Take Test: Test 1 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
Multiple Attempts	This Test allows 3 attempts. This is attempt number 1.
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	This test does not allow backtracking. Changes to the answer after submission are prohibited.

Close Window

⚠ Moving to the next question prevents changes to this answer.

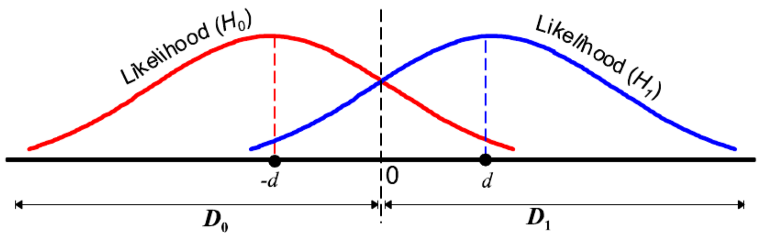
Question **1** of **10**

Question 1

10 points Save Answer

C

. Consider a binary communication system which uses the following two equiprobable signals $s_0(t)$ and $s_1(t)$ of equal energy E. The signals are transmitted over a communication channel which adds white Gaussian noise having a double-sided power spectral density of 10^{-6} W/Hz. The constellation diagram is given below, where the decision regions are also shown.



If the forward transition matrix $\mathbb{F}$ of the equivalent discrete channel is

$$\mathbb{F} = \begin{bmatrix} 0.994, & 0.006 \\ 0.006, & 0.994 \end{bmatrix}$$

then

(a) $d = 12.5 \times 10^{-3}$;

(b) $d = 6.25 \times 10^{-3}$;

(c) $d = 2.5 \times 10^{-3}$;

(d) $d = 5 \times 10^{-3}$;

(e) none of the above.

- a
- b
- c
- d
- e

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Question **1** of **10**

Close Window

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Question **2** of **10**

Question 2 $P(X(t)>0) = \int_0^\infty f(x)\,dx = T\{\frac{d}{\sigma_x}\}$

10 points Save Answer

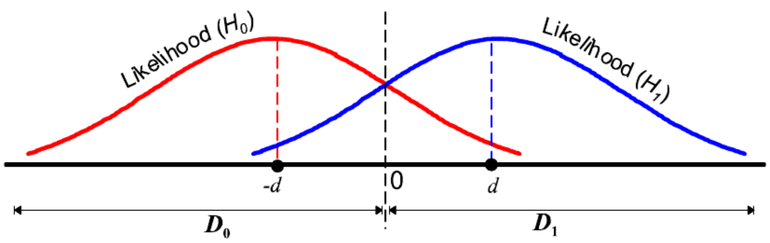
$\sigma_x = \sqrt{10^{-6}} = 10^{-3}$

C

$T\{\frac{d}{10^{-3}}\} = 0.006 \Rightarrow \frac{d}{10^{-3}} = 2.5 \Rightarrow d = 2.5\times10^{-3}$

Consider a binary communication system which uses the following two equiprobable signals $s_0(t)$ and $s_1(t)$ of equal energy E. The signals are transmitted over a communication channel which adds white Gaussian noise having a double-sided power spectral density of 10^{-6} W/Hz. The constellation diagram is given below, where the decision regions are also shown.

$E = d^2 = 6.25\times10^{-6}$



If the forward transition matrix $\mathbb{F}$ of the equivalent discrete channel is

$$\mathbb{F} = \begin{bmatrix} 0.994, & 0.006 \\ 0.006, & 0.994 \end{bmatrix}$$

the energy E of the signals $s_0(t)$ and $s_1(t)$ is

(a) 2.25×10^{-6};

(b) 4.26×10^{-6};

(c) 6.25×10^{-6};

(d) 8.25×10^{-6};

(e) none of the above.

- a
- b
- c
- d
- e

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Question **2** of **10**

Close Window

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Question **3** of **10**

Question 3

10 points Save Answer

C

A matched filter is used to detect the signal $s(t)$

$$\text{where } s(t) = 3\,\mathrm{rect}\left\{\frac{t - 10\times10^{-3}}{20\times10^{-3}}\right\}$$

which is corrupted by additive white Gaussian noise of double-sided power spectral density 10^{-3} W/Hz. The maximum Signal-to-Noise ratio at the filter output is

(a) 9000;

(b) 1800;

(c) 180;

(d) 90;

(e) none of the above.

$P_s = 3^2 = 9$

$P_n = \frac{N_0}{2}\cdot 2B = 10^{-3} \times \frac{1}{20\times10^{-3}} = \frac{1}{20}$

○ a

○ b

○ c

○ d

e

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Question **3** of **10**

Close Window

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Question **4** of **10**

Question 4

10 points Save Answer

B

The impulse response of an approximate-matched filter, matched (at time T_o) to the signal $\Lambda\left\{\frac{\tau}{2T}\right\}$ in the presence of non-white noise of autocorrelation function $R_{nn}(\tau) = \Lambda\left\{\frac{\tau}{2T}\right\}$ is

(a) $\delta(t)$;

(b) $\delta(t - T_o)$;

(c) $\text{sinc}^2(f2T_o)$;

(d) $2T_o\text{sinc}^2(f2T_o)$;

(e) none of the above.

$$\hat{H}_o(f) = \frac{S_{xx}(f)\, e^{-j2\pi f T_o}}{S_{nn}(f)} = \frac{\Lambda\{\frac{\tau}{2T}\}\, e^{-j2\pi f T_o}}{\Lambda\{\frac{\tau}{2T}\}} = e^{-j2\pi f T_o}$$

$$h_o(t) = \delta(t - T_o)$$

- a
- b
- c
- d
- e

⚠ Moving to the next question prevents changes to this answer.

Question **4** of **10** >

Close Window

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Question **5** of **10**

Question 5

10 points Save Answer

E

With reference to 'multi-user (MU) CDMA receivers', which of the following statements is correct?

(a) A RAKE receiver is a multi-user receiver.

(b) A ~~multi-user~~ RAKE receiver is used to resolve paths (in a multipath environment), delayed by more than the chip period T_c.

(c) Decorrelating MU receiver is an optimum multi-user receiver.

(d) A minimum-mse MU receiver requires no knowledge the cross-correlation matrix of the PN-signals.

(e) None of the above.

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question **5** of **10**

Close Window

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Close Window

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Question **6** of **10**

Question 6

10 points Save Answer

A Consider an array of 4 antennas with Cartesian coordinates given by the following matrix

$$\begin{bmatrix} -2, & 2, & 2, & -2 \\ -0.5, & -0.5, & 1, & 0.5 \\ 0, & 0, & 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

The array aperture is $\sqrt{4^2+1.5^2}$

(a) 4.272;

(b) 4.0311;

(c) 4;

(d) 1.5;

(e) none of the above.

- a
- b
- c
- d

- e

Moving to the next question prevents changes to this answer.

Question **6** of **10**

Close Window

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Close Window

Moving to the next question prevents changes to this answer.

Question **7** of **10**

Question 7

10 points Save Answer

D

With reference to SISO wireless channels, which of the following statements is correct?

(a) If the displacement of a wireless receiver is less than the "coherence distance" D_{coh} then the channel experiences small-scale fading. x

(b) The "coherence distance" D_{coh} is the largest distance that a wireless receiver can move with the channel appearing to be variable. x

(c) If the transfer function of a wireless channel varies with time then "space-selectivity" and "spatial-coherence" are identical concepts. x

(d) "Fast fading" implies that the magnitude of the transfer function of a wireless channel varies with time in the interval $nT_{cs} < t < (n+1)\,T_{cs}$ with T_{cs} denoting a channel symbol duration and n is an integer. v

(e) None of the above.

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question **7** of **10**

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$T_{spread} > T_c$ f-selective

$T_{spread} < T_c$ flat

$T_{coh} > T_c$ slow

$T_{coh} < T_c$ fast

Close Window

Moving to the next question prevents changes to this answer.

Question **8** of **10**

Question 8

10 points Save Answer

C

$T_{coh} = \frac{1}{B_D} = 6.25 \times 10^{-8} s$

If $B_D = 16MHz$ denotes the Doppler spread, B_{coh} represents the coherence bandwidth and T_c is the chip period, then in a frequency selective fast fading CDMA channel which of the following is correct?

(a) $T_c = 61ns$ and $B_{\text{coh}} = 3MHz$
(b) $T_c = 61ns$ and $B_{\text{coh}} = 100MHz$
(c) $T_c = 244ns$ and $B_{\text{coh}} = 3MHz$
(d) $T_c = 244ns$ and $B_{\text{coh}} = 100MHz$
(e) None of the above.

$T_{coh} = \frac{1}{B_D}$

$T_{spread} = \frac{1}{B_{coh}}$

$D_{coh} = \frac{1}{K_{spread}}$

fast: $T_{coh} < T_c \Rightarrow T_c = 244ns$

f-sel: $T_{spread} > T_c$

$\Rightarrow \frac{1}{B_{coh}} > T_c$

$\Rightarrow B_{coh} = 3MHz$

- a
- b
- c
- d
- e

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Question **8** of **10**

Close Window

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Question **9** of **10**

Question 9

10 points Save Answer

d

Consider that one of the paths from the transmitter of a CDMA user arrives at the reference point of an antenna array CDMA receiver from direction (azimuth, elevation)= $(60°, 0°)$. For this path, if the Cartesian coordinates of the antenna array elements are given by the columns of the following matrix

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3] = \begin{bmatrix} -1, & 0, & +1 \\ 0, & 0, & 0 \\ 0, & 0, & 0 \end{bmatrix} \text{ in units of half-wavelength,}$$

then manifold vector is

$S = e^{-j \underline{r}^T \underline{k}(\theta,\phi)}$

$k = [\cos\theta\cos\phi, \sin\theta\cos\phi, \sin\phi]^T \pi$

(a) $\underline{S}(\theta) = [j, \;\; 0 \;\; -j]$;
(b) $\underline{S}(\theta) = [-j, \;\; 0 \;\; j]$;
(c) $\underline{S}(\theta) = [j, \;\; 1 \;\; -j]$;
(d) $\underline{S}(\theta) = [-j, \;\; 1 \;\; j]$;
(e) none of the above.

$k = \begin{bmatrix} \frac{1}{2}\pi \\ \frac{\sqrt{3}}{2}\pi \\ 0 \end{bmatrix}$

$e^{-jr^Tk} = e^{-j\begin{bmatrix} -1 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}\begin{bmatrix} \frac{1}{2}\pi \\ \frac{\sqrt{3}}{2}\pi \\ 0 \end{bmatrix}}$

$= [e^{j\frac{\pi}{2}} \;\; 0 \;\; e^{-j\frac{\pi}{2}}]$

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e

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Question **9** of **10**

Close Window

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Close Window | Save and Submit

Click **Submit** to complete this assessment.

Question **10** of **10**

Question 10

10 points Save Answer

E

Consider a uniform linear array of N antennas. The carrier frequency is 2.4 GHz and the manifold vector for a signal with Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$$[-0.5902 - 0.8072i, 0.2089 + 0.9779i, 0.2089 - 0.9779i, -0.5902 + 0.8072i]^T$$

The origin of the Cartesian coordinates (array reference point) is the

(a) 1st antenna;

(b) 2nd antenna;

(c) 3rd antenna;

(d) 4th antenna;

(e) none of the above.

$S = e^{-j r^T k(\theta, \phi)}$

- a
- b
- c
- d
- e

Click **Submit** to complete this assessment.

Question **10** of **10**

Close Window

Save and Submit

You recently left the test 'Test 1 (2018-19)' without submitting it. Return to the test and click Save and Submit or contact your instructor for assistance.The timer will continue to run.

Take Test: Test 2 (2018-19)

Test Information

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$$\begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix}$$

$$\begin{bmatrix} -0.5 & 0.5j \\ 0.5j & -0.5 \end{bmatrix}\begin{bmatrix} 0.01j \\ -0.1 \end{bmatrix} = \begin{bmatrix} -0.005j - 0.05j \\ -0.005 + 0.05 \end{bmatrix} = \begin{bmatrix} -0.055j \\ 0.045 \end{bmatrix}$$

⚠ Moving to the next question prevents changes to this answer.

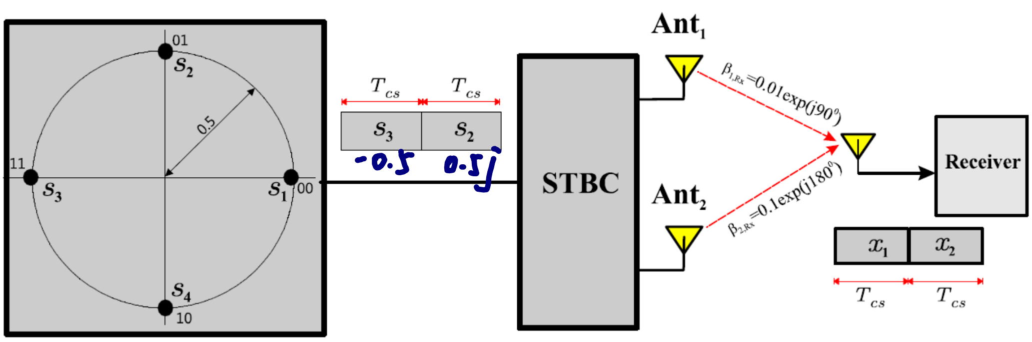
Question **1** of **8**

Question 1

D

12 points Save Answer

Consider the QPSK MISO system of 2 Tx antennas operating in a frequency flat wireless channel as shown the following figure:



If the QPSK symbols $[s_3, s_2]$ are transmitted using the above "Space-Time Block Coder" (STBC) then the receiver's input $[x_1, x_2]$, ignoring the noise, is

(a) $[0.045\text{j}, \quad -0.055]$;
(b) $[0.045, \quad -0.055\text{j}]$;
(c) $[-0.055, \quad 0.045\text{j}]$;
(d) $[-0.055\text{j}, \quad 0.045]$;
(e) none of the above.

- a
- b

- c
- d
- e

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Question **1** of **8**

Take Test: Test 2 (2018-19)

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Question **2** of **8**

$\lambda = \frac{c}{f} = 0.125\,m$

Question 2

aperture $= \sqrt{2 \times (0.6188 \frac{\lambda}{2})^2} = 0.547\,m$

12 points Save Answer

A

Consider a uniform linear array of N antennas with half-wavelength spacing. The carrier frequency is 2.4 GHz and the manifold vector for a signal with Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$[-0.1125-0.9936i, 0.6661-0.7458i, 1.0000+0.0000i, 0.6661+0.7458i, -0.1125+0.9936i]^T$

The array aperture is

$S = e^{-j\pi r_x \cos\theta}$ $\quad S = e^{-j\frac{\sqrt{3}}{2}\pi r_x}$

- 25 cm;
- 31.25 cm;
- 50 cm;
- 62.5 cm;
- none of the above

$\cos \frac{\sqrt{3}}{2}\pi r_{x_1} = -0.1125$

$\frac{\sqrt{3}}{2}\pi r_{x_1} = 1.6835$

$r_{x_1} = 0.6188$

Consider a uniform array of N antennas. The carrier frequency is 2.4 GHz and the manifold vector for a signal with Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$[-0.1125-0.9936i, 0.6661-0.7458i, 1.0000+0.0000i, 0.6661+0.7458i, -0.1125+0.9936i]^T$

$\cos \frac{\sqrt{3}}{2}\pi r_{x_2} = 0.6661$

The array aperture is

$\frac{\sqrt{3}}{2}\pi r_{x_2} = 0.8418$

- 25 cm;
- 31.25 cm;
- 50 cm;
- 62.5 cm;
- none of the above

$r_{x_2} = 0.3094$

○ a

- b
- c
- d
- e

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Question **2** of **8**

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$$r_{virtual} = T_x \otimes 1_N^T + 1_N^T \otimes R_x \qquad N=2 \Rightarrow 1_N^T = [1 \quad 1]$$

$$= \begin{bmatrix} -0.5[1 \quad 1] & 0.5[1 \quad 1] \end{bmatrix} + \begin{bmatrix} 1[-2 \quad 2] & 1[-2 \quad 2] \end{bmatrix}$$

⚠ Moving to the next question prevents changes to this answer.

Question **3** of **8**

$$= \begin{bmatrix} -2 & 2 & -2 & 2 \\ -0.5 & -0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Question 3 **12 points** Save Answer

A

Consider a MIMO wireless communication system, where the Cartesian coordinates of the Tx and Rx antenna arrays elements are given by the columns of the following matrices

$$\text{Tx} : [\overline{r}_1, \overline{r}_2] = \begin{bmatrix} 0, & 0 \\ -0.5, & 0.5 \\ 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

$$\text{Rx} : [\underline{r}_1, \underline{r}_2] = \begin{bmatrix} -2, & +2 \\ 0, & 0 \\ 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

Which of the following statements associated with the geometry (Cartesian coordinates) of its virtual MISO wireless communication system is correct?

(a) $\begin{bmatrix} -2, & 2, & -2, & 2 \\ -0.5, & -0.5, & 0.5, & 0.5 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a planar array).

(b) $\begin{bmatrix} -0.5, & -0.5, & 0.5, & 0.5 \\ -2, & 2, & -2, & 2 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a planar array).

(c) $\begin{bmatrix} -2.5, & 1.5, & -1.5, & 2.5 \\ 0, & 0, & 0, & 0 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a linear array).

(d) $\begin{bmatrix} 0, & 0, & 0, & 0 \\ -2.5, & 1.5, & -1.5, & 2.5 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a linear array).

(e) None of the above

(e) None of the above.

- a
- b
- c
- d
- e

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Question **3** of **8**

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Question **4** of **8**

Question 4

12 points Save Answer

Q4

Consider a linear array of 5 Rx-antennas having the following Cartesian coordinates:

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3, \underline{r}_4, \underline{r}_5] = \begin{bmatrix} -5, & -1, & +1, & +2, & +3 \\ 0, & 0, & 0, & 0, & 0, \\ 0, & 0, & 0, & 0, & 0, \end{bmatrix} \text{ in units of half-wavelength.}$$

The rate of change of the arclength $\dot{s}(\theta)$ of the array manifold for a source with Direction-of-Arrival (azimuth) $\theta = 30°$ is

(a) $\dot{s}(30°) = 19.631$;

(b) $\dot{s}(30°) = 9.9346$;

(c) $\dot{s}(30°) = 5.4414$;

(d) $\dot{s}(30°) = 3.1623$;

(e) none of the above.

$\dot{S}(\theta) = \|r_x\| \sin\theta \, \pi$

$= \sqrt{5^2+1^2+1^2+2^2+3^2}$

$= 9.93546$

- a
- b
- c
- d
- e

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Question **4** of **8**

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Question **5** of **8**

Question 5

13 points Save Answer

C

Consider an antenna array systems of 5 elements operating in the presence of one desired and two co-channel interfering signals all of power equal to $P_s = 1$. The power of the noise is equal to $\sigma_n^2 = 10$. If $\mathbb{R}_{xx}$ is the theoretical covariance matrix of the received signal vector $x(t)$ then which of the following statements is correct?

(a) The rank of $\mathbb{R}_{xx}$ is equal to 2. x

(b) The rank of $\mathbb{R}_{xx}$ is equal to 3. x

(c) The rank of $\mathbb{R}_{xx}$ is equal to 5. ✓

(d) The minimum eigenvalue of $\mathbb{R}_{xx}$ is equal to P_s. x

(e) The principal eigenvalue of $\mathbb{R}_{xx}$ is equal to σ_n^2. x

- a
- b
- c
- d
- e

⚠ Moving to the next question prevents changes to this answer.

Question **5** of **8**

Take Test: Test 2 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
Multiple Attempts	This Test allows 3 attempts. This is attempt number 1.
Force Completion	This Test can be saved and resumed at any point until time has expired. The timer will continue to run if you leave the test.
	This test does not allow backtracking. Changes to the answer after submission are prohibited.

⚠ Moving to the next question prevents changes to this answer.

Question **6** of **8**

Question 6

13 points Save Answer

Consider uniform linear antenna array system of 5 elements of halfwavelength spacing operating in the presence of one desired and two co-channel interfering signals all of power equal to $P_s = 0.9$. The power of the noise is equal to $\sigma_n^2 = 1$. If $\mathbb{R}_{xx}$ is the theoretical covariance matrix of the received signal vector $\underline{x}(t)$ then which of the following statements is correct?

(a) The rank of $\mathbb{R}_{xx}$ is equal to 2.

(b) The rank of $\mathbb{R}_{xx}$ is equal to 3.

(c) The minimum eigenvalue of $\mathbb{R}_{xx}$ is equal to P_s.

(d) The principal eigenvalue of $\mathbb{R}_{xx}$ is equal to 3.9.

(e) None of the above.

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e

⚠ Moving to the next question prevents changes to this answer.

Question **6** of **8**

Take Test: Test 2 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
Multiple Attempts	This Test allows 3 attempts. This is attempt number 1.
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⚠ Moving to the next question prevents changes to this answer.

Question **7** of **8**

Question 7

13 points Save Answer

Consider an antenna array systems of N elements operating in the presence M co-channel sources $(M < N)$. If $\underline{S}_i$ is the manifold vector associated with the i^{th} source and $\mathbb{E}_s$ and $\mathbb{E}_n$ denote the matrices with columns the signal eigenvectors and the noise eigenvectors respectively of data covariance matrix $\mathbb{R}_{xx}$ then which of the following expresssions is correct?

(a) $\mathbb{E}_n.\mathbb{E}_n^H.\underline{S}_i = \underline{S}_i$ ✗

(b) $\mathbb{E}_s.\mathbb{E}_s^H.\underline{S}_i = \underline{0}$ ✗

(c) $\left(\mathbb{I}_N - \mathbb{E}_n.\mathbb{E}_n^H\right).\underline{S}_i = \underline{0}$ ✗

(d) $\left(\mathbb{I}_N - \mathbb{E}_s.\mathbb{E}_s^H\right).\underline{S}_i = \underline{S}_i$ ✗

(e) None of the above.

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e

⚠ Moving to the next question prevents changes to this answer.

Question **7** of **8**

Take Test: Test 2 (2018-19)

Test Information

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Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
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Save and Submit

Click **Submit** to complete this assessment.

Question **8** of **8**

Question 8

13 points Save Answer

Consider a single transmitter whose signal arrives at the receiver via 4 coherent (fully correlated) multipaths. The receiver consists of a uniform linear antenna array of 10 antennas with half-wavelength interantenna spacing. The dimensionality of the signal subspace is:

(a) 1.
(b) 2.
(c) 3.
(d) 4.
(e) 10.

- a
- b
- c
- d
- e

Click **Submit** to complete this assessment.

Question **8** of **8**

Save and Submit

Take Test: Test 3 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
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⚠ Moving to the next question prevents changes to this answer.

Question **1** of **12**

Question 1

9 points Save Answer

C

Consider a SIMO communication system operating in the presence of a desired signal with signal power 100mW and one interferer with double-sided PSD(f) of 10^{-2} W/Hz. The noise is assumed to be AWGN with double-sided PSD(f) of 10^{-2} W/Hz. The receiver employs a complete intereference cancellation subspace beamformer and utilises a ULA of 10 antennas. If the channel bandwidth is 8 kHz what is the system/channel capacity?

×2

(a) 0 bits/sec. $C = B\log_2(1 + N \cdot SNIR)$

(b) 14.4 bits/sec.

(c) 72 bits/sec.

(d) 144 bits/sec.

(e) infinity bits/sec.

- a
- b
- c
- d
- e

⚠ Moving to the next question prevents changes to this answer.

Question **1** of **12**

Take Test: Test 3 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
Multiple Attempts	This Test allows 3 attempts. This is attempt number 1.
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Moving to the next question prevents changes to this answer.

Question **2** of **12**

Question 2

8 points Save Answer

D

With reference to a Wiener-Hopf beamformer, which of the following statements is correct?

(a) It is a superresolution beamformer. x

(b) It is robust to errors associated with the direction of the desired signal. x

(c) It provides, asymptotically, complete interference cancellation. x

(d) It is optimum with respect to SNIR criterion. ✓

(e) None of the above.

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question **2** of **12**

Take Test: Test 3 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
Multiple Attempts	This Test allows 3 attempts. This is attempt number 1.
Force Completion	This Test can be saved and resumed at any point until time has expired. The timer will continue to run if you leave the test.
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$$\begin{bmatrix} -1.5 \\ -0.5 \\ 0.5 \\ 1.5 \end{bmatrix} \quad \begin{bmatrix} \frac{\sqrt{3}}{2}\pi \\ \frac{1}{2}\pi \\ 0 \end{bmatrix}$$

⚠ Moving to the next question prevents changes to this answer.

Question 3 8 points Save Answer

$\frac{\lambda}{2} = \frac{c}{2f} = 0.0625m$ $\quad r_{Rx} = [-1.5 \quad -0.5 \quad 0.5 \quad 1.5]$

B

Consider a beamformer which employes the following uniform linear array of N antennas.

$w = S(\theta_{m1}) = e^{-j \underline{r}^T \underline{k}}$, $\underline{k} = \pi[\cos\theta\cos\phi, \sin\theta\cos\phi, \sin\phi]$

$$\begin{bmatrix} -0.0938, & -0.0313, & 0.0313, & 0.0938 \\ 0, & 0, & 0, & 0 \\ 0, & 0, & 0, & 0 \end{bmatrix} \text{ in metres}$$

$S = e^{-j r_x \pi \cos\theta} = e^{-j r_x \pi \frac{\sqrt{3}}{2}}$

The carrier frequency is 2.4 GHz and to steer the main lobe of the array towards the direction $(\theta = 30^0, \phi = 0^0)$, the weight vector $\underline{w}$ should be

(a) $[1, \quad 1, \quad 1, \quad 1]^T$; $= [-0.5902 - 0.8072i, 0.2089 + 0.9779i, 0.2089 - 0.9779i, -0.5902 + 0.8072i]$

(b) $[-0.5902 - 0.8072i, 0.2089 + 0.9779i, 0.2089 - 0.9779i, -0.5902 + 0.8072i]^T$;

(c) $[+0.5902 - 0.8072i, -0.2089 + 0.9779i, -0.2089 - 0.9779i, +0.5902 + 0.8072i]^T$;

(d) $[-0.5902 + 0.8072i, 0.2089 - 0.9779i, 0.2089 + 0.9779i, -0.5902 - 0.8072i]^T$;

(e) none of the above

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e

Moving to the next question prevents changes to this answer.

Question **3** of **12**

Take Test: Test 3 (2018-19)

Test Information

Description	
Instructions	
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⚠ Moving to the next question prevents changes to this answer.

Question **4** of **12**

Question 4

8 points Save Answer

C

Consider a beamformer which employes a uniform linear array of N antennas and uses the following weight vector:

$$[-0.1125 + 0.9936i, 0.6661 + 0.7458i, 1.0000, 0.6661 - 0.7458i, -0.1125 - 0.9936i]^T.$$

If the channel noise is additive white Gaussian noise with power $\sigma_n^2 = 0.001$ then the noise power at the beamformer's output is:

(a) 0.00025;

$P_n = \sigma^2 w^T w = 5\sigma^2$

(b) 0.0005;

(c) 0.005;

(d) 0.025;

(e) none of the above.

- a
- b
- c
- d
- e

⚠ Moving to the next question prevents changes to this answer.

Question **4** of **12**

Take Test: Test 3 (2018-19)

Test Information

Description	
Instructions	
Timed Test	This test has a time limit of 1 hour.This test will save and be submitted automatically when the time expires. Warnings appear when **half the time**, **5 minutes**, **1 minute**, and **30 seconds** remain.
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Moving to the next question prevents changes to this answer.

Question 5

9 points Save Answer

D

Consider a beamformer which employs a uniform array of N antennas and operates in the presence of a single signal with direction $(\theta = 30^0, \phi = 0^0)$. The carrier frequency is 2.4 GHz and the manifold vector for the Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$$[-0.1125 + 0.9936i, 0.6661 + 0.7458i, 1.0000, 0.6661 - 0.7458i, -0.1125 - 0.9936i]^T$$

$w = S(\theta_{main\text{-}lobe})$

Consider that the array steers its main lobe towards the direction $(\theta = 30^0, \phi = 0^0)$, the power of the received signal is 1 and the channel noise is additive white Gaussian noise of power 0.01. If at the output of the beamformer P_{out} is the power of the desired signal and SNR_{out} denotes the signal-to-noise ratio, which of the following statements is correct?

$P_{d.out} = P_1 (w^H S)^2 = 25 P_1 = 25$

$P_{n.out} = \sigma_n^2 (w^H w) = 5\sigma_n^2 = 0.05$

(a) P_{out}=5 and SNR_{out}=100.
(b) P_{out}=25 and SNR_{out}=100.
(c) P_{out}=5 and SNR_{out}=500.
(d) P_{out}=25 and SNR_{out}=500.
(e) None of the above.

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question **5** of **12**

Take Test: Test 3 (2018-19)

Test Information

Description	
Instructions	
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Moving to the next question prevents changes to this answer. Question **6** of **12**

Question 6

8 points Save Answer

D

For a uniform linear array of 5 sensors operating at 2.4GHz frequency with an inter-antenna spacing 6.25cm the beamwidth is

(a) 11.537°;

(b) 23.074°;

(c) 45.537°;

(d) 47.156°;

(e) none of the above.

$$\text{beamwidth} = 2\sin^{-1}\frac{\lambda}{ND}\cdot\frac{180}{\pi}$$

$$= 47.156^\circ$$

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer. Question **6** of **12**

Take Test: Test 3 (2018-19)

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⚠ Moving to the next question prevents changes to this answer.

Question **7** of **12**

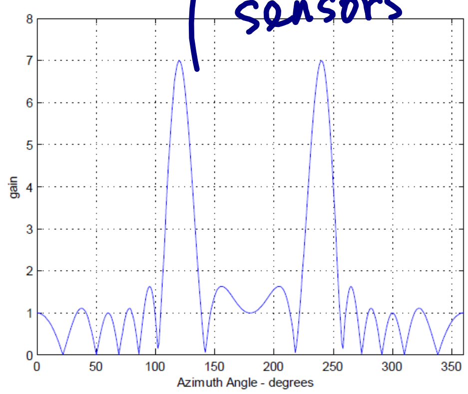
Question 7 **8 points** Save Answer

7,

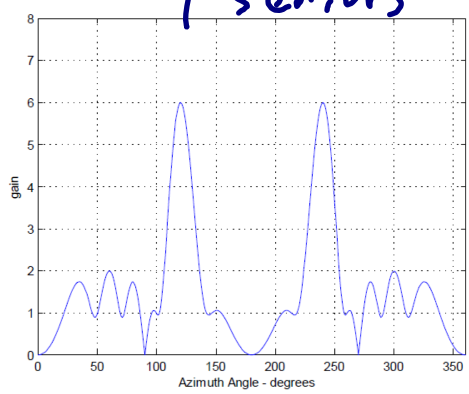
The two figures below show the array patterns of two different linear arrays.

7 sensors

7 8ensors



(1)



(2)

Which of the following statements is correct?

(a) In Figure (1) the array is a uniform linear array of 6 sensors.
(b) In Figure (1) the array has no weights (i.e. weights equal to 1)
(c) In Figure (2) the array is a uniform linear array of 6 sensors.
(d) In Figure (2) the array has no weights (i.e. weights equal to 1)
(e) None of the above.

- a
- b
- c

- d
- e

Moving to the next question prevents changes to this answer.

Question **7** of **12**

Take Test: Test 3 (2018-19)

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uniform (linear) array:

$S = e^{-j r_x \pi \cos\theta} = e^{-j r_x \pi \frac{\sqrt{3}}{2}}$

$= [0.666 - j0.746,\ -0.913 + j0.409,\ 1,\ 0.666 + j0.746,\ -0.913 - j0.409]$

⚠ Moving to the next question prevents changes to this answer.

Question 8 $\underline{w}_{wh} = c R_{xx}^{-1} S_{desired}$

9 points Save Answer

Consider a beamformer which employs a uniform array of N antennas with half-wavlength interantenna spacing. This beamformer operates in the presence of a desired signal with direction $(\theta = 30^0, \phi = 0^0)$ and two unknown co-channel interferences. The covariance matrix of the received signal $\underline{x}(t)$ has the covariance matrix of the received signal $\underline{x}(t)$ is

$S = e^{-j \underline{r}^T \underline{k}}$, $\underline{k} = \pi[\cos\theta\cos\phi, \sin\theta\cos\phi, \sin\phi]^T$

7.8000 - 0.0000i, -0.7327 + 2.1623i, 5.5846 - 3.7594i, 2.9266 + 4.3835i, 1.3609 - 3.8965i;
-0.7327 - 2.1623i, 7.8000 + 0.0000i, -0.7327 + 2.1623i, 5.5846 - 3.7594i, 2.9266 + 4.3835i;
5.5846 + 3.7594i, -0.7327 - 2.1623i, 7.8000 + 0.0000i, -0.7327 + 2.1623i, 5.5846 - 3.7594i;
2.9266 - 4.3835i, 5.5846 + 3.7594i, -0.7327 - 2.1623i, 7.8000 - 0.0000i, -0.7327 + 2.1623i;
1.3609 + 3.8965i, 2.9266 - 4.3835i, 5.5846 + 3.7594i, -0.7327 - 2.1623i, 7.8000 + 0.0000i;

(please copy the above matrix to MATLAB)

The Wiener-Hopf weight vector, normalised to have unity norm magnitude, is

(a) $[0.4326\text{-}0.3057i,\text{-}0.3849\text{-}0.2593i,\text{-}0.0903\text{+}0.0000i,\text{-}0.3849\text{-}0.2593i,0.4326\text{-}0.3057i]^T$

(b) $[0.4326\text{+}0.3057i,0.3849\text{+}0.2593i,\text{-}0.0903\text{+}0.0000i,0.3849\text{-}0.2593i,0.4326\text{-}0.3057i]^T$

(c) $[0.4326\text{+}0.3057i,\text{-}0.3849\text{-}0.2593i,\text{-}0.0903\text{+}0.0000i,\text{-}0.3849\text{+}0.2593i,0.4326\text{-}0.3057i]^T$

(d)

(d) [0.4326+0.3057i,-0.3849+0.2593i,-0.0903+0.0000i,-0.3849-0.2593i,0.4326-0.3057i]

(e) None of the above

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e

⚠ Moving to the next question prevents changes to this answer.

Question **8** of **12** >

Take Test: Test 3 (2018-19)

Test Information

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Moving to the next question prevents changes to this answer.

Question **9** of **12**

Question 9

9 points Save Answer

Consider a beamformer which employs a uniform array of N antennas with half-wavelength inter-antenna spacing. This beamformer operates in the presence of a desired signal with direction $(\theta = 30^0, \phi = 0^0)$ and two co-channel interferences of known directions $(50°, 0)$ and $(120°, 0)$. The weight vector, normalised to have unity norm magnitude, to complete supression of the two cochannel interferences is

(a) $[0.4391+0.1619i, -0.3796-0.2400i, 0.3981-0.0000i, -0.3796+0.2400i, 0.4391-0.1619i]^T$

(b) $[0.4391-0.1619i, -0.3796-0.2400i, 0.3981-0.0000i, -0.3796+0.2400i, 0.4391+0.1619i]^T$

(c) $[0.4391-0.1619i, 0.3796-0.2400i, 0.3981-0.0000i, 0.3796+0.2400i, 0.4391+0.1619i]^T$

(d) $[0.4391-0.1619i, 0.3796+0.2400i, 0.3981-0.0000i, 0.3796-0.2400i, 0.4391+0.1619i]^T$

(e) None of the above

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question **9** of **12**

Take Test: Test 3 (2018-19)

Test Information

Description	
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Moving to the next question prevents changes to this answer.

Question 10

8 points Save Answer

Consider a linear array of 5 antennas with locations

$$[-2, \quad -1, \quad 0, \quad 1, \quad 2]$$

operating in the presence of 3 sources transmitting the signals $m_1(t)$, $m_2(t)$ and $m_3(t)$. The directions-of-arrival of the three signals are correctly estimated to be equal to (30°,0°), (35°,0°) and (90°,0°) and the noise power is 0.1. If the covariance matrix of the received signal $\underline{x}(t)$ is

10.2040 - 0.0000i -0.5788 + 4.1396i 6.7444 - 4.5482i 4.5234 + 6.4366i 1.2585 - 4.0588i
-0.5788 - 4.1396i 7.2210 + 0.0000i -1.7454 + 0.1726i 5.9678 - 4.3653i 1.4498 + 3.4004i
6.7444 + 4.5482i -1.7454 - 0.1726i 8.0986 + 0.0000i -0.6623 + 4.4220i 4.8585 - 3.4939i
4.5234 - 6.4366i 5.9678 + 4.3653i -0.6623 - 4.4220i 9.5774 + 0.0000i -1.5253 + 1.1245i
1.2585 + 4.0588i 1.4498 - 3.4004i 4.8585 + 3.4939i -1.5253 - 1.1245i 6.5210 + 0.0000i

(please copy the above matrix to MATLAB)

which of the following results is correct?

(a) $\mathcal{E}\{m_1(t).m_2^*(t)\} =$0.2457 − 0.1721i,

(b) $\mathcal{E}\{m_1(t).m_2^*(t)\} =$0.3536

(c) $\mathcal{E}\{m_1(t).m_3^*(t)\} = -0.4500$

(d) $\mathcal{E}\{m_2^2(t)\} = 2.1$

(e) $\mathcal{E}\left\{m_3^2(t)\right\} = 3.2$

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question **10** of **12**

Take Test: Test 3 (2018-19)

Test Information

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mmWave

- huge propagation loss
- highly directional beams
- ADC/DAC: power consuming
- beamformer weight

baseband. (digital)
passband. (analogue)
baseband + passband (hybrid)

Moving to the next question prevents changes to this answer.

Question 11 of 12

Question 11

8 points Save Answer

Which of the following statements is correct?

(a) mmWave channels present very low level of penetration loss. x
(b) In a mmWave digital beamformer the weights are in the bandpass. x
(c) ADC/DAC operating at mmWave sampling rates are power efficient. x
(d) A massive MIMO has high hardware complexity but low evergy comsumption. x
(e) None of the above.

- a
- b
- c
- d
- e

Moving to the next question prevents changes to this answer.

Question 11 of 12

Take Test: Test 3 (2018-19)

Test Information

Description	
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Save and Submit

Click **Submit** to complete this assessment.

Question **12** of **12**

Question 12

8 points Save Answer

1 | 1 reg
coef & reg | mod 2
0 1
1 0
1 1

$D^2 + D + 1$ $\underbrace{\quad}_{\text{coef} = [1\ 1]}$

$\begin{bmatrix} -1 \\ -1 \\ 1 \end{bmatrix} N_c \rightarrow \underline{C} = \begin{bmatrix} -1 \\ -1 \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} 2N_c$

Consider that one of the paths from the transmitter of a CDMA user arrives at the reference point of an antenna array CDMA receiver from direction (azimuth, elevation)= $(30°, 0°)$. The corresponding PN-sequence, of period N_c, is generated by the polynomial $D^2 + D + 1$ in GF(2) while the discrete path delay (mod-N_c) is equal to two. If the Cartesian coordinates of the antenna array elements are given by the columns of the following matrix

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3] = \begin{bmatrix} -2, & 0, & +2 \\ 0, & 0, & 0 \\ 0, & 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

$$\begin{bmatrix} -2 & 0 & 0 \\ 0 & 0 & 0 \\ 2 & 0 & 0 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{3}}{2}\pi \\ \frac{1}{2}\pi \\ 0 \end{bmatrix} = \begin{bmatrix} -\sqrt{3}\pi \\ 0 \\ \sqrt{3}\pi \end{bmatrix}$$

then the spatio-temporal array manifold vector of the path is

(a) 1st column of $\mathbb{H}$;
(b) 2nd column of $\mathbb{H}$;
(c) 3rd column of $\mathbb{H}$;
(d) 4th column of $\mathbb{H}$;
(e) none of the above.

$\underline{S} = e^{-j\underline{r}^T\underline{k}}$, $\underline{k} = (\cos\theta\cos\phi,\ \sin\theta\cos\phi,\ \sin\phi)^T\pi$

$= \begin{bmatrix} 0.6661 - j0.7458 \\ 1 \\ 0.6661 + j0.7458 \end{bmatrix}$

where

$$\mathbb{H} = \begin{bmatrix}
0 & 0 & 0 & 0 \\
0 & \text{-0.6661 + 0.7458i} & 0 & 0 \\
\text{-0.6661 + 0.7458i} & \text{0.6661 + 0.7458i} & 0 & \text{-0.6661 + 0.7458i} \\
\text{-0.6661 + 0.7458i} & \text{0.6661 - 0.7458i} & 0 & \text{-1} \\
\text{0.6661 - 0.7458i} & 0 & 0 & \text{-0.6661 - 0.7458i} \\
0 & 0 & 0 & 0 \\
0 & 0 & \text{-0.6661 + 0.7458i} & 0 \\
0 & 0 & \text{-1} & 0 \\
-1 & -1 & \text{-0.6661 - 0.7458i} & \text{-0.6661 + 0.7458i} \\
-1 & -1 & \text{-0.6661 + 0.7458i} & \text{-1} \\
1 & 1 & \text{-1} & \text{-0.6661 - 0.7458i} \\
0 & 0 & \text{-0.6661 - 0.7458i} & 0 \\
0 & 0 & \text{0.6661 - 0.7458i} & 0 \\
0 & \text{-0.6661 - 0.7458i} & 1 & 0 \\
\text{-0.6661 - 0.7458i} & \text{-0.6661 - 0.7458i} & \text{0.6661 + 0.7458i} & \text{0.6661 - 0.7458i} \\
\text{-0.6661 - 0.7458i} & \text{0.6661 + 0.7458i} & 0 & 1 \\
\text{0.6661 + 0.7458i} & 0 & 0 & \text{0.6661 + 0.7458i} \\
0 & 0 & 0 & 0
\end{bmatrix}$$

$\underline{h} = \underline{S} \otimes \underline{\underline{J}}^2 \cdot \underline{C} = \underline{S} \otimes \begin{bmatrix} 0 \\ 0 \\ -1 \\ -1 \\ 1 \\ 0 \end{bmatrix} 2N_c = \begin{bmatrix} 0 \\ 0 \\ -0.6661 + j0.7458 \\ -0.6661 + j0.7458 \\ 0.6661 - j0.7458 \\ 0 \\ \hline 0 \\ 0 \\ 0 \\ -1 \\ -1 \\ 1 \\ 0 \\ \hline 0 \\ 0 \\ -0.6661 - j0.7458 \\ -0.6661 - j0.7458 \\ 0.6661 + j0.7458 \\ 0 \end{bmatrix}$

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e

Click **Submit** to complete this assessment.

Question **12** of **12**

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