University of Massachusetts Dartmouth

Department of Electrical and Computer Engineering

ECE 475/574 DISCRETE-TIME SIGNAL PROCESSING

Problem Set No. 2

Issued: Wednesday, September 11, 2024 **Due:** Friday, September 20, 2024

ECE 475/574: All Problems

Problem 2.1. The sequence $x[n]=\cos\left(\frac{\pi}{4}n\right)$ with $-\infty < n < \infty$, was obtained by sampling a continuous-time signal $x_C(t)=\cos(\Omega_0 t)$ with $-\infty < t < \infty$, at a sampling rate of 1000 samples/s. What are two possible positive values of Ω_0 that could have resulted in the sequence $x[n]$?

Rubric for Problem 2.1

Criterion/section	Points ECE 475 / ECE 574
Use correct procedure to determine a value of Ω_0	10 pt
Provide correct solution to determine a value of Ω_0	5 pt
Use correct procedure to determine a second value of Ω_0	5 pt
Provide correct solution to determine a second value of Ω_0	5 pt
	25 pt

Problem 2.2. Assume that the frequency response of a system is $H(e^{j\omega})=j\frac{\omega}{T}$ with $-\pi \le \omega < \pi$ and *T* = 1/10 sec. For each of the following inputs $x_C(t)$, find the corresponding output $y[n]$

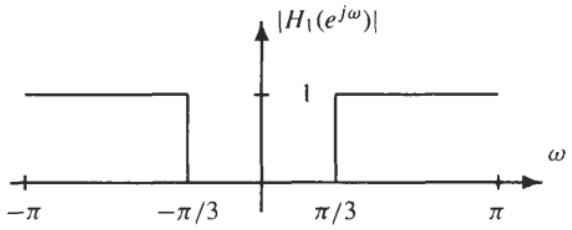
(a) $x_C(t)=\cos(6\pi t)$

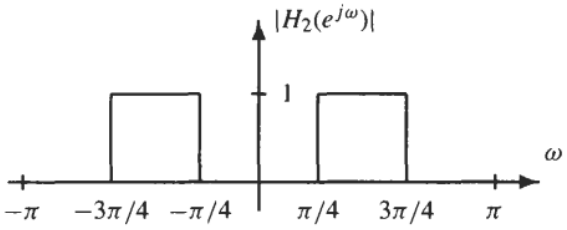
(b) $x_C(t)=\cos(14\pi t)$

Rubric for Problem 2.2

Criterion/section	Points ECE 475 / ECE 574
Transform the $x_C(t)$ signals into discrete signals $x[n]$	5 pt
Provide correct procedure to estimate the output signal $y[n]$	15 pt
Provide correct solution of the output signal $y[n]$	5 pt
	25 pt

Problem 2.3. The ideal filters that have frequency responses as shown in the figure below are connected in cascade. For an arbitrary x(n), find the range of frequencies that can be present in the output y(n). Repeat for the case in which the two systems are connected in parallel.





Rubric for Problem 2.3

Criterion	Points ECE 475/574
Express frequency response of the system connecting H_1 and H_2 in cascade	5
Discuss the range of frequencies passing the systems H_1 and H_2 connected in cascade	5
Provide correct range of the frequencies passing the systems H_1 and H_2 connected in cascade	5
Express frequency response of the system connecting H_1 and H_2 in parallel	5
Discuss the range of frequencies passing the systems H_1 and H_2 connected in parallel	5
Provide correct range of the frequencies passing the systems H_1 and H_2 connected in parallel	5
	30 pt

Problem 2.4. A 90-deg. phase shifter is a system with a frequency response

$$H\left(\mathrm{e}^{\mathrm{j}\omega}\right)=\begin{cases}-\mathrm{j} & 0<\omega<\pi\\ \mathrm{j} & -\pi<\omega<0\end{cases}$$

Whereas the magnitude is constant for all ω, and the phase is $-\frac{\pi}{2}$ for $0<\omega<\pi$ and $\frac{\pi}{2}$ for $-\pi<\omega<0$. Find the unit response of this system.

Rubric for Problem 2.4

Criterion/section	Points ECE 475 / ECE 574
Use correct procedure to determine the unit system response	15 pt
Provide correct solution to determine the system response	5 pt
	20 pt