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Courses » Mathematical Methods and Techniques in Signal Processing

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# Week 1 - Introduction to Signal Processing, State Space Representation and Vector Spaces - I

**Register for Certification exam**

## Course outline



# Assignment 01

**The due date for submitting this assignment has passed.**

**Due on 2019-02-13, 23:59 IST.**

**Assignment submitted on 2019-02-08, 13:44 IST**

**Instructions:**

1. **Attempt all questions.**
2. **Submission deadline**: 13th February 2019 23:59 IST
3. **Solutions to be posted**: 14th February 2019
4. Older browsers might show **unnecessary vertical bars** at the end of math equations.

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1) The inverse of a causal LTI system, $y(t) = x(t-m-n)$ is always causal. ***1 point***

- True
- False

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
*False*

2) Consider the causal LTI system described by the difference equation $2y[n] = 3y[n-1] + y[n-2] + x[n]$ . The given system is BIBO stable. ***1 point***

- True
- False

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
*False*

3) The composition of two linear maps is linear. ***1 point***

**Accepted Answers:**
*True*

4) Given the output of the LTI system $y(t) = x(t) * h(t)$. The value of $y(5t)$ is *1.5 points*

- $25(x(t) * h(t))$
- $\frac{1}{25}(x(5t) * h(5t))$
- $5(x(5t) * h(5t))$
- $\frac{1}{5}(x(t) * h(t))$

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
$5(x(5t) * h(5t))$

5) A reciprocal system is defined as $y[n] = T(x[n]) = \frac{1}{x[n]}$ . Which of the following statement(s) given below are true about the reciprocal system. *2 points*

- Linear
- Time invariant
- Non-linear
- Time variant
- Series connection of two such systems is not a linear system

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
*Time invariant*
*Non-linear*

6) Consider an LTI system described as *2 points*

$$\mathbf{x}[n+1] = \begin{bmatrix} -1 & 0 \\ 1 & 1 \end{bmatrix} \mathbf{x}[n] + \begin{bmatrix} 3 \\ 4 \end{bmatrix} f[n]; \quad y[n] = [1 \quad 0]\, \mathbf{x}[n].$$

Determine the number of modes present in the system? The transfer function of the system is given by $H(z) = \frac{Y(z)}{F(z)}$

- 0
- 1
- 2
- 4

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
*1*

7) Determine the modes of the system with impulse response $y(n) = \{1, \frac{3}{4}, \frac{1}{2}, \frac{5}{16}, \ldots\}$ . *2 points*

- $\frac{1}{4}$and $-\frac{1}{4}$

$\frac{1}{4}$ and $\frac{1}{2}$

$\frac{1}{2}$ and $\frac{1}{2}$

$-\frac{1}{2}$ and $\frac{1}{2}$

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
$\frac{1}{2}$ and $\frac{1}{2}$

8) Let an auto-regressive system with output $y[n]$ for the forcing function $f[n]$ be given by $y[n+2]+2y[n+1]+y[n]=f[n+2]+3f[n+1]+5f[n]$ . Which among the following gives a state-space representation of the system? ***3 points***

$$\mathbf{A}=\begin{bmatrix}0 & 1\\ -1 & -2\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}0\\1\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}4\\1\end{bmatrix},\quad d=1$$

$$\mathbf{A}=\begin{bmatrix}0 & -1\\ 1 & -2\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}0\\1\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}4\\1\end{bmatrix},\quad d=1$$

$$\mathbf{A}=\begin{bmatrix}-1 & 0\\ 2 & -1\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}0.5\\-1\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}8\\3\end{bmatrix},\quad d=1$$

$$\mathbf{A}=\begin{bmatrix}-2 & -1\\ 1 & 0\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}1\\0\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}1\\4\end{bmatrix},\quad d=1$$

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**

$$\mathbf{A}=\begin{bmatrix}0 & 1\\ -1 & -2\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}0\\1\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}4\\1\end{bmatrix},\quad d=1$$
$$\mathbf{A}=\begin{bmatrix}-1 & 0\\ 2 & -1\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}0.5\\-1\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}8\\3\end{bmatrix},\quad d=1$$
$$\mathbf{A}=\begin{bmatrix}-2 & -1\\ 1 & 0\end{bmatrix},\quad \mathbf{b}=\begin{bmatrix}1\\0\end{bmatrix},\quad \mathbf{c}=\begin{bmatrix}1\\4\end{bmatrix},\quad d=1$$

9) A discrete-time system with forcing function $f[n]$ and output $y[n]$ is represented using state variables $u[n]$ and $w[n]$ as ***2 points***

$$w[n+1]=2u[n]+3f[n],$$
$$u[n+1]=w[n]+2f[n],$$
$$y[n]=u[n]+3w[n]+f[n].$$

Which of the following represent the state space parameters $(\mathbf{A},\mathbf{b},\mathbf{c}^{\mathrm{T}},\mathbf{d})$ of the system?

$$\mathbf{A}=\begin{bmatrix}0 & 1\\ 2 & 0\end{bmatrix},\mathbf{b}=\begin{bmatrix}3\\2\end{bmatrix},\mathbf{c}^{\mathrm{T}}=\begin{bmatrix}1 & 3\end{bmatrix},\mathrm{d}=1$$

$$\mathbf{A}=\begin{bmatrix}0 & 2\\ 1 & 0\end{bmatrix},\mathbf{b}=\begin{bmatrix}3\\2\end{bmatrix},\mathbf{c}^{\mathrm{T}}=\begin{bmatrix}3 & 1\end{bmatrix},\mathrm{d}=1$$

$$\mathbf{A}=\begin{bmatrix}0 & 1\\ 2 & 0\end{bmatrix},\mathbf{b}=\begin{bmatrix}2\\3\end{bmatrix},\mathbf{c}^{\mathrm{T}}=\begin{bmatrix}1 & 3\end{bmatrix},\mathrm{d}=1$$

$\mathbf{A}=\begin{bmatrix}1 & 0\\ 0 & 2\end{bmatrix}, \mathbf{b}=\begin{bmatrix}2\\ 3\end{bmatrix}, \mathbf{c}^{\mathrm{T}}=[3 \quad 1], \mathrm{d}=1$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\mathbf{A}=\begin{bmatrix}0 & 2\\ 1 & 0\end{bmatrix}, \mathbf{b}=\begin{bmatrix}3\\ 2\end{bmatrix}, \mathbf{c}^{\mathrm{T}}=[3 \quad 1], \mathrm{d}=1$
$\mathbf{A}=\begin{bmatrix}0 & 1\\ 2 & 0\end{bmatrix}, \mathbf{b}=\begin{bmatrix}2\\ 3\end{bmatrix}, \mathbf{c}^{\mathrm{T}}=[1 \quad 3], \mathrm{d}=1$

10) The state space representation of a LTI system has $\mathbf{A}=\begin{bmatrix}a & b\\ c & d\end{bmatrix}$. Then which of the following statements should hold true always for $\mathbf{A}'=\begin{bmatrix}p & q\\ r & s\end{bmatrix}$ to also represent the same system? *1 point*

1. $\det(\mathbf{A})=\det(\mathbf{A}')$
2. eigenvalues of $\mathbf{A}$ = eigenvalues of $\mathbf{A}'$
3. $\mathrm{Trace}(\mathbf{A})=\mathrm{Trace}(\mathbf{A}')$

Which of the following statements are true:

- Only 1 and 2
- Only 1 and 3
- Only 2 and 3
- 1, 2 and 3
- None of the above

No, the answer is incorrect.
Score: 0

Accepted Answers:
*1, 2 and 3*

11) Let $\mathcal{S}_1$ and $\mathcal{S}_2$ be two different subspaces in the vector space $\mathcal{V}$ such that $\mathcal{S}_1 \not\subseteq \mathcal{S}_2$ and $\mathcal{S}_2 \not\subseteq \mathcal{S}_1$, then which of the following are vector spaces? *2.5 points*

- $\mathcal{S}_1 \setminus \mathcal{S}_2$
- $\mathcal{S}_1 \cup \mathcal{S}_2$
- $\mathcal{S}_1 \cap \mathcal{S}_2$
- $\{(\mathbf{v}_1,\mathbf{v}_2) \mid \mathbf{v}_1 \in \mathcal{S}_1, \mathbf{v}_2 \in \mathcal{S}_2\}$ with $(\mathbf{u}_1,\mathbf{u}_2)+(\mathbf{v}_1,\mathbf{v}_2)=(\mathbf{u}_1+\mathbf{v}_1,\mathbf{u}_2+\mathbf{v}_2)$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\mathcal{S}_1 \cap \mathcal{S}_2$
$\{(\mathbf{v}_1,\mathbf{v}_2) \mid \mathbf{v}_1 \in \mathcal{S}_1, \mathbf{v}_2 \in \mathcal{S}_2\}$ with $(\mathbf{u}_1,\mathbf{u}_2)+(\mathbf{v}_1,\mathbf{v}_2)=(\mathbf{u}_1+\mathbf{v}_1,\mathbf{u}_2+\mathbf{v}_2)$

12) Consider the vector space $\mathbb{R}^{n\times n}$. Then $\mathcal{W}=\{A\in\mathbb{R}^{n\times n} : Trace(A)=1\}$ is a subspace of $\mathbb{R}^{n\times n}$. *1 point*

- True
- False

**No, the answer is incorrect.**
**Score: 0**

**Accepted Answers:**
*False*

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