IIR & FIR filters

The main goal of this lab is to see how a filter is defined by its "a" and "b" coefficients. For all problems, use `N = 256` points, use `freqz()` for the spectral properties of these filters, use `n = [0:N-1]';` to plot filter responses in time, and use `step = [0;ones(N-1,1)];` for a "step" input (analogous to stepping onto the back of a pickup truck to test out its shock absorbers). Why is this input called a step?

1) Consider the lowpass filter with `[b,a]=ellip(4, 3, 50, 0.12)`.
   a) Is this filter FIR or IIR?
   b) Use `freqz()` to examine the spectral properties of these filters. For this lab, I recommend using `freqz(b,a,N,1)` *with no output variables*. But I also recommend using `ylim()` (or the zoom tool) to change range of the magnitude response to lie between 0 and -60 dB, to facilitate comparisons across filters. (You may need to click once on the magnitude subplot before typing `ylim()`, or it may affect the phase subplot instead of the magnitude subplot.)
   c) Is the phase linear? Is this consistent with your answer to (a)?

In addition to the spectral properties, we also care about the temporal properties. One of the main ways to examine the temporal properties is to examine the response to a step. We can look at, for instance, how smoothly the transition occurs (a good smoothing filter should spread it out); whether the response oscillates on its way to the final result ("ringing"); and whether it goes to the final result directly or it first overshoots.

   d) Calculate the step response using `s = filter(b,a,step);`.
   e) In another figure, use subplot to make two separate plots. In the top plot, use `stem` or `bar` to plot the step input as a function of time. Use `axis([0 74 0 1.1])` so that we concentrate on the first few (75) points and on the region between 0 and 1.
   f) In the second plot, use `stem` or `bar`, and the same axis, to plot the filter's response to the step as a function of time.
   g) Is the filter good at smoothing the transition, i.e. suppressing the fast features of the step?
   h) How many cycles (and how much time) does the response show ringing/oscillation (if any)?
   i) Does the response overshoot beyond the value it eventually ends up with?
   j) Does the response occur immediately (at zero time) or does it take time to build up? How many samples does it take for the output reach approximately half its final value?
   k) In another figure, plot the group delay of the filter using `grpdelay(b,a,N,1)`. The group delay only really matters in the "pass" region of the filter—why? What is the relationship between the group delay *in this region* to the answer in j)?

2) Repeat all of (1) with the lowpass filter of `[b,a]=ellip(3, 3, 20, 0.12)`.

3) Repeat all of (1) with the lowpass filter of `b = kaiser(16,3.299)/10;` and `a = [1]`. Kaiser is a

standard function, where 16 is the length and 3.299 is a spectral “width” parameter.

4) Repeat all of (1) with the lowpass filter of `b = [1/8; 3/8; 3/8; 1/8]` and `a = [1]`.

5) Repeat all of (1) with the lowpass filter of `b = [0.1]` and `a = [1; -0.9]`.

6) Consider the lowpass filter with `b = [0.1]` and `a = [1; -1.1]`.
   a) Compare the transfer function $H(f)$ to that of question (5). Is it very similar or very different? If very different, how so, and why?
   b) Compare the step response $s[n]$ to that of question (5). Is it very similar or very different? If very different, how so, and why? (You may wish to change your `axis` parameters to be different from in (1) to better see the actual behavior.)