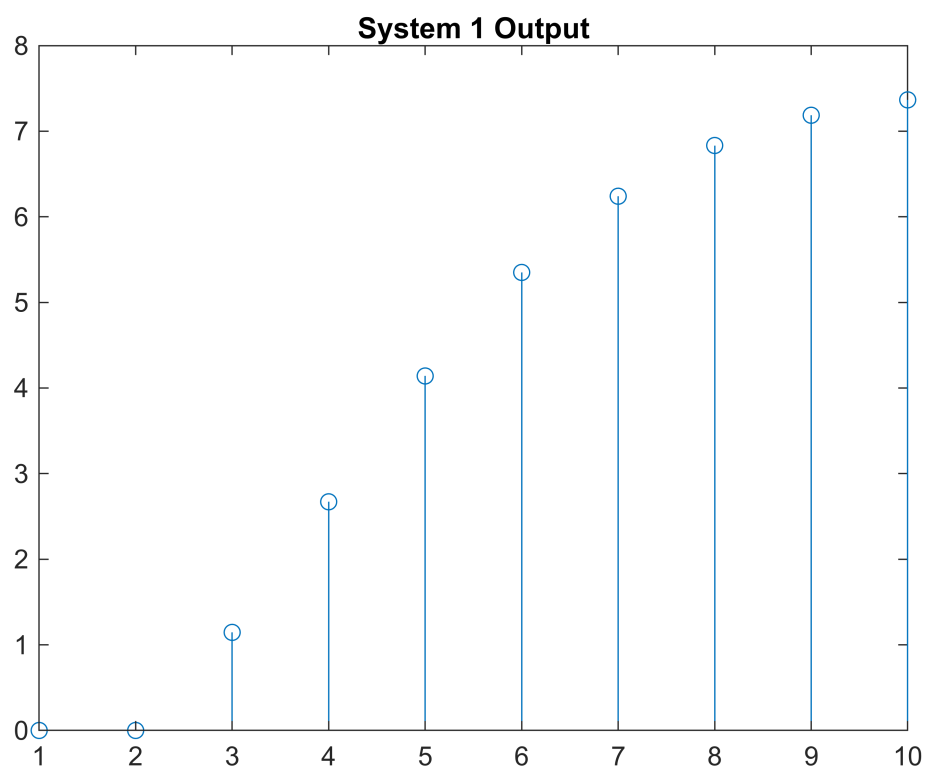
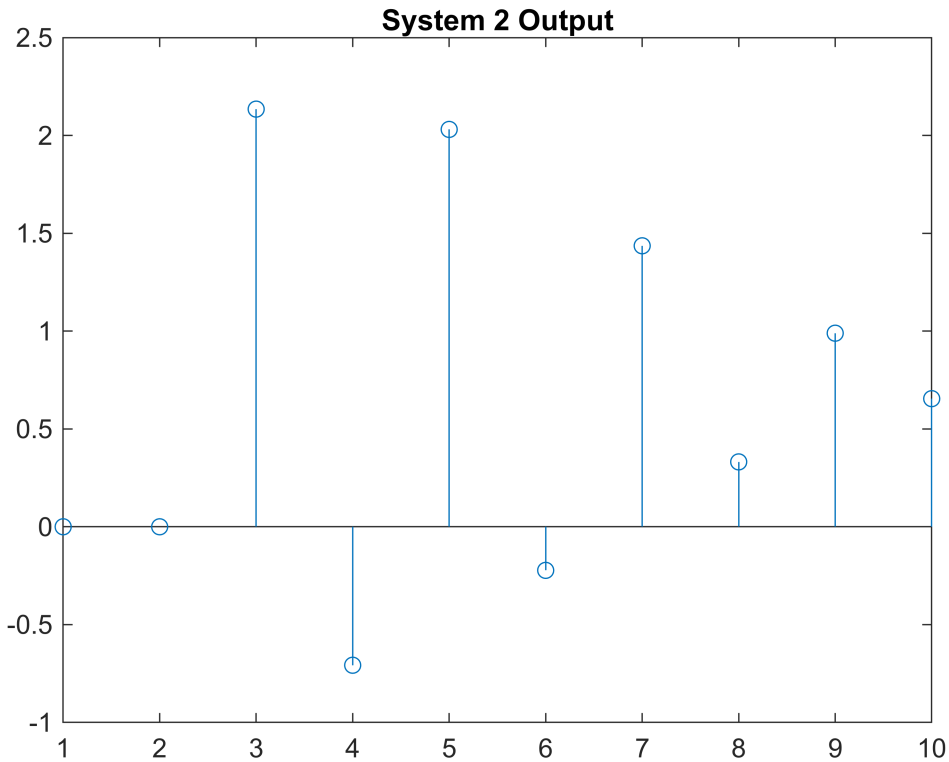
PART A

```
bk0 = [1, 1];
bk1 = [-0.4944, 0.4944];
bk2 = [0.64, 0.64];
ak1 = [-1.3315, 1.3315];
ak2 = [0.49, 0.49];

N = 10;
x = ones(1, N);

y1 = difference_equation(x, 1, bk0, bk1, bk2, ak1, ak2);

y2 = difference_equation(x, 2, bk0, bk1, bk2, ak1, ak2);

stem(y1);
title('System 1 Output');
```

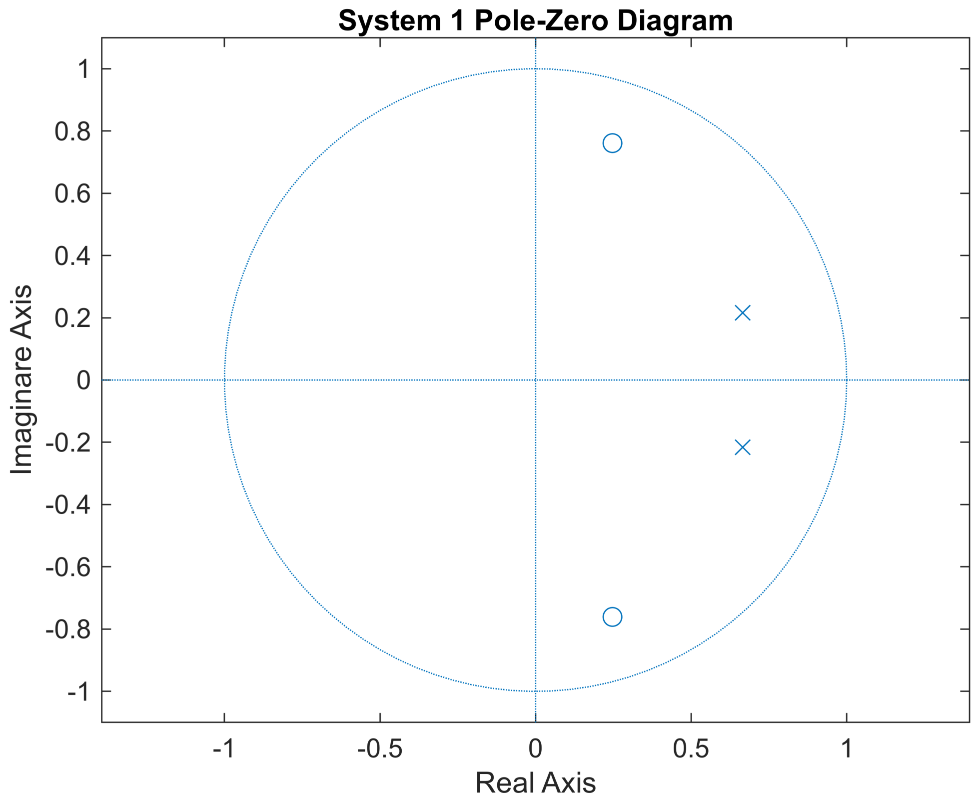


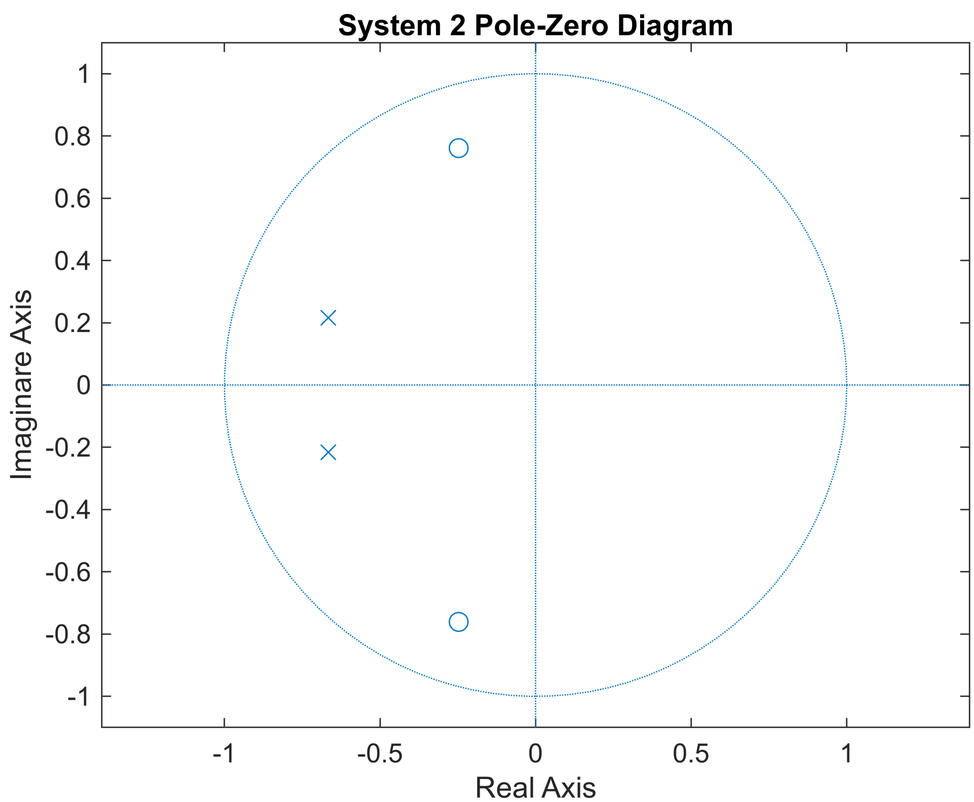

```
stem(y2);
title('System 2 Output');
```



PART B

```
for k = 1:length(bk0)
    b = [bk0(k) bk1(k) bk2(k)];
    a = [1 ak1(k) ak2(k)];

    z = roots(b);
    p = roots(a);

    figure;
    zplane(z, p);
    title(['System ', num2str(k), ' Pole-Zero Diagram']);
    xlabel('Real Axis');
    ylabel('Imaginare Axis');
end
```

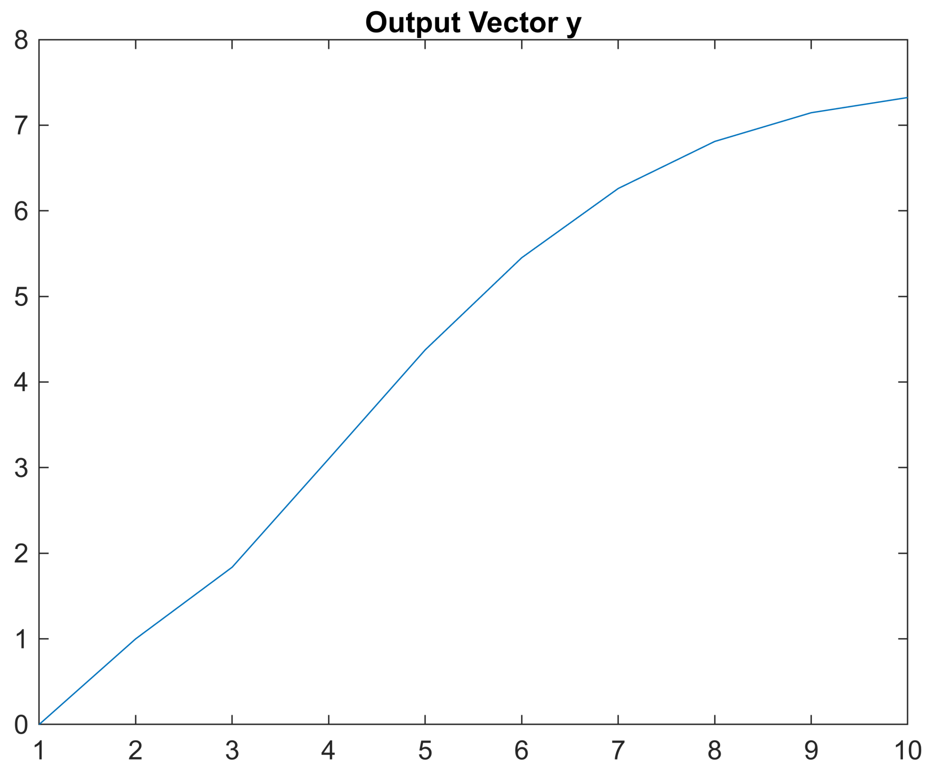




PART C

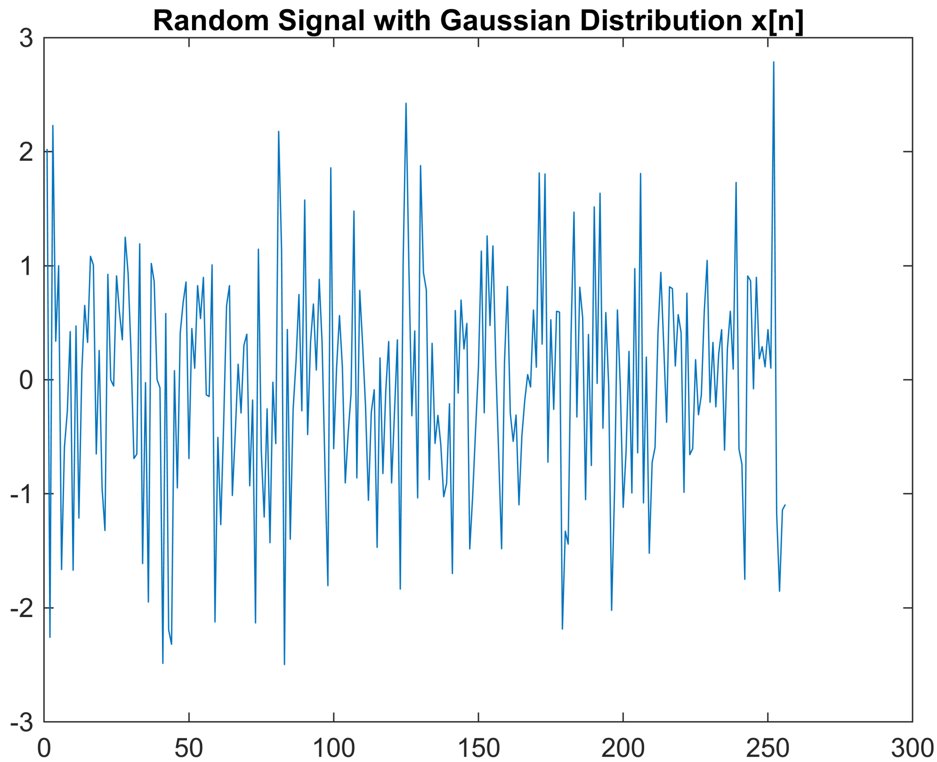
```
a = [1, -1.3315, 0.49];
```

```
b = [1, -0.4944, 0.64];

x = ones(1, 10);

y = compute_output(b, a, x);

plot(y);
title('Output Vector y');
```



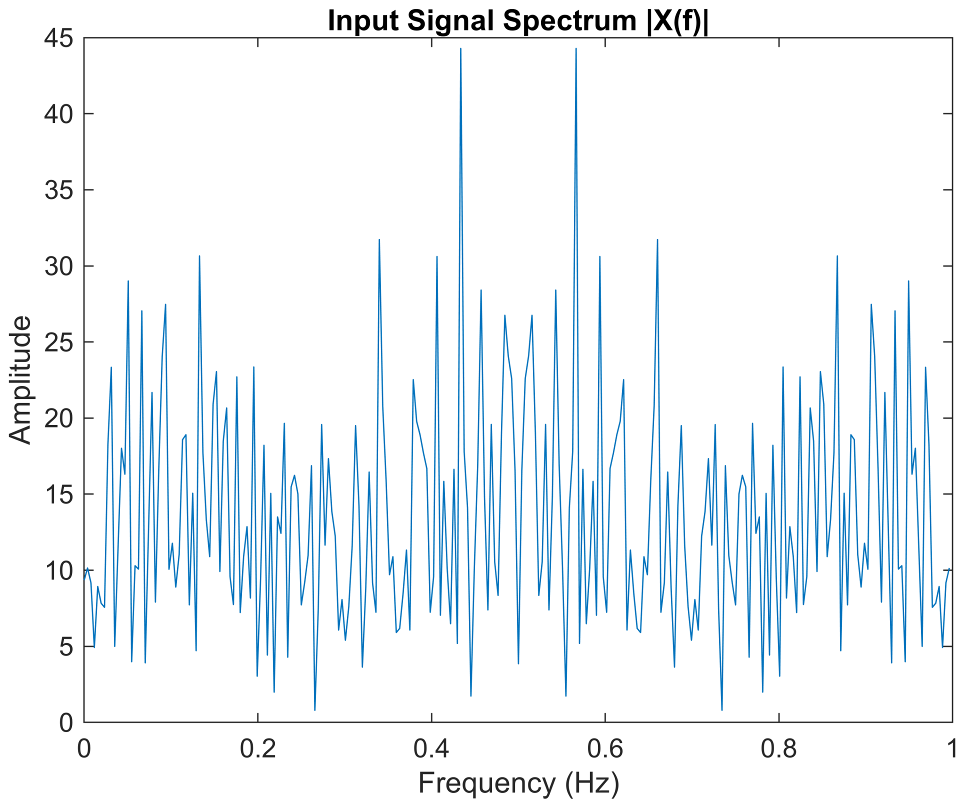
PART D

```
N = 256;
x_n = randn(1, N);

plot(x_n);
title('Random Signal with Gaussian Distribution x[n]');
```

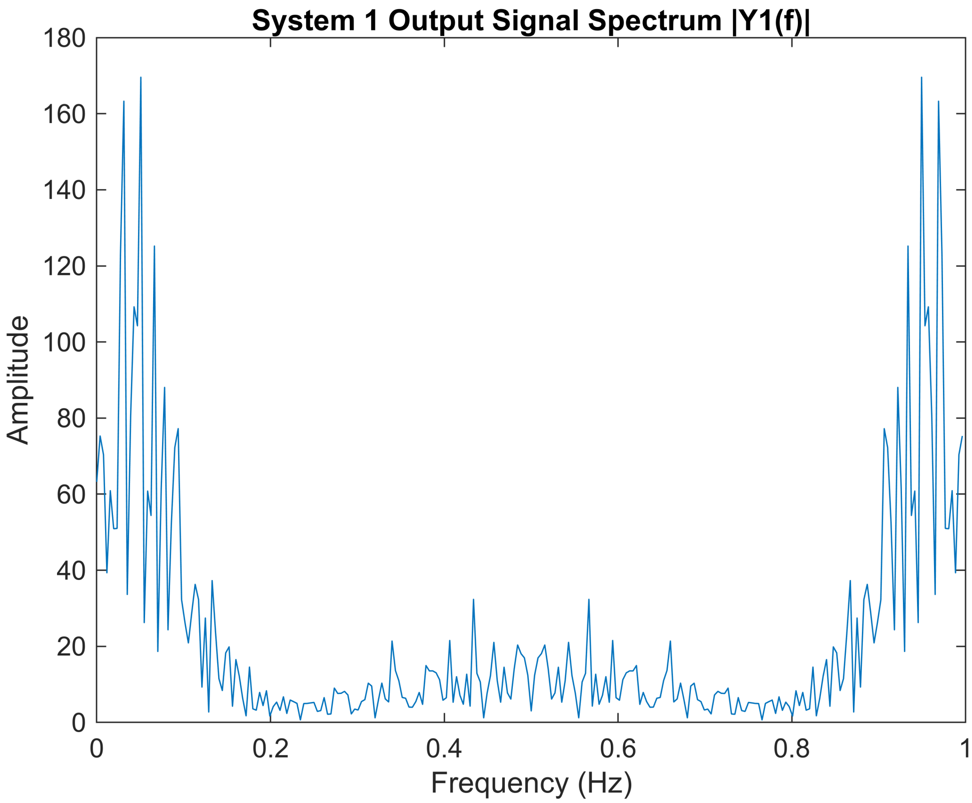


PART E

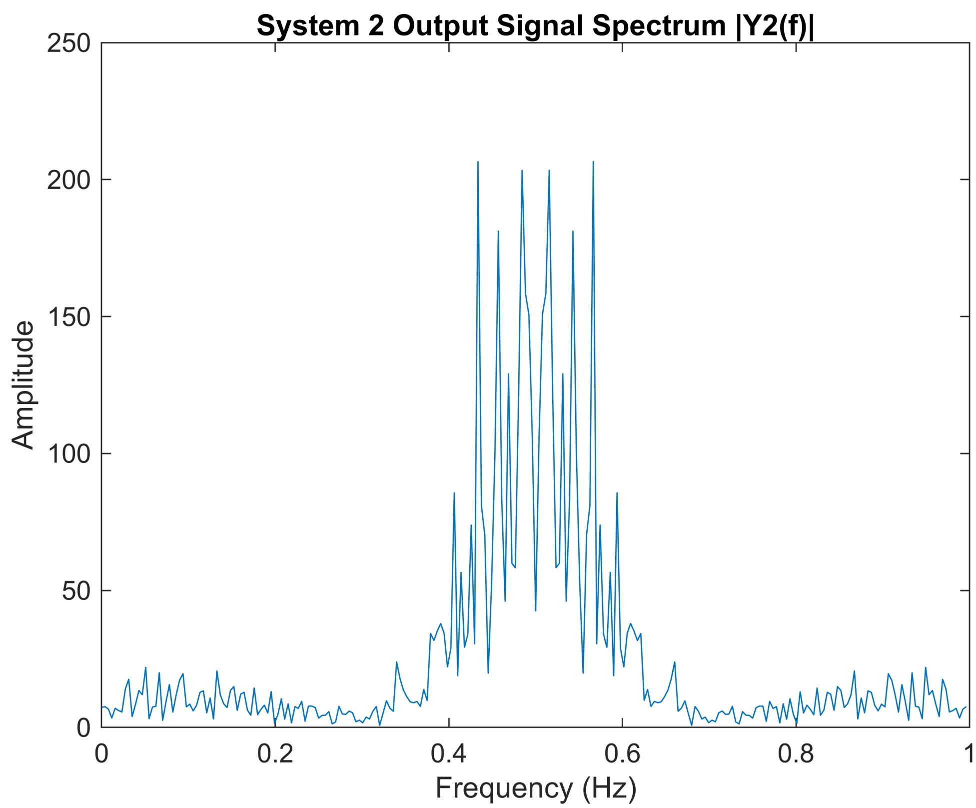
```
Fs = 1;

y1_n = compute_output([bk0(1), bk1(1), bk2(1)], [1, ak1(1), ak2(1)], x_n);
y2_n = compute_output([bk0(2), bk1(2), bk2(2)], [1, ak1(2), ak2(2)], x_n);

X_f = fft(x_n);
Y1_f = fft(y1_n);
Y2_f = fft(y2_n);

f = (0:N-1)*(Fs/N);

figure;
plot(f, abs(X_f));
title('Input Signal Spectrum |X(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```




```
figure;
plot(f, abs(Y1_f));
title('System 1 Output Signal Spectrum |Y1(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

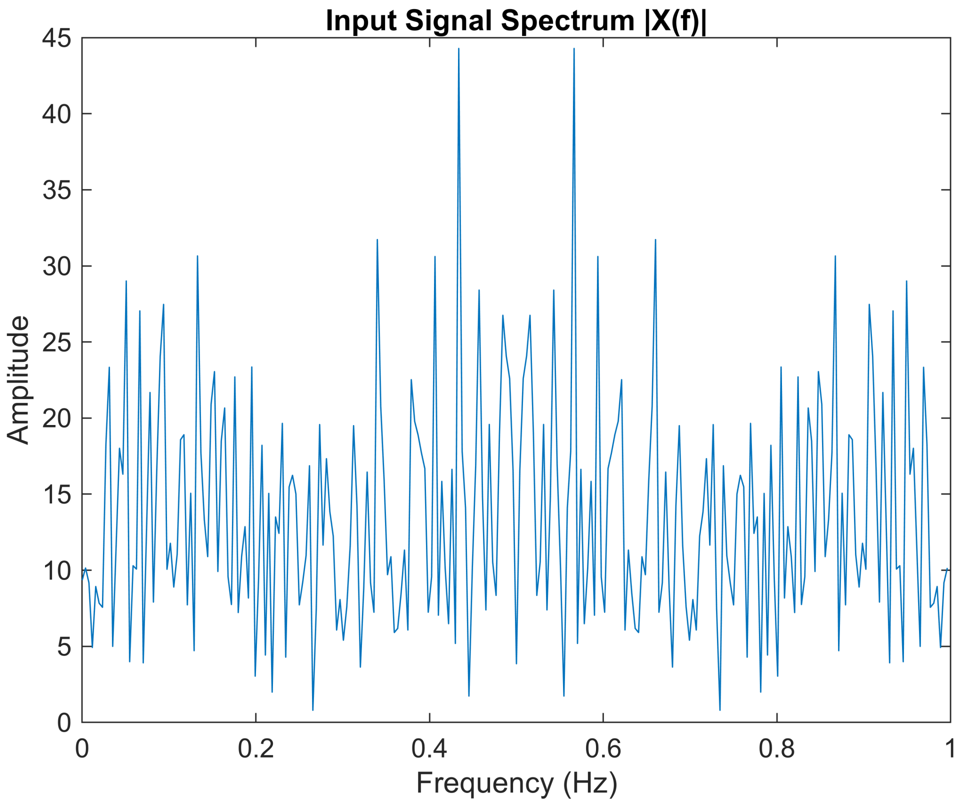



```
figure;
plot(f, abs(Y2_f));
title('System 2 Output Signal Spectrum |Y2(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

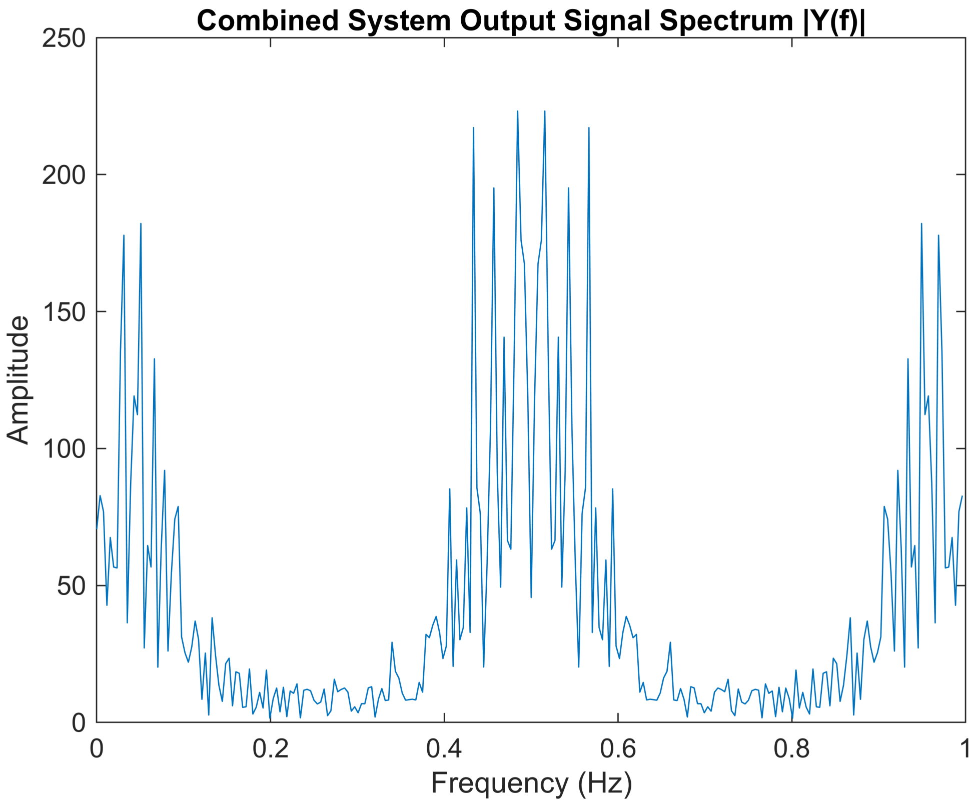


PART F

```
y_combined_n = y1_n + y2_n;

Y_combined_f = fft(y_combined_n);

f = (0:N-1)*(Fs/N);

figure;
plot(f, abs(X_f));
title('Input Signal Spectrum |X(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

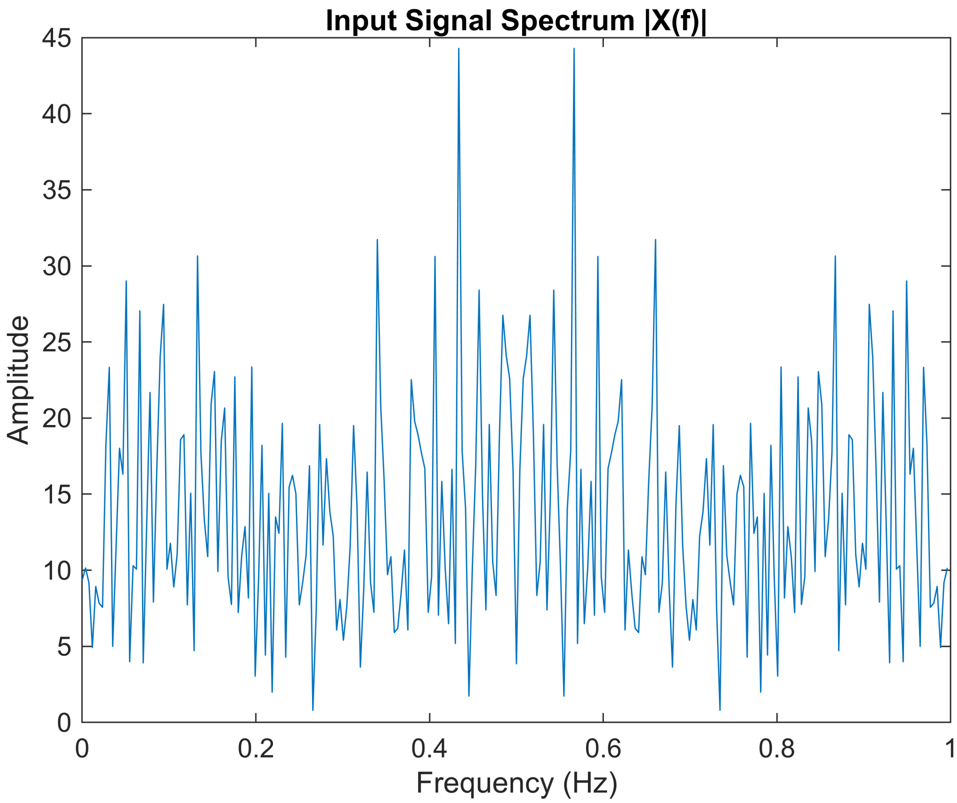



```
figure;
plot(f, abs(Y_combined_f));
title('Combined System Output Signal Spectrum |Y(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

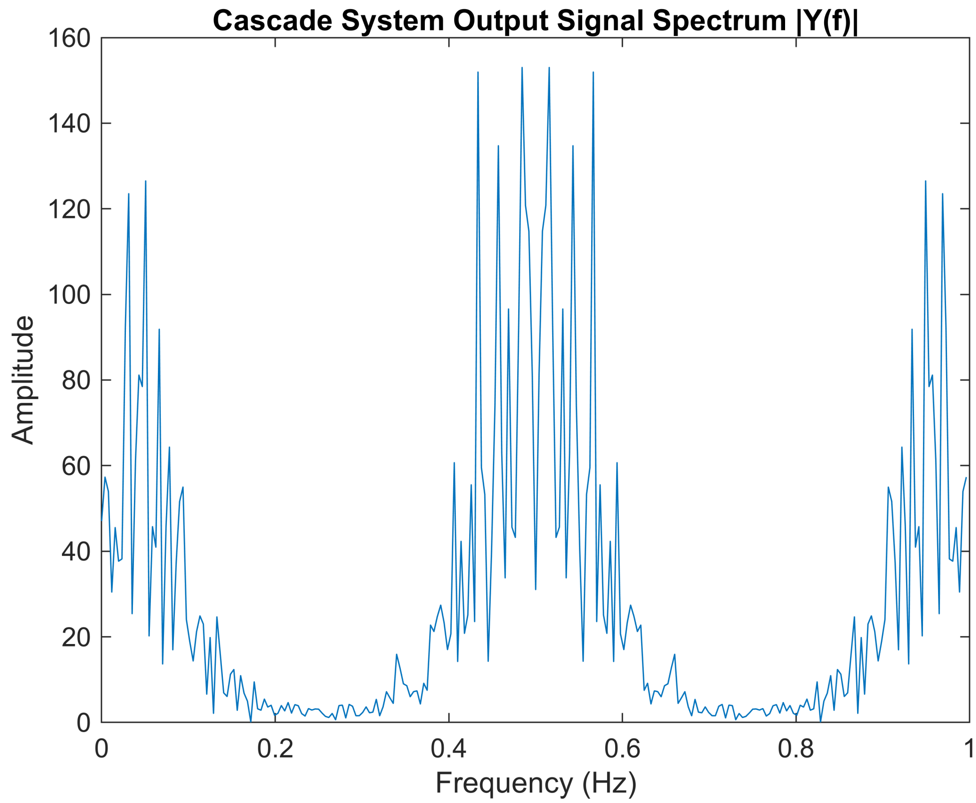


PART G

```
y_cascade_n = compute_output([bk0(2), bk1(2), bk2(2)], [1, ak1(2), ak2(2)], y1_n);

Y_cascade_f = fft(y_cascade_n);

f = (0:N-1)*(Fs/N);

figure;
plot(f, abs(X_f));
title('Input Signal Spectrum |X(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

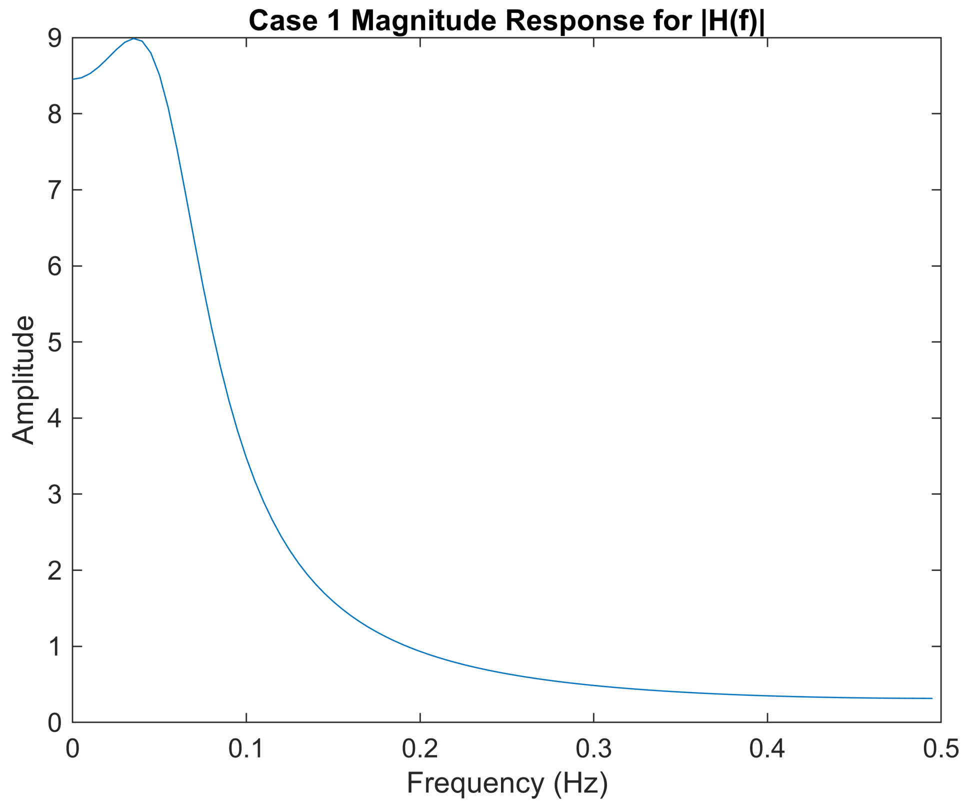


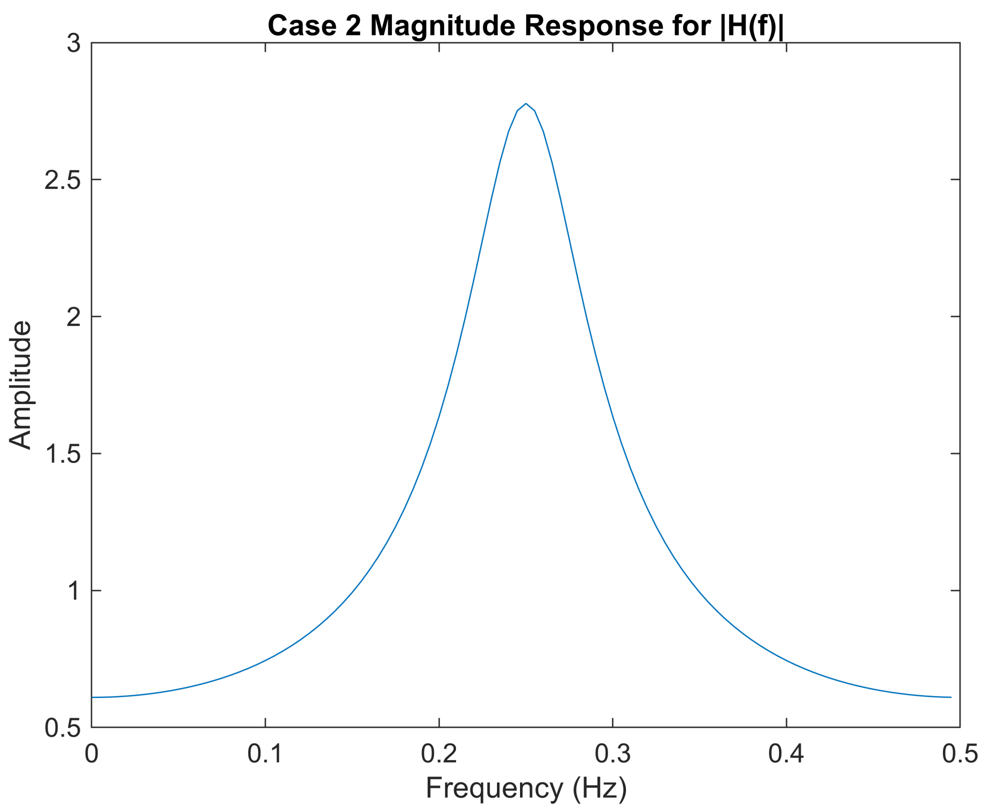

```
figure;
plot(f, abs(Y_cascade_f));
title('Cascade System Output Signal Spectrum |Y(f)|');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

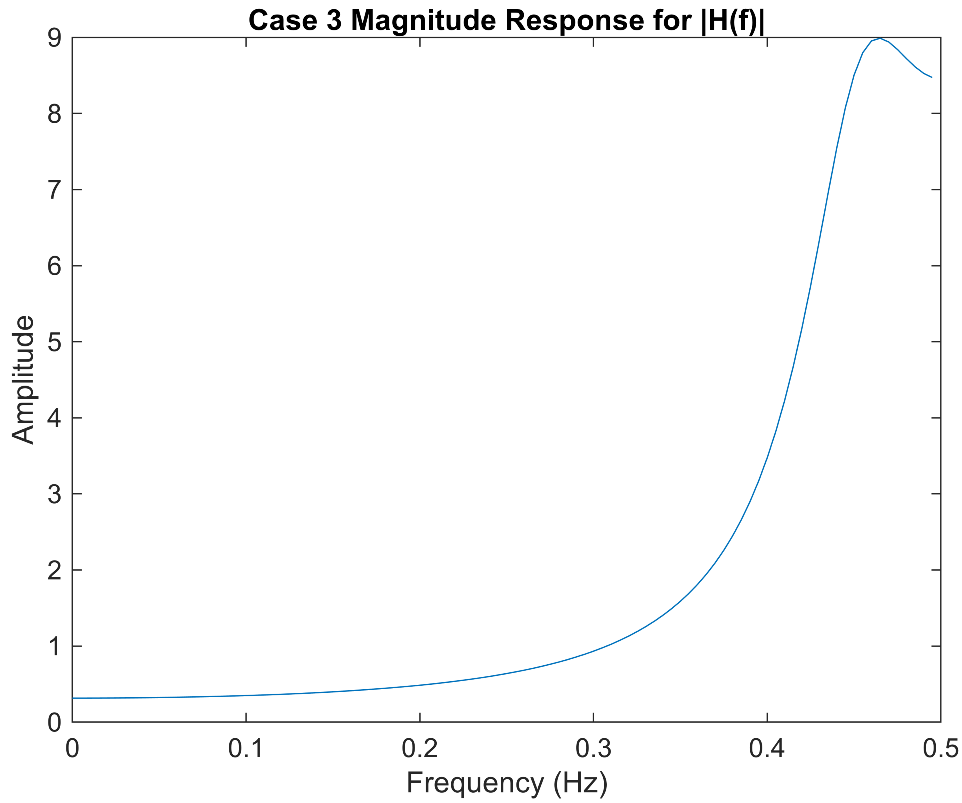


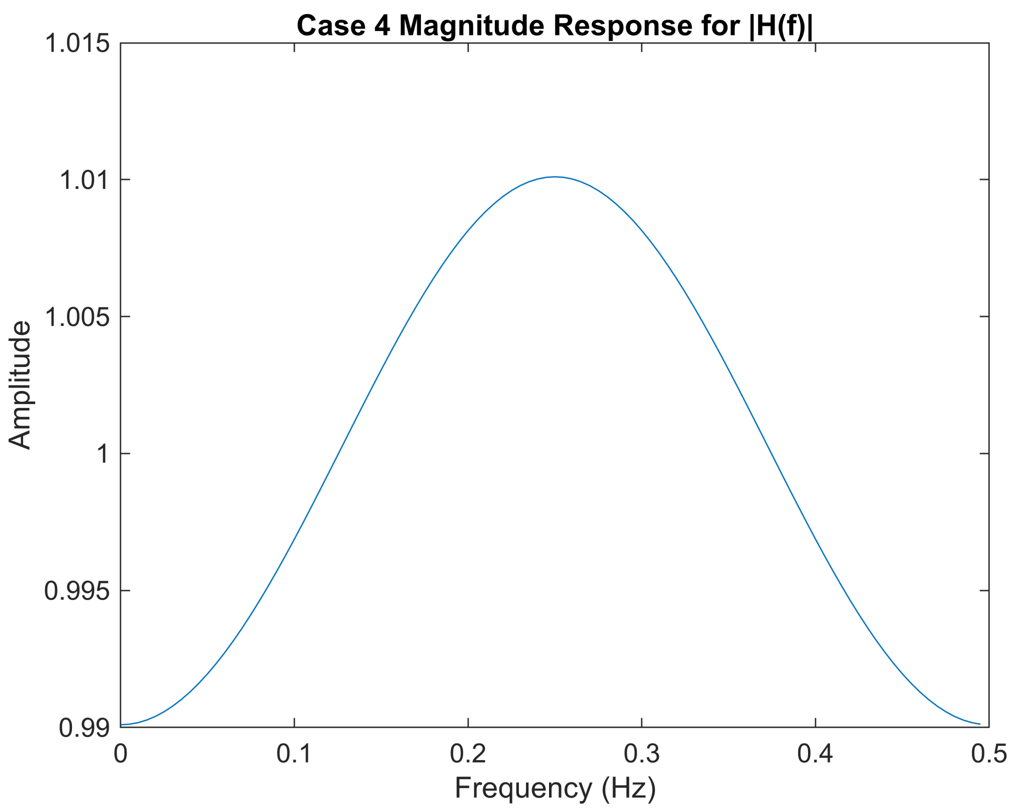
PART H

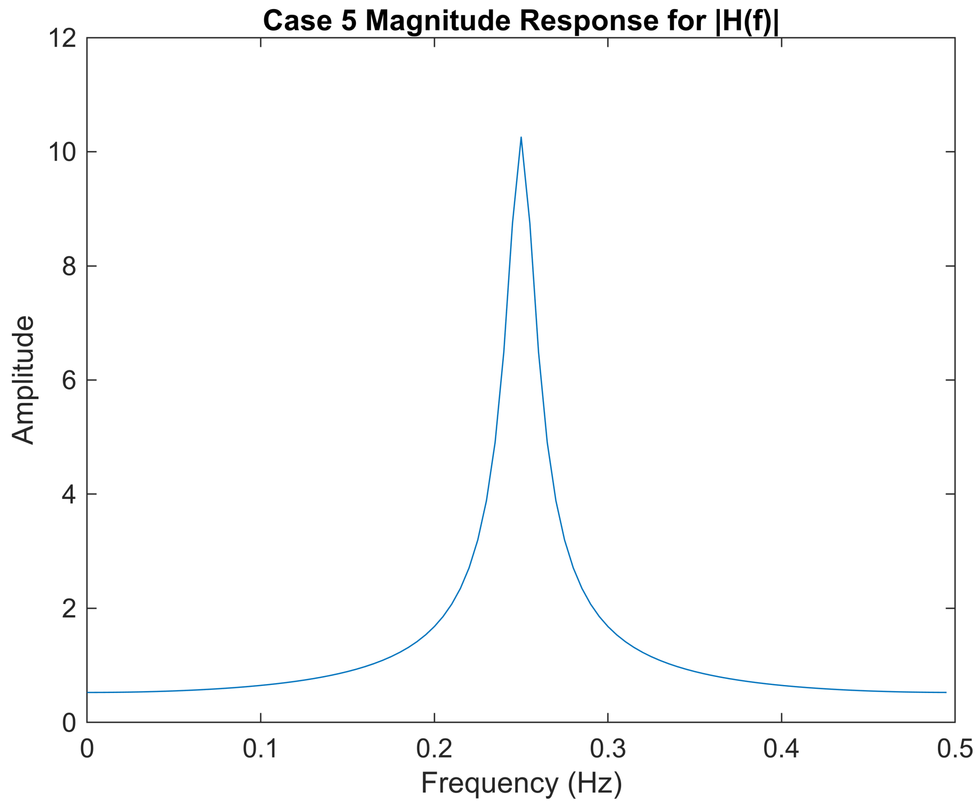
```
poles = {
    0.8 * exp(1j * 0.1 * pi), 0.8 * exp(-1j * 0.1 * pi);
    0.8 * exp(1j * 0.5 * pi), 0.8 * exp(-1j * 0.5 * pi);
    0.8 * exp(1j * 0.9 * pi), 0.8 * exp(-1j * 0.9 * pi);
    0.1 * exp(1j * 0.5 * pi), 0.1 * exp(-1j * 0.5 * pi);
    0.95 * exp(1j * 0.5 * pi), 0.95 * exp(-1j * 0.5 * pi)
};

for i = 1:length(poles)
    b = [1];
    a = poly([poles{i, 1}, poles{i, 2}]);

    [H, f] = freqz(b, a, 100, Fs);

    figure;
    plot(f, abs(H));
    title(['Case ', num2str(i), ' Magnitude Response for |H(f)|']);
    xlabel('Frequency (Hz)');
    ylabel('Amplitude');
end
```


Case 1 Magnitude Response for |H(f)|
Amplitude
Frequency (Hz)
0
1
2
3
4
5
6
7
8
9
0.1
0.2
0.3
0.4
0.5


Case 2 Magnitude Response for |H(f)|
Amplitude
Frequency (Hz)
0.5
1
1.5
2
2.5
3
0
0.1
0.2
0.3
0.4
0.5


Case 3 Magnitude Response for |H(f)|
Amplitude
Frequency (Hz)
0
1
2
3
4
5
6
7
8
9
0.1
0.2
0.3
0.4
0.5

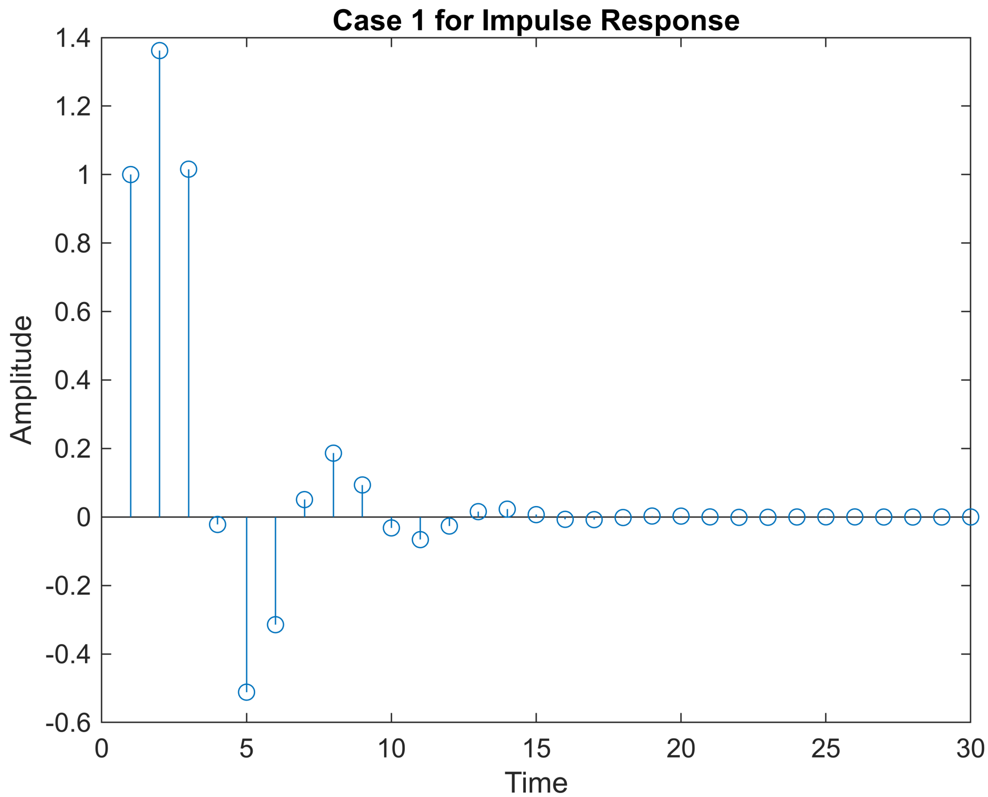

Case 4 Magnitude Response for |H(f)|
Amplitude
Frequency (Hz)
0.99
0.995
1
1.005
1.01
1.015
0
0.1
0.2
0.3
0.4
0.5

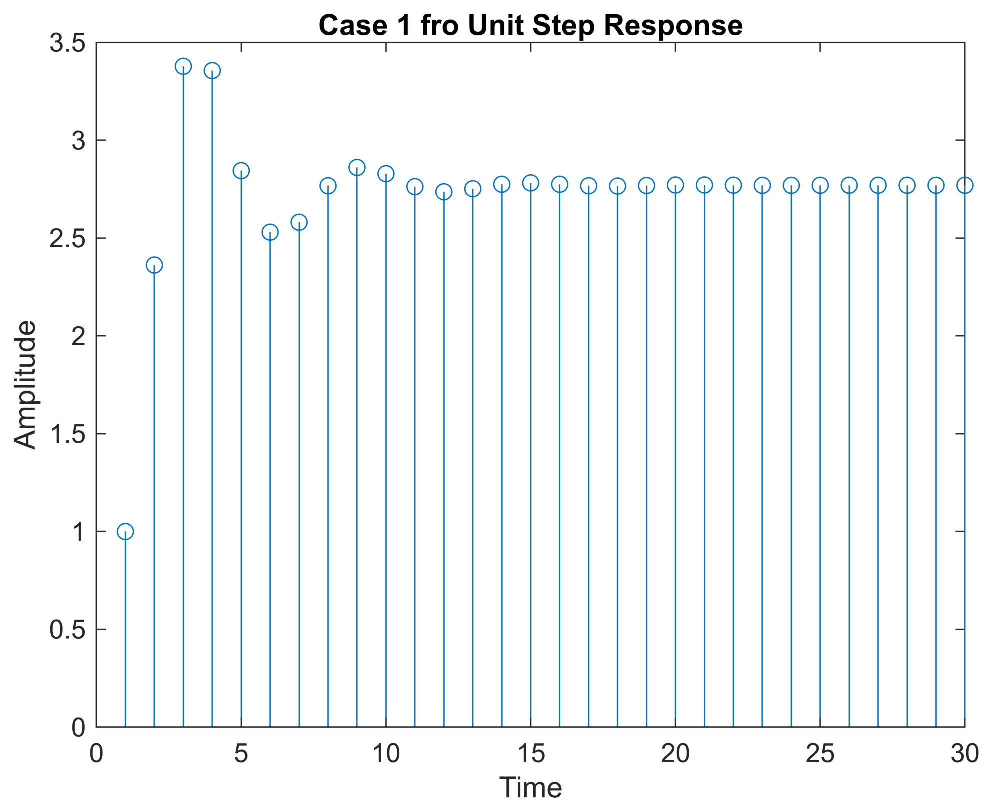


PART I

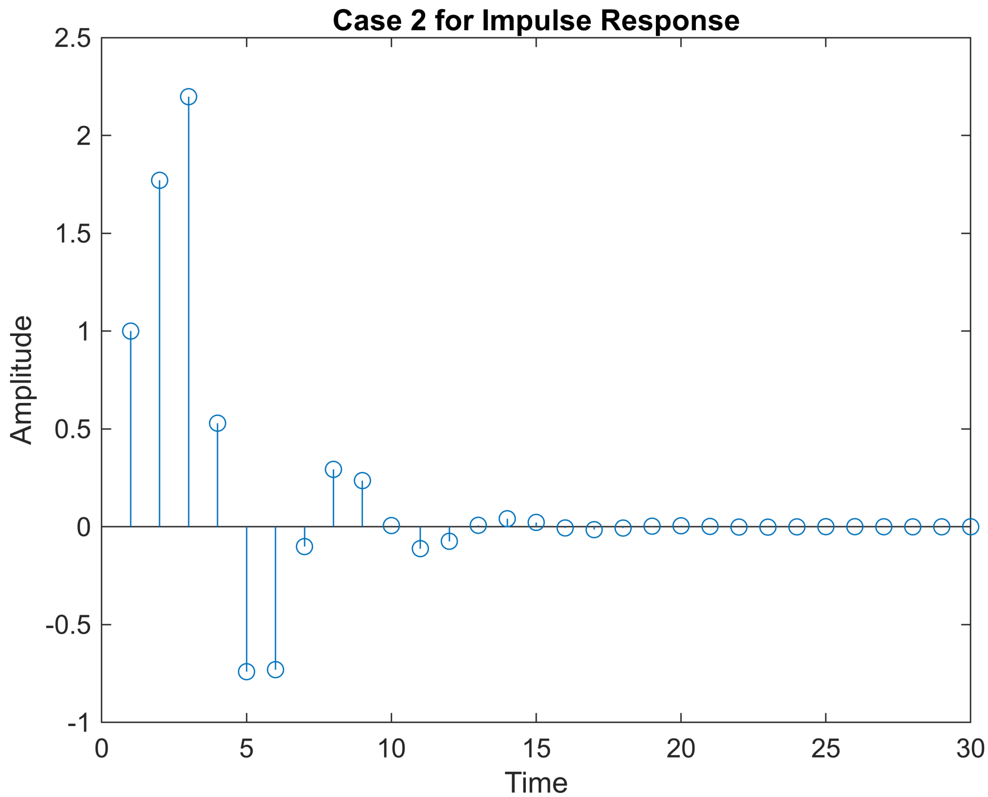
```
num_coeffs = {
    [1, 0.7264, 0.64],
    [1, 1.135, 1.5625],
    [1, 0.7264, 0.64]
};

den_coeffs = {
    [1, -0.6356, 0.49],
    [1, -0.6356, 0.49],
    [1, -1.362, 2.25]
};

for i = 1:length(num_coeffs)
    b = num_coeffs{i};
    a = den_coeffs{i};

    z = roots(b);
    p = roots(a);

    is_stable = all(abs(p) < 1);

    impulse_response = impz(b, a, 30);

    step_response = stepz(b, a, 30);
```

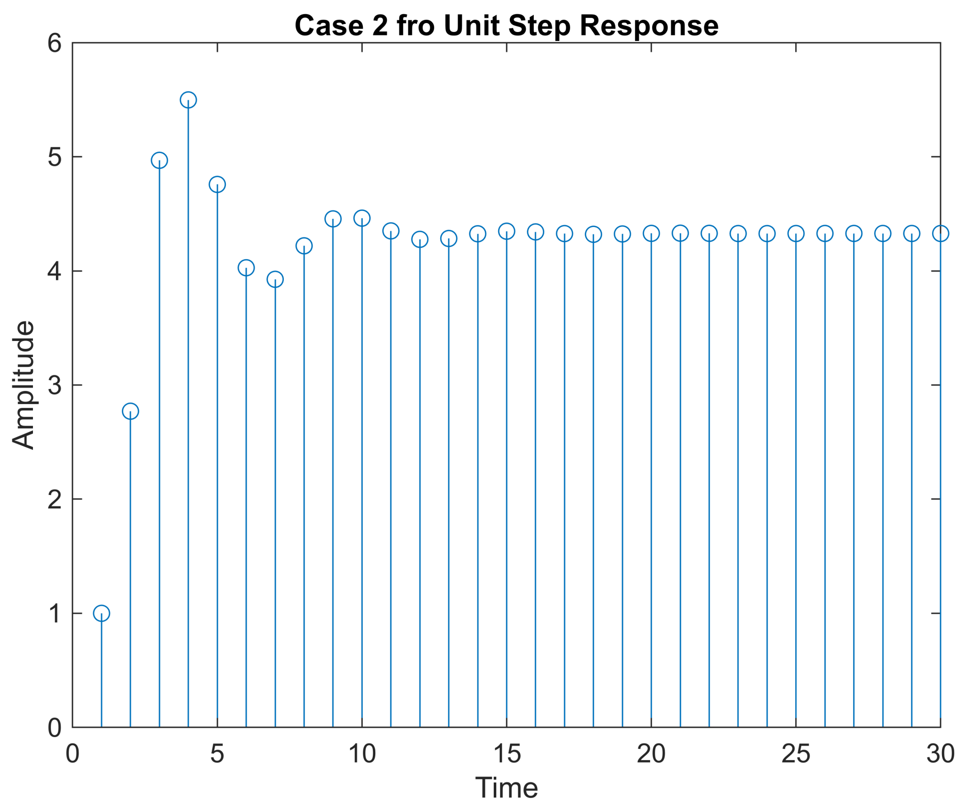
```
    figure;
    stem(impulse_response);
    title(['Case ', num2str(i), ' for Impulse Response']);
    xlabel('Time');
    ylabel('Amplitude');

    figure;
    stem(step_response);
    title(['Case ', num2str(i), ' fro Unit Step Response']);
    xlabel('Time');
    ylabel('Amplitude');

    disp(['Case ', num2str(i)]);
    if is_stable
        disp('The system is stable.');
    else
        disp('The system is unstable.');
    end

    if all(angle(z) >= 0) && all(angle(p) <= 0)
        disp('The system is minimum phase.');
    elseif all(angle(z) <= 0) && all(angle(p) >= 0)
        disp('The system is in maximum phase.');
    else
        disp('The system is neither maximum nor minimum phase.');
    end
end
```



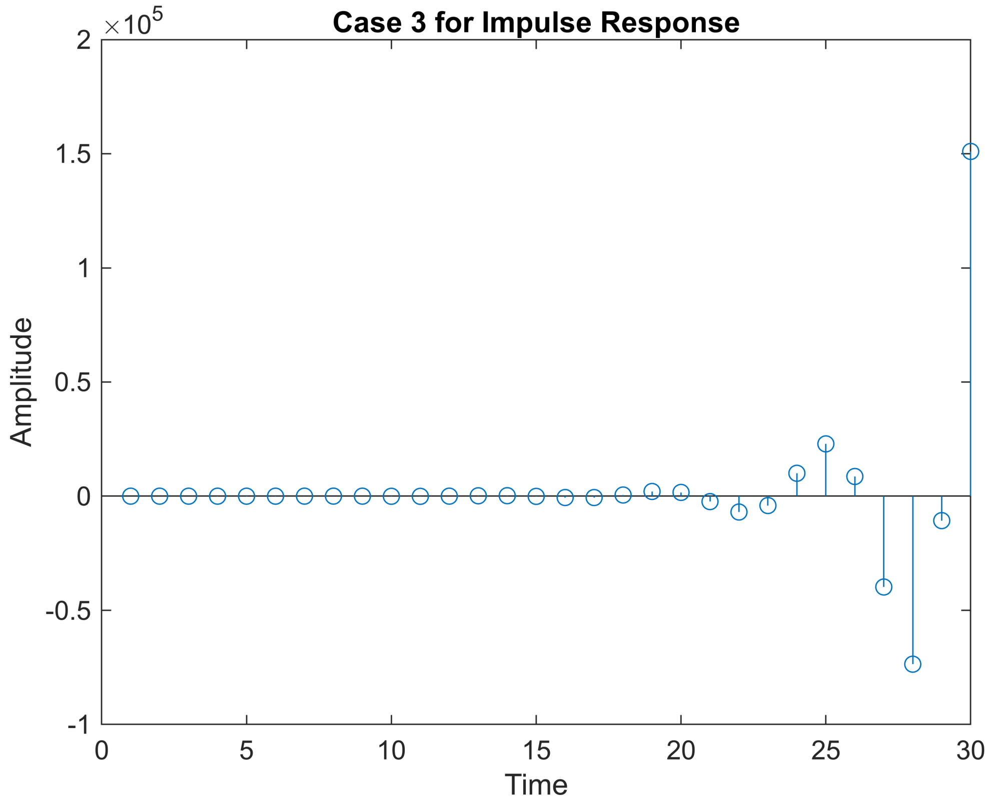


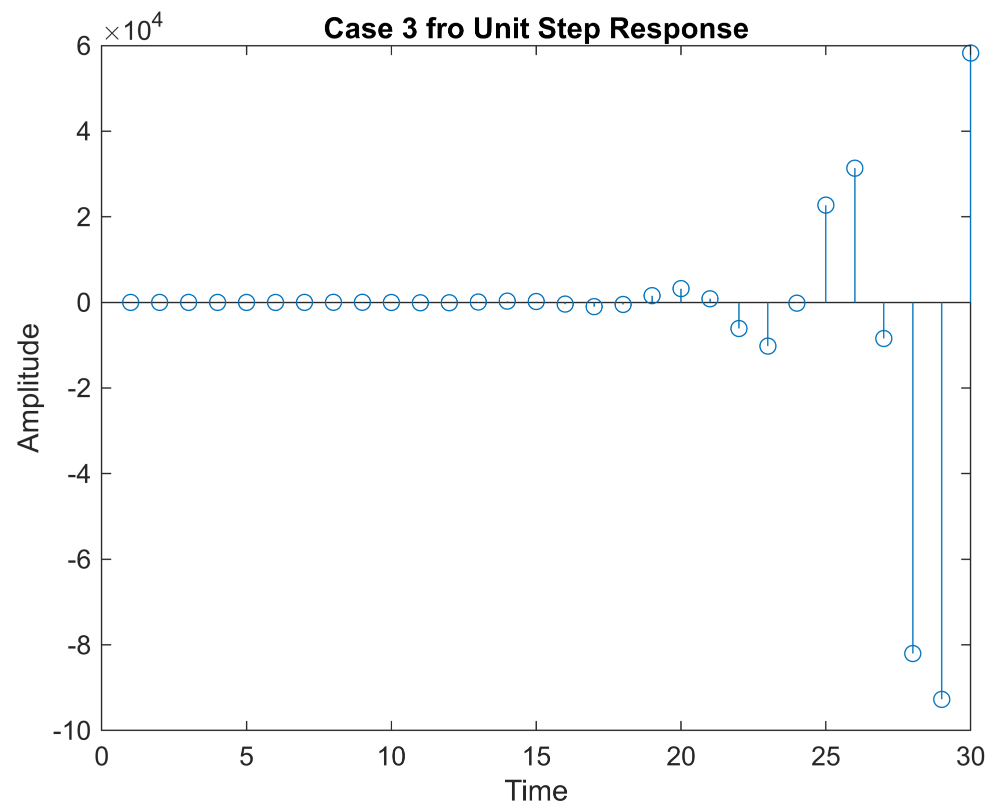

```
Case 1
The system is stable.
The system is neither maximum nor minimum phase.
```






```
Case 2
The system is stable.
The system is neither maximum nor minimum phase.
```

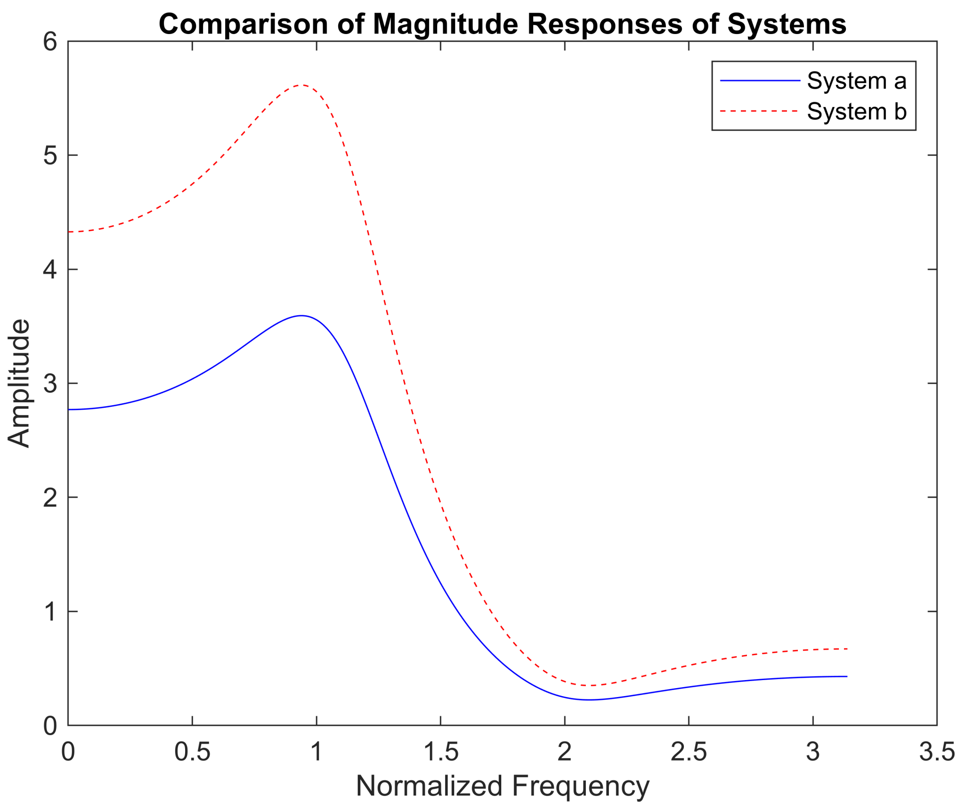





```
Case 3
The system is unstable.
The system is neither maximum nor minimum phase.
```

PART J

```
b_a = [1, 0.7264, 0.64];
a_a = [1, -0.6356, 0.49];

b_b = [1, 1.135, 1.5625];
a_b = [1, -0.6356, 0.49];

[H_a, f_a] = freqz(b_a, a_a, 1024);
[H_b, f_b] = freqz(b_b, a_b, 1024);

figure;
plot(f_a, abs(H_a), 'b', f_b, abs(H_b), 'r--');
legend('System a', 'System b');
title('Comparison of Magnitude Responses of Systems');
xlabel('Normalized Frequency');
ylabel('Amplitude');
```




```
disp('Comparing the magnitude responses of systems A and B:');
```

```
Comparing the magnitude responses of systems A and B:
```

```
disp('System A has a higher amplitude at lower frequencies, while system B has a
wider bandwidth.');
```

```
System A has a higher amplitude at lower frequencies, while system B has a wider bandwidth.
```

```
disp('This indicates that system B can transmit signals at higher frequencies
better.');
```

```
This indicates that system B can transmit signals at higher frequencies better.
```

```
disp('However, system A can better emphasize signals at lower frequencies.');
```

```
However, system A can better emphasize signals at lower frequencies.
```

```
disp('Since both systems have the same denominator coefficients, they have
similar');
```

```
Since both systems have the same denominator coefficients, they have similar
```

```
disp(' characteristics in terms of stability.');
```

```
 characteristics in terms of stability.
```

FUNCTIONS

```
function y = difference_equation(x, k, bk0, bk1, bk2, ak1, ak2)
    b0 = bk0(k);
    b1 = bk1(k);
    b2 = bk2(k);
    a1 = ak1(k);
    a2 = ak2(k);

    y = zeros(size(x));

    for n = 3:length(x)
        y(n) = b0*x(n) + b1*x(n-1) + b2*x(n-2) - a1*y(n-1) - a2*y(n-2);
    end
end


function y = compute_output(b, a, x)
    N = length(x);

    y = zeros(1, N);

    for n = 1:N
        for k = 1:length(b)
            if n-k >= 1
                y(n) = y(n) + b(k)*x(n-k+1);
            end
        end
        for k = 2:length(a)
            if n-k+1 >= 1
                y(n) = y(n) - a(k)*y(n-k+1);
```

```
                end
            end
        end
    end
```