```
% Load the ECG data
data = readtable('ekg.csv');
```

```
Warning: Column headers from the file were modified to make them valid MATLAB identifiers before creating
variable names for the table. The original column headers are saved in the VariableDescriptions property.
Set 'VariableNamingRule' to 'preserve' to use the original column headers as table variable names.
```

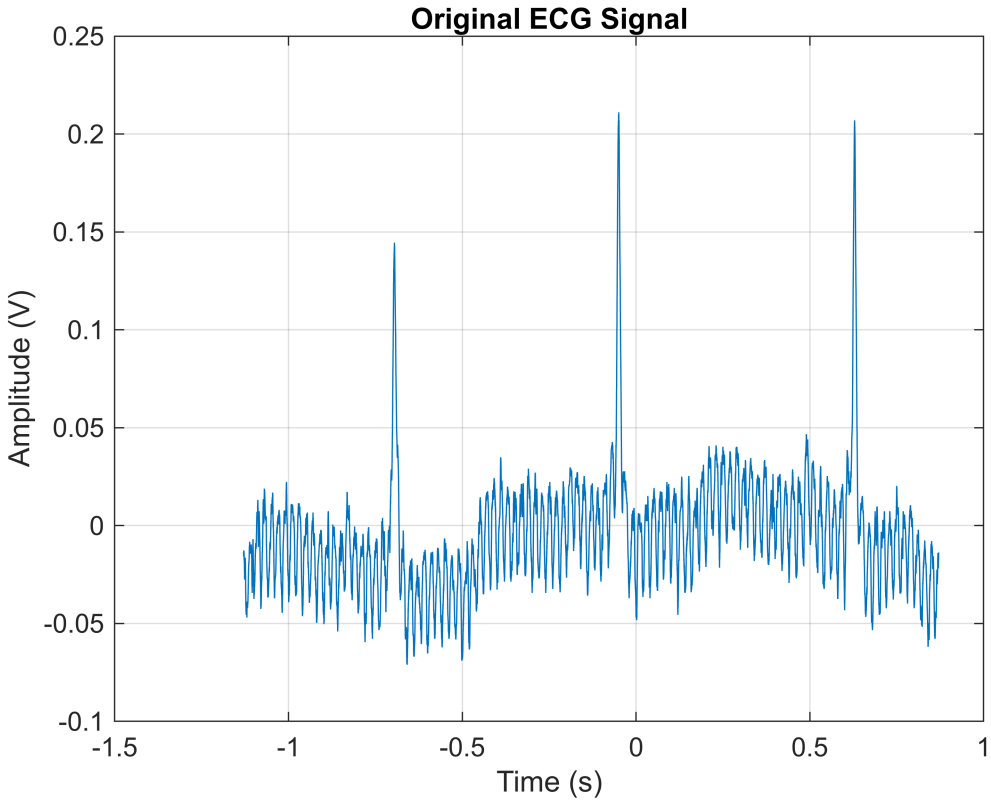
```
% Extract time and signal values
time = data.('Time_s_');
ecg_signal = data.('Channel1_V_');

% Display the first few rows of the data for verification
disp('First few rows of the ECG data:');
```

```
First few rows of the ECG data:
```

```
disp(data(1:10, :));
```

```
    Time_s_    Channel1_V_
    _______    ___________

    -1.1293     -0.015717
     -1.129     -0.013341
    -1.1287     -0.015038
    -1.1285     -0.012662
    -1.1282     -0.015378
     -1.128     -0.013341
    -1.1278     -0.017414
    -1.1275     -0.015717
    -1.1273     -0.018772
     -1.127     -0.017414
```

```
% Plot the original ECG signal
figure;
plot(time, ecg_signal);
title('Original ECG Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');
grid on;
```




```
% Define filter specifications
fs = 200;  % Sampling frequency
Wp = [6 40] / (fs / 2);  % Passband edge frequencies (normalized)
Ws = [1 45] / (fs / 2);  % Stopband edge frequencies (normalized)
Rp = 1;   % Passband ripple in dB
Rs = 40;  % Stopband attenuation in dB

% Design Butterworth filter
[n_butt, Wn_butt] = buttord(Wp, Ws, Rp, Rs);
[b_butt, a_butt] = butter(n_butt, Wn_butt);

% Design Chebyshev Type I filter
[n_cheb1, Wp_cheb1] = cheb1ord(Wp, Ws, Rp, Rs);
[b_cheb1, a_cheb1] = cheby1(n_cheb1, Rp, Wp_cheb1);

% Design Chebyshev Type II filter
[n_cheb2, Ws_cheb2] = cheb2ord(Wp, Ws, Rp, Rs);
[b_cheb2, a_cheb2] = cheby2(n_cheb2, Rs, Ws_cheb2);

% Design Elliptic filter
[n_ellip, Wp_ellip] = ellipord(Wp, Ws, Rp, Rs);
[b_ellip, a_ellip] = ellip(n_ellip, Rp, Rs, Wp_ellip);

% Display filter orders
disp('Filter Orders:');
```

Filter Orders:

```
disp(['Butterworth: ', num2str(n_butt)]);
```

```
Butterworth: 27
```

```
disp(['Chebyshev Type I: ', num2str(n_cheb1)]);
```

```
Chebyshev Type I: 10
```

```
disp(['Chebyshev Type II: ', num2str(n_cheb2)]);
```

```
Chebyshev Type II: 10
```

```
disp(['Elliptic: ', num2str(n_ellip)]);
```

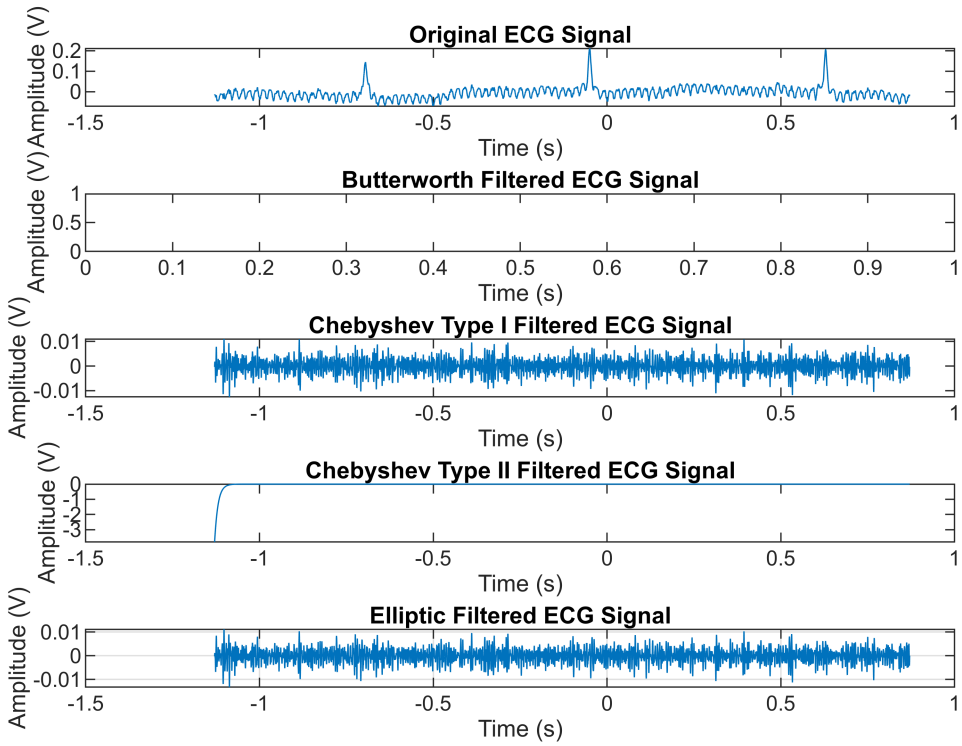
```
Elliptic: 5
```

```
% Apply the Butterworth filter
ecg_butt = filtfilt(b_butt, a_butt, ecg_signal);

% Apply the Chebyshev Type I filter
ecg_cheb1 = filtfilt(b_cheb1, a_cheb1, ecg_signal);

% Apply the Chebyshev Type II filter
ecg_cheb2 = filtfilt(b_cheb2, a_cheb2, ecg_signal);
```

```
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.727987e-16.
```

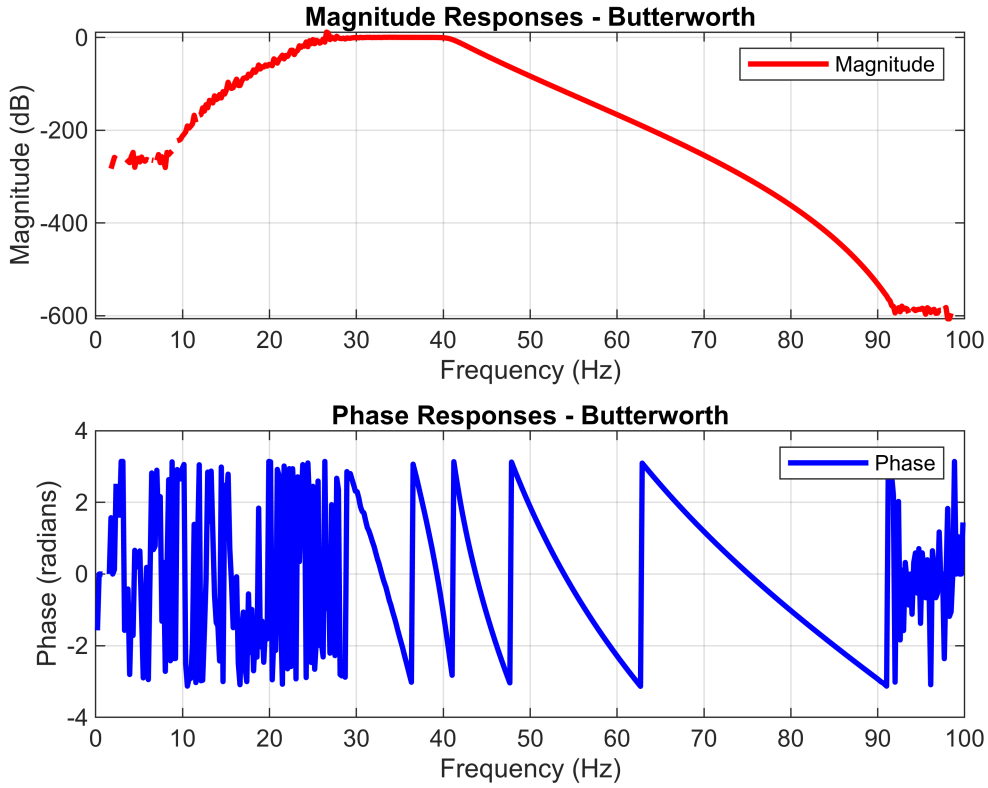
```
% Apply the Elliptic filter
ecg_ellip = filtfilt(b_ellip, a_ellip, ecg_signal);

% Plot the original and filtered signals in the time domain
figure;
subplot(5, 1, 1);
plot(time, ecg_signal);
title('Original ECG Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');

subplot(5, 1, 2);
plot(time, ecg_butt);
title('Butterworth Filtered ECG Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');

subplot(5, 1, 3);
plot(time, ecg_cheb1);
title('Chebyshev Type I Filtered ECG Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');
```

```
subplot(5, 1, 4);
plot(time, ecg_cheb2);
title('Chebyshev Type II Filtered ECG Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');

subplot(5, 1, 5);
plot(time, ecg_ellip);
title('Elliptic Filtered ECG Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');
grid on;
```



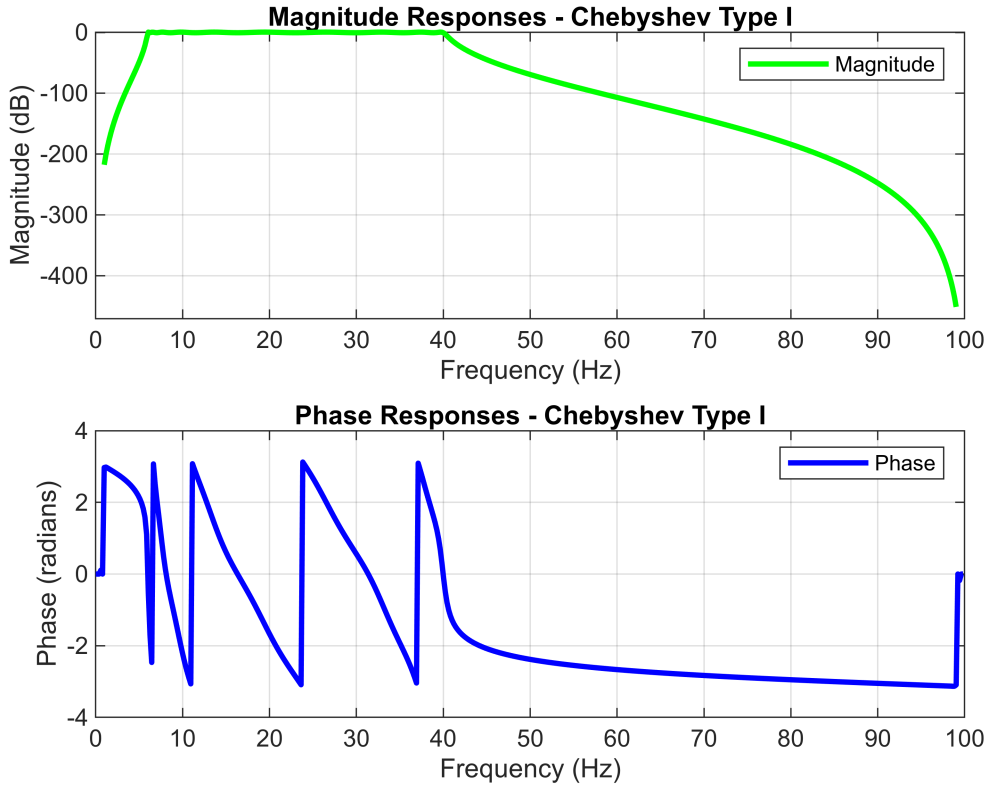

```
% Frequency response of each filter
[H_butt, w_butt] = freqz(b_butt, a_butt);
[H_cheb1, w_cheb1] = freqz(b_cheb1, a_cheb1);
[H_cheb2, w_cheb2] = freqz(b_cheb2, a_cheb2);
[H_ellip, w_ellip] = freqz(b_ellip, a_ellip);

% Plot magnitude and phase responses of each filter
figure;

% Plot magnitude and phase responses of Butterworth filter
subplot(2, 1, 1);
plot(w_butt/pi*fs/2, 20*log10(abs(H_butt)), 'r', 'LineWidth', 2);
```

```
grid on;
xlabel('Frequency (Hz)');
ylabel('Magnitude (dB)');
title('Magnitude Responses - Butterworth');
legend('Magnitude');

subplot(2, 1, 2);
plot(w_butt/pi*fs/2, angle(H_butt), 'b', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
title('Phase Responses - Butterworth');
legend('Phase');
```

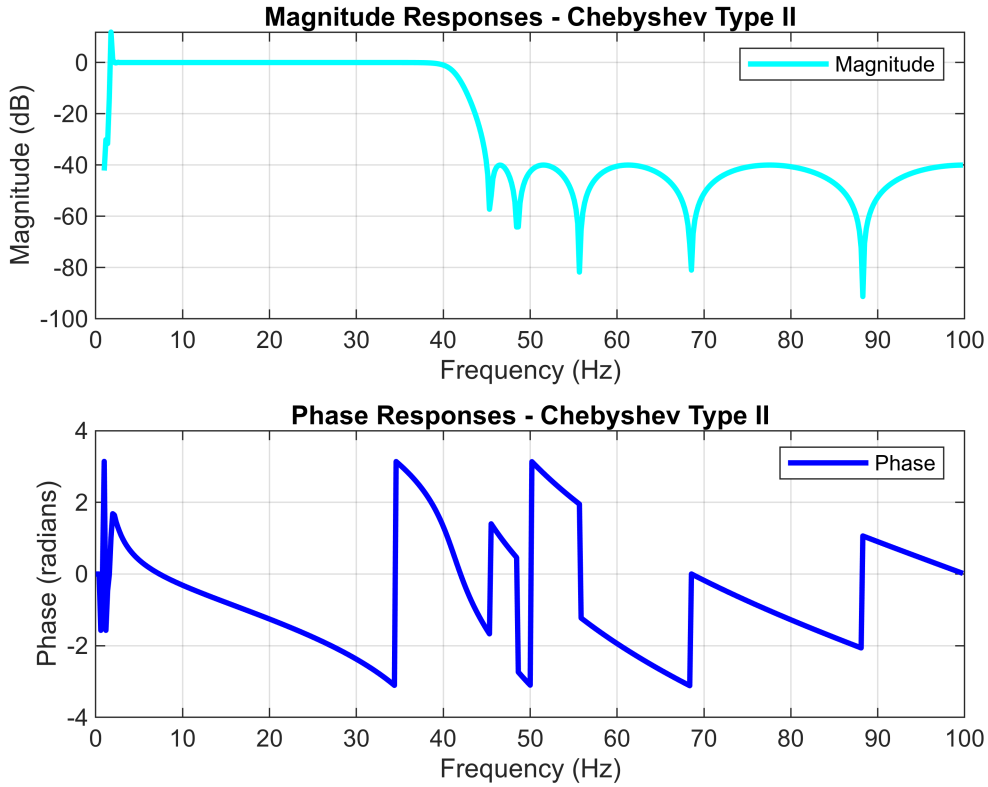



```
% Plot magnitude and phase responses of Chebyshev Type I filter
figure;

subplot(2, 1, 1);
plot(w_cheb1/pi*fs/2, 20*log10(abs(H_cheb1)), 'g', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Magnitude (dB)');
title('Magnitude Responses - Chebyshev Type I');
legend('Magnitude');

subplot(2, 1, 2);
```

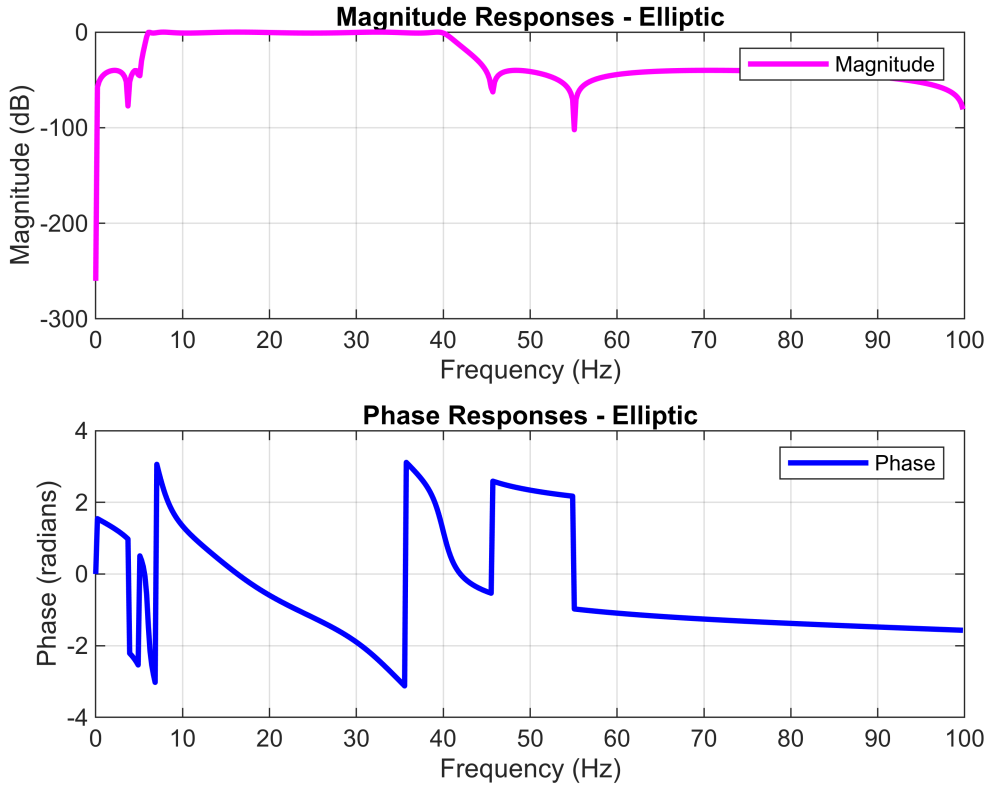
```
plot(w_cheb1/pi*fs/2, angle(H_cheb1), 'b', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
title('Phase Responses - Chebyshev Type I');
legend('Phase');
```




```
% Plot magnitude and phase responses of Chebyshev Type II filter
figure;

subplot(2, 1, 1);
plot(w_cheb2/pi*fs/2, 20*log10(abs(H_cheb2)), 'c', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Magnitude (dB)');
title('Magnitude Responses - Chebyshev Type II');
legend('Magnitude');

subplot(2, 1, 2);
plot(w_cheb2/pi*fs/2, angle(H_cheb2), 'b', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
title('Phase Responses - Chebyshev Type II');
legend('Phase');
```



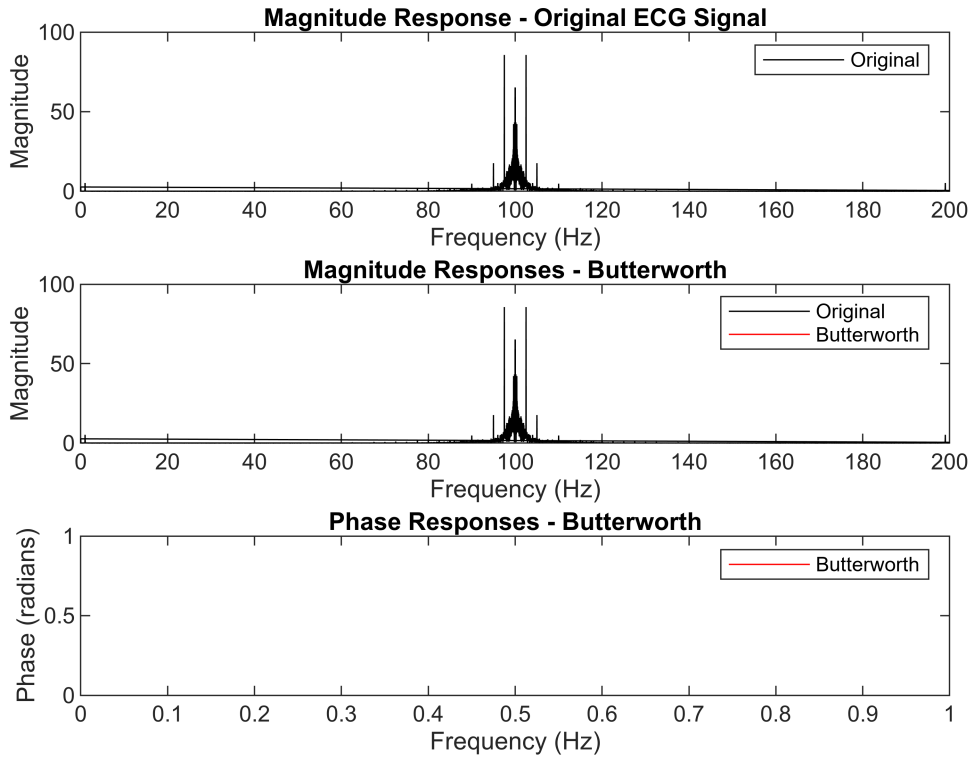

```
% Plot magnitude and phase responses of Elliptic filter
figure;

subplot(2, 1, 1);
plot(w_ellip/pi*fs/2, 20*log10(abs(H_ellip)), 'm', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Magnitude (dB)');
title('Magnitude Responses - Elliptic');
legend('Magnitude');

subplot(2, 1, 2);
plot(w_ellip/pi*fs/2, angle(H_ellip), 'b', 'LineWidth', 2);
grid on;
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
title('Phase Responses - Elliptic');
legend('Phase');
```




```
% Plot magnitude and phase responses of the original and filtered ECG signals
figure;
% Calculate the FFT of the signals
n = length(ecg_signal);
f = (0:n-1)*(fs/n);

% Original ECG signal
fft_orig = fft(ecg_signal);
mag_orig = abs(fft_orig);
phase_orig = angle(fft_orig);

% Butterworth filtered ECG signal
fft_butt = fft(ecg_butt);
mag_butt = abs(fft_butt);
phase_butt = angle(fft_butt);

% Chebyshev Type I filtered ECG signal
fft_cheb1 = fft(ecg_cheb1);
mag_cheb1 = abs(fft_cheb1);
phase_cheb1 = angle(fft_cheb1);

% Chebyshev Type II filtered ECG signal
fft_cheb2 = fft(ecg_cheb2);
mag_cheb2 = abs(fft_cheb2);
phase_cheb2 = angle(fft_cheb2);
```

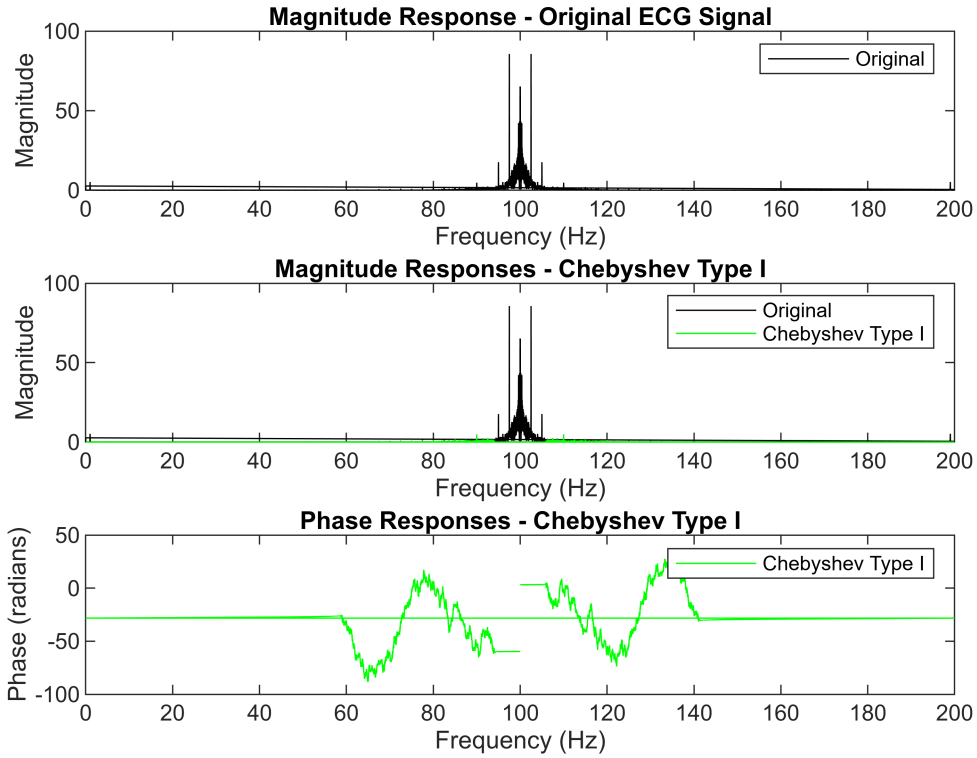
```
% Elliptic filtered ECG signal
fft_ellip = fft(ecg_ellip);
mag_ellip = abs(fft_ellip);
phase_ellip = angle(fft_ellip);
```

```
% Plot magnitude and phase responses of the original and filtered ECG signals
figure;

% Shift frequencies
f_shifted = fftshift(f);

% Plot the magnitude responses and original signal
subplot(3, 1, 1);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
title('Magnitude Response - Original ECG Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 2);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
hold on;
plot(f_shifted, mag_butt, 'r', 'DisplayName', 'Butterworth');
hold off;
title('Magnitude Responses - Butterworth');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 3);
plot(f_shifted, unwrap(phase_butt), 'r', 'DisplayName', 'Butterworth');
title('Phase Responses - Butterworth');
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
legend show;
```



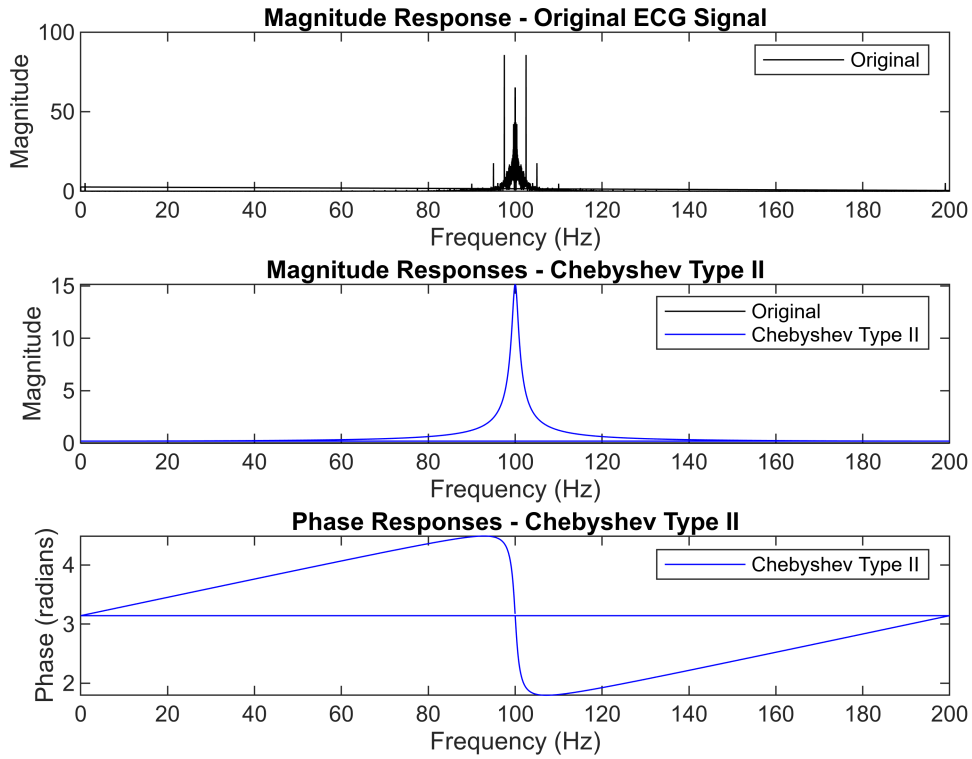

```
% Plot the magnitude responses and original signal
figure;

subplot(3, 1, 1);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
title('Magnitude Response - Original ECG Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 2);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
hold on;
plot(f_shifted, mag_cheb1, 'g', 'DisplayName', 'Chebyshev Type I');
hold off;
title('Magnitude Responses - Chebyshev Type I');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 3);
plot(f_shifted, unwrap(phase_cheb1), 'g', 'DisplayName', 'Chebyshev Type I');
title('Phase Responses - Chebyshev Type I');
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
```

```
legend show;
```




```
% Plot the magnitude responses and original signal
figure;

subplot(3, 1, 1);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
title('Magnitude Response - Original ECG Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 2);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
hold on;
plot(f_shifted, mag_cheb2, 'b', 'DisplayName', 'Chebyshev Type II');
hold off;
title('Magnitude Responses - Chebyshev Type II');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 3);
plot(f_shifted, unwrap(phase_cheb2), 'b', 'DisplayName', 'Chebyshev Type II');
title('Phase Responses - Chebyshev Type II');
xlabel('Frequency (Hz)');
```

```
ylabel('Phase (radians)');
legend show;
```




```
% Plot the magnitude responses and original signal
figure;

subplot(3, 1, 1);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
title('Magnitude Response - Original ECG Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 2);
plot(f_shifted, mag_orig, 'k', 'DisplayName', 'Original');
hold on;
plot(f_shifted, mag_ellip, 'm', 'DisplayName', 'Elliptic');
hold off;
title('Magnitude Responses - Elliptic');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
legend show;

subplot(3, 1, 3);
plot(f_shifted, unwrap(phase_ellip), 'm', 'DisplayName', 'Elliptic');
title('Phase Responses - Elliptic');
```

```
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
legend show;
```