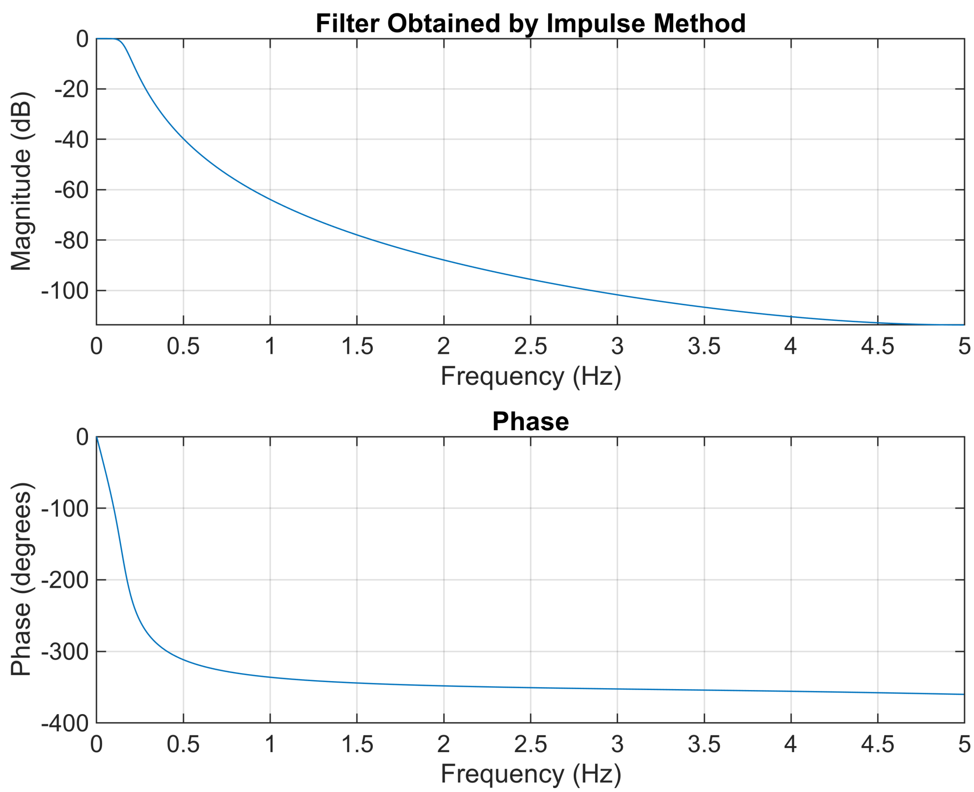
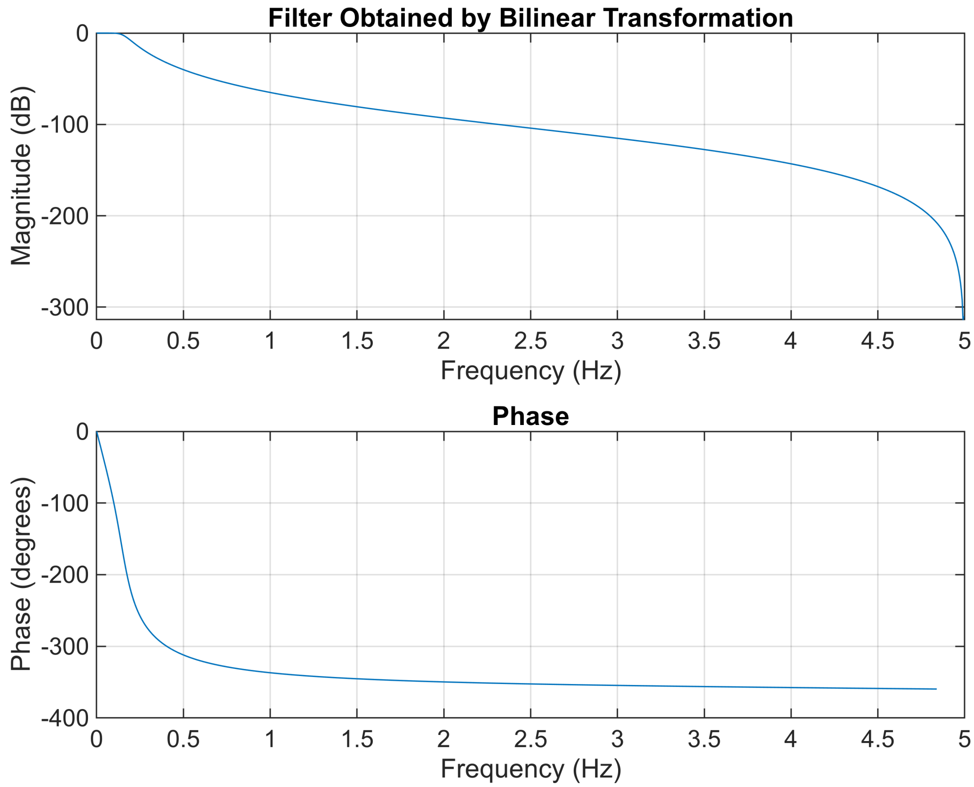
PART A

```
N = 4;
Wn = 1;

[b, a] = butter(N, Wn, 's');

Fs = 10;

[bz_imp, az_imp] = impinvar(b, a, Fs);

[bz_bilin, az_bilin] = bilinear(b, a, Fs);

freqz(bz_imp, az_imp, 1024, Fs);
title('Filter Obtained by Impulse Method');
```

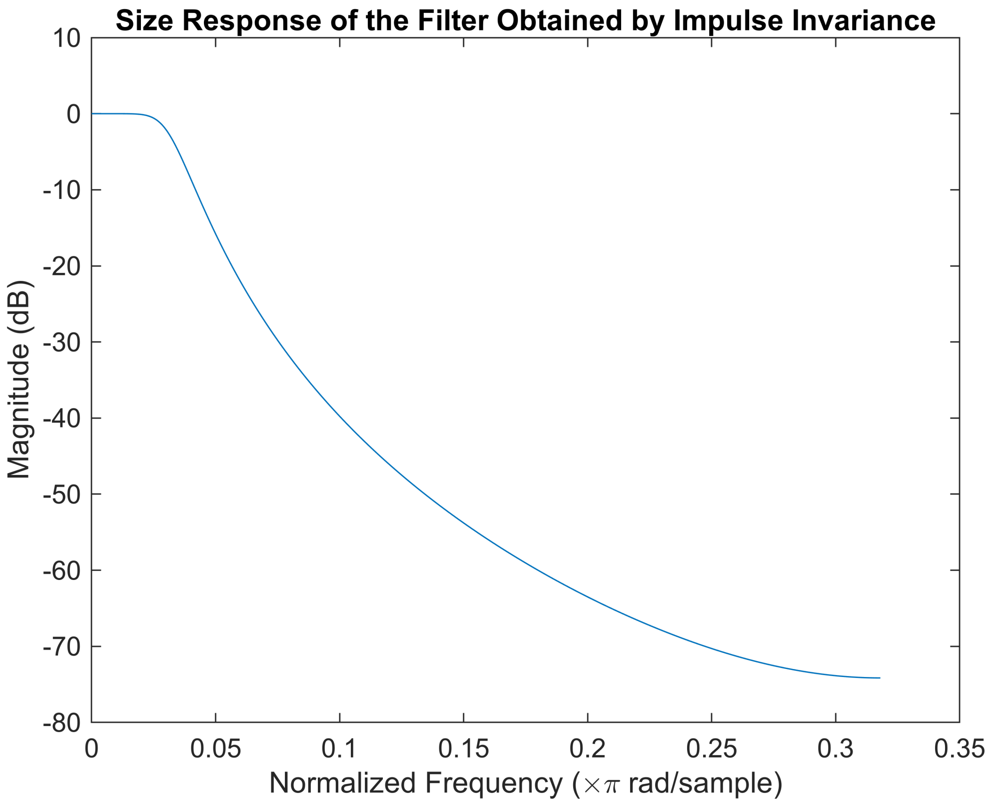



```
figure;
freqz(bz_bilin, az_bilin, 1024, Fs);
title('Filter Obtained by Bilinear Transformation');
```

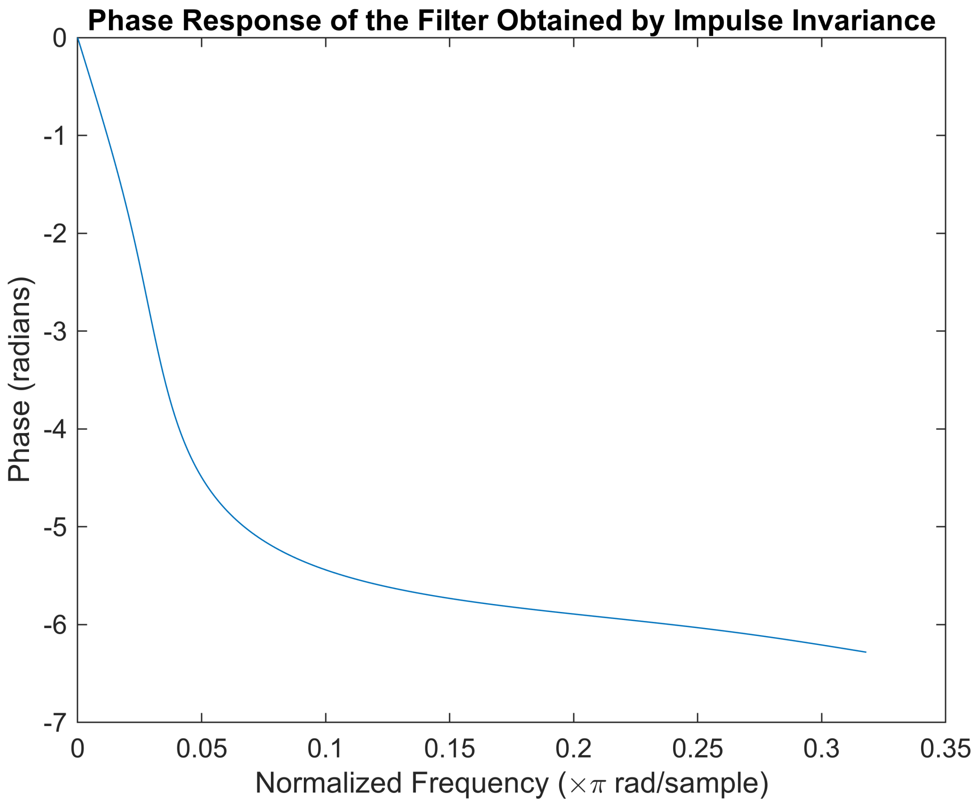


PART B

```
N = 4;
Wn = 0.2*pi;

[b, a] = butter(N, Wn, 's');

Fs = 2;

[bz_imp, az_imp] = impinvar(b, a, Fs);

[h, w] = freqz(bz_imp, az_imp, 'half', 1024, Fs);
mag = 20*log10(abs(h));
phase = unwrap(angle(h));

figure;
plot(w/pi, mag);
title('Size Response of the Filter Obtained by Impulse Invariance');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Magnitude (dB)');
```

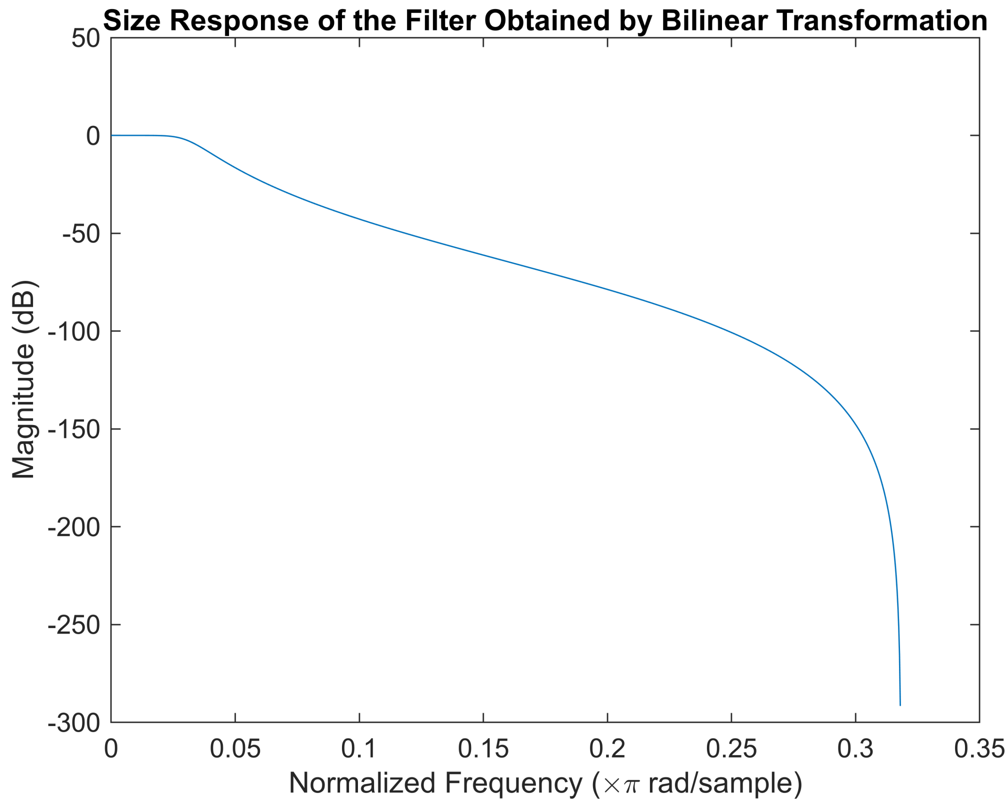



```
figure;
plot(w/pi, phase);
title('Phase Response of the Filter Obtained by Impulse Invariance');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Phase (radians)');
```

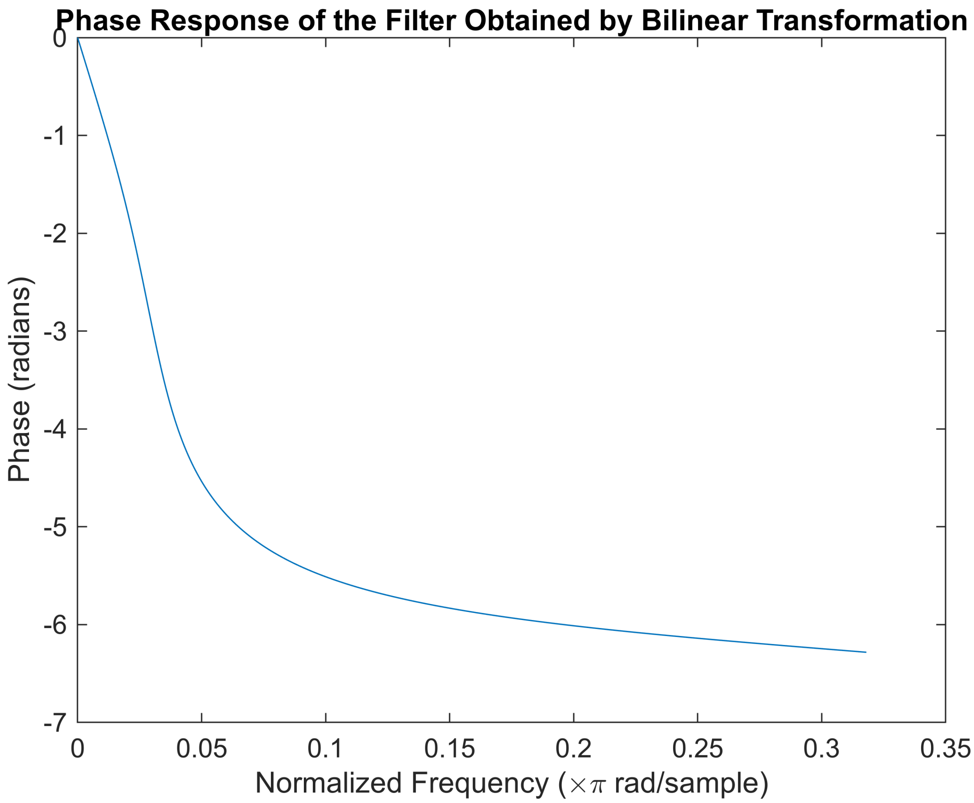


PART C

```
N = 4;
Wn = 0.2*pi;

[b, a] = butter(N, Wn, 's');

Fs = 2;

[bz_bilin, az_bilin] = bilinear(b, a, Fs);

[h_bilin, w_bilin] = freqz(bz_bilin, az_bilin, 'half', 1024, Fs);
mag_bilin = 20*log10(abs(h_bilin));
phase_bilin = unwrap(angle(h_bilin));

figure;
plot(w_bilin/pi, mag_bilin);
title('Size Response of the Filter Obtained by Bilinear Transformation');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Magnitude (dB)');
```

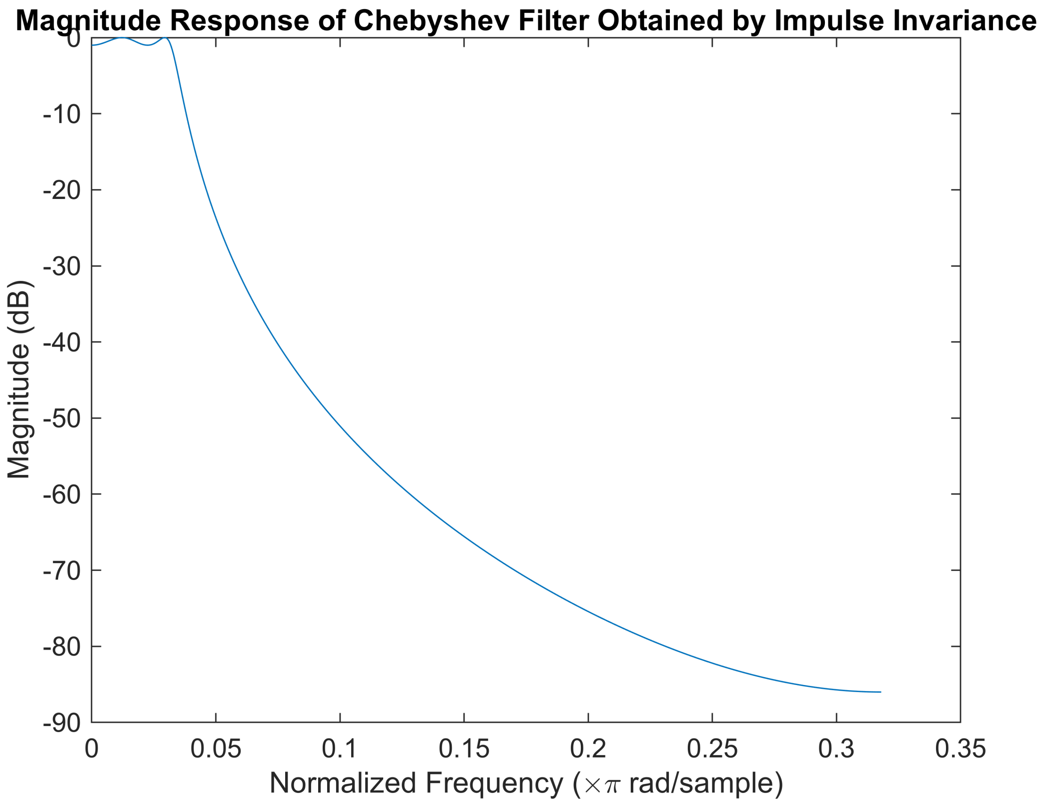



```
figure;
plot(w_bilin/pi, phase_bilin);
title('Phase Response of the Filter Obtained by Bilinear Transformation');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Phase (radians)');
```

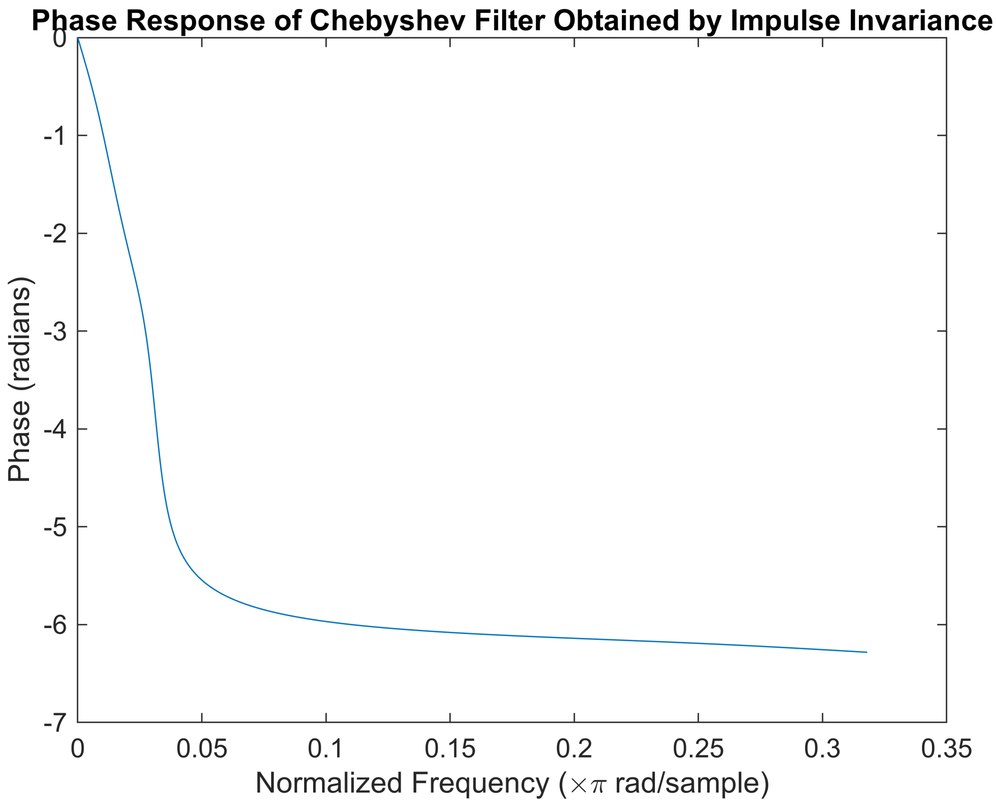


PART D

```
N = 4;
Rp = 1;
Wn = 0.2*pi;

[b, a] = cheby1(N, Rp, Wn, 's');

Fs = 2;

[bz_imp, az_imp] = impinvar(b, a, Fs);

[h_imp, w_imp] = freqz(bz_imp, az_imp, 'half', 1024, Fs);
mag_imp = 20*log10(abs(h_imp));
phase_imp = unwrap(angle(h_imp));

figure;
plot(w_imp/pi, mag_imp);
title('Magnitude Response of Chebyshev Filter Obtained by Impulse Invariance');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Magnitude (dB)');
```

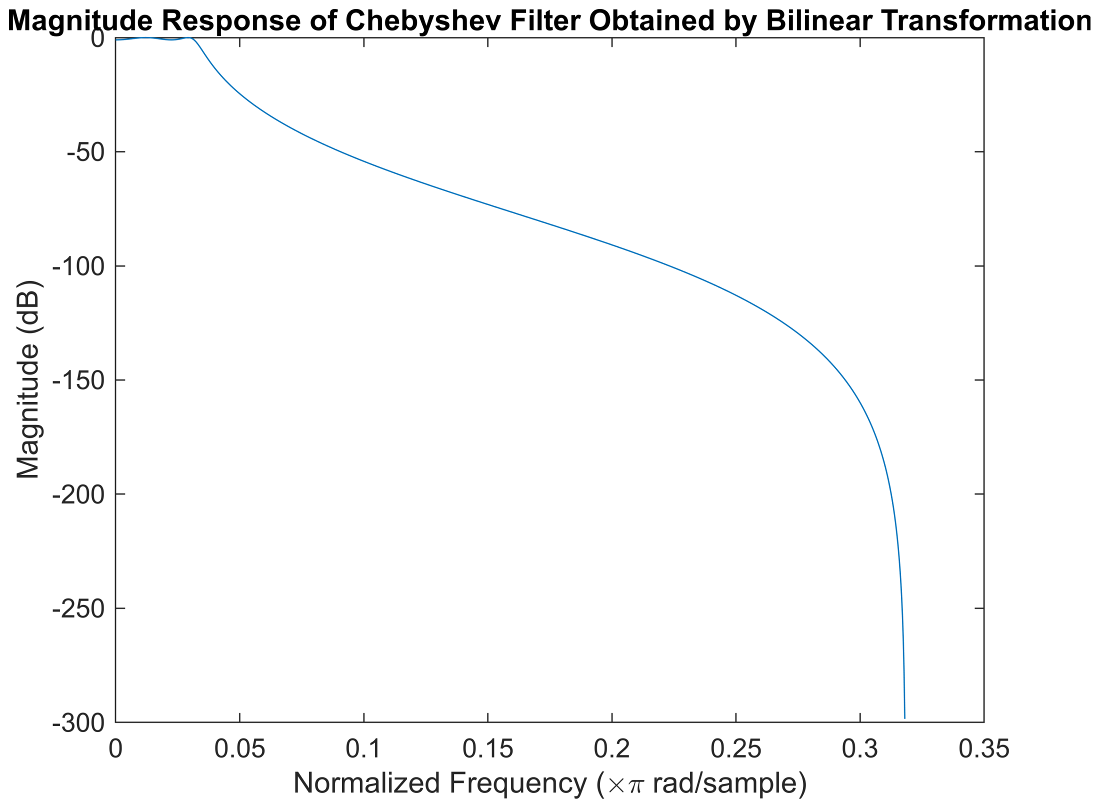



```
figure;
plot(w_imp/pi, phase_imp);
title('Phase Response of Chebyshev Filter Obtained by Impulse Invariance');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Phase (radians)');
```

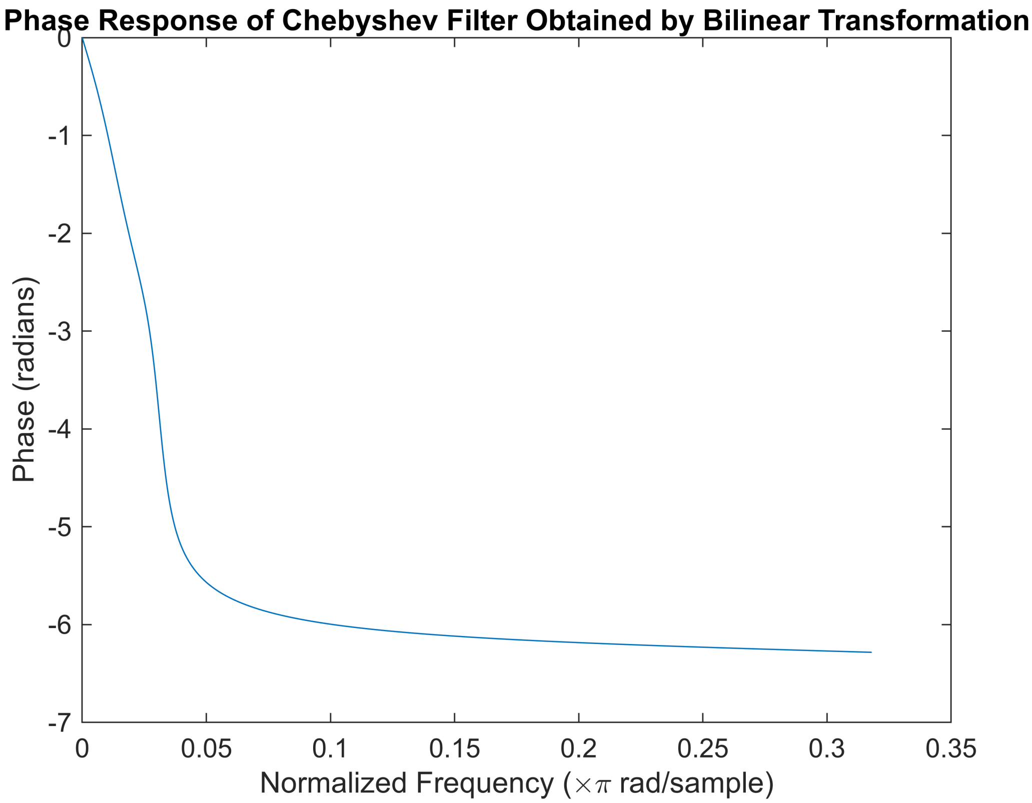


PART E

```
N = 4;
Rp = 1;
Wn = 0.2*pi;

[b, a] = cheby1(N, Rp, Wn, 's');

Fs = 2;

[bz_bilin, az_bilin] = bilinear(b, a, Fs);

[h_bilin, w_bilin] = freqz(bz_bilin, az_bilin, 'half', 1024, Fs);
mag_bilin = 20*log10(abs(h_bilin));
phase_bilin = unwrap(angle(h_bilin));

figure;
plot(w_bilin/pi, mag_bilin);
title('Magnitude Response of Chebyshev Filter Obtained by Bilinear Transformation');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Magnitude (dB)');
```

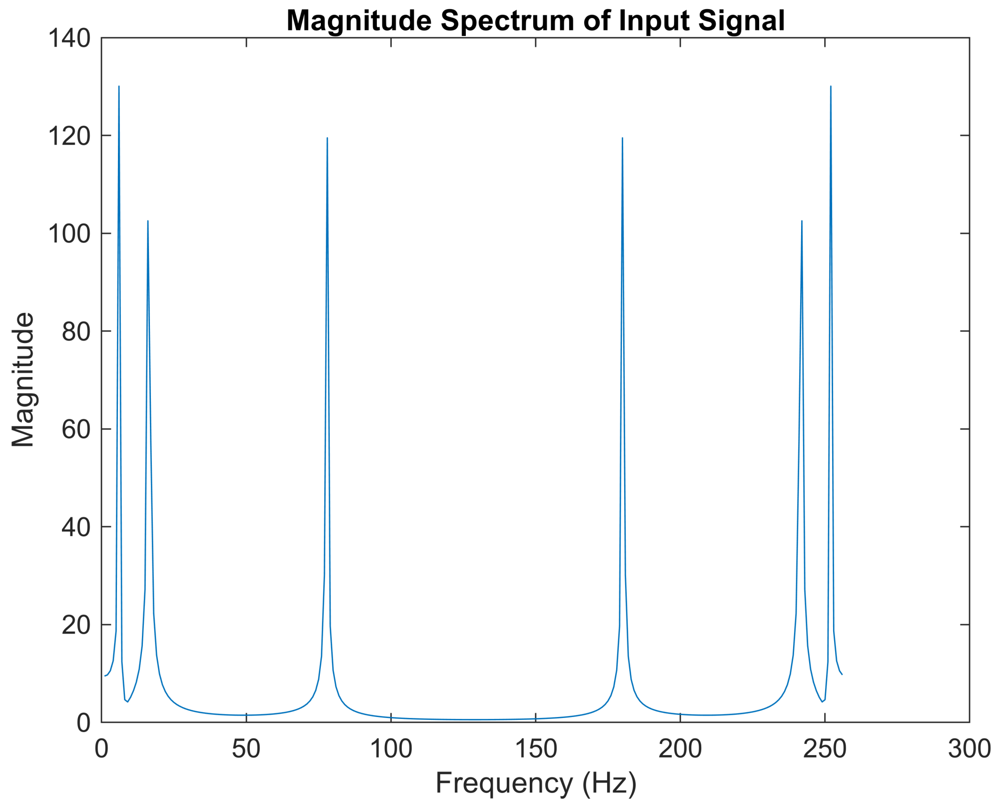



```
figure;
plot(w_bilin/pi, phase_bilin);
title('Phase Response of Chebyshev Filter Obtained by Bilinear Transformation');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Phase (radians)');
```

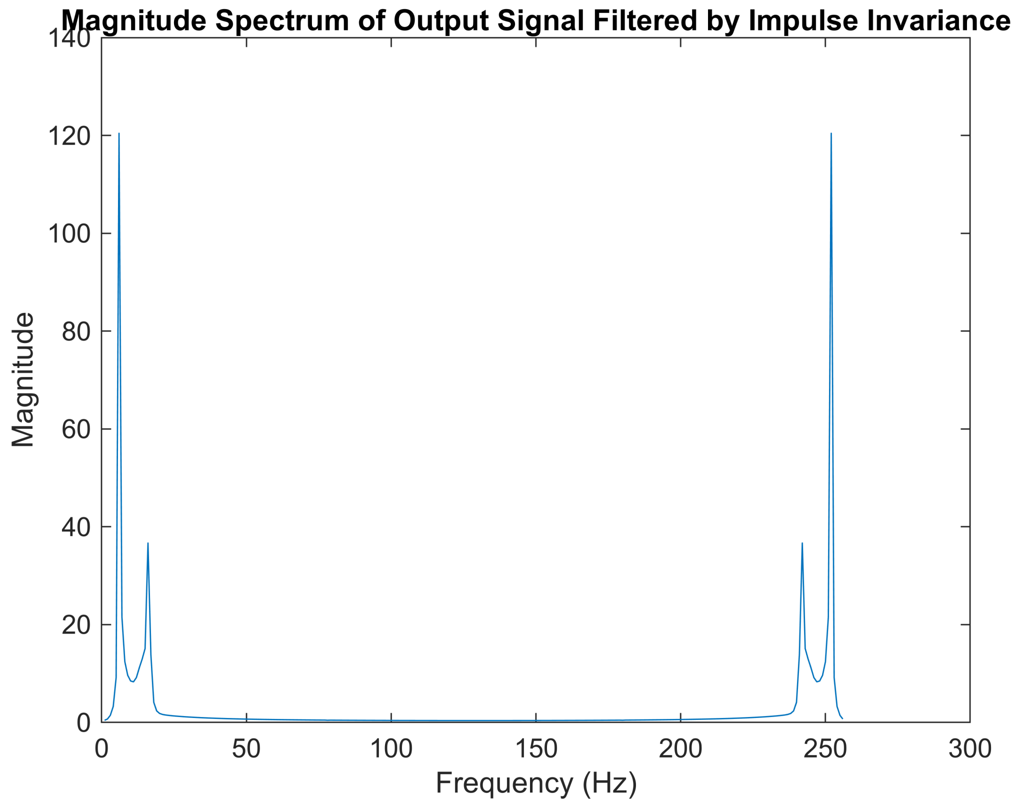


PART F

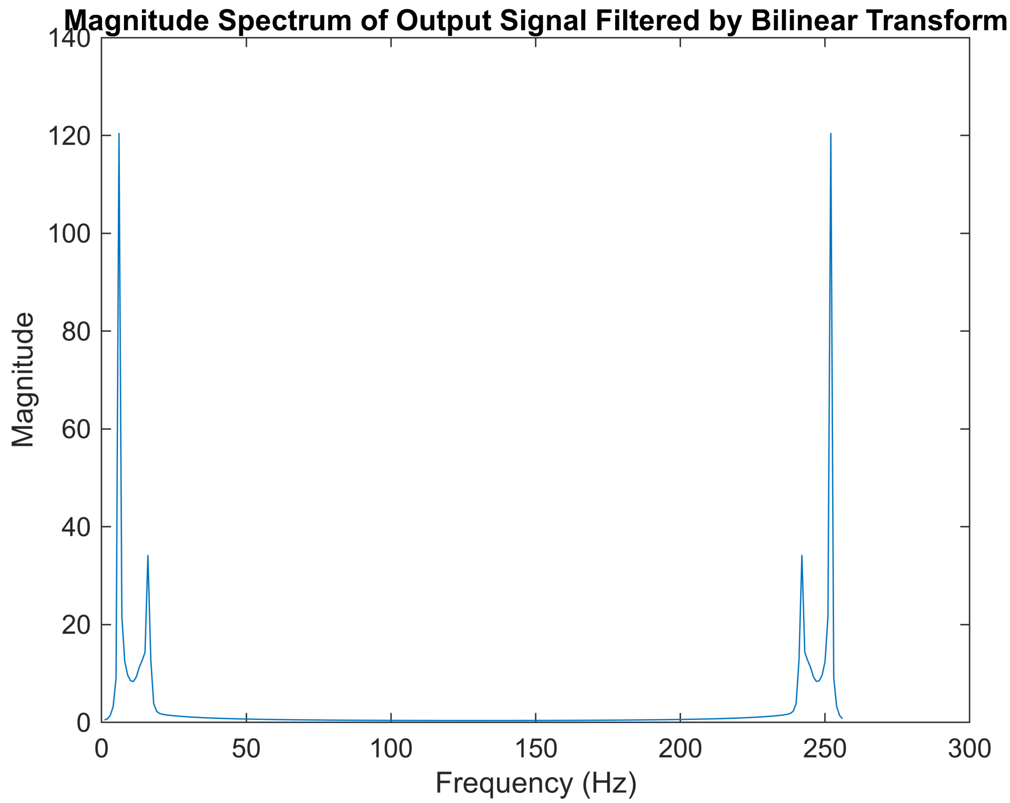
```
n = 0:255;
x = cos(2*pi*n*0.02) + sin(2*pi*n*0.06) + cos(2*pi*n*0.3);

y_imp = filter(bz_imp, az_imp, x);

y_bilin = filter(bz_bilin, az_bilin, x);

X_magnitude = abs(fft(x));
Y_imp_magnitude = abs(fft(y_imp));
Y_bilin_magnitude = abs(fft(y_bilin));

figure;
plot(X_magnitude);
title('Magnitude Spectrum of Input Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



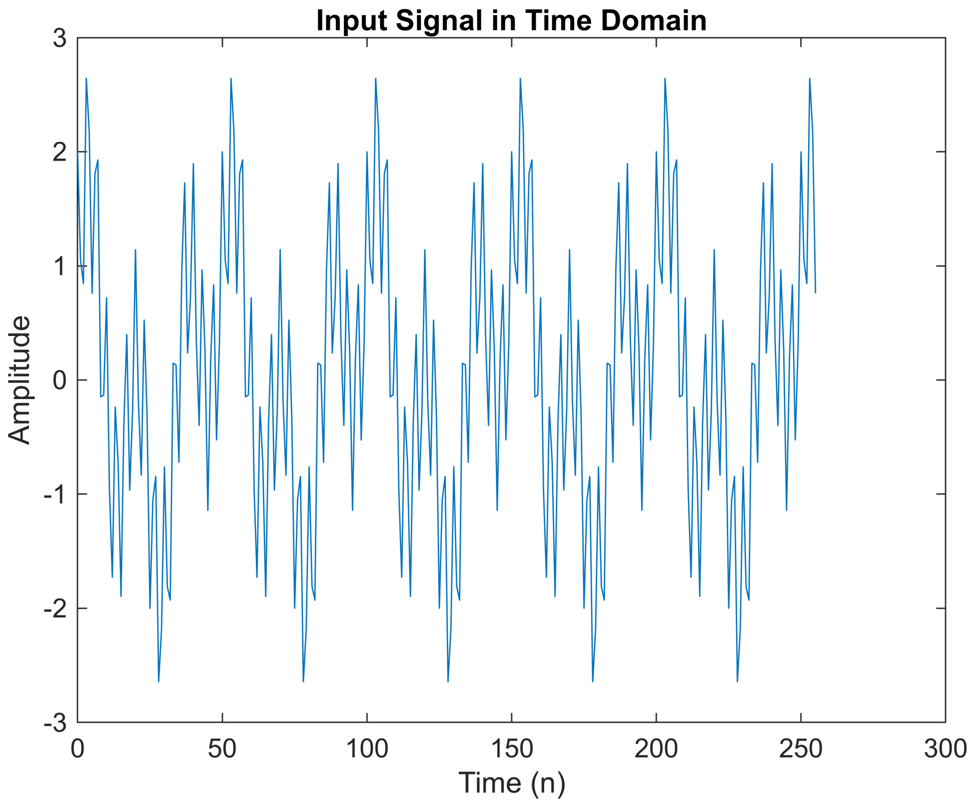

```
figure;
plot(Y_imp_magnitude);
title('Magnitude Spectrum of Output Signal Filtered by Impulse Invariance');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



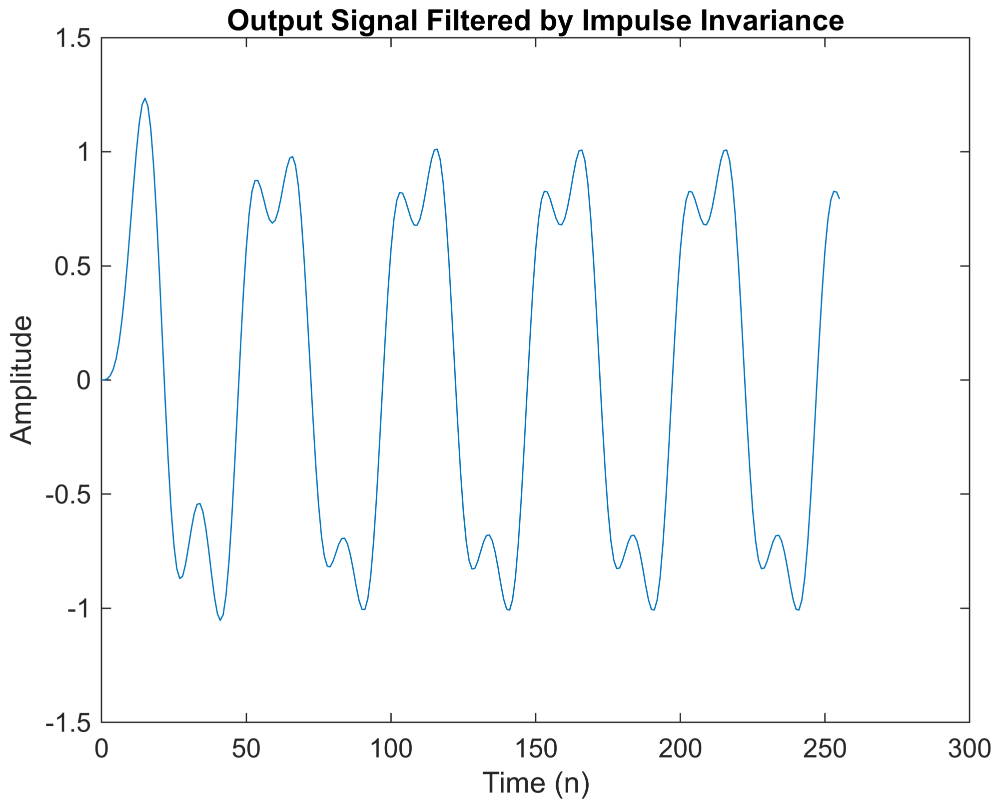

```
figure;
plot(Y_bilin_magnitude);
title('Magnitude Spectrum of Output Signal Filtered by Bilinear Transform');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



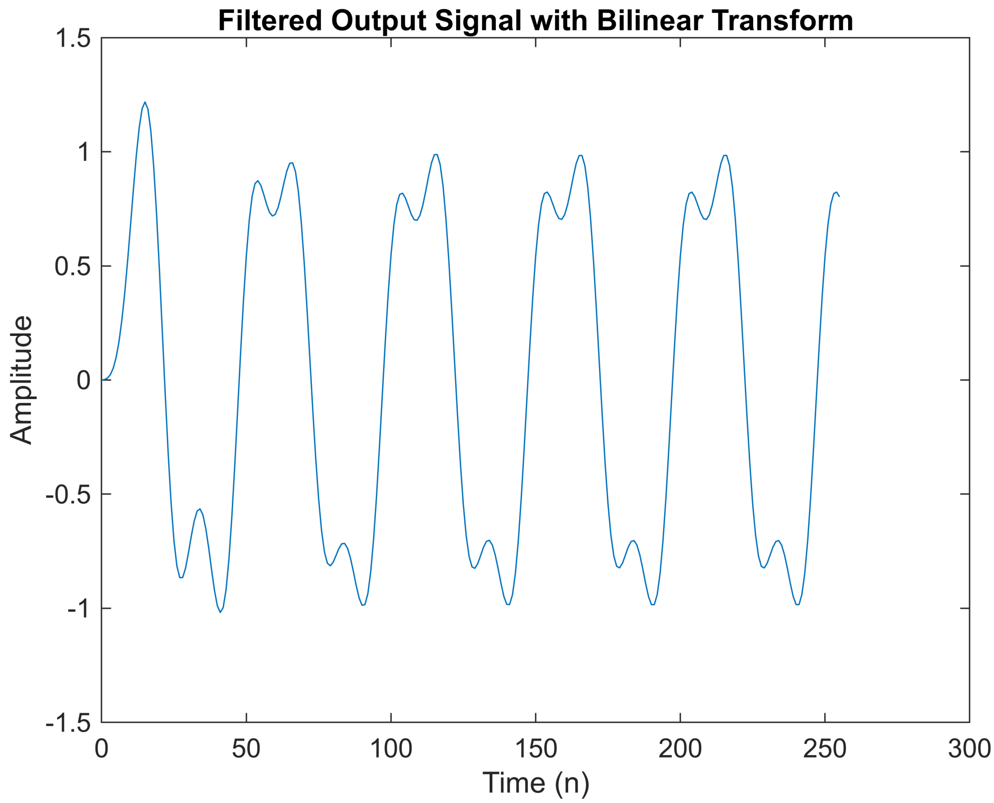

```
figure;
plot(n, x);
title('Input Signal in Time Domain');
xlabel('Time (n)');
ylabel('Amplitude');
```




```
figure;
plot(n, y_imp);
title('Output Signal Filtered by Impulse Invariance');
xlabel('Time (n)');
ylabel('Amplitude');
```

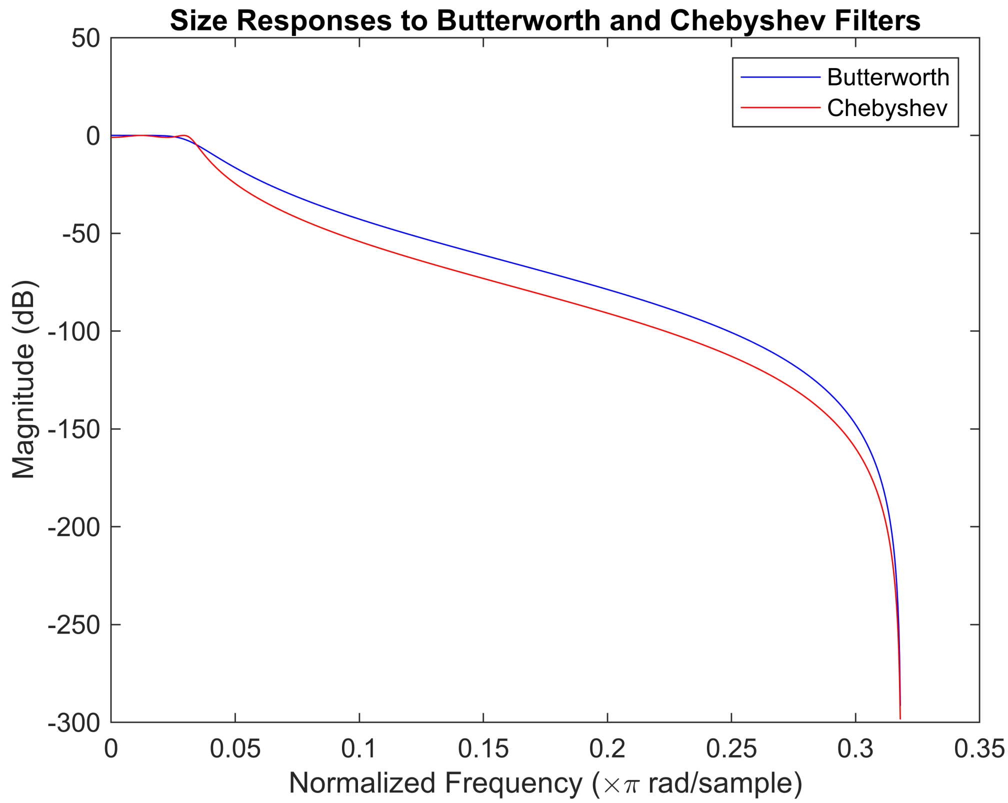



```
figure;
plot(n, y_bilin);
title('Filtered Output Signal with Bilinear Transform');
xlabel('Time (n)');
ylabel('Amplitude');
```

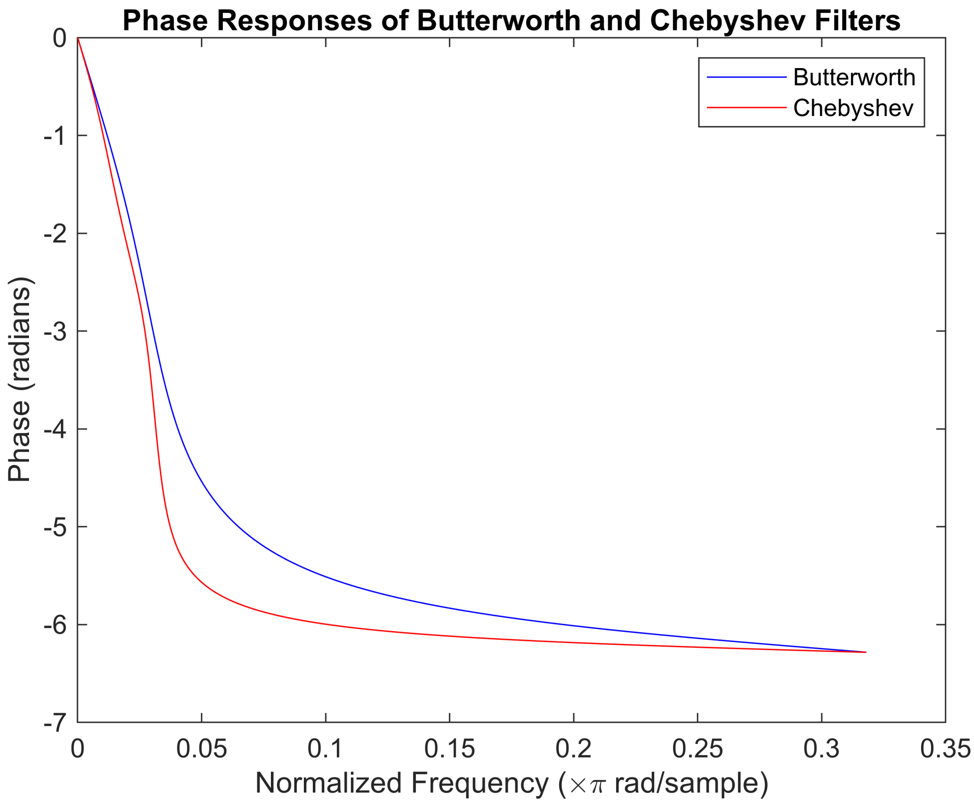


PART G

```
N = 4;
Wn = 0.2*pi;
Rp = 1;

[b_butter, a_butter] = butter(N, Wn, 's');
[bz_butter, az_butter] = bilinear(b_butter, a_butter, Fs);

[b_cheby, a_cheby] = cheby1(N, Rp, Wn, 's');
[bz_cheby, az_cheby] = bilinear(b_cheby, a_cheby, Fs);

[h_butter, w_butter] = freqz(bz_butter, az_butter, 'half', 1024, Fs);
[h_cheby, w_cheby] = freqz(bz_cheby, az_cheby, 'half', 1024, Fs);

figure;
plot(w_butter/pi, 20*log10(abs(h_butter)), 'b');
hold on;
plot(w_cheby/pi, 20*log10(abs(h_cheby)), 'r');
title('Size Responses to Butterworth and Chebyshev Filters');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Magnitude (dB)');
legend('Butterworth', 'Chebyshev');
```




```
figure;
plot(w_butter/pi, unwrap(angle(h_butter)), 'b');
hold on;
plot(w_cheby/pi, unwrap(angle(h_cheby)), 'r');
title('Phase Responses of Butterworth and Chebyshev Filters');
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Phase (radians)');
legend('Butterworth', 'Chebyshev');
```




```
% It is quite interesting to compare the Butterworth and Chebyshev approaches in
terms of
% complexity, magnitude and phase response. Both filters are widely used in signal
% processing and offer certain advantages and disadvantages.

% Butterworth Filters are known for having a flat passband. This ensures that the
signal
% is filtered as close to the original as possible, without unwanted fluctuations
in the
% frequency spectrum. The phase response of Butterworth filters is generally linear,
% which means that the phase of the signal changes proportional to frequency. In
terms
% of complexity, Butterworth filters generally have a simpler structure because
they do
% "not need extra parameters.

% Chebyshev Filters stand out with their sharp cut-off frequency. Chebyshev filters
% have a certain ripple in the passband, representing a more aggressive approach to
% filter design. This approach allows filtering the signal more sharply, but some
% fluctuations in the signal may occur in the process. The phase response of
Chebyshev
% filters is generally more complex and can vary with the frequency components of
the
```

```
% signal. In terms of complexity, Chebyshev filters generally require more
parameters because
% additional adjustments must be made to control ripple in the passband.

% In general, Butterworth filters offer a flatter passband and simpler structure,
% while Chebyshev filters offer a sharper cutoff frequency and more complex
structure.
% The choice varies depending on the requirements of the application and the nature
of
% the signal being delivered. If a flatter pass band is desired, Butterworth is
preferred,
% while Chebyshev may be preferred if a sharper cutoff frequency is required. Both
types of
% filters are valuable tools in the fields of engineering and signal processing,
and their
% advantages and disadvantages should be carefully evaluated depending on their use.
```