EEGR4124 **FINAL EXAM** **SPRING 1997**

Do NOT begin until told to do so
Make sure that you have all pages before starting
You may not leave the room during the exam
No calculators, open book, 2 page notes

ACADEMIC INTEGRITY:
Students have the responsibility to know and observe the requirements of The UNCC Code of Student Academic Integrity (1995-97 Catalog page 310). This code forbids cheating, fabrication or falsification of information, multiple submission of academic work, plagiarism, abuse of academic materials, and complicity in academic dishonesty.

Name: ______________________________

Student Number: __________________________

Unless otherwise noted:

Show all work, even for multiple choice
Multiple choice answers should be within 5% of correct value
$\mathcal{F}\{\}$ denotes either continuous Fourier transform or DTFT
$\mathcal{F}^{-1}\{\}$ denotes inverse Fourier transform or DTFT
$\mathcal{F}_D\{\}$ denotes DFT
$\mathcal{Z}\{\}$ denotes z-transform
Ω denotes the continuous-time frequency variable
ω denotes the normalized discrete-time frequency variable
$*$ denotes linear convolution
$\otimes$ denotes circular convolution
$x^*(t)$ denotes the conjugate of x(t)
Discrete functions are denoted with square brackets, $x[n]$
Continuous functions are denoted with round brackets, $x(n)$
$\mathcal{L}\{\}$ denotes Laplace transform

Useful constants, etc:

$$\begin{array}{cccc} e \approx 2.72 & \pi \approx 3.14 & 1/e \approx 0.37 & \sqrt{2} \approx 1.41 \\ \sqrt{3} \approx 1.73 & \sqrt{5} \approx 2.22 & \sqrt{7} \approx 2.64 & \sqrt{10} \approx 3.16 \\ log_{10}[2] \approx 0.30 & log_{10}[3] \approx 0.48 & log_{10}[5] \approx 0.70 & log_{10}[10] \approx 1.0 \\ log_{10}[0.1] \approx -1.0 & log_{10}[0.5] \approx -0.3 & log_{10}[e] \approx 0.43 & cos(\pi/4) \approx 0.79 \end{array} \tag{1}$$

$cos(A)cos(B) = \frac{1}{2}cos(A-B) + \frac{1}{2}cos(A+B)$ $\qquad$ $e^{j\theta} = cos(\theta) + jsin(\theta)$
$cos^2(A) = \frac{1}{2} + \frac{1}{2}cos(2A)$ $\qquad$ $\mathcal{L}\{e^{-at}u(t)\} = 1/(s+a)$

3 Points Each (Circle the best answer)

1. The z-transform of $2^n u[n]$ is

   (a) $2\delta(z)$ (b) $z/(z-2)$ (c) $z/(z-a)$ (d) None above

2. The DTFT of $4\delta(n-2)$ is

   (a) $4e^{-j2\omega}$ (b) $4\omega e^{j\omega}$ (c) $4z/(z-2)$ (d) None above

3. FIR filters

   (a) can be linear phase (b) are always linear phase (c) are never linear phase

4. IIR filters are always stable.

   (a) True (b) False

5. The length 4 sequence $\{1,2,3,4\}$ undergoes a circular shift of 2. The resulting sequence is:

   (a) $\{1,2,3,4\}$ (b) $\{4,2,3,1\}$ (c) $\{3,4,1,2\}$ (d) None above

6. A filter with impulse response 1,2,3,2,1 is linear phase.

   (a) True (b) False

7. A causal filter with $H(z) = \frac{z-1}{(z-.5)(z+.5)}$ is BIBO stable.

   (a) True (b) False

8. Frequency warping occurs when filters are designed using

   (a) impulse invariance method (b) window method
   (c) frequency sampling method (d) None above

3 Points Each (Circle the best answer)

9. If the sampling period in a system is 0.01 seconds, the highest frequency component in the signal must be less than

   (a) 50 Hz (b) 100 π Hz (c) 2000 Hz (d) None above

10. To transform a discrete lowpass filter with $\omega_c = \pi/4$ to a new highpass filter with $\omega_c = 3\pi/4$ using the transformation $-\frac{z^{-1}+\alpha}{1+\alpha z^{-1}}$, the value of α must be

    (a) 0 (b) $-\sqrt{2}$ (c) 1 (d) None above

11. The DC response of a discrete time filter with impulse response $h[n] = \{1, 2, 3, 4\}$ is

    (a) 0 (b) 2.5 (c) 10 (d) None above

12. In a system with sample rate of 1000 Hz, the response to a filter with $H(z) = z^2/(z^2 + 0.8)$ at $\omega = \pi/2$ is

    (a) $\sqrt{2}$ (b) 1/(0.8) (c) 5 (d) None above

13. If the z-transform of a causal filter is $H(z) = (z - 2)/(z^2 - .5)$, then $h[0] =$

    (a) 0 (b) .25 (c) 4 (d) None above

14. The choice of window in the window method affects

    (a) transition width and passband ripple (b) frequency sampling
    (c) the Hamming distance (d) None above

15. If $H(z) = z - 1/2$, the DC gain of the system is

    (a) 1/2 (b) - 0.9 (c) 5 (d) None above

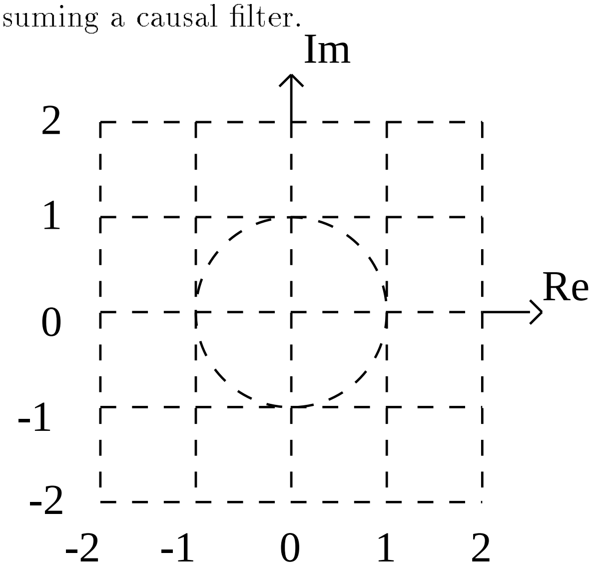
5 points

16. Write the difference equation for the causal filter $H(z) = \frac{z^{-1}+2}{6z^{-2}+4z^{-1}+2}$.

$$H(z) = \frac{z^2+z-2}{z^2+1}$$

10 points

17. Find the poles and zeroes, and plot the pole-zero diagram and region of convergence for H(z) above, assuming a causal filter.



$$H(s) = \frac{0.25}{s+1} + \frac{0.5}{s+3}$$

5 points

18. (a) Find the discrete-time version $H(z)$ of the above continuous time filter using the impulse invariance method when the sampling rate is $f_s = 1/2Hz$. Express the result in partial fraction expansion form. You need not reduce expressions of the form e^{ax}.

5 points

19. (b) Find $h[0]$.

$$H(s) = \frac{8}{(s+2)(s+4)}$$

10 points

20. Find the discrete-time version $H(z)$ of the above continuous time filter using the bilinear transform method when the sampling rate is $f_s = 1Hz$. Express the result in the form of the ratio of two polynomials in z.

$$H(s) = \frac{3}{(s+3)}$$

5 points

21. Find the frequency response $H(\omega)$ for the discrete-time version of the above filter when it is designed using the bilinear transform method in a system where the sample rate is $f_s = 2Hz$. Express the result in terms of the tangent function.

$$H(z) = \frac{(z+2)(z+3)}{(z-0.5)(z+0.25)}$$

10 points

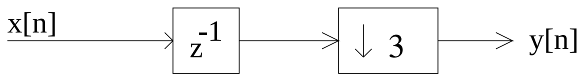
22. Sketch the block diagram for the above causal filter.

$$h_D[n] = (0.5)^n u[n]$$

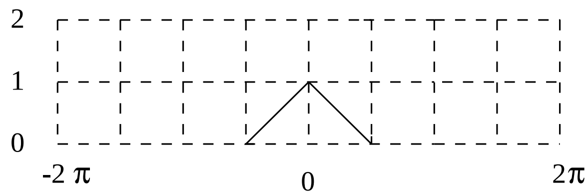
10 points

23. For the desired impulse response $h_D[n]$ above, find the impulse response $h[n]$ for a length 3 FIR filter approximating $h_D[n]$ using the Hanning window method.
NOTE: do NOT shift $h_D[n]$ since it is a causal response, however, shift the window as required.

Useful information: $cos(\pi/8) = 0.92$, $cos(\pi/4) = 0.707$, $cos(\pi/3) = 0.5$, $cos(\pi/2) = 0$, , $cos(3\pi/5) = -0.31$, $cos(2\pi/3) = -0.5$.

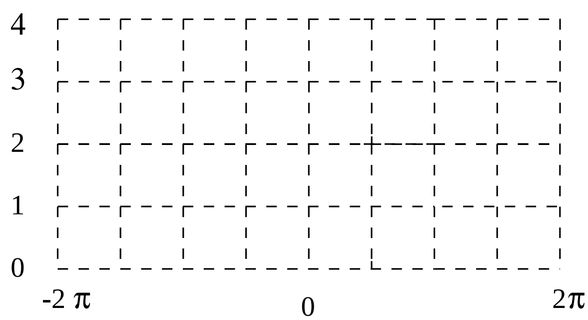


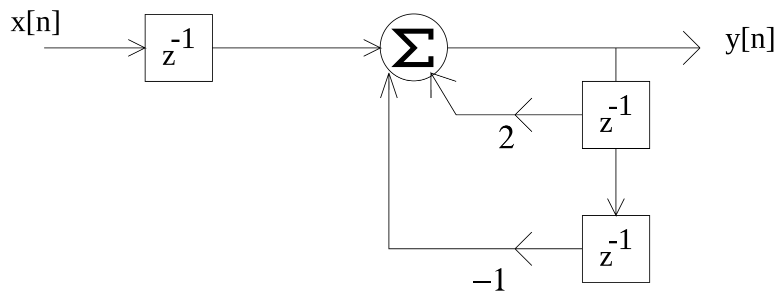
$|X(\omega)|$



5 points

24. Given $|X(\omega)|$ for the system above, and sketch $|Y(\omega)|$ below.





10 points

25. Find the *analytic* expresion for impulse response $h[n]$ of the above filter from $n = 0$ to $n = \infty$.

10 points

26. Find and plot the poles of $H(s)$ for a third order butterworth filter with cutoff frequency of 200π radians/second. Label the axes of the s-plane below.
NOTE: plot the poles of $H(s)$, not the poles of $|H(s)|^2$.