

# ECE 401 Signal and Image Analysis

## Homework 4

UNIVERSITY OF ILLINOIS  
Department of Electrical and Computer Engineering

Assigned: 10/11/2022; Due: 10/19/2022  
Reading: *DSP First* Chapter 6

### Problem 4.1

Consider this filter:

$$y[n] = x[n] + x[n - 1]$$

Show that the magnitude response of this filter is  $|H(\omega)| = 2 \cos(\omega/2)$ .

### Problem 4.2

Suppose you have a filter whose frequency response is

$$H(\omega) = 14e^{-j6\omega}$$

Show that, if  $x[n] = \cos(\omega n)$ , the effect of convolving  $y[n] = x[n] * h[n]$  is to

- (a) scale  $x[n]$  by a factor of 14, and
- (b) delay it by 6 samples.

### Problem 4.3

The signals  $x_1(t)$  and  $x_2(t)$  are cosines an octave apart (roughly C6 and C7):

$$x_1(t) = \cos(2\pi 1000t)$$

$$x_2(t) = \cos(2\pi 2000t)$$

The signals are sampled (at  $F_s = 16000$  samples/second), then the resulting signals  $x_1[n]$  and  $x_2[n]$  are passed through a first-difference operator:

$$y_1[n] = x_1[n] - x_1[n - 1]$$

$$y_2[n] = x_2[n] - x_2[n - 1]$$

What are the amplitudes of the signals  $y_1[n]$  and  $y_2[n]$ ?

### Problem 4.4

The signals  $x_1(t)$  and  $x_2(t)$  are cosines an octave apart (roughly C6 and C7):

$$x_1(t) = \cos(2\pi 1000t)$$

$$x_2(t) = \cos(2\pi 2000t)$$

The signals are sampled (at  $F_s = 16000$  samples/second), then the resulting signals  $x_1[n]$  and  $x_2[n]$  are passed through a seven-sample local average:

$$y_1[n] = \frac{1}{7} \sum_{m=-3}^3 x_1[n-m]$$

$$y_2[n] = \frac{1}{7} \sum_{m=-3}^3 x_2[n-m]$$

What are the amplitudes of the signals  $y_1[n]$  and  $y_2[n]$ ?