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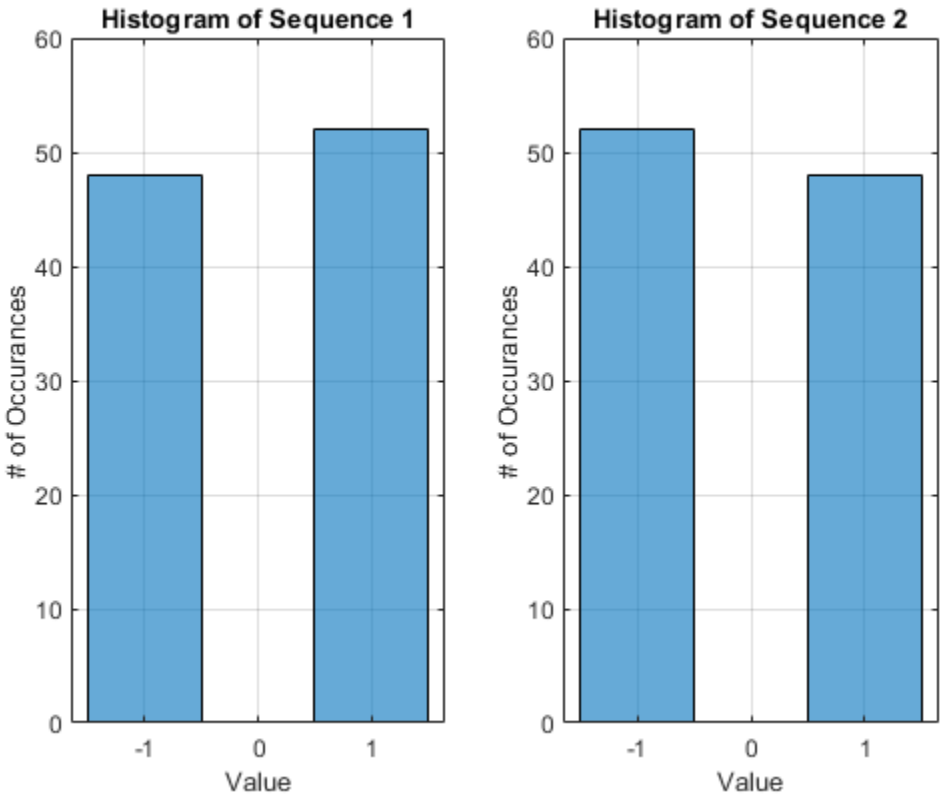
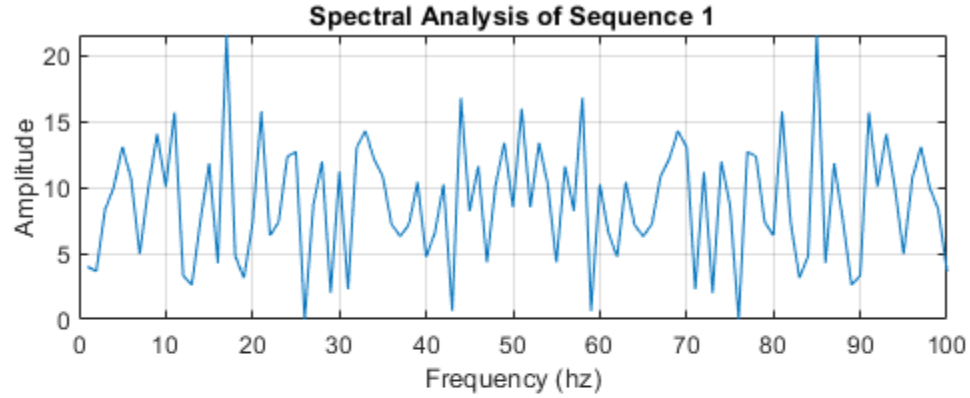
```
clear;clc;close all
```

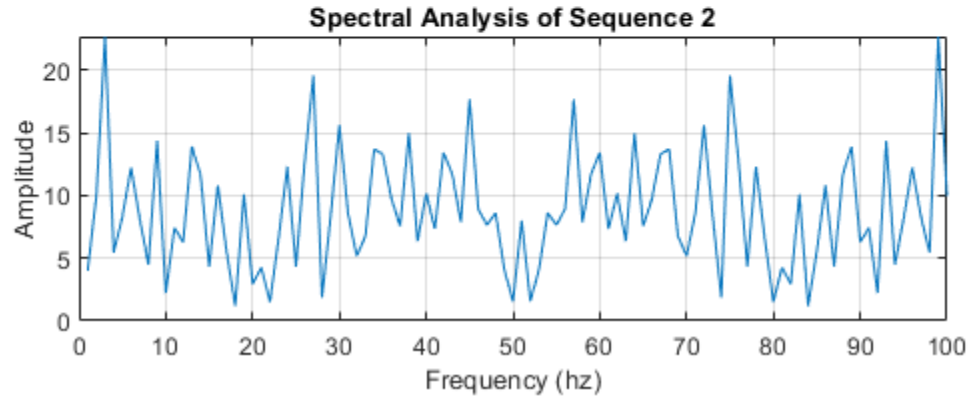
Problem 2

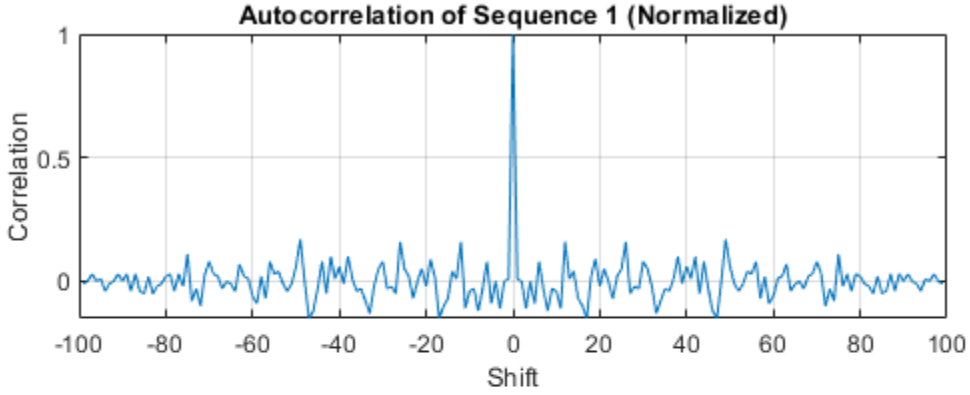
```
seq1 = 2*ceil((rand(100,1)-.5))-1;
seq2 = 2*ceil((rand(100,1)-.5))-1;

% Part A - Plot Histogram of Each Sequence
subplot(1,2,1)
histogram(seq1)
grid on
title("Histogram of Sequence 1")
xlabel("Value")
ylabel("# of Occurances")
subplot(1,2,2)
histogram(seq2)
grid on
title("Histogram of Sequence 2")
xlabel("Value")
ylabel("# of Occurances")
snapnow

% Part B - Plot Spectral Analysis of Each Sequence
figure
subplot(2,1,1)
plot(abs(fft(seq1)))
grid on
title("Spectral Analysis of Sequence 1")
xlabel("Frequency (hz)")
ylabel("Amplitude")
subplot(2,1,2)
plot(abs(fft(seq2)))
grid on
title("Spectral Analysis of Sequence 2")
xlabel("Frequency (hz)")
ylabel("Amplitude")
snapnow

% Part C - Plot Autocorrelation for Each Sequence
[aCorr1,shift1] = autoCorrelation(seq1,"normalized");
[aCorr2,shift2] = autoCorrelation(seq2,"normalized");

figure
```

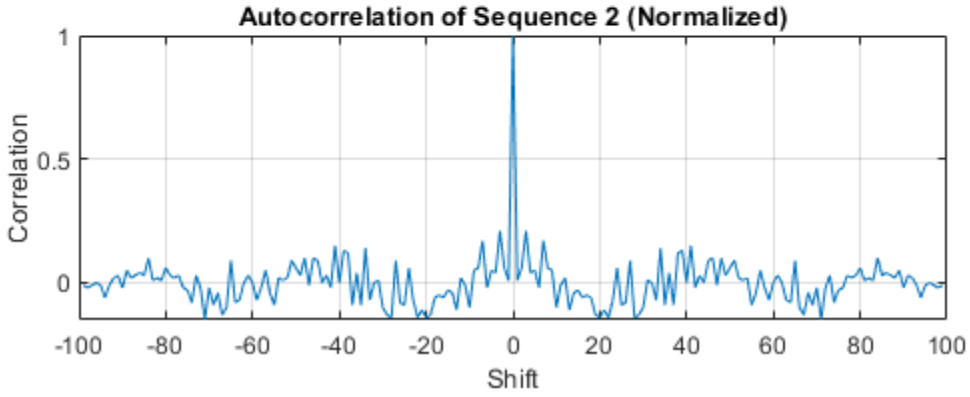
```
subplot(2,1,1)
plot(shift1,aCorr1)
grid on
title("Autocorrelation of Sequence 1 (Normalized)")
xlabel("Shift")
ylabel("Correlation")
subplot(2,1,2)
plot(shift2,aCorr2)
grid on
title("Autocorrelation of Sequence 2 (Normalized)")
xlabel("Shift")
ylabel("Correlation")
snapnow

% Part D - Plot Cross Correlation Between the Two Sequences
[xCorr,shift] = crossCorr(seq1,seq2,"normalized");

figure
plot(shift,xCorr)
grid on
title("Cross Correlation of Sequence 1 & 2 (Normalized)")
xlabel("Shift")
ylabel("Correlation")
snapnow
```

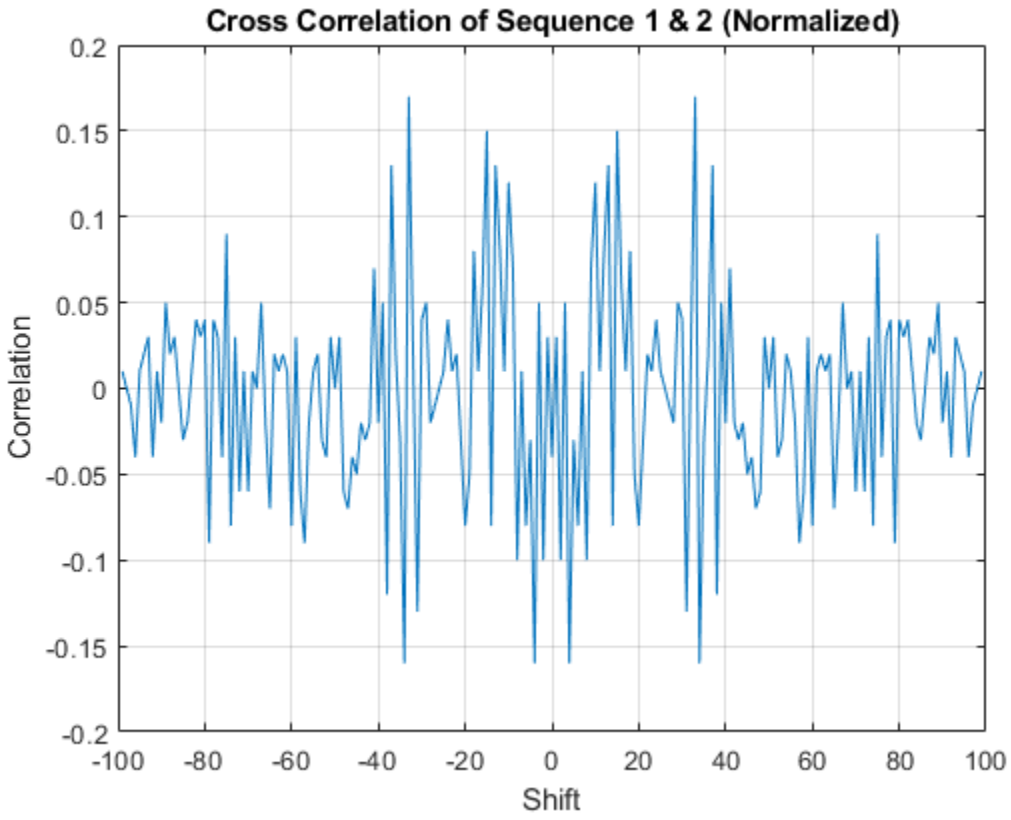



Spectral Analysis of Sequence 1
Amplitude
Frequency (hz)


Spectral Analysis of Sequence 2
Amplitude
Frequency (hz)


Autocorrelation of Sequence 1 (Normalized)
Correlation
Shift


Autocorrelation of Sequence 2 (Normalized)
Correlation
Shift

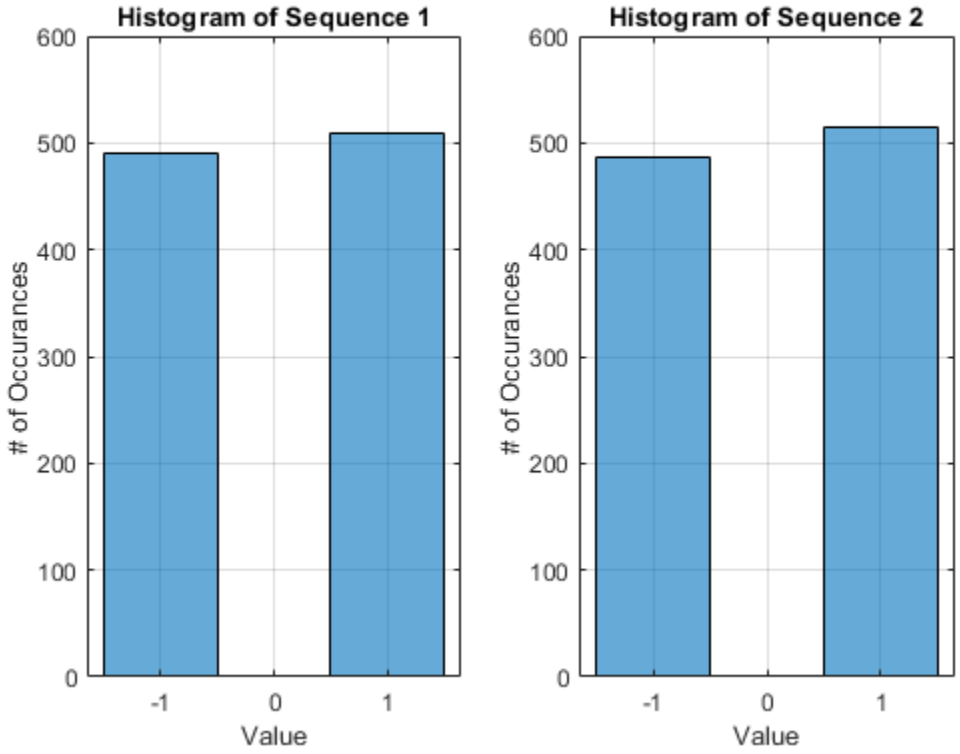


Problem 2 Bonus 1

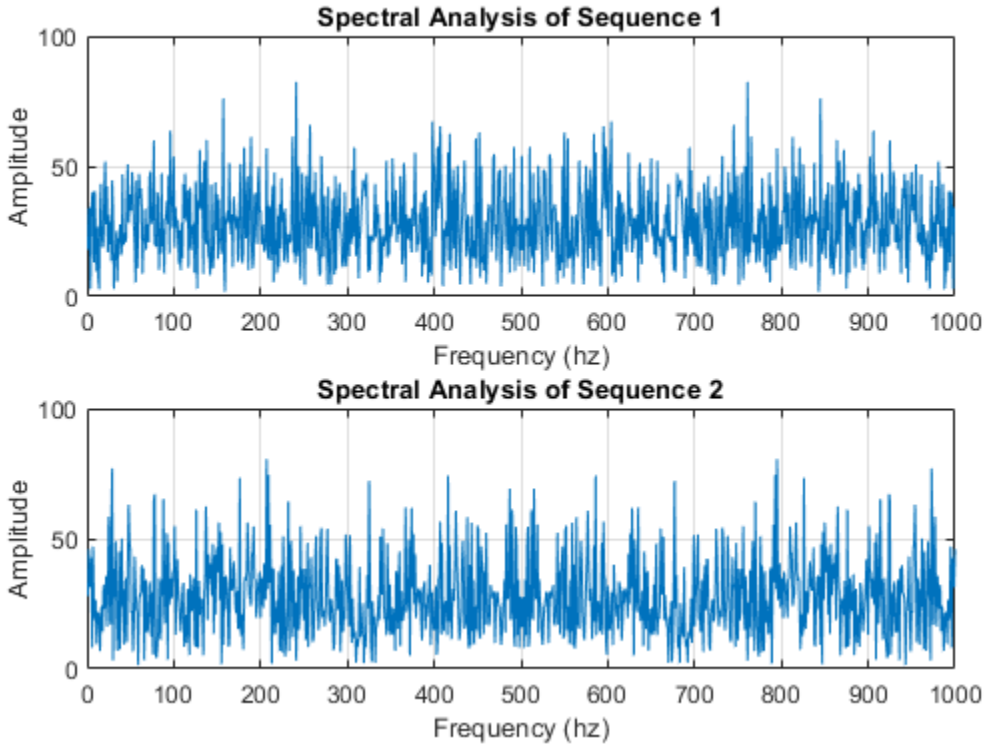
```
seq1 = 2*ceil((rand(1000,1)-.5))-1;
seq2 = 2*ceil((rand(1000,1)-.5))-1;

% Part A - Plot Histogram of Each Sequence
subplot(1,2,1)
histogram(seq1)
grid on
title("Histogram of Sequence 1")
xlabel("Value")
ylabel("# of Occurances")
subplot(1,2,2)
histogram(seq2)
grid on
title("Histogram of Sequence 2")
xlabel("Value")
ylabel("# of Occurances")
sgtitle('2a Bonus')
snapnow

% Part B - Plot Spectral Analysis of Each Sequence
figure
subplot(2,1,1)
plot(abs(fft(seq1)))
```

```
grid on
title("Spectral Analysis of Sequence 1")
xlabel("Frequency (hz)")
ylabel("Amplitude")
subplot(2,1,2)
plot(abs(fft(seq2)))
grid on
title("Spectral Analysis of Sequence 2")
xlabel("Frequency (hz)")
ylabel("Amplitude")
sgtitle('2b Bonus')
snapnow

% Part C - Plot Autocorrelation for Each Sequence
[aCorr1,shift1] = autoCorrelation(seq1,"normalized");
[aCorr2,shift2] = autoCorrelation(seq2,"normalized");

figure
subplot(2,1,1)
plot(shift1,aCorr1)
grid on
title("Autocorrelation of Sequence 1 (Normalized)")
xlabel("Shift")
ylabel("Correlation")
subplot(2,1,2)
plot(shift2,aCorr2)
grid on
title("Autocorrelation of Sequence 2 (Normalized)")
xlabel("Shift")
ylabel("Correlation")
sgtitle('2c Bonus')
snapnow

% Part D - Plot Cross Correaltion Between the Two Sequences
[xCorr,shift] = crossCorr(seq1,seq2,"normalized");

figure
plot(shift,xCorr)
grid on
title("Bonus - Cross Correlation of Sequence 1 & 2 (Normalized)")
xlabel("Shift")
ylabel("Correlation")
snapnow
```

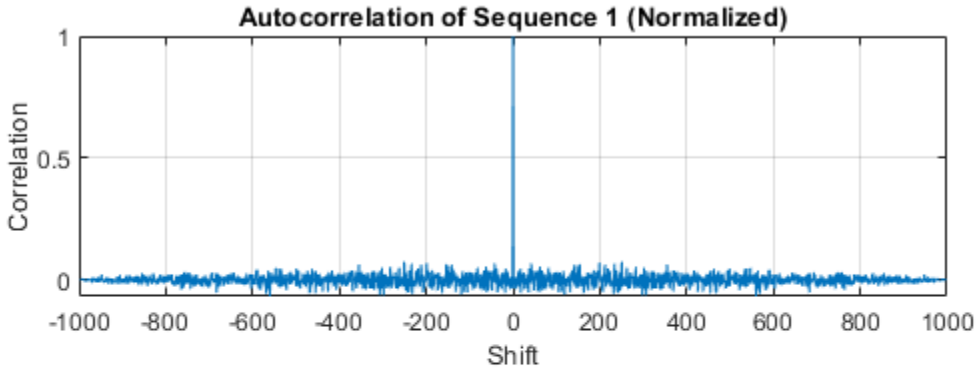
2a Bonus

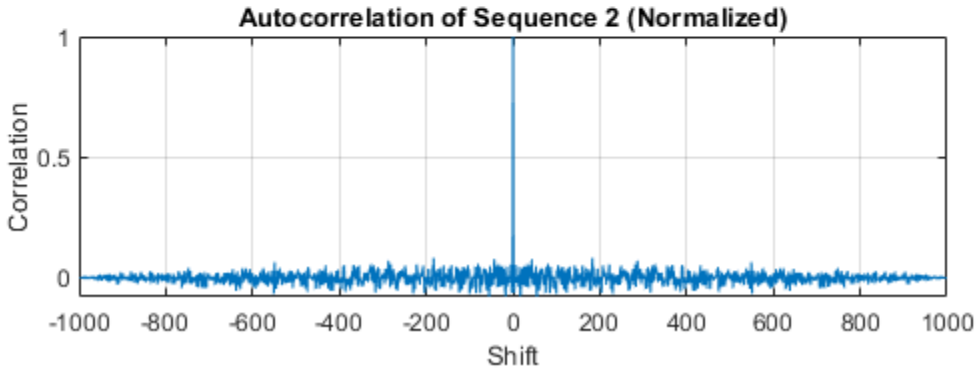


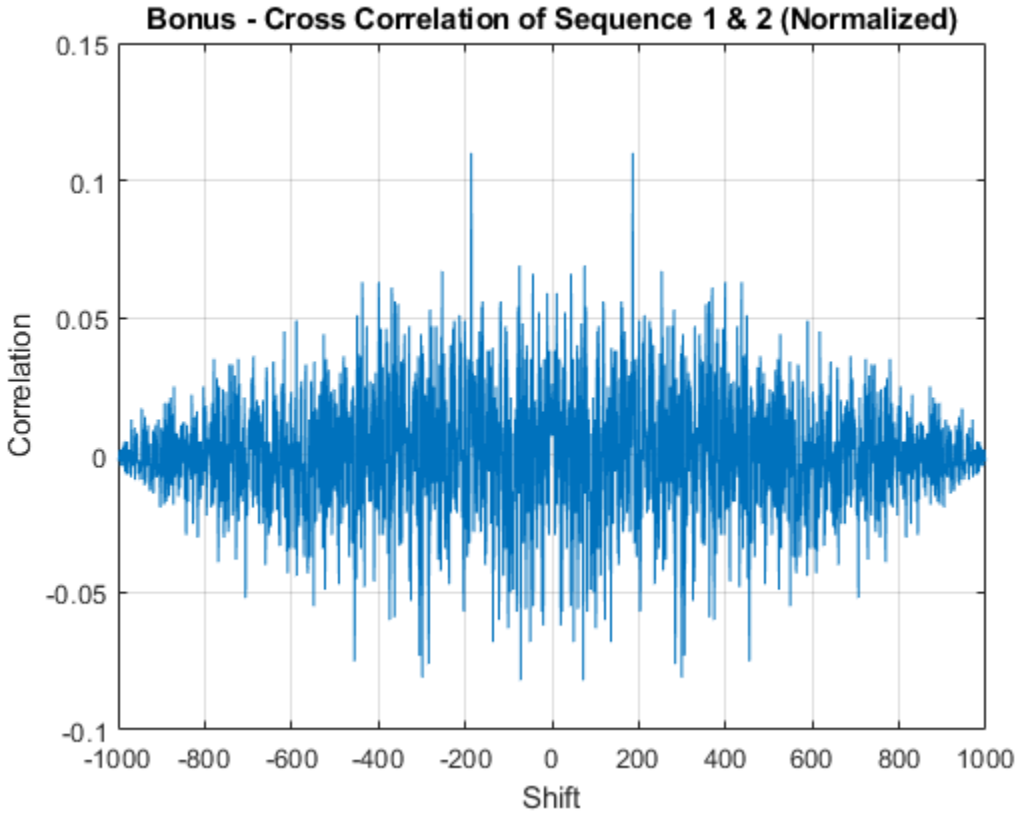
2b Bonus



2c Bonus


Autocorrelation of Sequence 1 (Normalized)
Correlation
Shift
1
0.5
0
-1000
-800
-600
-400
-200
0
200
400
600
800
1000


Autocorrelation of Sequence 2 (Normalized)
Correlation
Shift
1
0.5
0
-1000
-800
-600
-400
-200
0
200
400
600
800
1000


Bonus - Cross Correlation of Sequence 1 & 2 (Normalized)
Correlation
Shift
0.15
0.1
0.05
0
-0.05
-0.1
-1000
-800
-600
-400
-200
0
200
400
600
800
1000

Question 2 Bonus 2

```
seq1 = 2*ceil((rand(100,1)-.5))-1;
for i = 1 : 100

    seq2 = 2*ceil((rand(100,1)-.5))-1;

    [xCorr,shift] = crossCorr(seq1,seq2);

    x_bar(i) = mean(xCorr);
    sigma(i) = std(xCorr);

end

figure
plot(1:100,x_bar)
hold on
grid on
plot(1:100,sigma)
title("Monte Carlo Simulation Bonus")
legend(["Mean","Standard Deviation"])
xlabel("Sequence #")
ylabel("Value")

function [aCorr,shift] = autoCorrelation(seq,type)

    if nargin < 2
        type = "";
    end

    n = length(seq);
    m = 2*n-1;
    for i = 1 : n
        aCorr(i) = sum(seq(n-i+1:n) .* seq(1:i));
        aCorr(m+1-i) = aCorr(i); % autocorrelation is symmetric
    end

    if type == "normalized"
        aCorr = aCorr/n;
    end

    shift = [-n+1:n-1];
end

function [xCorr,shift] = crossCorr(seq1,seq2,type)

    if nargin < 3
        type = "";
    end

    n = length(seq1);
    for i = -n+1 : n-1
        if i < 0
```

```
            xCorr(i+n) = sum(seq1(1:end+i) .* seq2(-i+1:end));
        elseif i > 0
            xCorr(i+n) = sum(seq1(1:end-i) .* seq2(i+1:end));
        else
            xCorr(i+n) = sum(seq1 .* seq2);
        end
    end

    if type == "normalized"
        xCorr = xCorr/n;
    end

    shift = [-n+1:n-1];
end
```

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