Test ID: TESTID Name: _____

MAT 321 **Quiz 4** Spring 2026

Unless otherwise indicated, all signals and systems will be assumed to be discrete time, with time values given as all integer multiples of one sample.

1. Let $\mathbf{u}$ be the two-sided phasor signal with values $e^{i\theta t}$, and $\mathbf{v}$ be the one-sided phasor signal with the same values but zero for $t < 0$, and $\mathbf{x}$ be the finite stretch of a phasor, with the same values as $\mathbf{v}$ but zero for $t \geq n$, with $n = 32$. Also, let $\mathbf{y}$ be the windowed phasor signal which is $\mathbf{x}$ multiplied by the Hamming window. Which signal has the best *resolution* of the frequency θ?

   a) $\mathbf{u}$ b) $\mathbf{v}$ c) $\mathbf{x}$ d) $\mathbf{y}$ e) none of them

   Correct Answer: $\mathbf{u}$

2. Same signals as in the previous question. Which signals have infinitely many frequencies with non-zero contribution to the spectrum (or frequency content) of the signal?

   a) $\mathbf{v}$ and $\mathbf{x}$ only b) $\mathbf{v}$ only c) all of them d) all but $\mathbf{u}$ e) none of them

   Correct Answer: all but $\mathbf{u}$

3. Same signals as in the previous question. Which signals have frequency content graph with more than one critical point, where the graph has derivative zero?

   a) $\mathbf{u}$ and $\mathbf{v}$ only b) $\mathbf{x}$ only c) $\mathbf{x}$ and $\mathbf{y}$ only d) $\mathbf{y}$ only e) all of them

   Correct Answer: $\mathbf{x}$ and $\mathbf{y}$ only

4. Same signals as in the previous question. If we sample the magnitude frequency content of the signal $\mathbf{x}$ at the ω-values $\frac{2\pi}{N}k$ for $k = 0, 1, \ldots, n-1$ we get the magnitude of ...

   a) a Fourier coefficient b) a Z-transform c) a Transfer function d) a DFT e) none of these

   Correct Answer: a DFT

5. Let $\mathbf{w}$ be the rectangular window signal with $w_t = 1$ for $t = 0, \ldots, n-1$ and 0 otherwise. Let $\mathbf{x}$ be the phasor $x_t = e^{i\theta t}$ and let $\mathbf{y}$ be the product $y_t = x_t w_t$. Also, let the Z-transforms of these signals be given as $\mathcal{F}_{\mathbf{x}}(z)$, $\mathcal{F}_{\mathbf{y}}(z)$, and $\mathcal{F}_{\mathbf{w}}(z)$. Then the Z-transform of $\mathbf{y}$ can be written as:

   a) $\mathcal{F}_{\mathbf{w}}(i\theta z)$ b) $\mathcal{F}_{\mathbf{w}}(e^{-i\theta} z)$ c) $\mathcal{F}_{\mathbf{x}}(i\theta z)$ d) $\mathcal{F}_{\mathbf{x}}(z)\mathcal{F}_{\mathbf{w}}(z)$ e) $\mathcal{F}_{\mathbf{x}}(e^{-i\theta} z)$

   Correct Answer: $\mathcal{F}_{\mathbf{w}}(e^{-i\theta} z)$

6. Same signals $\mathbf{x}$, $\mathbf{y}$, and $\mathbf{w}$ as in the previous problem. Also let the frequency content functions, or DTFT's, of these signals be $X(\omega)$, $Y(\omega)$, and $W(\omega)$. Then $Y(\omega)$ can also be written as:

   a) $W(\omega - \theta)$ b) $W(\omega + \theta)$ c) $X(\omega)W(\omega)$ d) $X(\omega)W(\theta)$ e) $X(\omega - \theta)$

   Correct Answer: $W(\omega - \theta)$

7. Suppose we have two discrete time signals $\mathbf{x}$ and $\mathbf{y}$, with frequency contents (DTFT) $X(\omega)$ and $Y(\omega)$, and let $\mathbf{w} = \mathbf{x} * \mathbf{y}$ be the convolution of the signals $\mathbf{x}$ and $\mathbf{y}$. If $X(\omega) = 1 - \sin(\omega)$ and $Y(\omega) = 1 + \sin(\omega)$ then what is the frequency content $W(\omega)$ of $\mathbf{w}$?

   a) $\cos^2 \omega$ b) $\sin(\omega) * \cos(\omega)$ c) $\cos(\omega) * \cos(\omega)$ d) $2\cos(\omega)$ e) 2

   Correct Answer: $\cos^2 \omega$

8. Let $\mathbf{w}$ be the rectangular window signal with $w_t = 1$ for $t = 0, \ldots, n-1$ and 0 otherwise. Let $\mathbf{x} = \mathbf{w} * \mathbf{w}$ be the convolution of $\mathbf{w}$ with itself, and let $\mathbf{y} = \mathbf{x} * \mathbf{w}$ be the convolution of $\mathbf{x}$ and $\mathbf{w}$. Find y_{n-1}.

   a) $n(n-1)$ b) n c) n^2 d) $\frac{n(n-1)}{2}$ e) $\frac{n(n+1)}{2}$

   Correct Answer: $\frac{n(n+1)}{2}$