PRINT YOUR NAME HERE:

HONOR CODE PLEDGE: "I have neither given nor received aid on this exam, nor have I concealed any violations of the honor code." Closed book; 4 sides of 8.5×11 "cheat sheet."

SIGN YOUR NAME HERE:

26 multiple-choice questions, worth 5 points each, and two 10-point questions. **LECTURE**
Write your answer to each question in the space to the right of that question. **SESSION**
NOTE: Problems vary in difficulty. Some problems are harder than others.

$\sin\frac{\pi}{6} = \cos\frac{\pi}{3} = \frac{1}{2}$; $\sin\frac{\pi}{4} = \cos\frac{\pi}{4} = \frac{\sqrt{2}}{2}$; $\sin\frac{\pi}{3} = \cos\frac{\pi}{6} = \frac{\sqrt{3}}{2}$; $\sin\frac{\pi}{2} = \cos(0) = 1$.

1. The system (transfer) function of a LTI system described by the difference equation $y[n] + 2y[n-1] + 3y[n-2] = 4x[n] + 5x[n-1] + 6x[n-2]$ is:
(a) $\frac{z^2+2z+3}{4z^2+5z+6}$ **(b)** $\frac{3z^2+2z+1}{6z^2+5z+4}$ **(c)** $\frac{4z^2+5z+6}{z^2+2z+3}$ **(d)** $\frac{6z^2+5z+4}{3z^2+2z+1}$ **(e)** z^2+z+1

2. One system (transfer) function of a LTI system with zeros $\{0, 3\}$ and poles $\{1, 2\}$ is:
(a) $\frac{z+2}{0z+3}$ **(b)** $\frac{3}{z+2}$ **(c)** $\frac{3}{z^2-3z+2}$ **(d)** $\frac{z^2-3z+2}{z^2+3}$ **(e)** $\frac{z^2-3z}{z^2-3z+2}$

3. The system function of a LTI system with impulse response $h[n] = u[n] + 2^n u[n]$ is:
(a) $\frac{z+2}{z}$ **(b)** $\frac{z+2}{z-1}$ **(c)** $\frac{z+2}{z^2-3z+2}$ **(d)** $\frac{z^2-3z}{z^2-3z+2}$ **(e)** $\frac{2z^2-3z}{z^2-3z+2}$

4. The system (transfer) function if $2^n u[n] \to \boxed{LTI} \to u[n] + 2^n u[n]$ is:
(a) $\frac{1+2z}{z+2}$ **(b)** $1 + \frac{1}{z+2}$ **(c)** $\frac{2z-3}{z-1}$ **(d)** $\frac{1}{z^2-3z+2}$ **(e)** $1 + \frac{1}{z-1}$

5. The system (transfer) function if the frequency response is $1 + 2e^{-j\omega} + 3e^{-j2\omega}$ is:
(a) $\frac{z^2+2z+3}{3z^2+2z+1}$ **(b)** $\frac{3z^2+2z+1}{z^2}$ **(c)** $\frac{z^2+2z+3}{z^2}$ **(d)** $\frac{z^2+2z+3}{z}$ **(e)** $\frac{3z^2+2z+1}{z^2+2z+3}$

6. The z-transform of $\{\underline{1}, 2, 3\} + u[n]$ is: **(a)** $1 + 2z + 3z^2 + \frac{1}{z}$
(b) $1 + 2z^{-1} + 3z^{-2} + \frac{1}{z}$ **(c)** $\frac{z^2+2z+1}{z-1}$ **(d)** $\frac{2z^3+z^2+z-3}{z^3-z^2}$ **(e)** $1 + 2z + 3z^2 + \frac{z}{z-1}$

7. If $x[n] = \cos(\frac{\pi}{2}n) + \cos(\pi n)$ then $y[n] = x[n] + x[n-1] + x[n-2] + x[n-3] =$:
(a) $\cos(\frac{\pi}{2}n)$ **(b)** $\cos(\pi n)$ **(c)** $2\cos(\frac{\pi}{2}n) + 3\cos(\pi n)$ **(d)** $4x[n]$ **(e)** 0

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8. Which of these signals is eliminated by $y[n] = x[n] - x[n-1] + x[n-2]$:
(a) 1 **(b)** $\cos(\frac{\pi}{4}n)$ **(c)** $\cos(\frac{\pi}{3}n)$ **(d)** $\cos(\frac{\pi}{2}n)$ **(e)** $\cos(\frac{2\pi}{3}n)$

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9. Which of these filters eliminates 60 Hz in a signal sampled at 240 Hz? $h[n] =$:
(a) $\{1, 1, 1\}$ **(b)** $\{1, -1, 1\}$ **(c)** $\{1, 0, 1\}$ **(d)** $\{1, 0, -1\}$ **(e)** $\{1, \sqrt{2}, 1\}$

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10. Let $x[n] = \cos(2\pi\frac{3}{25}n)$ and $y[n] = \cos(2\pi\frac{7}{25}n)$. Their correlation is:
(a) non-zero imaginary **(b)** always zero **(c)** a nonzero multiple of $\frac{2\pi}{25}$
(d) $\left(\sum x[n]^2\right)\left(\sum y[n]^2\right)$ **(e)** $\left(\sum X(k) + \sum Y(k)\right)$

For #11-#13: L=Linear; TI=Time-Invariant; C=causal; S=BIBO stable.

11. The system $y[n] = \sin(3n)x[n]$ is:
(a) L AND TI **(b)** L NOT TI **(c)** TI NOT L **(d)** NOT L; NOT TI **(e)** Can't tell

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12. The system $y[n] = x[n+1] + 2x[n-1]$ is:
(a) C AND S **(b)** C NOT S **(c)** S NOT C **(d)** NOT C; NOT S **(e)** Can't tell

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13. The system $y[n] + 2y[n-1] = 3x[n] + 4x[n-1]$ is:
(a) C AND S **(b)** C NOT S **(c)** S NOT C **(d)** NOT C; NOT S **(e)** Can't tell

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14. $(3 + j4)(1 + j)^n + (3 - 4j)(1 - j)^n$ can be rewritten as:
(a) $5\cos(\sqrt{2}n + 0.93)$ **(b)** $5(\sqrt{2})^n\cos(0.78n + 0.93)$ **(c)** $10(\sqrt{2})^n\cos(0.78n + 0.93)$
(d) $\sqrt{2}(5)^n\cos(0.93n + 0.78)$ **(e)** $2\sqrt{2}(5)^n\cos(0.93n + 0.78)$

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15. A LTI system with a zero at $\{0.95\}$ and pole at $\{-0.95\}$ acts as what kind of filter?
(a) High-pass **(b)** Low-pass **(c)** Band-pass **(d)** Band-reject

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16. An LTI system with a zero at $\{0.25\}$ and poles at $\{0.5, -0.25\}$ has impulse response
(a) $\frac{1}{3}(0.5)^n u[n]$ **(b)** $\frac{1}{2}(0.5)^n u[n] - (-0.25)^n u[n]$
(c) $\frac{1}{3}(0.5)^n u[n] + \frac{2}{3}(-0.25)^n u[n]$ **(d)** $\frac{1}{3}((0.5)^n + (0.25)^n)u[n]$

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17. The zeros of a LTI system with impulse response $h[n] = \frac{1}{4}((0.9)^n + (-0.4)^n)u[n]$ are:
(a) $\{0, 0.25\}$ **(b)** $\{1\}$ **(c)** $\{0, 1.3\}$ **(d)** $\{0.9, -0.4\}$

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18. System output spectrum is $0.5\delta(\omega + 0.25\pi) + 0.5\delta(\omega - 0.25\pi)$ for input spectrum $0.5\delta(\omega + 0.25\pi) + 0.25\delta(\omega + 0.1\pi) + 0.25\delta(\omega - 0.1\pi) + 0.5\delta(\omega - 0.25\pi)$. System has: **(a)** IIR **(b)** Poles at $\{e^{\pm j0.25\pi}\}$ **(c)** Zeros at $\{e^{\pm j0.25\pi}\}$ **(d)** Zeros at $\{e^{\pm j0.1\pi}\}$

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19. H_1 has poles $\{0, 0.2\}$ and zeros $\{0.9e^{\pm j0.5\pi}\}$. H_2 has impulse response $(-0.9)^n u[n]$. The cascade or series connection of H_1 and H_2 has: **(a)** Zeros at $\{0, 0.9e^{\pm j0.5\pi}\}$ **(b)** Poles at $\{0.9, -0.2\}$ **(c)** Zeros at $\{0.9e^{\pm j0.5\pi}\}$ **(d)** Zeros at $\{-0.7, 0.9e^{\pm j0.5\pi}\}$

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20. A causal LTI system has a single zero at $\{0\}$ and a single real pole. If $h[0] = 10$ and $h[10] = 0.04343...$ then the pole could be located at: **(a)** 0.92... **(b)** 1.373... **(c)** 0.58... **(d)** 1.158...

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21. Let $y[n] = -\sum_{k=1}^{9} y[n-k] + x[n]$. Which statement **isn't** true: **(a)** System is IIR **(b)** The system has 9 poles uniformly spaced along the unit circle except at $z = 1$ **(c)** The impulse response is not absolutely summable **(d)** The system is low-pass

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22. Impulse response satisfies $h[n] = ah[n-1] - h[n-2]$ with $|a| < 1$. The system has: **(a)** 2 real poles **(b)** 2 poles on the unit circle **(c)** 2 zeros on the unit circle **(d)** 1 pole on the unit circle and 1 pole inside the unit circle.

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23. If $H(e^{j\omega}) = 1/(1 - 0.9e^{j\theta_o}e^{-j10\omega})$, then the system has: **(a)** a single pole at $\{0.9e^{j\theta_o}\}$ **(b)** exactly 2 poles at $\{0.9e^{\pm j\theta_o}\}$ **(c)** 10 poles on the unit circle **(d)** $|POLES| = 0.9^{0.1}$

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24. System $H(z) = (1 - e^{j0.1\pi}z^{-1})(1 - e^{-j0.1\pi}z^{-1})(1 - e^{j0.11\pi}z^{-1})(1 - e^{-j0.11\pi}z^{-1})$ is: **(a)** Not BIBO stable **(b)** Band-reject **(c)** Has 4 poles **(d)** Band-pass

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25. For $y[n] = x[n] * x[n]$ ($*$ denotes convolution): **(a)** If $x[n] = \delta[n]$ then $y[n] = \delta[n]$ **(b)** If $x[n]$ is sum of 2 sinusoids, then $y[n]$ is the sum of 2 sinusoids **(c)** If $x[n]$ has 4 nonzero values, then $y[n]$ has 8 nonzero values **(d)** there are some finite-length and bounded $x[n]$ that result in unbounded $y[n]$

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26. The response of a LTI system to a unit step $u[n]$ is $Y(z) = \frac{5z^2 - 0.1z + 1}{z^2 - z}$. Then: **(a)** $h[n] = (1 + (-0.1)^n + 5^n)u[n]$ **(b)** There are 2 poles at zero and no other poles **(c)** $h[n] = \delta[n] - 0.1\delta[n+1] + 5\delta[n+2]$ **(d)** The system has poles at $\{0, 1\}$.

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(10) 27. A LTI system has $H(z) = \frac{(z-1)(z-j)(z+1)(z+j)}{(z-0.9e^{j\pi/4})(z-0.9e^{-j\pi/4})(z-0.9e^{j3\pi/4})(z-0.9e^{-j3\pi/4})}$.
Sketch the relative magnitude of its frequency response on the plot below.

$-\pi$ 0 π

(10) 28. 2 LTI systems have impulse responses $h_1[n] = (0.4)^n u[n]$ and $h_2[n] = \delta[n] - 0.4\delta[n-1]$.
Prove that the impulse response of their cascade or series connection is $h_3[n] = \delta[n]$.

DID YOU REMEMBER TO SIGN THE HONOR PLEDGE?