Problem 1
An IIR filter is defined as: \[ y[n] = -\frac{1}{3} y[n-1] + 3x[n] \]
(a) Determine the system function \( H(z) \). What are its poles and zeros?
(b) Suppose the input to the system is given as: \[ x[n] = \begin{cases} 1 & n = 0,1,2,3 \\ 0 & \text{otherwise} \end{cases} \]
Determine the output signal \( y[n] \). Assume \( y[n]=0 \) when \( n<0 \).

Problem 2
Given an IIR filter defined as: \[ y[n] = -y[n-4] + 2x[n] \]
(a) Determine the system function \( H(z) \).
(b) Compute and plot its poles and zeros
(c) Given the input to the system as: \[ x[n] = \begin{cases} 2 & n = 0,1,2 \\ 0 & \text{otherwise} \end{cases} \]
Determine the output signal \( y[n] \). Assume \( y[n]=0 \) when \( n<0 \).
Is the output signal periodic? If yes, determine the period.

Problem 3
Determine the inverse z-transform of the following \( H(z) \):
(a) \[ H(z) = \frac{1 - 4z^{-1}}{1 - 0.8z^{-1}} \]
(b) \[ H(z) = \frac{2 - z^{-2}}{1 - 0.5z^{-1}} \]
(c) \[ H(z) = \frac{-z^{-3}}{1 - 0.2z^{-1}} \]
(d) \[ H(z) = 2 - z^{-1} + 0.3z^{-2} + 0.7z^{-5} \]

Problem 4
Determine the inverse z-transform of the following \( H(z) \):
(a) \[ H(z) = \frac{1 - z^{-1}}{1 - 0.2z^{-1} - 0.48z^{-2}} \]
(b) \[ H(z) = \frac{z^{-2}}{1 + 0.5z^{-1} + 0.06z^{-2}} \]
(c) \[ H(z) = \frac{1 + 4z^{-1} - z^{-2}}{1 - z^{-1} + 0.25z^{-2}} \]
Problem 5

Suppose we have a feedback system with the IIR filter defined as:

\[ y[n] = 0.4y[n-4] + 2x[n] \]

(a) If the input is the unit-step sequence \( u[n] \), determine the functional form of the output \( y[n] \). Assume \( y[n]=0 \) for \( n<0 \). (hint: use the method of inverse z-transform)

(b) If the input is \( x[n] = e^{j(\pi/3)n}u[n] \), find the output \( y[n] \);

(c) From (b), identify the steady-state component of the response, and compare its magnitude and phase to the frequency response at \( \omega = \pi / 3 \)

Problem 6

Suppose we have a system as the figure above. We have an input to the C-to-D converter defined as:

\[ x[n] = 10 - 2\cos(200\pi t) + 3\cos(750\pi t) \]

The system function for the LTI system is:

\[ H(z) = \frac{(1 - e^{j3\pi/4}z^{-1})(1 - e^{-j3\pi/4}z^{-1})}{(1 - 0.9e^{j\pi/5}z^{-1})(1 - 0.9e^{-j\pi/5}z^{-1})} \]

If \( fs=1000 \) samples/sec, determine an expression for \( y(t) \).

Problem 7

Given a discrete-time signal as:

\[ y[n] = (0.8)^n \cos(0.3\pi n)u[n] \]

(a) Plot \( y[n] \) versus \( n \) with MATLAB or MATHCAD for \( n \in [0,20] \).

(b) Design an IIR filter that will synthesize \( y[n] \). Give your answer in the form of a difference equation with numerical values for the coefficients.

Problem 8: Signal Processing First 8.13

Problem 9: Signal Processing First 8.14
Problem 10: Signal Processing First 8.16

Problem 11: Signal Processing First 8.17

Problem 12: Signal Processing First 8.22