# Engineering 253 – 2005
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# MATLAB Exercise #2
# TOPIC: FIR Filter Design and Windows

In class we have discussed three methods for designing FIR filters. This exercise asks you to apply each method and draw some conclusions as the relative effectiveness of the three methods using a music bandpass filter design as an example.

## The Filter Parameters

The filter to be designed is to be used directly on data sampled at 44.1kHz, the frequency a CD ROM uses. It is to have a passband of 2431Hz to 4862Hz, the lower stopband ends at 1768Hz and the upper stopband starts at 5967Hz. The passband should have no more than 1dB of ripple and each stopband should be at least 60dB down from the nominal passband level.

## Length Prediction

The first job is to predict the length of the optimal filter from either the Kaiser formula, suitably done for bandpass filters or from another formula for optimal bandpass FIR filters you find by some book or web research. Make sure you cite the source for the formula. Comment in the report on the accuracy of this prediction after you have done the real designs.

1. **Window Method**

   a) Derive the expression for the infinite discrete-time filter sequence by taking the inverse DTFT for the desired filter. This is an analytic derivation and should be included with the write-up. Choose sensible cutoffs for the ideal filter used in this method, i.e., the ideal cutoffs are not necessarily at 1100Hz and 2200Hz.
   b) Using the result from a), select a length of the filter, N (usually odd), and apply a window. You may want to experiment with several different window types.
   c) You need to look in the frequency domain to see whether your design (the window type and length N) meet the attenuation criteria. To do this you need to take a DFT of the filter. However, you will need greater frequency resolution than simply taking an N-point DFT. You have to figure out how to do this.

Show the magnitude frequency response of your design and make sure you state the length N and the window type you recommend.

## 2. Frequency Sampling Method

a) All you have to do in this method is select N and take the inverse DFT. Do this, if you can, until you have made N large enough to satisfy the design criteria.
b) If you cannot do it, you can relax a sample or two in the ideal filter to be of value ½ or other fractional value until you can achieve the design criteria. Show your ideal design and that the frequency response truly satisfies the criteria. Show the magnitude frequency function.

## 3. Optimal Equiripple Method

a) Use the MATLAB program *fdatool* to design the optimal Equiripple filter exactly for the specifications given. Find the value of N that is smallest yet satisfies the criteria. Note the easier way the specifications fit into thee way an engineer designs a filter. Also make certain that you know what the "N" in the *fdatool* is relative to the "N" of the real filter.
b) Show the magnitude frequency response and give the value of N that compares with those derived above.
c) Comment on the comparisons of the above designs relative to their ease of design and cost of implementation.
d) Now would you really use the filter you just designed? Are there any problems with it? If there are, what would you do as an engineer to correct them?