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EEE 321 Lab 1

Introduction

In the first lab of EEE321, we plotted and debated upon 12 given discrete signals which were cosine functions. We had the chance to compare signals and investigate their periods. The following MATLAB code was written in order to plot the given functions, that consists of a loop that repeats a process for 12 times for each question.

MATLAB CODE

```
clc
clear all
close all

range_int = 0:127;
des_val = [3 7 114 127];
w = [0.13 * pi , 2.2 * pi , -1.8 * pi , 0.26 * pi , 0.26 * pi , 0.01 * pi , 0.39 * pi , pi , pi , 1.08 * pi , 0.92 * pi , 1 , 0.9];
p = [0.5, 0, 0, 0, 0.7, 0, 0, 0, 0, 0, 0, 0.3];


%creating a for loop to solve each question 1-12
for q = 1:12
    if q == 1
        signal = 3*cos(w(q) * range_int + p(q));
    else
        signal = cos(w(q) * range_int + p(q));
    end

    s = [num2str(q),'.mat'];
    save(s, 'signal');
    clear signal;
    load(s, 'signal');

    disp(['q: ', num2str(q), ', signal(3): ', num2str(signal(des_val(1)+1)), ', signal(7): ', num2str(signal(des_val(2)+1)), ', ' ...
        'signal(114): ', num2str(signal(des_val(3)+1)), ', signal(127): ', num2str(signal(des_val(4)+1))]);



    figure();
    stem(range_int, signal);
```

Figure 1: MATLAB Code 1

```
    ax = gca;
    ax.XAxis.LineWidth = 1.5; %thicken x-axis
    ax.YAxis.LineWidth = 1.5; %thicken y-axis
    axh.XAxisLocation = 'origin';
    axh.YAxisLocation = 'origin';
    xlabel('n', 'FontSize', 12, 'FontWeight', 'bold');
    ylabel(['x', num2str(q), '[n]'], 'FontSize', 12, 'FontWeight', 'bold');
    title(['Graph of Question ', num2str(q)], 'FontSize', 14, 'FontWeight', 'bold');

    grid on;
    axis tight; %adjust axes limits




end %end of loop
```

Figure 2: MATLAB Code 2

The code begins by the creation of range_int, des_val, w and p that dictate followingly the desired range, printed values from the saved file, omega and phi values for the cosine functions. These values were used in the loop, and in every iteration their graphs were plotted using the default stem function.

For a certain discrete signal x[n] to be periodic, there should be an integer N that satisfies

$$x[n] \ = \ x[n+N].$$

Furthermore, x[n] can be defined as: x[n] = $e^{j\omega n}$, and this means $x[n+N] = e^{j\omega n}e^{j\omega N}$. This implies that $e^{j\omega N} = 1$, and this ωN should equal 2πk, k being an integer. All this concludes to the following equation:

$$\frac{\omega}{2\pi} = \frac{k}{N}$$

Here, k/N is rational and reveals a necessity for both sides to be rational, creating us a method to test if the signals are periodic. Additionally, the following can be used for rational cases to find the fundamental period. ω must be in form 2πk for a discrete signal to be periodic. (Q14)

$$N = \frac{2\pi}{\omega}k$$

Questions

Q1

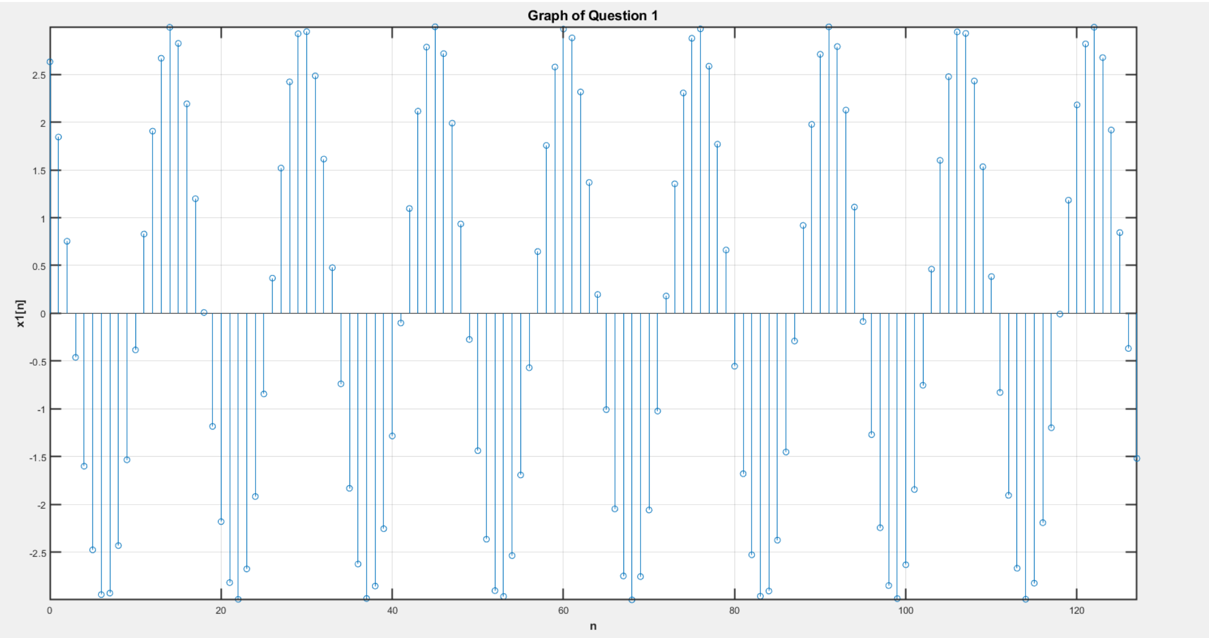

Figure 3: Q1 Graph

Omega here is equal to 0.13*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 1, signal(3): -0.46144, signal(7): -2.9295, signal(114): -2.9936, signal(127): -1.5203

Since 0.13*π/2*π = 13/200 which is rational, the signal is periodic. This implies N = k*200/13, meaning k=13 and the fundamental period is 200.

During quantization and analog to digital conversion is made, and each signal is sampled at some intervals to be mapped to finite quantization levels. For instance, a 16-bit quantizer can represent 65536 levels in binary, and this kind of mapping causes rounding problems.

Q2

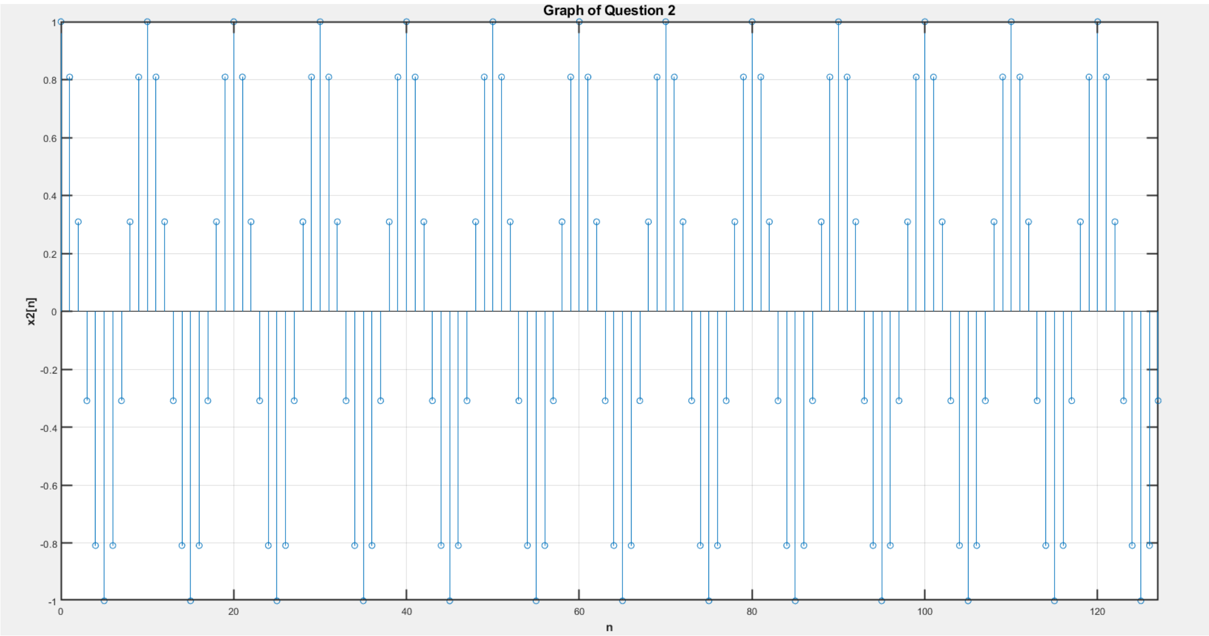

Figure 4: Q2 Graph

Omega here is equal to 2.2*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 2, signal(3): -0.30902, signal(7): -0.30902, signal(114): -0.80902, signal(127): -0.30902

Since 2.2*π/2*π = 11/10 which is rational, the signal is periodic. This implies N = k*10/11, meaning k=11 and the fundamental period is 10.

Q3

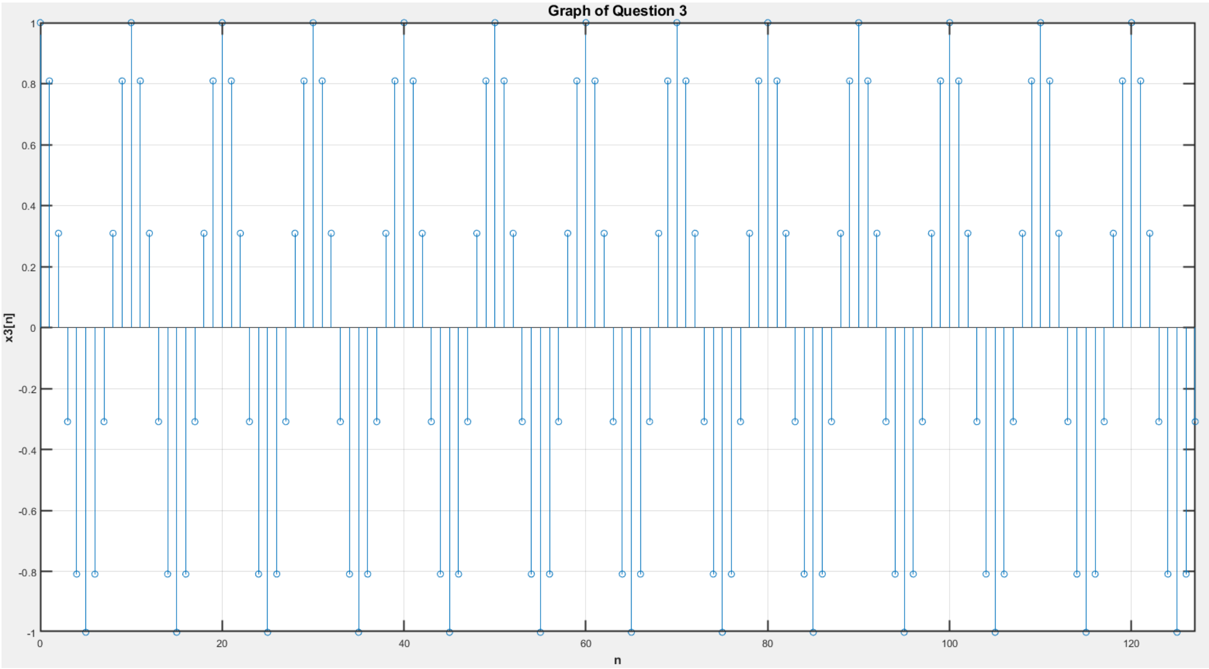

Figure 5: Q3 Graph

Omega here is equal to -1.8*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 3, signal(3): -0.30902, signal(7): -0.30902, signal(114): -0.80902, signal(127): -0.30902

Since -1.8*π/2*π = -9/10 which is rational, the signal is periodic. This implies N = k*10/9, meaning k=9 and the fundamental period is 10.

The graphs for 2 and 3 are the same, and this is because in discrete signals omega values are recursive in 2π long ranges, one being the range -π to π. Here -1.8π and 2.2π have 4π between them, making them equal. In a discrete time signal, the output increases from 0 to π and decreases to 2π, and this process repeats.

Q4

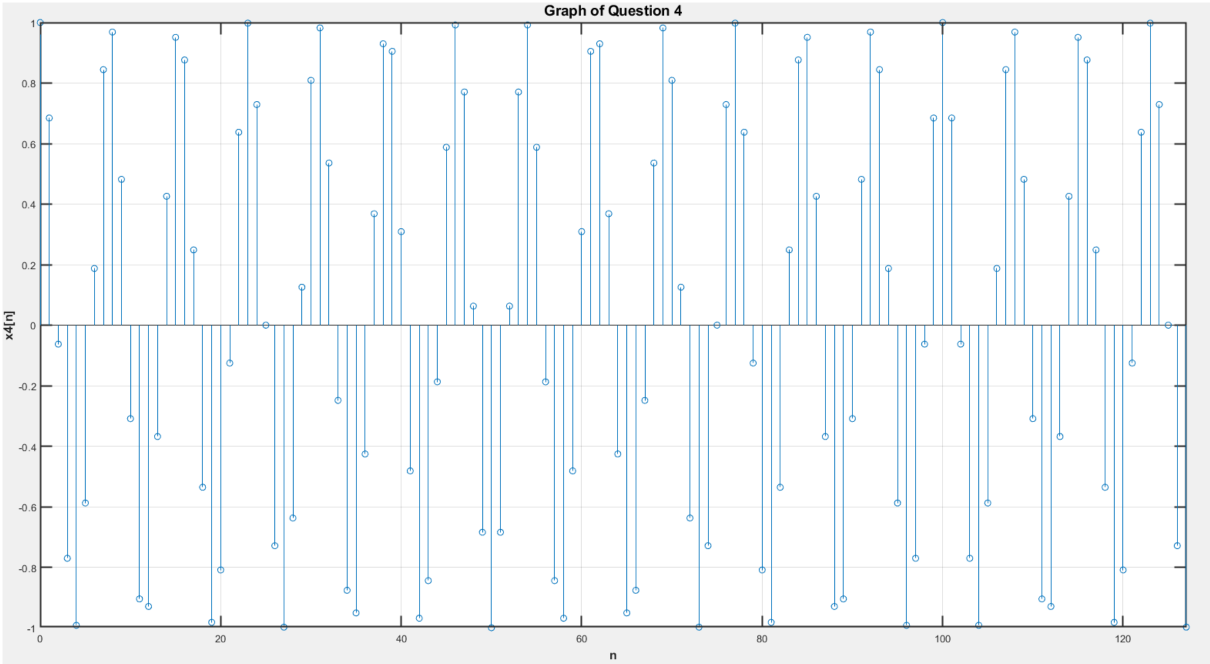

Figure 6: Q4 Graph

Omega here is equal to 0.26*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 4, signal(3): -0.77051, signal(7): 0.84433, signal(114): 0.42578, signal(127): -0.99803

Since 0.26*π/2*π = 26/200 which is rational, the signal is periodic. This implies N = k*100/13, meaning k=13 and the fundamental period is 100.

Q5

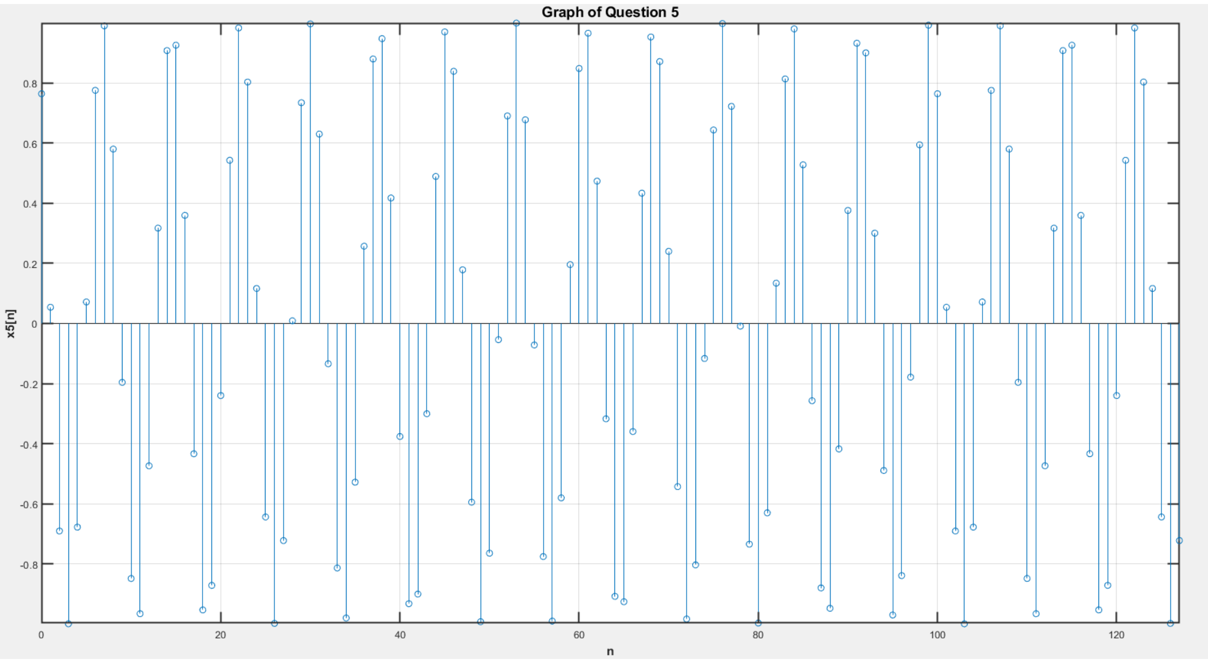

Figure 7: Q5 Graph

Omega here is equal to 0.26*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 5, signal(3): -0.99996, signal(7): 0.99097, signal(114): 0.90856, signal(127): -0.72288

Since 0.26*π/2*π = 26/200 which is rational, the signal is periodic. This implies N = k*100/13, meaning k=13 and the fundamental period is 100.

The signals for Q4 and Q5 have the same period, but different phases. If these were continuous time functions, or if φ for Q5 was a multiple of π then they would be shifted versions of each other, but since 0.7 is not a multiple of π the plots are different in their outputs even though they have the same period. This happens because in discrete time signals the phase difference (being in terms of radians) needs to be a multiple of π to correlate with the created angular difference and maintain integers to represent the new signal's inputs.

Q6

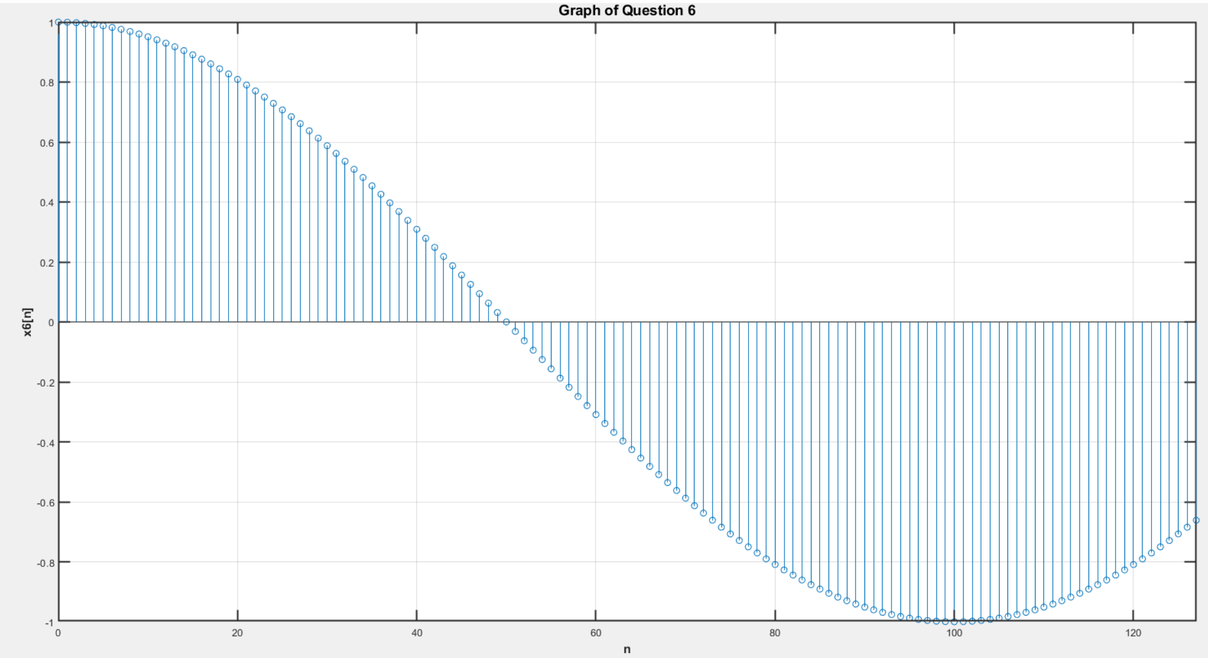

Figure 8: Q6 Graph

Omega here is equal to 0.01*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 6, signal(3): 0.99556, signal(7): 0.97592, signal(114): -0.90483, signal(127): -0.66131

Since 0.01*π/2*π = 1/200 which is rational, the signal is periodic. This implies N = k*200/1, meaning k=1 and the fundamental period is 200.

Q7

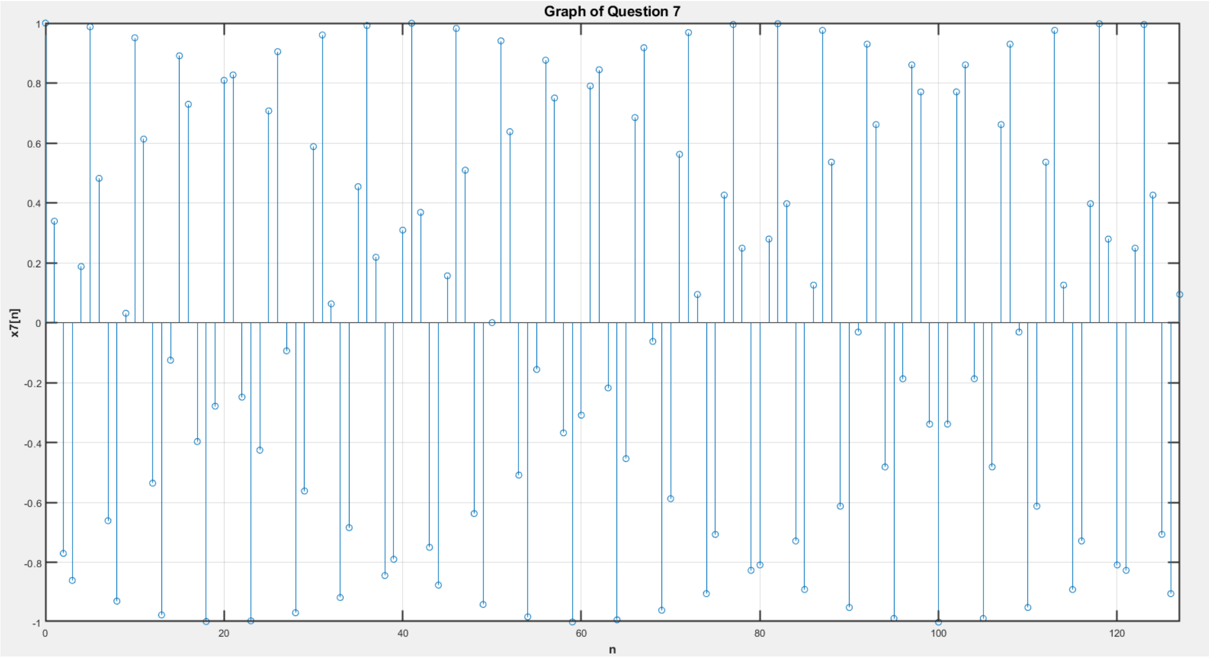

Figure 9: Q7 Graph

Omega here is equal to 0.39*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 7, signal(3): -0.86074, signal(7): -0.66131, signal(114): 0.12533, signal(127): 0.094108

Since 0.39*π/2*π = 39/200 which is rational, the signal is periodic. This implies N = k*200/39, meaning k=39 and the fundamental period is 200.

Q8

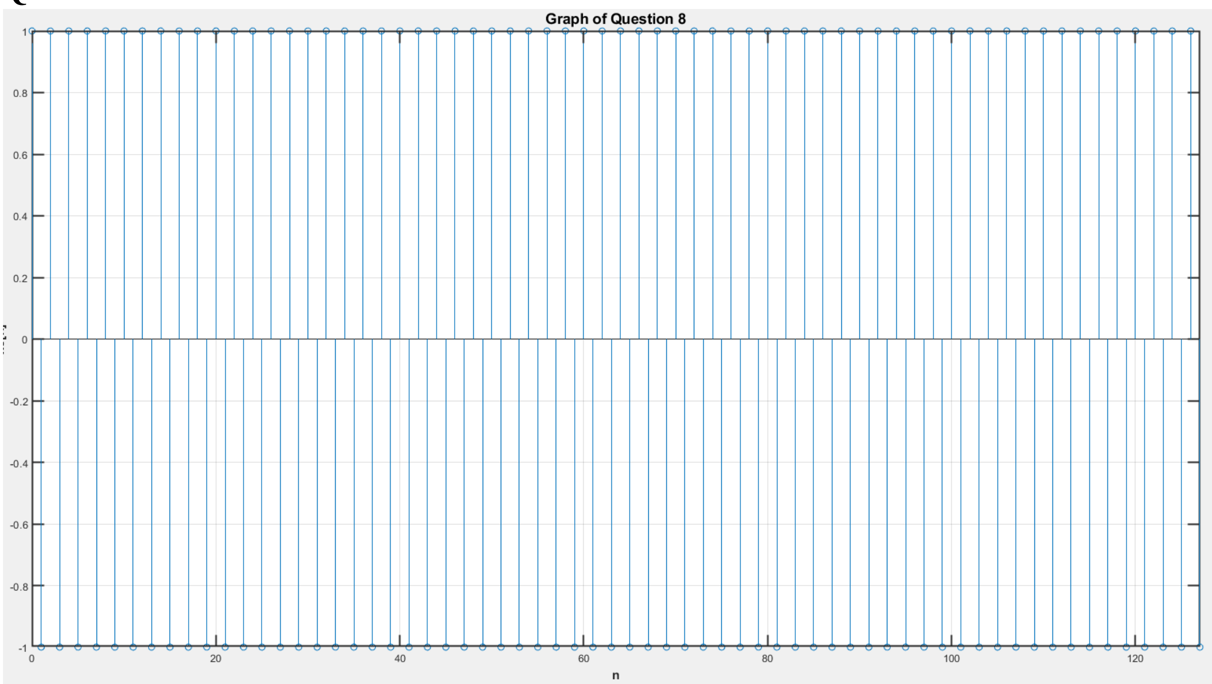

Figure 10: Q8 Graph

Omega here is equal to π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 8, signal(3): -1, signal(7): -1, signal(114): 1, signal(127): -1

Since π/2*π = 1/2 which is rational, the signal is periodic. This implies N = k*2, meaning k=1 and the fundamental period is 2.

Q9

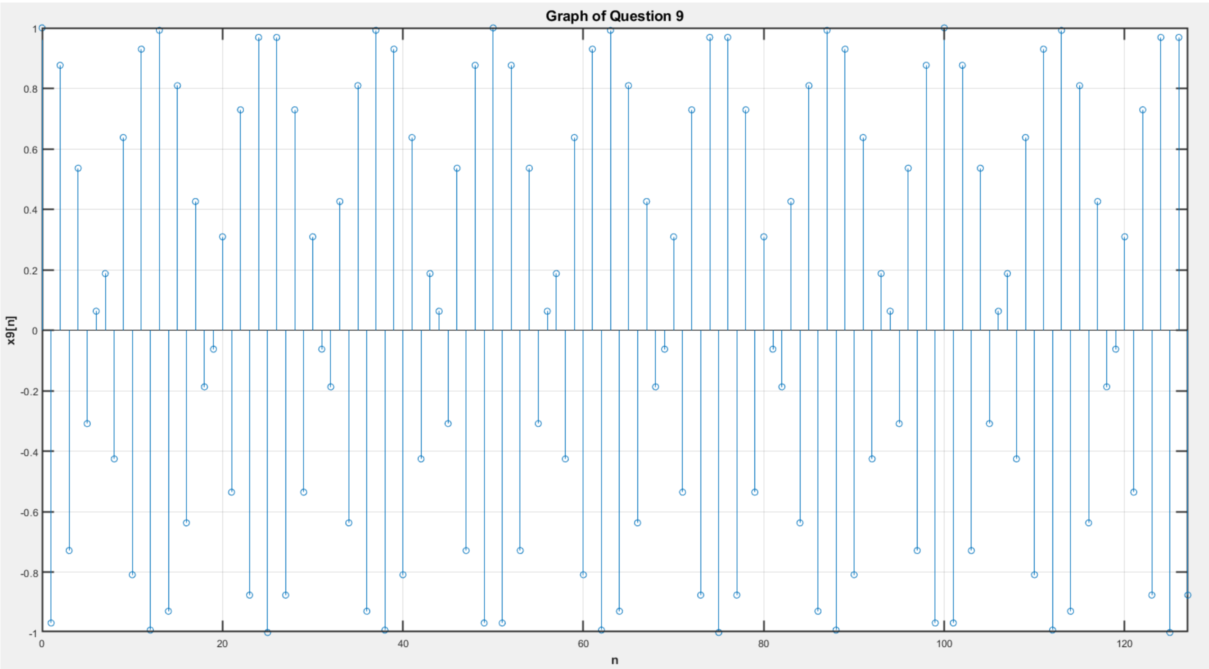

Figure 11: Q9 Graph

Omega here is equal to 1.08π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 9, signal(3): -0.72897, signal(7): 0.18738, signal(114): -0.92978, signal(127): -0.87631

Since 1.08*π/2*π = 108/200 which is rational, the signal is periodic. This implies N = k*50/27, meaning k=27 and the fundamental period is 50.

Q10

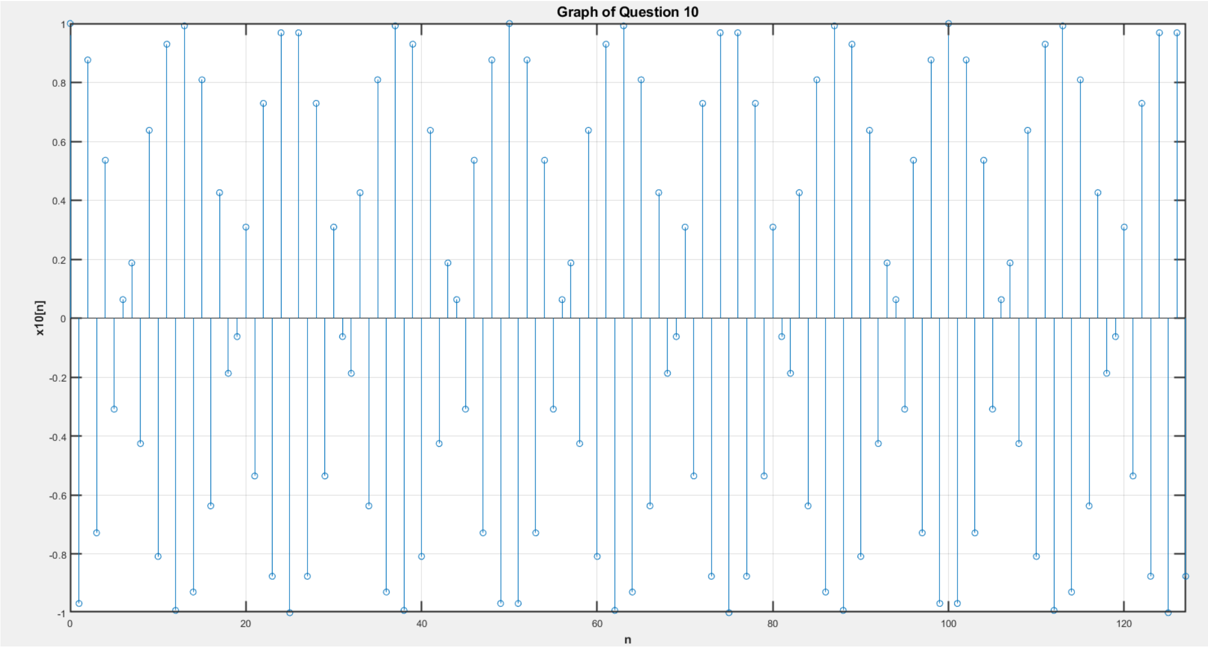

Figure 12: Q10 Graph

Omega here is equal to 0.92*π radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 10, signal(3): -0.72897, signal(7): 0.18738, signal(114): -0.92978, signal(127): -0.87631

Since 0.92*π/2*π = 92/200 which is rational, the signal is periodic. This implies N = k*50/23, meaning k=23 and the fundamental period is 50.

The graphs of Q9 and Q10 are identical, and this is because of the behaviour of discrete time signals that the rate of oscillation for such signals increase from 0 until π and decrease to 2π in 2π ranges for ω values. These imply the highest rate of oscillation occurs for midpoints of 2π ranges. This is because the highest rate of oscillation occurs when ω equals π and the discrete time signal takes the form $e^{j\,\omega\,\mathrm{n}} = e^{j\,\pi\,\mathrm{n}} = e^{(j\,\pi)\,\mathrm{n}} = (-1)^n$. This process is the same for every 2π interval.

Q11

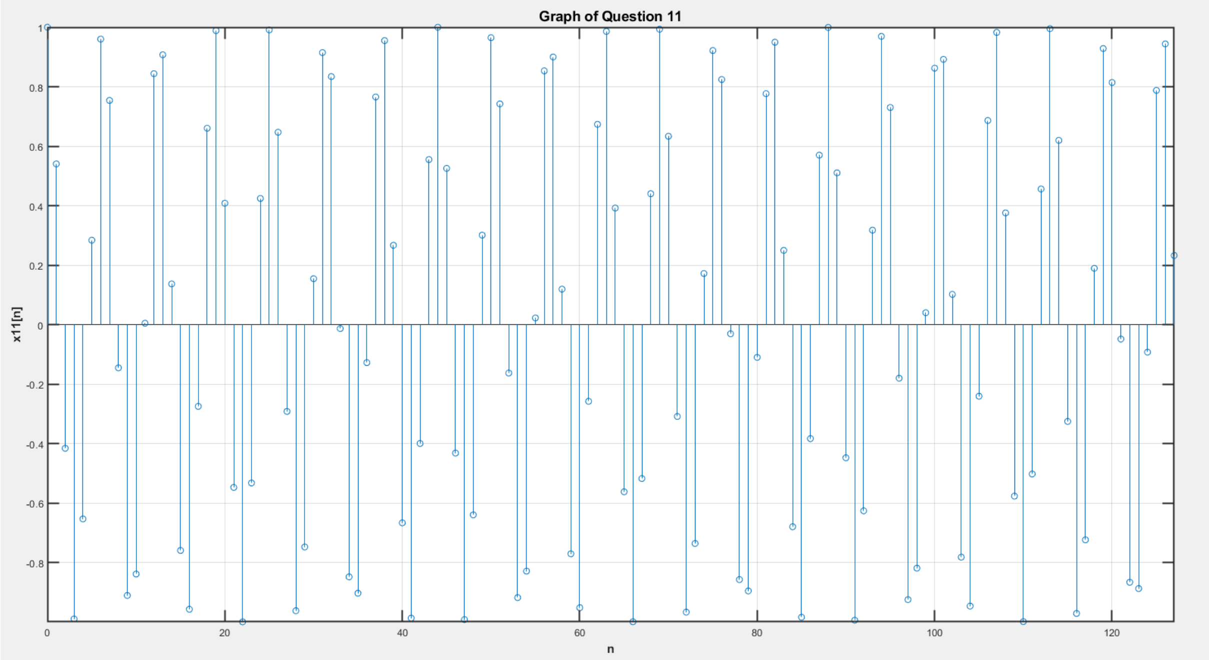

Figure 13: Q11 Graph

Omega here is equal to 1 radian, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 11, signal(3): -0.98999, signal(7): 0.7539, signal(114): 0.61952, signal(127): 0.23236

Since 1/2*π is not rational, the signal is not periodic and a fundamental period cannot be found.

Q12

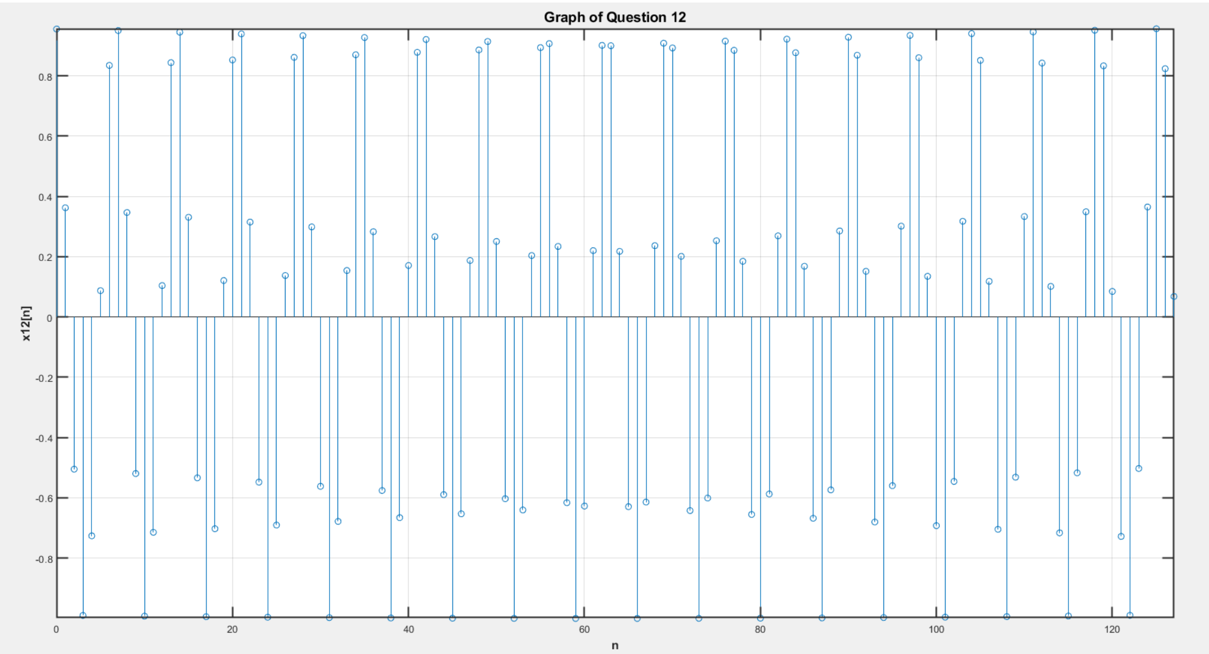

Figure 14: Q12 Graph

Omega here is equal to 0.9 radians, and the outputs for the desired values 3, 7, 114, 127 are as in the outputted MATLAB line:

q: 12, signal(3): -0.98999, signal(7): 0.95023, signal(114): -0.71613, signal(127): 0.068079

Since 0.9/2*π is not rational, the signal is not periodic and a fundamental period cannot be found.

(Q13 and Q14 are already answered)

Q15

For a continuous cosine signal, the period is $\frac{2\pi}{\omega}$, and every function is periodic. The difference of two maximas or minimas reveal the period for such signals.

For a discrete cosine signal, it is said to be periodic only if the $\omega/2\pi$ ratio is rational, and the possible period is always an integer. The period is the difference between two repeated values which may not be in the same period. Most of the discrete signals are not periodic, since ω can take infinitely many values but needs to have a multiple of π to create a rational rate.