Instructions: 1) Answer any five.
   2) All questions carry equal marks.

1. a) The signal \( x(n) \) is defined by

\[
x(n) = \begin{cases} 
   a^n & n > 0 \\
   0 & \text{otherwise}
\end{cases}
\]

i) Write the expression and plot the signal, if \( x(n) \) is decimated with a factor of three.

ii) Write the expression and plot the signal, if \( x(n) \) is interpolated with a factor of three.

b) Consider the structure shown below with input transforms and filter responses as indicated. Sketch the quantities \( Y_0(e^{j\omega}) \) and \( Y_1(e^{j\omega}) \) and interpret.

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P.T.O.
2. a) Explain a 2 channel QMF bank. What are the distortions present? How is perfect reconstruction achieved?
   b) Let \( H_0(z) = (1+z^{-1})/2 \) and \( H_1(z) = (1-z^{-1})/2 \). Determine the synthesis filters \( G_0(z) \) and \( G_1(z) \) so that the structure shown below is a perfect reconstruction filter bank.

   ![Diagram](image)

3. a) Discuss causality issue of a decimator.
   b) Obtain 2 band polyphase decomposition of the transfer function given below: \( H(z) = (1-5z^{-1})/(1+3z^{-1}) \).
   c) Let \( H(z) \) represents an FIR filter of length 8 with impulse response coefficients \( h(n) = (0.3)^n \) for \( 0 \leq n \leq 7 \) and zero otherwise. Find the poly phase components \( E_0(z) \) and \( E_1(z) \).

4. a) Basis sets of scaling functions span a nested space. State your comments on the above statement.
   b) A signal in \( V_1 \) space is designated as follows: \([4, 2, 6, -2, 4, 6, 2, 2]\). Perform Haar decomposition into \( V_0 \) and \( W_0 \) spaces.
   c) State uncertainty principle and discuss its significance using time frequency tiling.

5. a) State the relationship between different function spaces in a biorthogonal wavelet system. What is the motivation for designing biorthogonal systems?
   b) Project the function \( f(x) = x \) onto the space spanned by \( \varphi(x), \psi(x) \).

\[
\psi(2x), \psi(2x - 1) \in L^2[0,1] \text{ where}
\]
\[
\varphi(x) = \begin{cases} 1, & 0 \leq x \leq \frac{1}{2} \\ 0, & \text{otherwise} \end{cases}
\]
\[
\psi(x) = \begin{cases} 1, & 0 \leq x \leq \frac{1}{2} \\ -1 \frac{1}{2} \leq x \leq 1 \\ 0, & \text{otherwise} \end{cases}
\]

Sketch the projection of \( f(x) \) to this space.

6. What is the basic concept of linear prediction analysis? Explain Levinson-Durbin algorithm.