- - - Final-Term Exam - - -

- **(1)**: Design an FIR filter ($q[n]$), subtype I, of order $M = 8$ to cut-off frequencies within the range 2000 Hz $\sim$ 4000 Hz, allowing for all the others to pass through. Assume that the input signal to be filtered ($x[n]$) was sampled at 22050 samples per second. Normalize the filters' coefficients in such a way that the filter presents a gain of 0dB in the pass-band. Lastly, write down the difference equation to filter an input signal $x[n]$ by using $q[n]$.
- **(2)**: Design an FIR filter with the following specifications:
  - $0.98 \leqslant |H(e^{j\omega})| \leqslant 1.02$, in the range $0 \leqslant \omega \leqslant 0.1\pi$
  - $|H(e^{j\omega})| \leqslant 0.06$, in the range $0.4\pi \leqslant \omega \leqslant \pi$

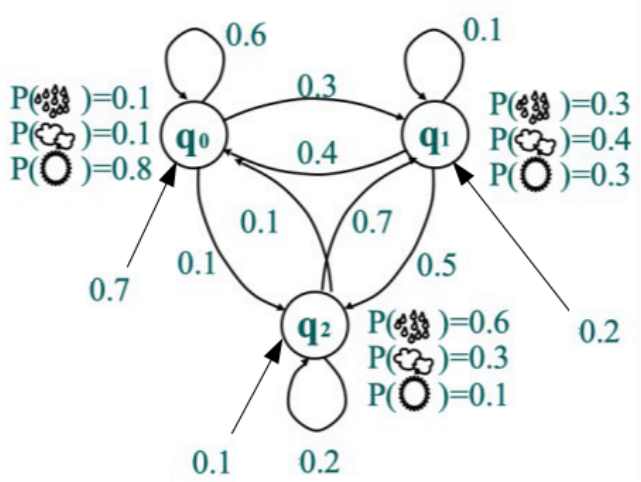
  Then, normalize the windowed filter, write down the difference equation to implement the filter you have just designed in a computer-based application, and depict the corresponding block diagram.
- **(3)**: Explain, in a short paragraph, the concept of window. What is it used for? Why is it important?

- - - Final-Term Exam - - -

- **(4)**: Find the transfer function $H[z]$ whose poles are at $z = -\frac{1}{4}$ and $z = \frac{1}{3}$, in addition to one zero at $z = \frac{1}{5}$. Write down the corresponding difference equation. Is the transfer function stable and causal?
- **(5)**: Consider the hypothetical speech signal segment $s[n] = \{-1, 2, -3, 3, 2, 1, -1, -1, -4, 5, 5, 4\}$, sampled at 16000 samples per second. Assume that a sliding rectangular window $w[n]$ traverses it in order to extract features for inclusion in the feature vector $f[n]$, covering 0.125ms at each placement, with 50% overlap between consecutive windows. What is the length of $f[n]$? What are the values in $f[n]$, considering the ordinary entropy, calculated with the log basis $\beta = 10$, as being the feature used?
- **(6)**: Explain, in a short paragraph, the concept of Bark scale. Why is it important?
- **(7)**: Estimate the 4^{rd} order LPC coefficients $\{a_1, a_2, a_3, a_4\}$ for the signal $y[n] = \{2, 5, 2, 3, 5, 8, 4, 8, 10, 6\}$.

- - - Final-Term Exam - - -

- **(8)**: Explain the differences between, the advantages, and disadvantages of handcrafted features in comparison with those learned.
- **(9)**: Answer the first two HMM-related questions on page 103 for the weather-related model below, considering the observation sequence $O = \{rainy, sunny\}$.



- **(10)**: Given the template model for classes C_A and C_B, i.e., $\{0.2, 1, 0.7\}$ and $\{0.3, 0.9, 0.8\}$, respectively, find the best matching class for the testing signal $t[n] = \{0.2, 0.9, 0.9\}$ by using the ordinary Euclidian distance metric. What would you do to find that match in case the testing signal and the template models have different dimensions?