Signal and System
MATLAB Homework #3

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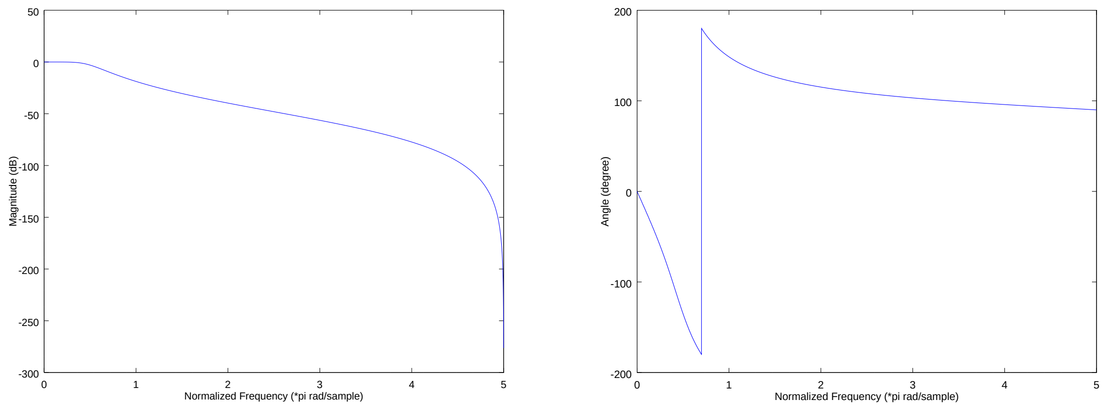
1 Problem 1

(b) **Find the frequency response $H(e^{i\omega})$ in (a). Plot the magnitude response and the phase response (in degrees) of the filter.**



(a) Magnitude response (b) Phase response

Figure 1: Plots of the frequency response

(c) **Find and plot the filtered signal of $x[n]$.**

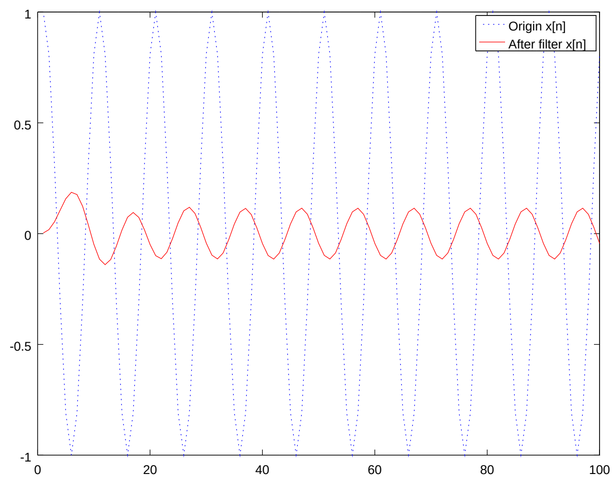
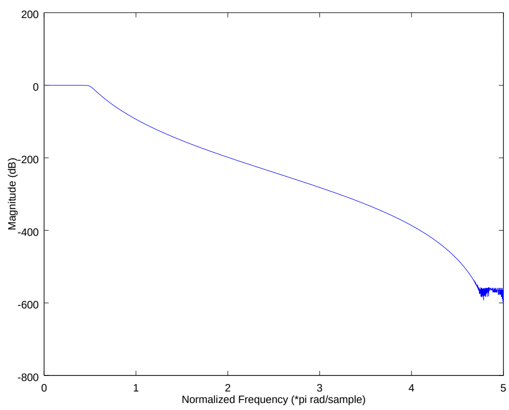
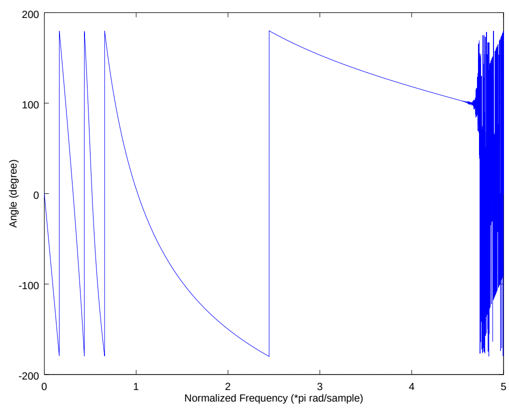


Figure 2: Plot of filtered $x[n]$.

(d) **Please repeat parts (a)–(c) with $L = 7, f_c = 0.1$ and $f_s = 10$.**



(a) Magnitude response



(b) Phase response

Figure 3: Plots of the frequency response

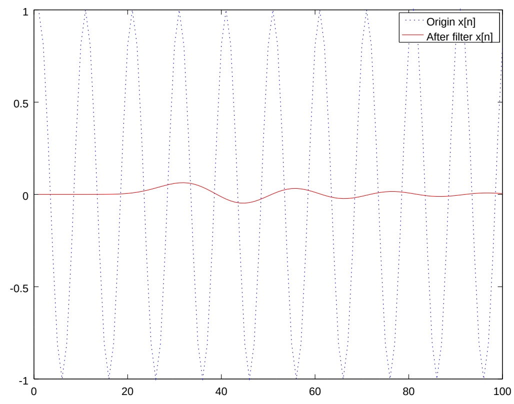
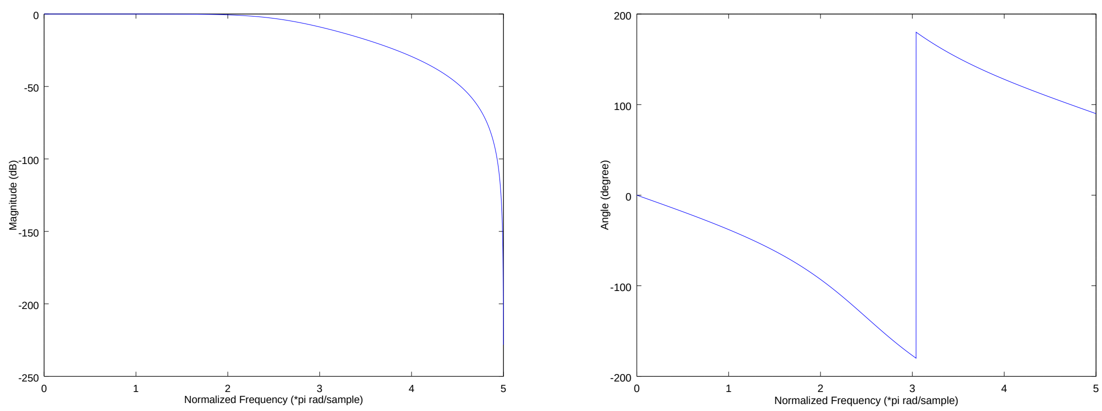


Figure 4: Plot of filtered $x[n]$.

(e) **Please repeat parts (a)–(c) with $L = 3, f_c = 0.5$ and $f_s = 10$.**



(a) Magnitude response

(b) Phase response

Figure 5: Plots of the frequency response

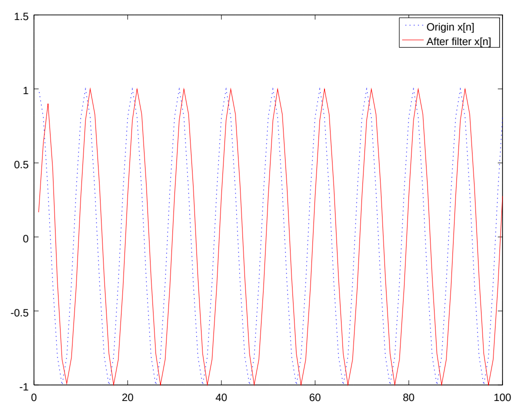


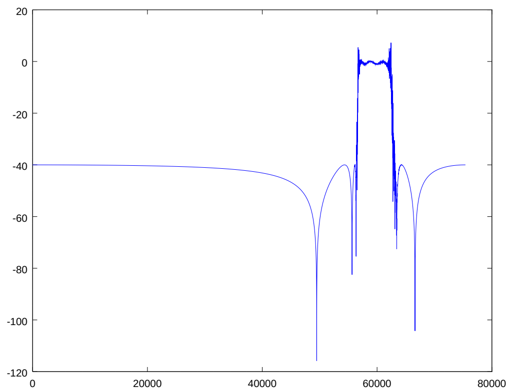
Figure 6: Plot of filtered $x[n]$.

(f) **What is the effect of increasing L? What about increasing f_c?**

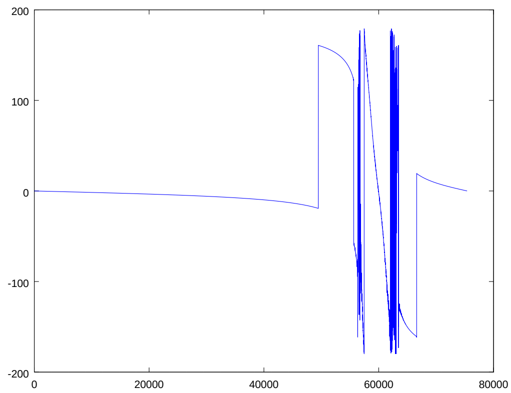
Increasing L makes the cutoff sharper. Increasing f_c shift the cutoff frequency to higher frequency.

2 Problem 2

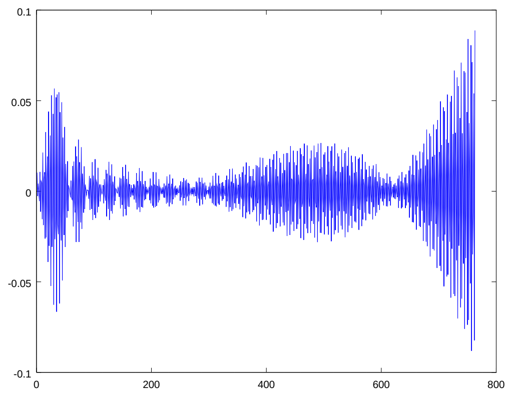
(a) **Plot the magnitude response, phase response and impulse response of the filter.**



(a) Magnitude response



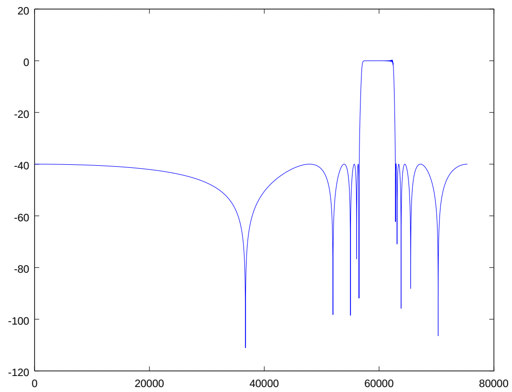
(b) Phase response



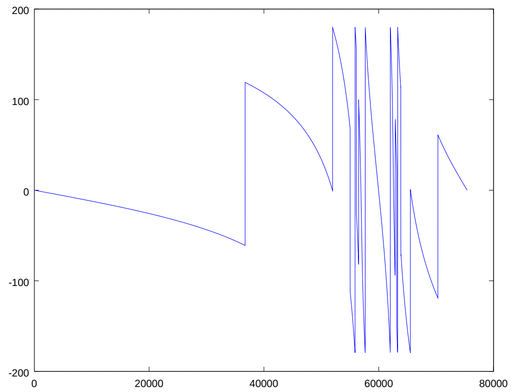
(c) Impulse response

Figure 7: Plots of the responses

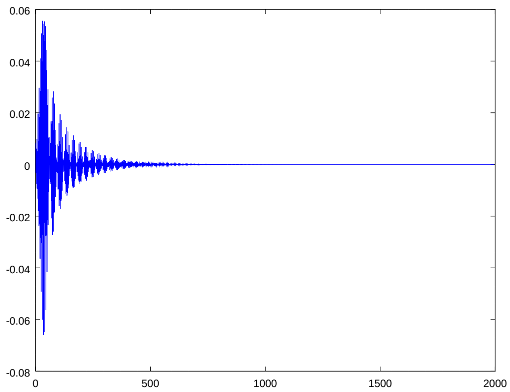
(b) **Change the filter type as "Chebyshev II" and repeat parts (a)–(b), what is the difference?**



(a) Magnitude response



(b) Phase response



(c) Impulse response

Figure 8: Plots of the responses

Chebyshev II seems smoother than elliptic filter, and their impulse response is different.

3 Problem 3

(a) **Design a 16-order lowpass filter such that**

$$y[n] \approx \cos\left(2\pi(n-1)T_s\right),\ n = 1, 2, \cdots, M,$$

when $T_s = 0.002, f_1 = 100$ and $M = 1000$. Write down the filter coefficients and plot the output signal in your report.

The coefficients are

$$B = [5.8242 \times 10^{-10}, 9.3187 \times 10^{-9}, 6.9890 \times 10^{-8}, 3.2616 \times 10^{-7}, 1.0600 \times 10^{-6},$$
$$2.5440 \times 10^{-6}, 4.6640 \times 10^{-6}, 6.6629 \times 10^{-6}, 7.4957 \times 10^{-6}, 6.6629 \times 10^{-6},$$
$$4.6640 \times 10^{-6}, 2.5440 \times 10^{-6}, 1.0600 \times 10^{-6}, 3.2616 \times 10^{-7}, 6.9890 \times 10^{-8},$$
$$9.3187 \times 10^{-9}, 5.8242 \times 10^{-10}]$$

$$A = [1.0000, -9.5922, 4.3995 \times 10^{1}, -1.2779 \times 10^{2}, 2.6265 \times 10^{2},$$
$$-4.0445 \times 10^{2}, 4.8212 \times 10^{2}, -4.5335 \times 10^{2}, 3.3956 \times 10^{2}, -2.0310 \times 10^{2},$$
$$9.6627 \times 10^{1}, -3.6160 \times 10^{1}, 1.0429 \times 10^{1}, -2.2398, 3.3768 \times 10^{-1},$$
$$-3.1918 \times 10^{-2}, 1.4244 \times 10^{-3}]$$

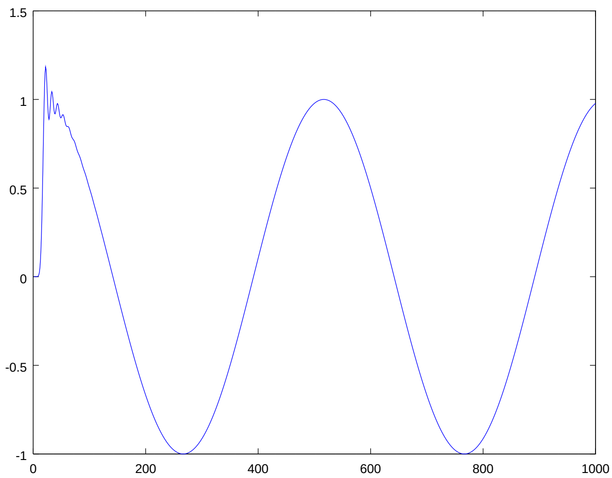


Figure 9: Plot of signal after filter

(b) **Design a 16-order bandpass filter such that**

$$y[n] \approx \cos(2\pi f_s (n-1) T_s), \; n = 1, 2, \cdots, M,$$

when $T_s = 0.002, f_1 = 100$ **and** $M = 1000$**. Write down the filter coefficients and plot the output signal in your report.**

The coefficients are

$$
\begin{aligned}
B = [&1.1637 \times 10^{-1}, -2.5839 \times 10^{-16}, -1.1507, -4.7545 \times 10^{-15}, 5.7994, \\
&-3.2248 \times 10^{-14}, -1.9555 \times 10^{1}, 2.0837 \times 10^{-13}, 4.9048 \times 10^{1}, -9.4593 \times 10^{-13}, \\
&-9.6595 \times 10^{1}, 3.2545 \times 10^{-12}, 1.5406 \times 10^{2}, -9.5254 \times 10^{-13}, -2.0258 \times 10^{2}, \\
&7.4087 \times 10^{-12}, 2.2171 \times 10^{2}, -6.1386 \times 10^{-12}, -2.0258 \times 10^{2}, 7.4219 \times 10^{-12}, \\
&1.5406 \times 10^{2}, -2.1432 \times 10^{-12}, -9.6595 \times 10^{1}, 2.2491 \times 10^{-13}, 4.9048 \times 10^{1}, \\
&1.3561 \times 10^{-13}, -1.9555 \times 10^{1}, 4.1343 \times 10^{-14}, 5.7994, -3.3074 \times 10^{-15}, \\
&-1.1507, -1.2920 \times 10^{-16}, 1.1637 \times 10^{-1}]
\end{aligned}
$$

$$
\begin{aligned}
A = [&1.0000, -3.8858 \times 10^{-15}, -6.6622, -1.3234 \times 10^{-13}, 2.4075 \times 10^{1}, \\
&-3.6238 \times 10^{-13}, -6.0089 \times 10^{1}, -1.5952 \times 10^{-11}, 1.1397 \times 10^{2}, -9.3806 \times 10^{-11}, \\
&-1.7227 \times 10^{2}, -2.9684 \times 10^{-10}, 2.1318 \times 10^{2}, -8.6462 \times 10^{-10}, -2.1919 \times 10^{2}, \\
&-1.0678 \times 10^{-9}, 1.8858 \times 10^{2}, -3.6786 \times 10^{-10}, -1.3590 \times 10^{2}, 3.3623 \times 10^{-11}, \\
&8.1627 \times 10^{1}, 3.8085 \times 10^{-12}, -4.0406 \times 10^{1}, -1.5429 \times 10^{-11}, 1.6158 \times 10^{1}, \\
&-4.6336 \times 10^{-12}, -5.0495, -3.8525 \times 10^{-13}, 1.1647, -1.1713 \times 10^{-14}, \\
&-1.7760 \times 10^{-1}, -1.9429 \times 10^{-16}, 1.3542 \times 10^{-2}]
\end{aligned}
$$

I bet you would never ever want to look at these ugly coefficients!

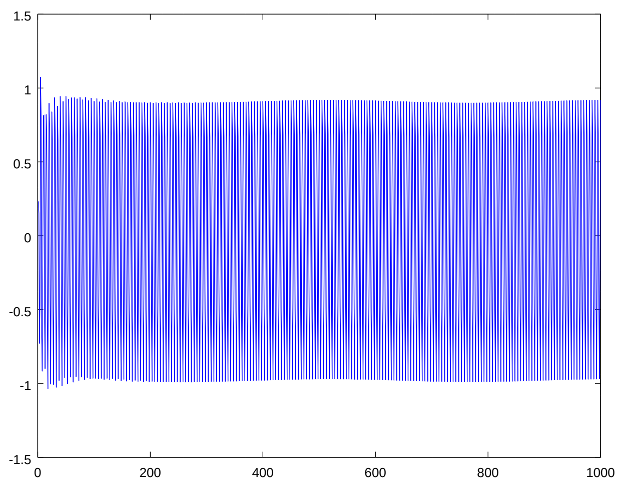


Figure 10: Plot of signal after filter