a = 0.2, the above system is also BIBO stable. Plot for $y[k]$ when $a = 0.2$: