Program: BS (CS, SE, DS) Semester: Fall Duration: 3 hours Total Marks: 100 Paper Date: 20-1-22 Weight 50-54% Section: All Page(s): 0.3 Exam: Final term Roll No: 201-108 Programmable calculators are not allowed. Show complete working in all questions. 54% witg is applicable to only those sections who had no quiz-3 due University Closure. QP9 is BONUS question.  Application in Computer Graphics Question#105+05   CLO-1 : Use Elementary Matrices to find the Inverse of $A = \begin{bmatrix} 0 & -1 \\ -1 & 0 \end{bmatrix}$ . Also were method used to evaluate the inverse will not be considered for marking.  Application in Computer Graphics Question#2[2+5+5+5+3] CLO-1,5]: Discuss the Geometric Effect on the Unit Square of multiplication by the matrix $A = \begin{bmatrix} 0 & -1 \\ -1 & 0 \end{bmatrix}$ using the following steps:  1. Decompose $A = E_1^{-1} E_2^{-1} E_3^{-1} \dots E_{k-1}^{-1} E_k^{-1}$ for some $k$ .  2. Show the effect of $E_1^{-1} E_2^{-1} E_3^{-1} \dots E_{k-1}^{-1} E_k^{-1}$ on the unit square. Also show the action of elementary matrix (each) via diagram separately.  3. Show mathematically action of each elementary matrix on the end points of the edges.  4. Illustrate the geometric effects at each step.  4. Illustrate the geometric effects at each step.  5. Puestion#3(a) [05] [CLO-2]: Find the vector and parametric equation of the plane in $R^3$ that passes through the origin and is orthogonal to $= (3,1,-6)$ .  5. Show the process for Orthonormal basis  6. Puestion#4[20] [CLO-4]: Suppose $A = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix}$ define the column vectors $u_1$ , $u_2$ and $u_3$ as $u_1 = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix}$ define the column vectors $u_1$ , $u_2$ and $u_3$ as $u_1 = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix}$ define the column vectors $u_1$ , $u_2$ and $u_3$ as $u_1 = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix}$ define the column vectors $u_1$ , $u_2$ and $u_3$ as $u_1 = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix}$	THE RESERVE THE PERSON NAMED IN COLUMN TWO IS NOT THE PERSON NAMED IN COLUMN TWO IS NAMED IN COLU	Course:	Linear Algebra	Course Code:	
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3. Show mathematically action of each elementary matrix on the end points of the edges.  4. Illustrate the geometric effects at each step.  ines & Planes in R <sup>3</sup> uestion#3(a) [05] [CLO-2]: Find the vector and parametric equation of the plane in R <sup>3</sup> that passes through e origin and is orthogonal to = $(3,1,-6)$ .  b) [5] [CLO-2]: Find a vector parallel to the line of intersection of two planes $3x - 6y - 2z = 15$ & $-(-1)$   estion#4[20][CLO-4]: Suppose $A = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix}$ define the column vectors $u_1$ , $u_2$ and $u_3$ as			ne following steps:		[107
Show mathematically action of each elementary matrix on the end points of the edges.  Illustrate the geometric effects at each step.  ines & Planes in R <sup>3</sup> uestion#3(a) [05] [CLO-2]: Find the vector and parametric equation of the plane in R <sup>3</sup> that passes through e origin and is orthogonal to = $(3,1,-6)$ .  b) [5] [CLO-2]: Find a vector parallel to the line of intersection of two planes $3x - 6y - 2z = 15$ & $-(-1)$   $-$			ne following steps:		[107
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ines & Planes in R <sup>3</sup> uestion#3(a) [05][CLO-2]: Find the vector and parametric equation of the plane in R <sup>3</sup> that passes through e origin and is orthogonal to = $(3,1,-6)$ .  b) [5] [CLO-2]: Find a vector parallel to the line of intersection of two planes $3x - 6y - 2z = 15$ & $-(-1)$   $-(-1)$	<ol> <li>Decompose A</li> <li>Show the effect matrix (each)</li> </ol>	$= E_1^{-1} E_2^{-1} E_3^{-1}$ et of $E_1^{-1} E_2^{-1} E_3^{-1}$ via diagram sepa	the following steps: $ \dots E_{k-1}^{-1} E_k^{-1}                                    $	uare. Also show the actio	$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ $\frac{1}{1-0} =$ n of elementary
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$\begin{bmatrix} 1 & 2 & 0 \end{bmatrix}$ and $\begin{bmatrix} u_1 & u_2 & u_3 & u_3 \end{bmatrix}$ as	<ol> <li>Decompose A</li> <li>Show the effect matrix (each)</li> <li>Show mathem</li> <li>Illustrate the g</li> <li>Planes in R<sup>3</sup></li> <li>Question#3(a) [05] [Content of the property of the origin and is orthorous.</li> </ol>	$= E_1^{-1} E_2^{-1} E_3^{-1}$ et of $E_1^{-1} E_2^{-1} E_3^{-1}$ via diagram sepanatically action of geometric effects $ELO-2]: Find the gonal to = (3,1,1)$	the following steps: $E_{k-1}^{-1} E_k^{-1}$ for some $k$ . $E_{k-1}^{-1} E_k^{-1}$ on the unit squarately.  If each elementary matrix on at each step.  Vector and parametric equation $k$ .	uare. Also show the action the end points of the edge on of the plane in $\mathbb{R}^3$ that	$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ $= \begin{bmatrix} 1 & 0 \\ 1 & 0 \end{bmatrix}$ of elementary es. $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ passes through $= 2z = 15 & \& $
$u_1 = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}, u_2 = \begin{bmatrix} 0 \\ 1 \\ 2 \end{bmatrix} \& u_3 = \begin{bmatrix} 2 \\ 1 \\ 0 \end{bmatrix}.$	<ol> <li>Decompose A</li> <li>Show the effect matrix (each)</li> <li>Show mathem</li> <li>Illustrate the g</li> <li>Planes in R<sup>3</sup></li> <li>Puestion#3(a) [05] [C</li> <li>e origin and is orthod</li> <li>y - 2z = 5.</li> </ol>	$= E_1^{-1} E_2^{-1} E_3^{-1}$ et of $E_1^{-1} E_2^{-1} E_3^{-1}$ via diagram separatically action of geometric effects $ELO-2]: \text{Find the gonal to} = (3,1,1)$ and a vector paralleless for Orthonores	ine following steps: $E_{k-1}^{-1} E_k^{-1}$ for some $k$ . $E_{k-1}^{-1} E_k^{-1}$ on the unit squarately.  If each elementary matrix on at each step.  If each step.  If each elementary matrix on at each step.	the end points of the edge on of the plane in $R^3$ that of two planes $3x - 6y - 6y - 6y$	passes through $-2z = 15 &$
	<ol> <li>Decompose A</li> <li>Show the effect matrix (each)</li> <li>Show mathem</li> <li>Illustrate the g</li> <li>Planes in R<sup>3</sup></li> <li>Puestion#3(a) [05] [C</li> <li>e origin and is orthod</li> <li>y - 2z = 5.</li> </ol>	$= E_1^{-1} E_2^{-1} E_3^{-1}$ et of $E_1^{-1} E_2^{-1} E_3^{-1}$ via diagram separatically action of geometric effects $ELO-2]: \text{Find the gonal to} = (3,1,1)$ and a vector paralleless for Orthonores	ine following steps: $E_{k-1}^{-1} E_k^{-1}$ for some $k$ . $E_{k-1}^{-1} E_k^{-1}$ on the unit squarately.  If each elementary matrix on at each step.  If each step.  If each elementary matrix on at each step.	the end points of the edge on of the plane in $R^3$ that of two planes $3x - 6y - 6y - 6y$	passes through $-2z = 15 &$

(0+0) (0+0)

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4(a)[10]: Use the Gram – Schmidt process to find the orthogonal set of vectors  $\{v_1, v_2, v_3\}$  and orthonormal set of vectors  $\{q_1, q_2, q_3\}$  by considering standard inner product between the vector

(a)[10]. Also find a matrix R and verify A = QR where,  $Q = [q_1 \mid q_2 \mid q_3]$  and R is given by

$$R = \begin{bmatrix} \langle u_1, q_1 \rangle & \langle u_2, q_1 \rangle & \langle u_3, q_1 \rangle \\ 0 & \langle u_2, q_2 \rangle & \langle u_3, q_2 \rangle \\ 0 & 0 & \langle u_3, q_3 \rangle \end{bmatrix}.$$

## General Linear Transformations

 $\sqrt{\text{Question}#5} [2+2+2+2+2][\text{CLO-5}]: \text{Let } T: \mathbb{R}^2 \to \mathbb{R}^3 \text{ be the linear transformation defined by the formula}$ 

$$T(x_1, x_2) = (x_1 + 3x_2, x_1 - x_2, x_1)$$

- a. Find the Standard Basis Matrix (A) for the above transformation.
- b. Find the rank of A i.e. rank(A).
- c. Find the nullity of A i.e. null(A).
- d. Find the rank of the At i.e. rank(At).
- e. Find the nullity of the At i.e. null(At).

Question#6 [10][CLO-5]: Let 
$$T: R^2 \to R^3$$
 be defined as  $\binom{x_1}{x_2} = \begin{bmatrix} x_1 + 2x_2 \\ -x_1 \\ 0 \end{bmatrix}$ . Find the matrix  $[T]_{B',B} = \begin{bmatrix} [T(u_1)]_{B'} + [T(u_2)]_{B'} \end{bmatrix}$  relative to the basis  $B = \{u_1, u_2\}$  and  $B' = \{v_1, v_2, v_3\}$ , where

$$u_1 = \begin{bmatrix} 1 \\ 3 \end{bmatrix}$$
,  $u_2 = \begin{bmatrix} -2 \\ 4 \end{bmatrix}$ ,  $v_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$ ,  $v_2 = \begin{bmatrix} 2 \\ 2 \\ 0 \end{bmatrix}$ ,  $v_3 = \begin{bmatrix} 3 \\ 0 \\ 0 \end{bmatrix}$ 

Question #7[2+2+2+2][CLO-5]: Let  $T: \mathbb{R}^3 \to \mathbb{R}^3$  be a linear operator defined as

$$T(x_1, x_2, x_3) = (0x_1 + x_2 - x_3, x_1 + 0x_2 + 2x_3, -1x_1 + x_2 + 0x_3) \text{ defined by } T(X) = AX \text{ as, where}$$

$$A = \begin{bmatrix} 0 & 1 & -1 \\ 1 & 0 & 2 \\ -1 & 1 & 0 \end{bmatrix}$$

- a) Check whether T is One to One.
- b) Check whether T is Onto.
- c) Find Kernel of T and Basis for Kernel of T.
- d) Find Range of T and Basis for Range of T.
- e) Find Null space of T and Row space of T.

$$\begin{bmatrix} 1/\sqrt{5} & 0 & 56/6 \\ -1/\sqrt{5} & 1/\sqrt{5} & 56/3 \\ -56/6 & 56/3 & -56/6 \end{bmatrix} \begin{bmatrix} 52 & 52 & 52 \\ 0 & 53 & -53/3 \\ 0 & 0 & 256/3 \end{bmatrix} = 1$$

Question#8[10]: STATE ONLY the Equivalent Statements (as much as you remember) for the n x n Matrix, if it's given that:

- a) A is invertible.
- b) .....

Note: For each equivalent statement one point will be given. Maximum points are 10.

## Similarity of Operators (Bonus)

Question#9[05+05][CLO-3,5]: If 
$$C = \begin{bmatrix} 1 & 1 \\ -2 & 4 \end{bmatrix}$$
 and  $= \begin{bmatrix} 2 & 0 \\ 0 & 3 \end{bmatrix}$ , then

- a. Find a matrix P (consisting of the Eigen vectors of the matrix C) using Eigenvalues of C & show that  $P^{-1}CP = D$ . Also, find the dimension of Eigen Spaces associated with each Eigen value.
- b. Show that C and D represents the same linear operator  $T: \mathbb{R}^2 \to \mathbb{R}^2$  by showing  $P^{-1}CP = D$ ,  $P^{-1} = P_{B \to B'}$ ,  $B' = \{u'_1, u'_2\}$ ,  $B = \{e_1, e_2\}$ ,  $u'_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \& u'_2 = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$ . Here  $P \& P^{-1}$  represents the where  $P = P_{B' \to B} = [[u'_1]_B \ [u'_2]_B]$  and transition matrices.

## Good Luck

$$2+2$$
  $2-4$   $-1-2$   $-1+4$ 

$$\begin{bmatrix}
4 & -2 \\
-3 & 3
\end{bmatrix}
\begin{bmatrix}
1 & 1 \\
1 & 2
\end{bmatrix}$$

$$4+-2 & 4-4 \\
-3+3 & -3+6$$