Solutions for lab 8 (MFCC)

1a) Sorry, I had no time to do that :(, here are some hints:

$s(t) = e(t) * h(t)$ $\quad * $ – convolution

Fourier transform $\qquad$ From convolution theorem

$$DFT(s(t)) = DFT(e(t) * h(t)) = E(\omega_k) \cdot H(\omega_k)$$

$$E(\omega_k) = \sum_{n=0}^{N-1} e(n) \cdot e^{-j 2\pi k n / N}, \quad k = 0, 1, 2 \ldots N-1$$

$$H(\omega_k) = \sum_{n=0}^{N-1} h(n) \cdot e^{-j 2\pi k n / N}$$

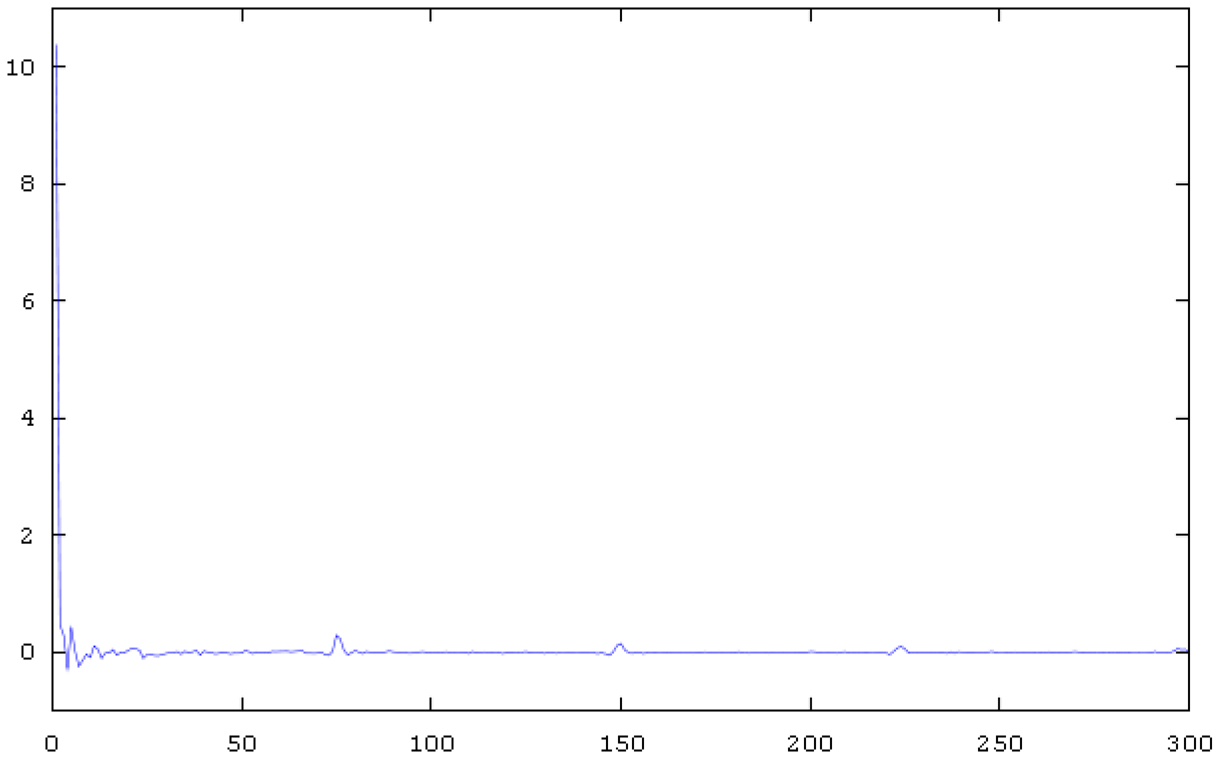
$$S(\omega_k) = E(\omega_k) \cdot H(\omega_k)$$

$$\log(|S\omega_k|) = \log(|E(\omega_k) \cdot H(\omega_k)|) = \log(|E(\omega_k)|) + \log(|H(\omega_k)|)$$

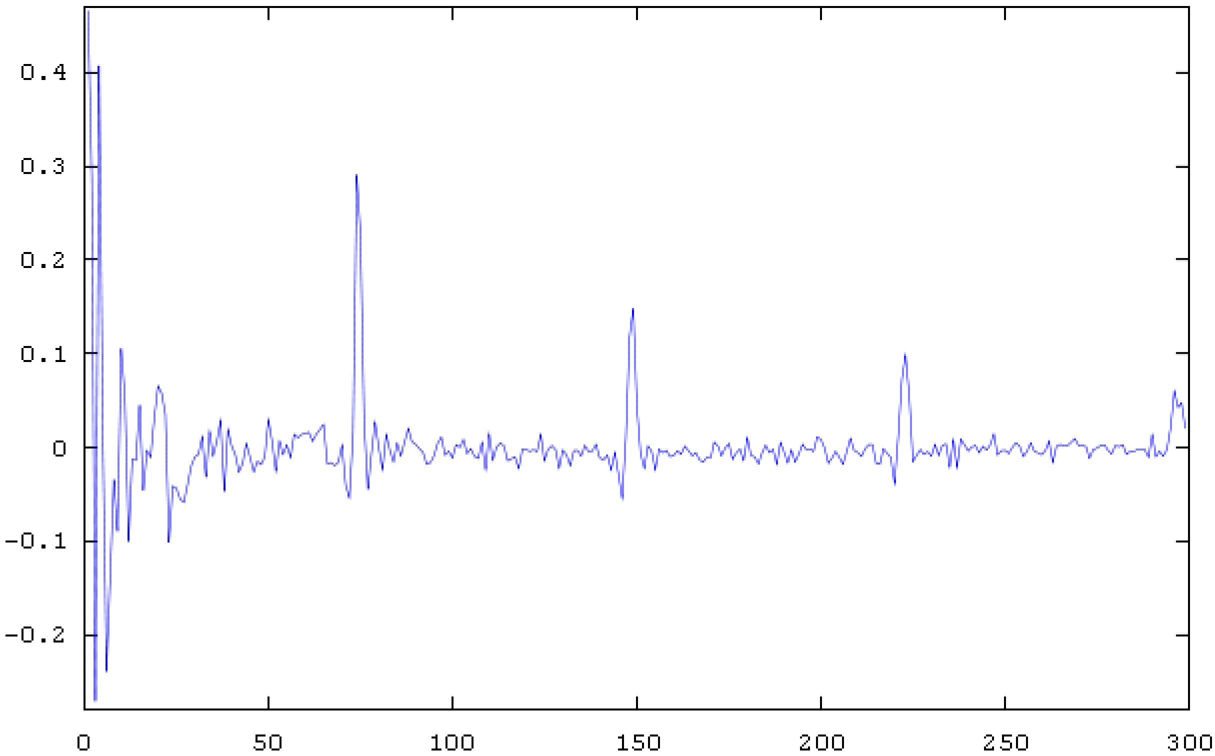
1b) Look at the theory at http://ccrma.stanford.edu/~jos/mdft/Symmetry.html

1c) The code:

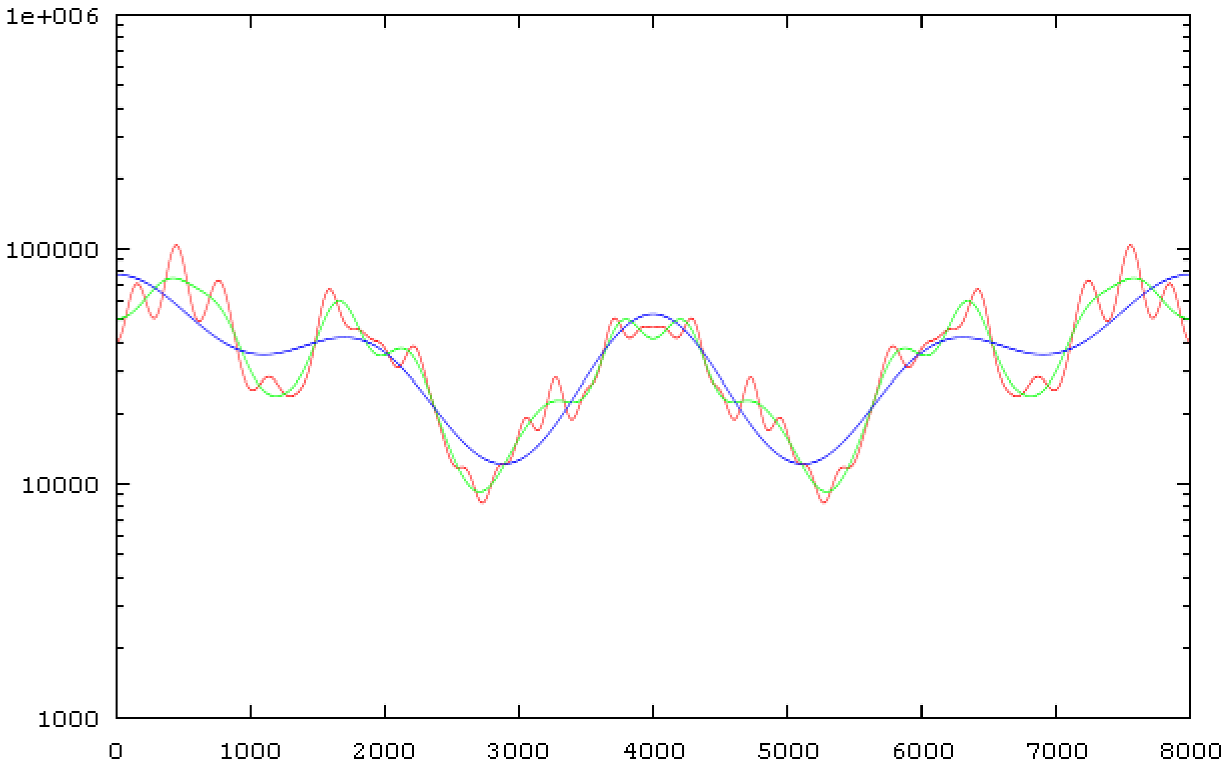
```
octave.exe:37> [snd,Fs]=wavread('a.wav');
octave.exe:38> snd32=snd*32768.0;
octave.exe:39> Fs
Fs =  16000
octave.exe:40> ftSnd32=fft(snd32);
octave.exe:41> aftSnd32=abs(ftSnd32);
octave.exe:42> laftSnd32=log(aftSnd32);
octave.exe:43> cepstrum=ifft(laftSnd32);
octave.exe:46> plot(real(cepstrum(1:300)));
```



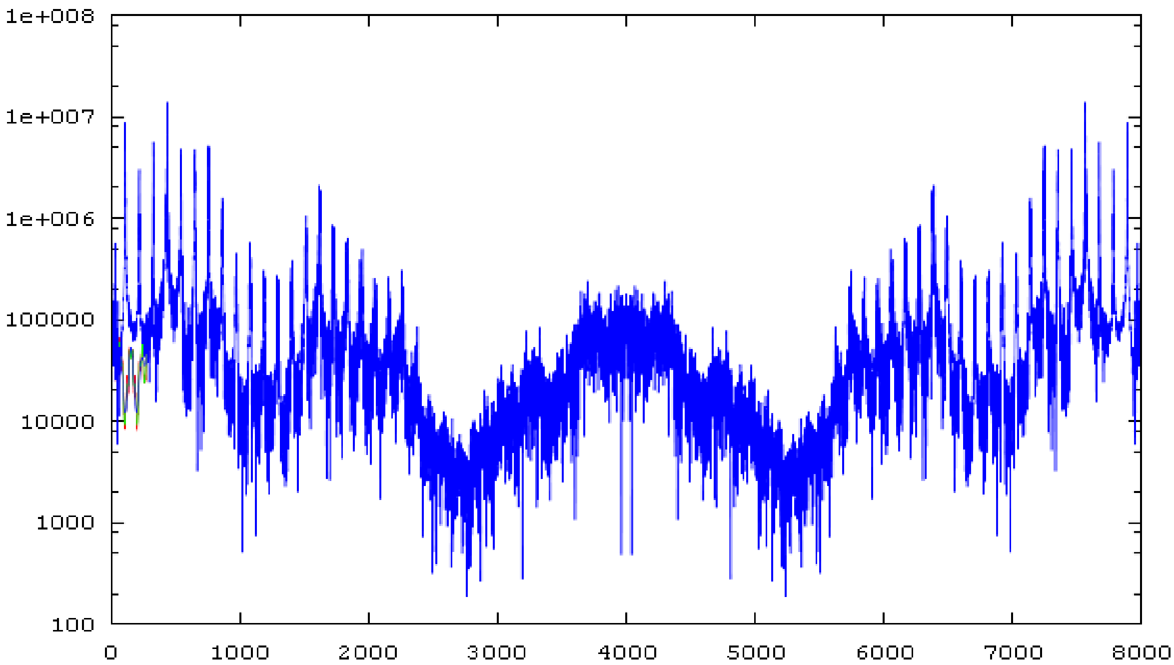
To see something more sensible, let's skip the first value:
octave.exe:49> plot(real(cepstrum(2:300)));



1d,e,f) *octave.exe:50> cliftered=zeros(1,length(cepstrum));*
octave.exe:51> cliftered(1:40)=cepstrum(1:40)
octave.exe:56> aspec=abs(exp(fft(cliftered)));
octave.exe:57> semilogy(real(aspec));
analogic from remaining 2 lifters, we get:



Lower MFCC's



Amplitude spectrum

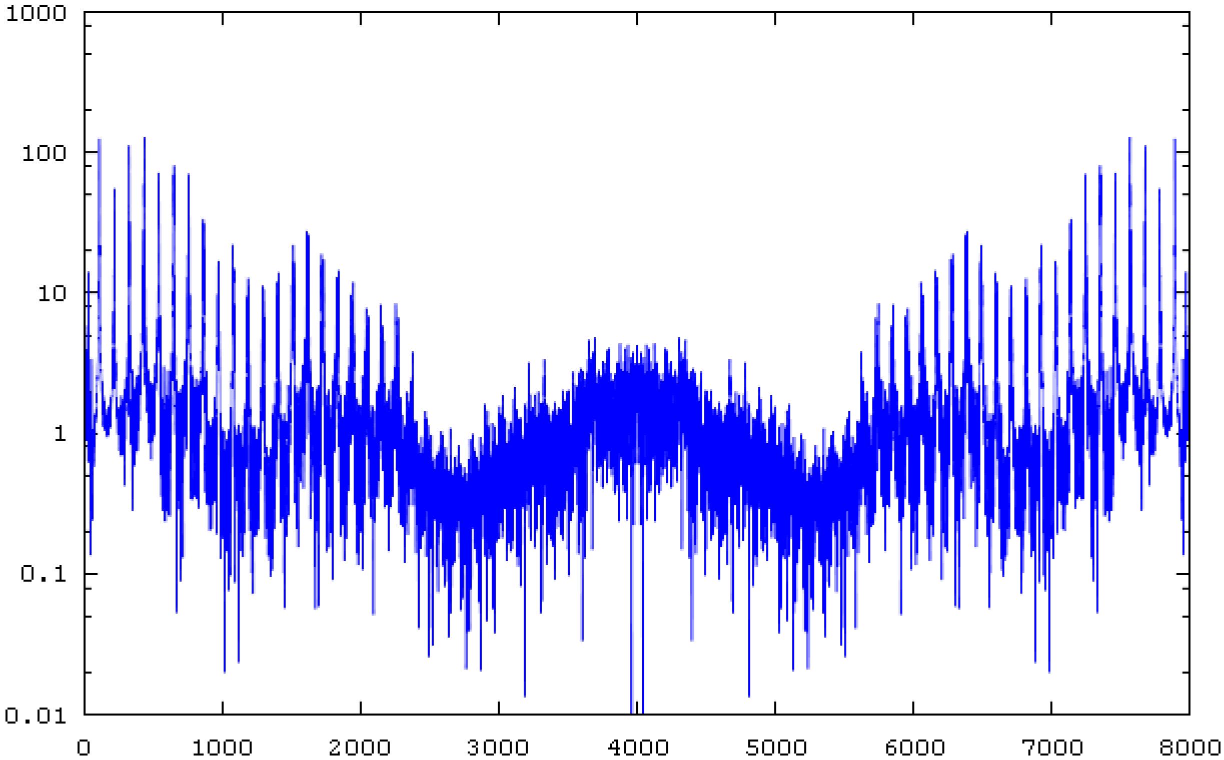
The plots above has been obtained by:

octave.exe:9> clift1=zeros(1,length(cepstrum));
octave.exe:10> clift2=clift1
octave.exe:11> clift3=clift1;
octave.exe:12> clift4=clift1;
octave.exe:13> clift1(1:40)=cepstrum(1:40);
octave.exe:14> clift2(1:20)=cepstrum(1:20);

octave.exe:15> clift3(1:5)=cepstrum(1:5);
octave.exe:16> clift4(70:length(cepstrum)=cepstrum(70:length(cepstrum));
octave.exe:17> m1=abs(exp(fft(clift1)));
octave.exe:18> m2=abs(exp(fft(clift2)));
octave.exe:19> m3=abs(exp(fft(clift3)));
octave.exe:20> m4=abs(exp(fft(clift4)));
octave.exe:21> semilogy(real(m1),'r',real(m2),'g',real(m3),'b')
octave.exe:26> aspec=abs(fft(s32));
octave.exe:27> semilogy(aspec);

As you can see, the lower MFCC's carry **the spectral envelope of the signal**

1g) *semilogy(real(m4));*



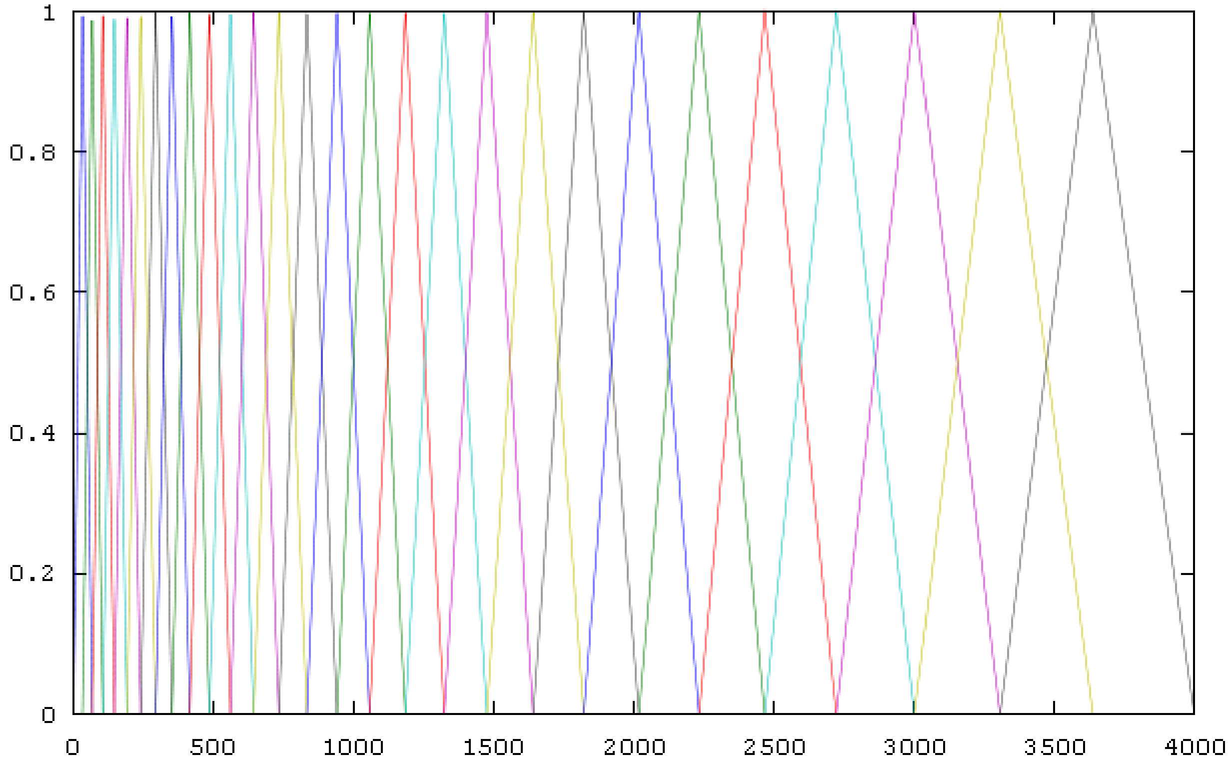
As we can see, we get flattened magnitude spectrum of the signal.

2a) m2f.m

function f=m2f(m)

f=700(10.^(m/2595)-1);*

2b)



Mel filter bank

2c) I am not sure... You can read them from the graph, the lower bound is 63 Hz, the upper is around 700 Hz

2d)