Lesson Plan

	UNIVERSITAS PENDIDIKAN GANESHA JURUSAN TEKNIK INFORMATIKA PROGRAM STUDI ILMU KOMPUTER	Document Code

RENCANA PEMBELAJARAN SEMESTER

COURSE	CODE	TYPE OF COURSE	CREDIT (sks)		SEMESTER	Date
Linear Algebra	KOMS120301	Core Course of the Major	**T=3**	**P=0**	4	02/09/2022

AUTORISATION	Pengembang RPS	Coordinator	Head of Study Program
	Ni Luh Dewi Sintiari, Ph.D.	A.A. Gede Yudhi Paramartha, S.Kom., M.Kom.	A.A. Gede Yudhi Paramartha, S.Kom., M.Kom.

Learning Outcomes (CPL)	Learning Outcomes of Study Program Charged to the Course	
	S1	Pious of God Almighty and able to show a religious attitude;
	S2	Upholding human values in carrying out duties based on religion, morals, and ethics;
	S8	Internalize academic values, norms and ethics;
	S9	Demonstrate a responsible attitude towards work in their area of expertise independently;
	S10	Internalize the spirit of independence, struggle, and entrepreneurship;
	P1	Able to understand and master the basic concepts of computer science in general such as mathematics, algorithms, programming, and databases.
	P2	Able to understand and master the concept of software development, starting from requirements analysis, design, development, and implementation of software.
	KU1	Able to apply logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies humanities values in accordance with the field of computer science;
	KU2	Able to demonstrate independent, quality, and measurable performance;
	KU3	Able to study the implications of the development or implementation of science and technology that pays attention to and applies humanities values in accordance with the field of computer science based on scientific principles, procedures and ethics in order to produce solutions, ideas, designs or art criticism.
	KK1	Skilled in analyzing requirements, designing, and implementing designs, and testing software.

	Learning outcomes (CPMK)	
	CPMK	Students are able to explain the concepts of Linear Algebra, and are skilled in applying these concepts to solve various cases related to Linear Algebra in the theoretical aspect as well as its applications in the field of Computer Science.
	Learning outcomes of each topic (Sub-CPMK)	
	Sub-CPMK 1	Students are able to understand the role of Linear Algebra in Computer Science as well as the basic topics of mathematics supporting Linear Algebra course.
	Sub-CPMK 2	Students are able to understand the concept of matrices, types of matrices, and operations on matrices, and apply them in problem solving properly and correctly.
	Sub-CPMK 3	Students are able to understand the concept of the System of Linear Equations (SLE), the representation of the SLE in the form of a matrix, as well as the operations that can be performed to solve the SLE, and implement them in problem solving properly and correctly.
	Sub-CPMK 4	Students are able to apply Gaussian elimination and Gauss-Jordan elimination methods to solve multi-variable SLE properly and correctly.
	Sub-CPMK 5	Students are able to apply the method of calculating determinants (either combinatorial or with cofactor expansion) to compute determinants of matrices and use them in problem solving properly and correctly.
	Sub-CPMK 6	Students are able to understand the concept of the inverse of a square matrix, as well as its relationship to determinants and SLE, and apply it in problem solving properly and correctly.
	Sub-CPMK 7	Students are able to understand the concept of vectors in spaces $R^{2,}$ R^3, and R^n, as well as operations related to them.
	Sub-CPMK 8	Students are able to understand the concept of Euclid's vector space, general vector space, and sub-vector space, as well as related operations (addition and multiplication of scalar vectors) and apply them in solving simple problems properly and correctly.
	Sub-CPMK 9	Students are able to understand the concept of spanned sets in vector space and linear combinations between vectors in vector space, and apply the concepts to find the standard/non-standard basis and compute the dimensions of vector spaces properly and correctly.

	Sub-CPMK 10	Students are able to perform transformation between bases in a vectors space, and relate it to the column, row, and null spaces.
	Sub-CPMK 11	Students are able to understand the concept of linear transformation and solve related problems properly and correctly.
	Sub-CPMK 12	Students are able to understand the concepts of eigenvalues, eigenvectors, eigenspaces, and matrix diagonalizations, and solve related problems properly and correctly.
	Sub-CPMK 13	Students are able to understand the concept of inner product and related operations, inner product space, Gram-Schmidt procedure, and solve related problems properly and correctly.
	Sub-CPMK 14	Students are able to understand the concept of matrix decomposition, such as QR decomposition, LU decomposition, and singular value decomposition, and solve related problems properly and correctly.
Course decription	Linear Algebra course discusses the basics of Linear Algebra related to Computer Science and can be implemented in the field of Computer Science. The material discussed in this course includes the concepts of matrices and vectors, systems of linear equations, determinants and inverses of square matrices, Euclid's vector space, basis and dimensions of vector spaces, linear transformations, eigenvalues and eigenvectors, inner product space, diagonalization, decomposition. singular values, and the application of linear algebra.	
Topics	**Topics:** Matrices, Systems of Linear Equations, Determinants and Inverses, Vectors, Vector Spaces, Eigenvalues and Eigenvectors, Inner Product Spaces, Matrix Decomposition	**Materials:** Look at the table
Reference	**Main:**	Elementary Linear Algebra (Applications Version) Ed. 11, Howard Anton & Chris Rorres

	Supporting:	- Slide Kuliah Aljabar Linier, oleh Rinaldi Munir, Institut Teknologi Bandung - Slide Kuliah Aljabar Linier, oleh Dewi Sintiari
Dosen Pengampu	Ni Luh Dewi Sintiari, Ph.D.	
Matakuliah syarat	Basic Mathematics	

Mg Ke-	**Kemampuan akhir tiap tahapan belajar (Sub-CPMK)**	**Penilaian**		**Bantuk Pembelajaran, Learning Methods, Assignment Mahasiswa, [Estimasi Waktu]**		**Materi Pembelajaran [Pustaka]**	**Bobot Penilaian (%)**
		Indikator	**Kriteria & Bentuk**	**On-site (*offline*)**	**Online**		
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
1	Students are able to understand the role of Linear Algebra in Computer Science as well as the basic topics of mathematics supporting Linear Algebra course.	Accuracy in: 1. explain basic mathematical concepts related to Linear Algebra courses; 2. explain the urgency of understanding Linear Algebra concepts in the study of Computer Science.	Assessment Form: • Non-test, oral question and answer	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion, question and answer	Media: elearning.undiksha.ac.id	1. Contract 2. The role of Linear Algebra in Computer Science 3. Reviewing the topics of during the semester 4. Overview of basic materials related to Linear Algebra	**3%**
2	Students are able to understand the concept of matrices, types of matrices, and operations on matrices, and apply them in problem solving	Accuracy in: 1. write a simple matrix correctly; 2. describes the row, column, diagonal, and indices of matrix entries;	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50']	Media: elearning.undiksha.ac.id	1. Basics of matrices 2. Matrix operations: scalar multiplication, addition, multiplication,	**5%**

	properly and correctly.	3. compute matrix operations, such as: scalar multiplication, matrix addition, matrix multiplication, matrix transpose, matrix power, and matrix polynomials; 4. apply the properties of matrix operations; 5. apply the concepts and properties of square matrices; 6. apply the block matrix concept to solve matrix operations.		<u>Learning Methods:</u> Discussion, question and answer, assignment <u>Assignment 1:</u>		transpose, exponent, matrix polynomial 3. Types of square matrices: identity matrices, up/down triangular matrices, symmetric matrices, block matrices 4. Properties of a square matrix: diagonal, trace, etc.	
3	Students are able to understand the concept of the System of Linear Equations (SLE), the representation of the SLE in the form of a matrix, as well as the operations that can be performed to solve the SLE, and implement them in problem solving properly and correctly.	Accuracy in: 1. describe the components of linear equations, such as variables, coefficients, constants, the number of linear equations, and the number of variables in the system of linear equations; 2. verify whether a set of values is a solution to a system of linear equations; 3. formulate coefficient matrices and augmented matrices of a system of	Assessment Form: • Non-test, oral question and answer • Assignment	<u>Learning Form:</u> Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] <u>Learning Methods:</u> Discussion, question and answer, assignment <u>Assignment 2:</u>	<u>Media:</u> elearning.undiksha.ac.id	1. Fundamentals of the system of linear equations (SLE) 2. SLE transformation in matrix form 3. Concept of Elementary Row Operations (ERO) 4. Geometric interpretation of SLE for 1, 2, or 3 variables 5. Elimination and	**7%**

		linear equations; 4. identify *homogeneous* and *non-homogeneous* systems of equations, and *degenerate* and *non-degenerate* systems of equations; 5. prove elementary row operations to convert a system of linear equations to another equivalent form; 6. analyze the geometric interpretation of a system of linear equations with 1, 2, and 3 variables; 7. apply an elimination algorithm and a substitution algorithm to solve a system of linear equations with two variables; 8. explain the concept of a system of linear equations in the form of a triangular matrix and an echelon matrix form.				substitution methods for solving SLE 6. SLE in the form of triangular matrix and echelon matrix 7. The number of SLE solutions, and write down the SLE solutions 8. Reduced echelon form	
4	Students are able to apply Gaussian elimination and Gauss-Jordan elimination methods to solve multi-variable SLE properly and correctly.	Accuracy in: 1. apply the Gaussian elimination algorithm to solve a system of linear equations with n variables; 2. apply the Gauss-Jordan elimination algorithm to solve a system of linear	Assessment Form: • Non-test, oral question and answer • Assignment	<u>Learning Form:</u> Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] <u>Learning Methods:</u>	<u>Media:</u> elearning.undiksha.ac.id	1. Gaussian elimination method 2. Gauss-Jordan . elimination method 3. Application of SLE in Computer Science	**6%**

		equations with n variables; 3. analyze the type of solution in a homogeneous system of equations (trivial solutions and non-trivial solutions); 4. implementing Gauss and Gauss-Jordan elimination algorithms in programming languages; 5. apply the concept of solving a system of linear equations to solve real-world related problems.		Discussion, question and answer, assignment <u>Assignment 3:</u>			
5	Students are able to apply the method of calculating determinants (either combinatorial or with cofactor expansion) to compute determinants of matrices and use them in problem solving properly and correctly.	Accuracy in: 1. explain the concept of determinants in solving systems of linear equations; 2. derive the determinant formula of a 2x2 matrix through a system of linear equations; 3. apply the procedure for calculating the determinant of a 3x3 matrix with the determinant formula; 4. analyze the relationship of a system of linear equations 3 variables with the determinant of the coefficient matrix; 5. explain the geometric interpretation of the	Assessment Form: • Non-test, oral question and answer • Assignment	<u>Learning Form:</u> Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] <u>Learning Methods:</u> Discussion, question and answer, assignment <u>Assignment 4</u>:	<u>Media:</u> elearning.undiksha.ac.id	1. The concept of determinant 2. The determinant formula of the 2x2, 3x3, and nxn. matrices 3. Finding the SLE solution with the determinant matrix 4. Geometric interpretation of matrix determinants 5. Combinatorial rules for calculating determinants of matrices 6. Determinant properties 7. Cofactor expansion	**7%**

		determinants of matrices of size 2x2 and 3x3; 6. derive the determinant formula of a matrix of size nxn; 7. analyze the relationship of elementary row operations on a matrix with the determinant of the matrix; 8. compute the determinant using the cofactor; 9. apply Cramer's rule to solve a system of linear equations; 10. explain the relationship of the block matrix and the determinant of the matrix.				8. Cramer's Rules 9. Determinant of block matrix	
6	Students are able to understand the concept of the inverse of a square matrix, as well as its relationship to determinants and SLE, and apply it in problem solving properly and correctly.	Accuracy in: 1. explain the concept of the inverse matrix and its relationship to the determinant of the matrix; 2. formulate the procedure for calculating the inverse of a 2x2 . matrix; 3. formulate the procedure for calculating the inverse of a 2x2 . matrix; 4. explain the concepts of orthogonality and orthonomality; 5. prove the inverse properties of matrices;	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: Class Activities [3x50’], Structured Tasks [3x60’], Independent Learning [3x50’] Learning Methods: Discussion, question and answer, assignment Assignment 5:	Media: elearning.undiksha.ac.id	1. Calculation of the inverse of 2x2 and 3x3 . square matrices 2. Inverse matrix nxn with adjoin 3. Orthogonal matrix 4. Orthonomalities in orthogonal matrices 5. Properties of the inverse matrix 6. Matrix inverse relation with Gauss elimination method, Gauss-Jordan elimination.	**7%**

		6. apply the Gaussian elimination algorithm to compute the inverse of the matrix; 7. apply the Gauss-Jordan elimination algorithm to compute the inverse of the matrix; 8. apply the concept of inverse matrix to solve a system of linear equations (homogeneous and non-homogeneous).				7. Rank matrix	
7	Students are able to understand the concept of vectors in spaces $R^{2,}$ R^3, and R^n, as well as operations related to them.	Accuracy in: 1. explain the concept of vectors in Linear Algebra, algebraically and geometrically; 2. explain the concept of vectors in Linear Algebra, algebraically and geometrically; 3. explain the concept of spatial vectors (in R^3) using unit vectors **i**, **j**, and **k**; 4. compute the dot product between vectors; 5. compute vector norms, distances between two vectors, angles between vectors and vector projections;	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: - Class Activities [3x50'] - Assignment mandiri [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion, question and answer, assignment Assignment 6:	Media: elearning.undiksha.ac.id	1. The concept of vectors in spaces R^2 and R^3 2. Operations between vectors on R^2 and R^3 3. Properties of vectors in R^2 and R^3 4. Geometric interpretation of vector operations in R^2 and R^3 5. Vector in space R^n	**7%**

		6. compute the cross product between two 3 dimensional vectors; 7. apply the properties of dot multiplication and cross multiplication in calculations; 8. formulate the cofactor expansion to compute the cross multiplication of 3-dimensional vectors; 9. to interpret geometrically the cross product in space R^2 and R^3.					
8							**10%**
9	Students are able to understand the concept of Euclid's vector space, general vector space, and sub-vector space, as well as related operations (addition and multiplication of scalar vectors) and apply them in solving simple problems properly and correctly.	Accuracy in: 1. explain the concept of Euclid's vector space with dimension n; 2. perform vector addition operations, vector scalar multiplication, and linear combinations between vectors in space R^n; 3. deriving the properties of vector operations on Rn; 4. interpret geometrically the linear combination between vectors in R^2; 5. explain the concept of general vector space through the axioms of	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion, question and answer, assignment Assignment 7:	Media: elearning.undiksha.ac.id	1. Euclid vector space 2. Common vector space 3. Vector subspace	**7%**

		vector space; 6. connect the concept of Euclid's vector space and general vector space; 7. prove whether a set of vectors forms a vector space; 8. explain the concept of vector sub-space; 9. prove the vector sub-space theorem; 10. prove whether a set of vectors is a sub-vector space of a given vector space.					
10	Students are able to understand the concept of spanned sets in vector space and linear combinations between vectors in vector space, and apply the concepts to find the standard/non-standard basis and compute the dimensions of vector spaces properly and correctly.	Accuracy in: 1. explain the concept of spanning set in a vector space through linear combinations; 2. identify linearly independent and non-linearly independent vectors in the space R^n; 3. explain the concept of basis in vector space Rn and general vector space; 4. explain the difference between standard and nonstandard basis of a vector space; 5. explain the concept of vector space dimensions and	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion, question and answer, assignment Assignment 8:	Media: elearning.undiksha.ac.id	1. Combination liner 2. Linear independence 3. Base vector space Rn and general vector space 4. Standard and nonstandard base 5. Dimensions of vector space and sub-vector space	**7%**

		their relation to vector space bases; 6. find the dimensions of a vector space.					
11	Students are able to perform transformation between bases in a vectors space, and relate it to the column, row, and null spaces.	Accuracy in: 1. derive the transformation matrix from one basis to another in the same vector space; 2. explain the concept of column space; 3. explain the concept of row space; 4. explain the concept of null space; 5. find the rank and nullity of a vector space.	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion, question and answer, assignment Assignment 9:	Media: elearning.undiksha.ac.id	1. Vector space base replacement 2. Matrix column space 3. Matrix row space 4. Null space	**5%**
12	Students are able to understand the concept of linear transformation and solve related problems properly and correctly.	Accuracy in: 1. explain the concept of transformation and transformation matrices; 2. explain the concept of linear transformation; 3. find the standard transformation matrix of a linear transformation;	Assessment Form: • Tanya-jawab lisan • Assignment membuat video	Learning Form: Class Activities [3x50'] Learning Methods: Discussion, question and answer, assignment	Media: elearning.undiksha.ac.id	1. Transformation concept 2. Zero transformation and identity operator 3. Properties of linear transformation 4. The concept of linear	**5%**

		4. derive the standard matrix for the reflection vector at R^2 and R^3; 5. derive the standard matrix for vector projection in R^2 and R^3; 6. derive the standard matrix for the rotation of the vectors in R^2 and R^3; 7. derive the standard matrix for the dilation and contraction vectors in R^2 and R^3; 8. derive the standard matrix for vector expansion and compression in R^2 and R^3; 9. derive the standard matrix for the shear vector transformation in R^2 and R^3; 10. determine the result of vector transformation composition.		Assignment 10:		transformation 5. Standard matrix of linear transformation 6. Transformations in R^2 and R^3: reflection, projection, rotation, dilation, expansion, shear 7. Properties of transformation matrices	
13	Students are able to understand the concepts of eigenvalues, eigenvectors, eigenspaces, and matrix diagonalizations, and solve related problems properly and correctly.	Accuracy in: 1. explain the concept of eigenvalues and eigenvectors; 2. compute the eigenvalues of the matrix; 3. compute the eigenvector matrix; 4. compute the basis of the	Bentuk PeniAssessment Form: • Non-test, oral question and answer • Assignment laian: • Non-test,	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion,	Media: elearning.undiksha.ac.id	1. The concept of eigenvalues 2. The concept of eigenvectors 3. Base eigenspace 4. Diagonalization 5. Application of eigenvectors	**7%**

		eigenspace matrix; 5. explain the concept of matrix diagonalization; 6. explain the properties of the matrix that is maintained in the diagonalization operation; 7. analyze whether a matrix can be diagonalized; 8. find a matrix that can be used to diagonalize a matrix; 9. diagonalize the matrix.	oral question and answer • Assignment	question and answer, assignment <u>Assignment 11</u>:			
14	Students are able to understand the concept of inner product and related operations, inner product space, Gram-Schmidt procedure, and solve related problems properly and correctly.	Accuracy in: 1. explain the concept of product in; 2. compute the inner product of two vectors; 3. compute the angle between two vectors with the principle of the inner product; 4. compute the distance between two vectors; 5. investigate the orthogonality of two vectors with an inner product; 6. explain the concepts of orthogonal sets and orthonormal sets; 7. compute the QR decomposition of a matrix;	Assessment Form: • Non-test, oral question and answer • Assignment	<u>Learning Form:</u> Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] <u>Learning Methods:</u> Discussion, question and answer, assignment <u>Assignment 12</u>:	<u>Media:</u> elearning.undiksha.ac.id	1. Inner product space 2. Angles and orthogonalities in the inner product space 3. Gram-Schmidt 4. QR Decomposition 5. Least squares problem 6. Application of deep product space	**7%**

		8. explain the concept of the least squares problem; 9. determine the least squares solution of a system of linear equations.					
15	Students are able to understand the concept of matrix decomposition, such as QR decomposition, LU decomposition, and singular value decomposition, and solve related problems properly and correctly.	Accuracy in: 1. explain the concept of matrix decomposition; 2. determine the singular value of a matrix; 3. apply singular value decomposition algorithm to a matrix; 4. explain the application of singular value decomposition of a matrix.	Assessment Form: • Non-test, oral question and answer • Assignment	Learning Form: Class Activities [3x50'], Structured Tasks [3x60'], Independent Learning [3x50'] Learning Methods: Discussion, question and answer, assignment Assignment 13:	Media: elearning.undiksha.ac.id	1. Types of matrix decomposition 2. Singular value decomposition 3. An example of applying singular value decomposition	**5%**
16	**Final Evaluation**						**15%**