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Notes ! (1) $\sqrt{32} = 5.65$

(2) IGNORE X's & O's in p. 6. Answer

ECGR4124 Digital Signal Processing Exam 2 Spring 2017

Name: ______________________________

LAST 4 NUMBERS of Student Number: _____

Do NOT begin until told to do so
Make sure that you have all pages before starting
NO TEXTBOOK, NO CALCULATOR, NO CELL PHONES/WIRELESS DEVICES
Open handouts, 2 sheet front/back notes, NO problem handouts, NO exams, NO quizzes
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 time Fourier transform *{DTFT, DFT, or Continuous, as implied in problem}*
F^{-1}{} denotes inverse Fourier transform
ω denotes frequency in rad/sample, Ω denotes frequency in rad/second
$*$ denotes linear convolution, (N) denotes circular convolution
$x^*(t)$ denotes the conjugate of $x(t)$

Useful constan

$e \approx 2.72$	≈ 3.14
$e^2 \approx 7.39$	≈ 54.6
$e^{-0.5} \approx 0.607$	$^{25} \approx 0.779$
$1/e \approx 0.37$	≈ 1.41
$e^{-2} \approx 0.135$	≈ 1.73
$e^{-4} \approx 0.0183$	≈ 2.22
$\sqrt{7} \approx 2.64$	$10 \approx 3.16$
$\ln(2) \approx 0.69$	$\ln(4) \approx 1.38$
$\log_{10}(2) \approx 0.3$	$\log_{10}(3) \approx 0.48$
$\log_{10}(10) \approx 1.$	$\log_{10}(0.1) \approx -1$
$1/\pi \approx 0.318$	$\sin(0.1) \approx 0.1$
$\tan(1/9) \approx 1/9$	$\cos(\pi / 4) \approx 0.71$

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

5 Points Each, Circle the Best Answer

1. A continuous-time sinusoid of 250 Hz sampled at 1000 samples/second has a corresponding discrete-time frequency of ω =

   a) $\pi/4$ rad/sample b) $\pi/2$ rad/sample c) π rad/sample d) none above

$$2\pi \frac{250}{1000} = \frac{2\pi}{4} = \pi/2$$

2. The impulse response of a system is $h[n] = \delta[n] - \delta[n-1]$, the frequency response is $H(\omega)$=

   a) $\text{sinc}(2\omega)\, e^{-j\omega}$ b) $e^{-j\omega} - e^{-j2n\omega}$ c) $1 - e^{-j\omega}$ d) none above

$$1 - z^{-1}\Big|_{z=e^{j\omega}} = 1 - e^{-j\omega}$$

3. Pre-warped bilinear transform filter designs suffer from aliasing.

   a) True b) False

4. Circle the causal BIBO stable impulse response below.

   a) $h[n]= e^{-j2n\pi}\, u[n]$ b) $h[n]= j\, u[n]$ c) $h[n]= e^{-2n\pi}\, u[n]$ d) none above

5. If a filter has z-transform $H(z) = \frac{z^3+2z+2}{5z^3}$; $|z|>0$, then the filter is

   a) FIR b) IIR c) two-sided d) none above

$$= \frac{1}{5} + 2z^{-2} + \frac{2}{5} z^{-3}$$

5 Points Each, Circle the Best Answer

$Y(z) = 15X(z)z^{-1} + \frac{1}{2}Y(z)z^{-1}$

6. The dc response of a system with difference equation y[n] = 15 x[n-1] + 0.5 y[n-2] is:

a) 7.5 b) 10 c) 30 d) none above

$\frac{Y}{X} = H = \frac{15z^{-1}}{1-\frac{1}{2}z^{-1}} = \frac{15}{z-1/2}$

7. If a filter has $H(z) = \frac{2z-2}{5z+3}$ and ROC |z|>0.6 then, the response at $\omega=\pi$ is $H(\omega)|_{\omega=\pi} = H(\pi)=$

a) -1/2 b) 0 c) 1/2 d) 2 e) none above

$\omega=\pi \Rightarrow z=-1 \Rightarrow \frac{-2-2}{-5+3} = \frac{-4}{-2} = 2$

8. If $Y(z)=1+z^{-1}$; |z|>0, and $X(z)= 1+z^{-1}$; |z|>0 , then the convolution $x[n] * y[n]=$

a) $\delta[n-1]- \delta[n-2]$ b) $\delta[n] + 2\delta[n-1] + \delta[n-2]$ c) $\delta[n] - 2\delta[n-1] + \delta[n-2]$ d) none above

$y[n] = \{1, 1, \ldots\}$
$x[n] = \{1, 1, \ldots\}$ $* \Rightarrow$

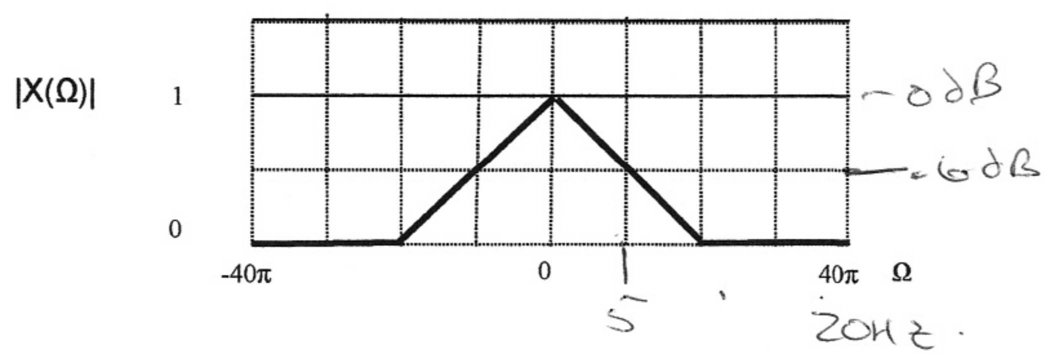
1 1 0 ...
0 1 1 ...
{1, 2, 1, 0 ...}

9. If a filter is to be designed using the windowing methods where $h[n]=w[n]\, h_d[n]$, and where $h_d[n]= 2^{-n} u[n]$, which of the following windows has the lowest relative peak sidelobe:

a) {1, 1, 1, 1, 1} b) {0, 1/2, 1, 1/2, 0} c) {1, 1, 1, 0, 0} d) {0, 1, 1, 1, 0}

10. The magnitude of the frequency spectrum of a signal $|X(\Omega)|$ is given below. The 6 dB bandwidth of the signal is

a) 5 Hz b) 10 Hz c) 15 Hz d) 20 Hz e) none above



-.01

5 Points Each, Circle the Best Answer

11. For a system with $h[n] = (-0.99)^n u[n]$, the 3 dB bandwidth is

$@z=1 \approx \left|\frac{1}{1+0.99}\right| = \frac{1}{2}$

$@z=j \approx \left|\frac{1}{j+0.99}\right| \Rightarrow \approx \frac{1}{\sqrt{2}}$

$@z=-1 \approx \frac{1}{.01} \Rightarrow \frac{100}{\sqrt{2}}$

a) $\pi/8$ rad/sample b) $\pi/4$ rad/sample ~~c) $\pi/2$ rad/sample~~ d) none above

$H(1) \approx \frac{1}{2}$

$H(z) = \frac{z}{z+0.99}$

@DC 2

@z=j 1 $\approx \frac{1}{\sqrt{2}}$

$\Rightarrow$ 3dB.

12. For a system with $H(z) = \frac{z^2+1}{z^2}$; $|z|>0$, the corresponding 4-point DFT is X[k]=

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

$\Rightarrow \left\{\frac{1^2+1}{1}, \frac{j^2+1}{j^2}, \frac{(-1)^2+1}{(-1)^2}, \frac{(-j)^2+1}{(-j)^2}\right\} = \{2, 0, 2, 0\}$

13. The stable 2-sided LTI system with z-transform $H(z) = \frac{2z+0.5}{(z+2)(3z+1)}$ has an ROC of

-2 -1/3

a) 1/3 < |z| < 2 b) 1/3 < |z| < 1/2 c) 1/2 < |z| < 3 d) none above

14. The z-transform of $h[n]= 4^{-(n-1)} u[n-1]$ is H(z) =

$\left(\frac{1}{4}\right)^n \Rightarrow \frac{z}{z-1/4}$

a) $\frac{4z^2}{4z-1}$; |z|>1/4

b) $\frac{4z^{-1}}{4z-1}$; |z|>1/4

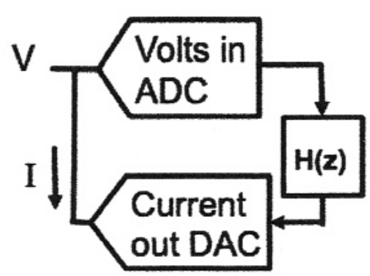
c) $\frac{4}{4z-1}$; |z|>1/4

d) none above

$\Rightarrow \frac{1}{z-1/4} = \frac{4}{4z-1}$

15. In the system below, $H(z)= -5.0\,(1-z^{-1})$ and the clock period is T=1 nanosecond, impedance of the circuit looks like the impedance a capacitor of

a) -5 nF b) 5 nF c) -5 uF d) none above



$i = C\,dv/dt \approx \frac{C}{T}\left(v[n]-v[n-1]\right)$

$\frac{C}{T} = -5$

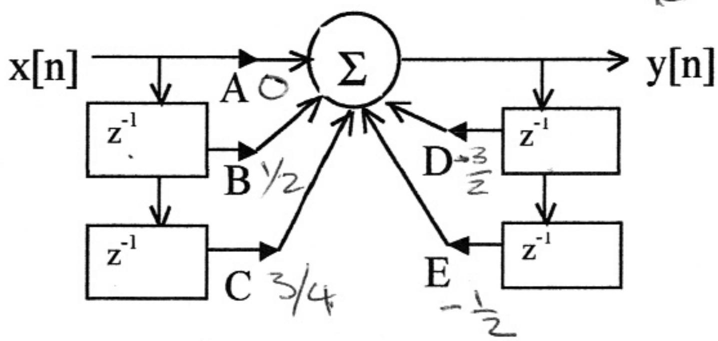
$C = -5T = -5\times10^{-9}$

5 Points Each, Circle the Best Answer

5 Points Each, Circle the Best Answer

Let the following causal system be initially at rest, and let h[n] be the impulse response, with z-transform $H(z) = \frac{2z+3}{4z^2+6z+2}$.

$$= \frac{z/2 + 3/4}{z^2 + \frac{3}{2}z + \frac{1}{2}}$$



16. The system is BIBO stable

a) True   b) False

$$\frac{-6 \pm \sqrt{36 - 4\cdot 4\cdot 2}}{8} = \frac{-6 \pm \sqrt{4}}{8} =$$

Pole @ $z = \cancel{0}\,1$.

17. The filter coefficient A in the block diagram above is A =

a) -1/2   b) 0   c) 1/2   d) 2/3   e) none above

18. The filter coefficient C in the block diagram above is C =

a) -1/2   b) 1/2   c) 3/4   d) 3   e) none above

19. The filter coefficient E in the block diagram above is E =

a) -1/2   b) -1/3   c) 1/2   d) 2/3   e) none above

20. The *second point* of the impulse response is, h[1] =

a) 0   b) 1/3   c) 1/2   d) 3/2   e) none above

5 Points Each, Circle the Best Answer

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

a) $0.5\,(2^{-n})\, u[n]$ b) $2^{-2n}\, u[n]$ c) $2\,(2^{-n/2})\, u[n]$ d) none above

$T_s h(nT_s) = \frac{1}{2} 2^{-2n/2} = \frac{1}{2} 2^{-n}.$

22. The difference equation of a causal system is $3y[n] = 5x[n] + y[n-1]$. The z-transform of the system is H(z)=

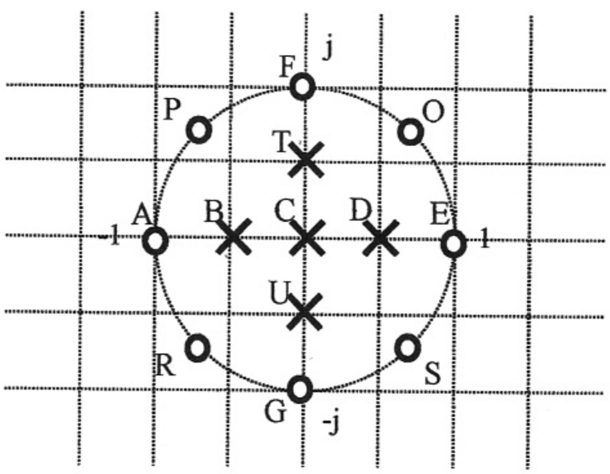
A) $\frac{5z}{3z-1}$; $|z|>1/3$ b) $\frac{5z}{3z+1}$; $|z|>1/3$

c) $\frac{5z}{z-3}$; $|z|>3$ d) $\frac{5z}{z+3}$; $|z|>3$ e) none above

$Y(z)(3 - z^{-1}) = 5X(z)$

$\frac{Y}{X} = H = \frac{5}{3-z^{-1}} = \frac{5z}{3z-1}.$

The following questions are for an causal LTI filter with $H(z) = \frac{z^2+1/4}{z^2+z/2}$.



$\frac{(z+j/2)(z-j/2)}{z(z+\frac{1}{2})}$

0 $-1/2$

Ignore the X's and O's in the plot.
Only be concerned with their locations.
they do not necessarily indicate a pole or a zero at each location,
only their coordinates are important in the questions below.
(sorry for any confusion)

23. The proper locations of the poles of H(z) are at locations

a) C and D b) B and C c) T and U d) none above

24. The proper locations of the zeroes of H(z) are at locations

a) T and C b) B and C c) T and U d) none above

$|\cdot| = \frac{2}{1}$ @ dc

$\to |\cdot| = \frac{\sqrt{2}}{1}$ @ $z=j$

5 Points Each, Circle the Best Answer

zero @ −1.

25. For a system with $H(z) = \frac{z+1}{z^2}$; |z|>0, the corresponding 3 dB bandwidth is

a) π/8 rad/sample b) π/4 rad/sample c) π/2 rad/sample d) none above

26. The z-transform of x[n] = $(-1)^n$ u[n] is X(z) =: $\frac{z}{z-(-1)} = \frac{z}{z+1}$ $|z|>1$.

a) $(-z)^n$, |z|>1 b) $\frac{-z}{z+1}$, |z|>1 c) $\frac{z}{z+1}$, |z|>1 d) none above

$\approx 25(z^2-1) \to$ zeroes @ $x = \pm 1$

27. The system with z-transform $H(z) = \frac{25z^2-24}{z(20z+1)}$; |z|>1/20 would be best described as

poles @ $0, -\frac{1}{20}$

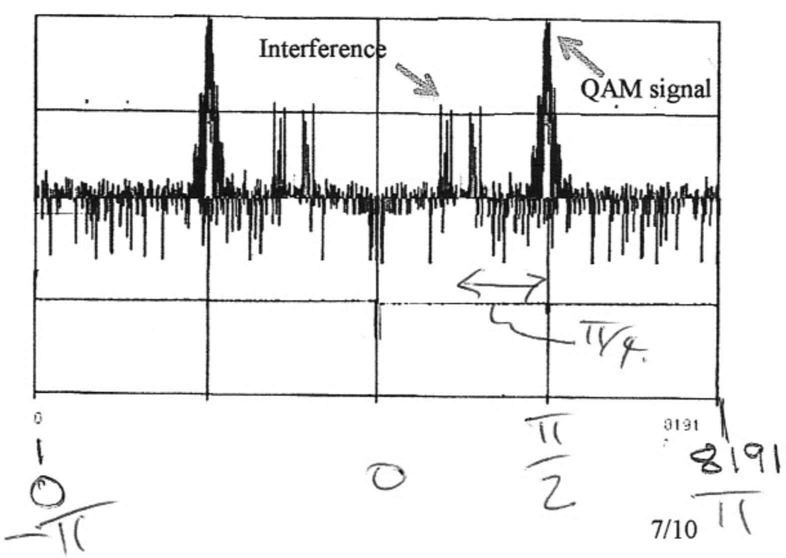
a) lowpass b) bandstop c) bandpass d) highpass

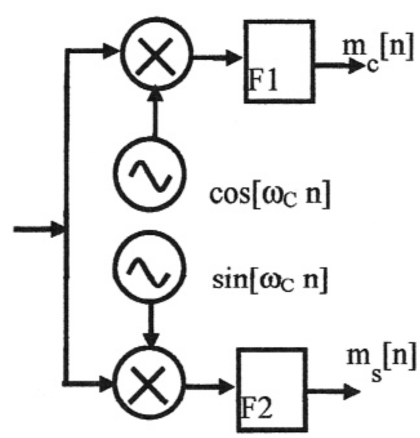
28. As in the projects this semester, a QAM signal plus an interference signal is present in the centered FFT frequency spectrum below. In the receiver shown below, the proper cosine function to demodulate the QAM and recover the data signal m_C [n] is

a) cos[2000πn] b) cos[4000πn] c) cos[πn/4] d) cos[πn/2] e) none above

29. As in the projects, a QAM signal plus an interference signal is present in the centered FFT frequency spectrum below. In the receiver shown below, F1 is a moving average filter with second null falling in the middle of the interference. Then, F1 has impulse response h[n]=

a) (u[n]-u[n-4])/4 b) (u[n]-u[n-8])/8 c) (u[n]-u[n-16])/16 d) none above





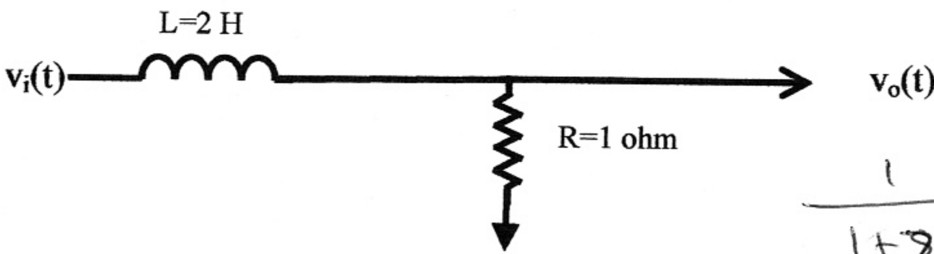
8

$\Rightarrow \frac{2\pi}{8} = \frac{\pi}{4}$ rad/s.

1st Null

5 Points Each, Circle the Best Answer

In the following questions, a discrete-time filter is to be designed using the impulse invariance method. The sample rate of the digital system is 2 samples/second. The discrete-time filter is to replace the causal continuous-time filter below, with H(s) = Vo(s)/Vi(s) .



$\frac{1}{1+2s} = \frac{1/2}{s+\frac{1}{2}} = \frac{\frac{1}{2}}{s-(-\frac{1}{2})}$

30. For the above continuous-time circuit, H(s) =Vo(s)/Vi(s) =

a) $\frac{2s}{1+s}$ b) $\frac{1}{1+s}$ c) $\frac{2}{s+1}$ d) $\frac{1}{1+2s}$ d) none above

$= \frac{T_s \cdot 1/2}{1-e^{sT_s}z^{-1}} = \frac{1/4}{1-e^{-1/4}z^{-1}}$

31. The z-transform of the discrete-time filter is H(z)=

a) $\frac{1}{1-e^{-1}z^{-1}}$; $|z|> e^{-1}$ b) $\frac{0.25}{1-e^{-0.25}z^{-1}}$; $|z|> e^{-0.25}$

c) $\frac{0.2}{1-e^{-0.2}z^{-1}}$; $|z|> e^{-0.2}$ d) $\frac{0.5}{1-e^{-0.5}z^{-1}}$; $|z|> e^{-0.5}$

e) none above

32. For the discrete-time filter, the first point in the impulse response of the filter is h[0]=

a) 1/2 b) 1 c) $e^{-1/5}$ d) e^{-1} e) none above

1/4.

33. If the filter design is modified for a new sampling rate of 2000 samples/second, the resulting discrete-time filter is BIBO stable.

a) True b) False

5 Points Each, Circle the Best Answer

A discrete-time filter is to be designed using the bilinear transform method. The sampling rate of the digital system is 2 samples/second. The continuous-time filter is given as:

$$H(s) = \frac{2s+1}{s+3} \Rightarrow \frac{2\,\frac{2}{T_s}\frac{z-1}{z+1}+1}{\frac{2}{T_s}\frac{z-1}{z+1}+3}$$

$$= \frac{8\,\frac{z-1}{z+1}+1}{4\,\frac{z-1}{z+1}+3} = \frac{8z-8+z+1}{4z-4+3z+3} = \frac{9z-7}{7z-1}$$

34. H(z)=

a) $\frac{9z-7}{7z-1}$; |z|>1/7

b) $\frac{5z-3}{5z+1}$; |z|>1/5

c) $\frac{5z-1}{6z+2}$; |z|>1/3

d) $\frac{3z+1}{3z+2}$; |z|>2/3

e) none above

35. At frequency ω=0 rad/sample, the frequency response of the discrete-time filter |H(ω)| most nearly equals

a) 4/9 b) 1/2 c) 1/3 d) 4/5 e) none above

$\frac{2s+1}{s+3}$ @ $s=0$ $= \frac{1}{3}$.

36. At frequency ω=π rad/sample, the frequency response of the discrete-time filter |H(ω)| most nearly equals

a) 0 b) 1/2 c) 3/2 d) 2 e) none above

$\frac{2(\infty)+1}{\infty+3} = 2$

37. If the filter is changed to a prewarped bilinear design with a prewarp frequency of 1 Hz, the dc frequency response of the discrete-time filter $|H(\omega)|_{\omega=0}$ would then equal

a) arctan(1) b) 1/3 c) 7/arctan(2π) d) 7/6 e) none above

$\frac{1}{3}$ AGAIN.

5 Points Each (Circle the best answer)

The following questions refer to the Java class below and the program main().

JAVA NO LONGER USED

```
public class Green {
   private int a;  private int b;

   public Green(int aa, int bb)
          { a=aa; b=bb; }
   public void equals(Green  c)
          { this.a= c.a;  this.b=c.b; }
   public void fn(Green c)
          { this.a =  c.a + this.a;
            this.b =  this.a – c.a; }
   public void gg()
          { this.a =  this.a + 2;
            this.b =  this.a - 1; }

   public static void main(String[] args) {
             Green x = new Green (1,2);
             Green y = new Green (2,1);
             Green z = new Green (1,1);
             int xx=1,yy=2,zz=3;
             x.fn(y);
             z.gg();
   }
}
```

(3, 1).

(3, 2).

38. At the end of the main program, x.a=

a) 1 b) 2 c) 3 d) None above

39. At the end of the main program, x.b=

a) 1 b) 2 c) 3 d) None above

40. At the end of the main program, z.a=

a) 1 b) 2 c) 3 d) None above