ECGR6114 Digital Signal Processing II Exam Spring 2006

Name: ____________________________________

***LAST 4 NUMBERS*** of Student Number: _____

Do NOT begin until told to do so
Make sure that you have all pages before starting
Opennotes, , NO CALCULATOR, NO CELL PHONES/WIRELESS DEVICES
Open mathcad
DO ***ALL WORK*** IN THE SPACE GIVEN
Do **NOT** use the back of the pages, do **NOT** turn in extra sheets of work/paper
Multiple-choice answers should be within 5% of correct value
Show ALL work, even for multiple choice

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

Unless otherwise noted:
*F*{} denotes Discrete timeFourier transform {*DTFT, DFT, or Continuous, as implied in problem}*
$F^{-1}${} denotes inverse Fourier transform, Z{} denotes z-transform
$\omega$ denotes frequency in rad/sample, $\Omega$ denotes frequency in rad/second
$*$ denotes linear convolution, $\textcircled{N}$ denotes circular convolution
x*(t) denotes the conjugate of x(t)

Useful constants, etc:

| | |
|---|---|
| $e \approx 2.72$ | $\pi \approx 3.14$ |
| $1/e \approx 0.37$ | $\sqrt{2} \approx 1.41$ |
| $\sqrt{3} \approx 1.73$ | $\sqrt{5} \approx 2.22$ |
| $\sqrt{7} \approx 2.64$ | $\sqrt{10} \approx 3.16$ |
| $\ln(2) \approx 0.69$ | $\ln(4) \approx 1.38$ & |
| $\log_{10}(2) \approx 0.30$ | $\log_{10}(3) \approx 0.48$ & |
| $\log_{10}(10) \approx 1.0$ | $\log_{10}(0.1) \approx -1$ |
| $\log_{10}(e) \approx 0.43$ | $\cos(\pi / 4) \approx 0.71$ |

$\cos(A)\cos(B) = 0.5\cos(A - B) + 0.5\cos(A + B)$
$e^{j\theta} = \cos(\theta) + j\sin(\theta)$

5 Points Each

1. A discrete-time sinusoid with $\omega = \pi$ rad/sample (sampled at 1000 samples/second) has a corresponding continuous-time frequency of $\Omega =$

   a) 250 $\pi$ rad/s  b) 500 $\pi$ rad/s  c) 1000 $\pi$ rad/s  d) none above

2. An FIR filter designed with a Hamming window has lower peak side-lobes than one designed with a Bartlett window.

   a) True  b) False

3. Bilinear transform filter designs filter designs suffer from frequency-domain aliasing.

   a) True  b) False

4. If an analog-to-digital converter has a resolution $\Delta v = 0.01$ volts, the second moment of the quantization noise would be.

   a) $8.3 \times 10^{-6}$  b) $8.3 \times 10^{-4}$  c) 0.029  d) none above

5. The DC frequency response ($H(\omega)$ at $\omega=0$) of a system with impulse response
   $h[n] = \delta[n-1] + 3\delta[n-2] - 4\delta[n-3]$ is:

   a) 0  b) $z^{-1} + 3z^{-2} - 4z^{-3}$  c) 5  d) none above

5 Points Each

6. The causal system with z-transform $H(z)=\frac{z^2+0.25}{z^2-0.25}$ is BIBO stable.

   a) True b) False

7. The causal system with z-transform $H(z)=\frac{z^2+0.25}{z^2-0.25}$ is minimum phase.

   a) True b) False

8. A minimum phase causal system is invertible.

   a) True b) False

9. The z-transform of h[n]= $\delta$[n] + 2$\delta$[n-1] is H(z) =

   a) $1+2z^{-1}$ ;|z|>0
   b) $1+e^{-j2\omega td}$ ;|z|>0
   c) $1+2z^{-1}e^{-j\omega}$ ;|z|>0
   d) none above

10. The circular convolution of the two 4-point sequences x[n] = {1,1,0,0} and y[n] = {1,2,0 ,0}

    a) {1,2,1,2} b) {0,1,2,1} c) {1,2,2,0} d) none above

5 Points Each

11. The z-transform of h[n]= $(1/3)^n$ u[n] is H(z) =

a) $\frac{z}{z-3}$ ;|z|<2

b) $\frac{z}{z+3}$ ;|z|>3

c) $\frac{z}{z-1/3}$ ;|z|>1/3

d) none above

12. A 4 sample/second filter with impulse response h[n] is constructed using the impulse invariance method for h(t) = $4(2^{-4t})$. Given this filter, h[2]=

a) 4 b) $4 / 2^{16}$ c) 2 d) none above

13. The difference equation of a system is y[n] = x[n] + 3y[n-1] . The z-transform of the system is H(z)=

a) $\frac{z}{z-3}$ ;|z|>3

b) $\frac{3z}{z-2}$ ;|z|>2

c) $\frac{z/3}{z-0.33}$ ;|z|>0.33

d) none above

14. A discrete-time filter H(z) that is designed using the impulse invariance method will be BIBO stable, if the continuous time filter H(s) is BIBO stable.

a) True b) False

15. The Pade Approximation always results in a stable system design.

a) True b) False

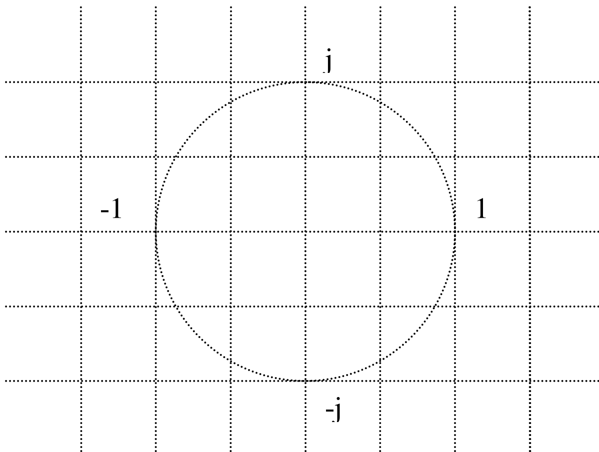
A discrete-time filter is to be designed using the bilinear transform method. The sampling rate of the digital system is 10 samples/second. The analog filter is given as:

$$H(s) = \frac{0.1}{s+1}$$

10 Points

16. Find H(z) .

The following questions are for a filter wth $H(z) = z^4/(z^4 + 1)$ with ROC $|z|>1$.

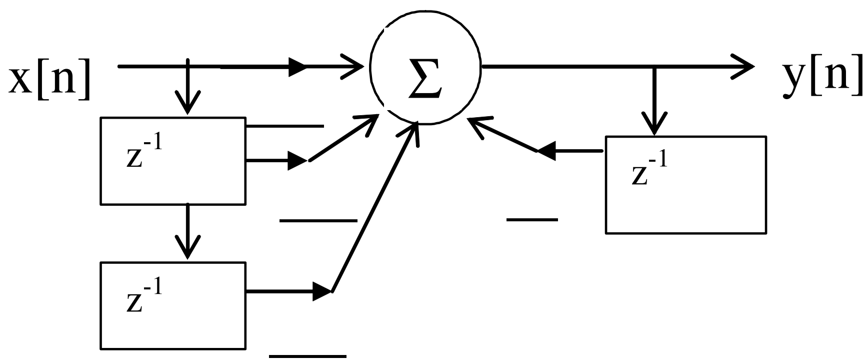



10 Points

17. Sketch the poles and zeroes of H(z) on the figure.

Assume the following system is initially at rest, and let h[n] be the impulse response.

The difference equation for the system is y[n]= 3y[n-1] +2x [n]+ 5x[n-2]




10 Points

18. Label the weights of the system on the block diagram above.

5 Points each

The following questions are for a **Pade** approximation to a system with impulse response g(t) = { 1, 2, -1, 0, 0.5, -0.25, 0, 0, 0, …} and second order model with **A**=[1 a1 a2] **B**=[b0 b1 b2].

19. In the Pade Approximation **GA**=**B**, the matrix **G** equals.

a) $\begin{bmatrix} 1 \\ 2 \\ -1 \\ 0 \\ 0.5 \end{bmatrix}$ b) $\begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \\ 0 & -1 & 2 \\ 0.5 & 0.5 & -1 \end{bmatrix}$ c) $\begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \end{bmatrix}$ d) none above

20. In the Pade Approximation **GA**=**B**, the matrix $\mathbf{G_T}$ equals.

a) $\begin{bmatrix} 1 \\ 2 \\ -1 \\ 0 \\ 0.5 \end{bmatrix}$ b) $\begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \\ 0 & -1 & 2 \\ 0.5 & 0.5 & -1 \end{bmatrix}$ c) $\begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \end{bmatrix}$ d) none above

21. In the Pade Approximation, the solution for **A** is.

a) $\begin{bmatrix} 1 \\ 1 \\ 0.5 \end{bmatrix}$ b) $\begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}$ c) $\begin{bmatrix} 1 \\ -1 \\ -0.5 \end{bmatrix}$ d) none above

22. In the Pade Approximation, the solution for **B** is.

a) $\begin{bmatrix} 1 \\ 3 \\ 1.5 \end{bmatrix}$ b) $\begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}$ c) $\begin{bmatrix} 1 \\ 1 \\ -0.5 \end{bmatrix}$ d) none above

5 Points each

The following questions are for a **Prony** approximation to a system with impulse response g(t) = { 1, 2, -1, 0, 0.5, -0.25, 0, 0, 0, …} and second order model with **A**=[1 a1 a2] **B**=[b0 b1 b2] using the first 8 points of g[n] (i.e., g[0] to g[7]).

23. In the Prony Approximation **GA**=**B**, the matrix $\mathbf{G_T}$ equals.

a) $\begin{bmatrix} 1 \\ 2 \\ -1 \\ 0 \\ 0.5 \end{bmatrix}$ b) $\begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \\ 0 & -1 & 2 \\ 0.5 & 0.5 & -1 \end{bmatrix}$ c) $\begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \end{bmatrix}$ d) none above

24. In the Prony Approximation, to within 5% the solution for **A** is.

a) $\begin{bmatrix} 1 \\ 0.41 \\ 0.52 \end{bmatrix}$ b) $\begin{bmatrix} 1 \\ 0.33 \\ -0.21 \end{bmatrix}$ c) $\begin{bmatrix} 1 \\ 0.7 \\ 0.38 \end{bmatrix}$ d) none above

25. In the Prony Approximation, the solution for **B** is.

a) $\begin{bmatrix} 1 \\ 3.2 \\ 1.35 \end{bmatrix}$ b) $\begin{bmatrix} 1 \\ 2.7 \\ 0.78 \end{bmatrix}$ c) $\begin{bmatrix} 1 \\ 0.36 \\ -0.5 \end{bmatrix}$ d) none above

26. The resulting causal Prony approximation is minimum phase and BIBO stable.

a) True b) False

5 Points each

The following questions are for a Prony approximation to a system where the solution for the system parameters **A** and **B** are :

A = $\begin{bmatrix} 1 \\ a1 \\ a2 \\ a3 \end{bmatrix} = \begin{bmatrix} 1 \\ 0.2 \\ 0.3 \\ 0.5 \end{bmatrix}$ B = $\begin{bmatrix} b0 \\ b1 \\ b2 \\ b3 \end{bmatrix} = \begin{bmatrix} 2 \\ 4 \\ 6 \\ 8 \end{bmatrix}$

27. The system is minimum phase and BIBO stable.

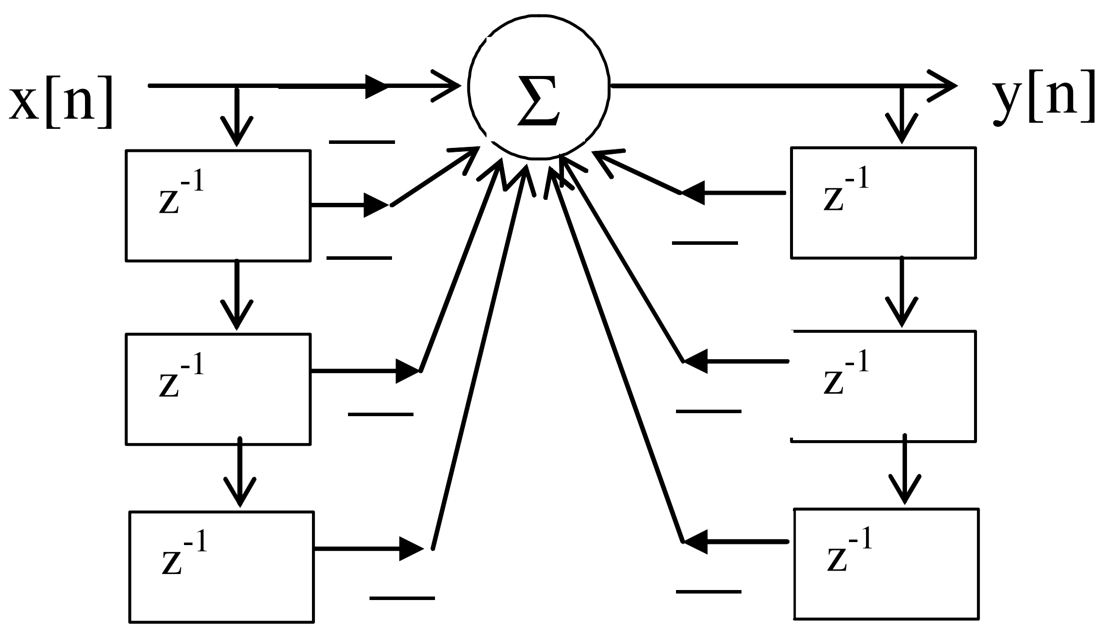
a) True b) False

28. The DC gain of the system is

a) 4 b) $4 / 2^{16}$ c) 2 d) none above

10 Points

29. Label the weights of the system on the block diagram below.



5 Points Each

Use the least-squares method to find the straight line (y = m x + b) that best fits the following measured x-y data point pairs: (Hint: one way might be **A** $[m, b]^T$ = **Y ,** if the proper form was given to **A** and **Y.**

$$(x,y) = \begin{bmatrix} -2 & 2 \\ 1 & 3 \\ 2 & 6 \\ 4 & 8 \\ 7 & 10 \end{bmatrix}$$

30. To within 5%, the solution (m,b) equals

a) (1.5,2) b) (1,3.5) c) (3.1,2.3) d) none above

31. Plot the data points (x,y) as X's on the graph below.

32. Plot the line corresponding to the least-squares solution on the same graph below.