Homework 2 (Due: 4/12)

(1) Write a Matlab or Python code that uses the frequency sampling method to design a (2k+1)-point discrete differentiation filter $H(F) = j2\pi F$ when $-0.5 < F < 0.5$ (k is an input parameter and can be any integer).   (25 scores)

The transition band is assigned to reduce the error (unnecessary to optimize).   (i) The impulse response and (ii) the imaginary part of the frequency response (DTFT of r[n], see pages 113 and 114) of the designed filter should be shown. The code should be handed out by NTU Cool.

(2) Can the techniques of the weight function and the transition band be applied in the FIR filter designed by (a) the MSE method and (b) the frequency sampling method? Why?   (10 scores)

(3) Suppose that the smooth filter is $h[n] = a$ for $|n| \leqq 5$, $h[n] = 0.023$ for $6 \leqq |n| \leqq 10$, and $h[n] = 0$ otherwise. (a) What is the value of a? (b) What is the efficient way to implement the convolution $y[n] = x[n] * h[n]$?   (10 scores)

(4) The following figures are the impulse responses of some filters. Which one is a suitable <u>smoother</u> when we want to extract (a) small scaled features? (b) large scaled features? <u>Also illustrate the reasons.</u>   (10 scores)

(i)   (ii)   (iii)   (iv)
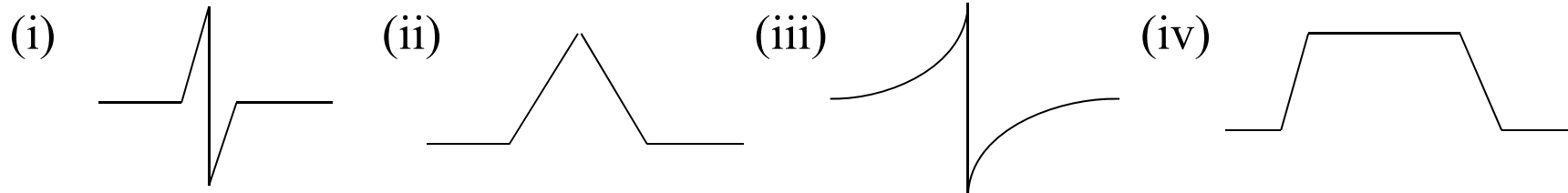
(5) If the z-transform of $h[n]$ is $H(z) = \dfrac{2z^4 - 2z^3 + 3z^2 + z - 2}{z^2 + 0.2z - 0.24}$

  (a) Determine the cepstrum of $h[n]$.

    (Hint: $z = 2^{-0.5}$ is one of the zeros of $H(z)$)

  (b) Convert the IIR filter into the minimum phase filter.   (20 scores)

(6) Suppose that the cepstrum of a signal $x[n]$ is

$$\hat{x}[2] = 0.7, \quad \hat{x}[n] = 0 \quad otherwise$$

<u>Determine $x[n]$</u> using the Z transform and exp( ).   (10 scores)

(7) (a) What are the two main advantages of the minimum phase filter? (b) In addition to time-frequency analysis, what are two main applications of the Hilbert transform? (c) Compared to the equalizer, what are the two main advantages of the cepstrum to deal with the multipath problem?   (15 scores)

(Extra): Answer the questions according to your student ID number.
     (ended with (4, 9), (0, 5), (1, 6), (2, 7))