Georgia Mathematics

Linear Algebra with Computer Science Applications

Mathematical Practices

0 Display perseverance and patience in problem-solving. Demonstrate skills and strategies needed to succeed in mathematics, including critical thinking, reasoning, and effective collaboration and expression. Seek help and apply feedback. Set and monitor goals. LACS.MP

- 0.1 Make sense of problems and persevere in solving them. LACS.MP.1
- 0.2 Reason abstractly and quantitatively. LACS.MP.2
- 0.3 Construct viable arguments and critique the reasoning of others. LACS.MP.3
- 0.4 Model with mathematics. LACS.MP.4
- 0.5 Use appropriate tools strategically. LACS.MP.5
- 0.6 Attend to precision. LACS.MP.6
- 0.7 Look for and make use of structure. LACS.MP.7
- 0.8 Look for and express regularity in repeated reasoning. LACS.MP.8

Mathematical Modeling

1 Apply mathematics to real-life situations; model real-life phenomena using mathematics. LACS.MM.1

- 1.1 Explain contextual, mathematical problems using a mathematical model. LACS.MM.1.1
- 1.2 Create mathematical models to explain phenomena that exist in the natural sciences, social sciences, liberal arts, fine and performing arts, and/or humanities contexts. LACS.MM.1.2
- 1.3 Using abstract and quantitative reasoning, make decisions about information and data from a contextual situation. LACS.MM.1.3
- 1.4 Use various mathematical representations and structures with this information to represent and solve real-life problems. LACS.MM.1.4

Abstract & Digital Reasoning

2 Investigate and describe real-life problems in linear algebra using an object-oriented programming language. LACS.ADR.2

- 2.1 Utilize sets, lists, dictionaries, indexing, and tuples in programming languages. LACS.ADR.2.1
- .2 Show and explain how to program and apply modules and control statements in programming languages. LACS.ADR.2.2

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2.3 Program input and output features to read from and write to files in a programming assignment. LACS.ADR.2.3

Geometric & Spatial Reasoning

3 Solve contextual, mathematical problems involving vectors to explain real-life phenomena. LACS.GSR.3

3.1 Use coordinates to represent points in n dimensions and define and use arithmetic operations on n-dimensional points. LACS.GSR.3.1

3.2 Use vectors to find and interpret geometrical relationships between points in two and three dimensions, such as distance, and generalize these relationships to higher dimensions using n-dimensional vectors. LACS.GSR.3.2

3.3 Interpret adding, scaling, and linear combinations of vectors geometrically and algebraically. LACS.GSR.3.3

3.4 Find and use the dot product of two n-dimensional vectors. LACS.GSR.3.4

3.5 Use properties of the dot product to prove statements about vectors and to solve problems in context. LACS.GSR.3.5

3.6 Use the triangle inequality in n-dimensions. LACS.GSR.3.6

3.7 Find and use the cross product of two 3-dimensional vectors. LACS.GSR.3.7

3.8 Represent and perform vector operations using programming language classes that define the use of vectors. LACS.GSR.3.8

3.9 Apply perfect secrecy, all-or-nothing secret sharing, and solving lights out games to vectors over GF(2). LACS.GSR.3.9

3.10 Use vector operations to program simple authentication schemes. LACS.GSR.3.10

5 Solve contextual, mathematical problems involving matrices as geometric transformations and to explain real-life phenomena. LACS.GSR.5

5.1 Given a 2-by-2 or 3-by-3 linear transformation matrix, describe the transformation a geometric figure undergoes. LACS.GSR.5.1

5.2 Find matrices that represent scalings, reflections, and rotations of geometric figures. LACS.GSR.5.2

5.3 Find a matrix that represents a combination of transformations. LACS.GSR.5.3

5.4 Find the image of a point under a transformation. LACS.GSR.5.4

5.5 Find the area of a polygon given its coordinates using matrices; find the area of the image of a polygon after a transformation. LACS.GSR.5.5

5.6 Write code to perform transformations in two-dimensional geometry using matrix operations. LACS.GSR.5.6

5.7 Define functions from n dimensions to m dimensions as vectors and/or matrices. LACS.GSR.5.7

5.8 Find the image and preimage of a linear map using matrices; determine whether the linear map is one-to-one. LACS.GSR.5.8

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5.9 Find and interpret geometrically the set of preimages of a vector under a given matrix. LACS.GSR.5.9

Patterning & Algebraic Reasoning

4 Solve contextual, mathematical problems involving matrices to explain real-life phenomena. LACS.PAR.4

4.1 Represent a linear system of three equations in three variables as an augmented matrix and reduce the matrix to row-echelon form. LACS.PAR.4.1

4.2 Interpret the nature of the solution of a system from its row-echelon form, and if there are infinitely many solutions, express them as a vector equation. LACS.PAR.4.2

4.3 Determine whether a vector is a linear combination of other given vectors; find the linear combination of vectors that results in a given vector. LACS.PAR.4.3

4.4 Interpret linear dependence of vectors geometrically. LACS.PAR.4.4

4.5 Find the kernel of a matrix and explore the relationship between the kernel, the orthogonality of the vectors in the kernel, and the linear dependence of the rows/columns. LACS.PAR.4.5

4.6 Add two matrices, multiply a matrix by a scalar, find the transpose of a matrix. LACS.PAR.4.6

4.7 Determine when matrix multiplication is defined, and if defined, multiply two matrices by considering the matrix product as a dot product of a group of vectors. LACS.PAR.4.7

4.8 Determine when the inverse of a square matrix exists, and if it exists, find it by augmenting the identity matrix to the matrix and then use row operations. LACS.PAR.4.8

4.9 Decompose a matrix into its symmetric and skew-symmetric parts; decompose a matrix into its LU factorization. LACS.PAR.4.9

4.10 Solve a matrix equation using inverses; find all solutions to a matrix equation given one solution and the kernel. LACS.PAR.4.10

4.11 Improve the simple authentication scheme over GF(2). LACS.PAR.4.11

4.12 Show and explain how threshold secret sharing works in conjunction with Gaussian elimination through programming. LACS.PAR.4.12

4.13 Write code utilizing error-correcting concepts. LACS.PAR.4.13

7 Solve contextual, mathematical problems using vector spaces to explain real-life phenomena. LACS.PAR.7

7.1 Determine whether a given set of vectors generates a vector space. LACS.PAR.7.1

7.2 Justify whether a subset of a vector space is a subspace. LACS.PAR.7.2

7.3 Determine whether a given vector is in the linear span of a set of vectors. LACS.PAR.7.3

.4 Determine whether two vector subspaces are orthogonal; find the orthogonal component of a given subspace. LACS.PAR.7.4

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7.5 Determine whether a set of vectors is a basis for a vector space. LACS.PAR.7.5

7.6 Find the dimension of a vector space; find the dimensions of the row space, column space, and kernel for a given matrix; find the rank of a matrix. LACS.PAR.7.6

7.7 Find a matrix representing a linear map. LACS.PAR.7.7

7.8 Determine the change of representation for a linear transformation given two different bases on a vector space. LACS.PAR.7.8

7.9 Determine if two matrices are similar; determine if two matrices are orthogonal. LACS.PAR.7.9

7.10 Find an orthogonal basis for a given basis or subspace by applying the Gram-Schmidt orthonormalization process. LACS.PAR.7.10

7.11 Perform QR factorization of a matrix to solve matrix equations. LACS.PAR.7.11

7.12 Apply the method of least squares to find the line or parabola of best fit to approximate data in context. LACS.PAR.7.12

7.13 Apply the grow-and-shrink algorithm in the minimum spanning forest problem in GF(2). LACS.PAR.7.13

7.14 Apply the Exchange Lemma to image perspective rendering. LACS.PAR.7.14

7.15 Use bases to represent images and sounds as wavelets; perform wavelet transformation, implementation, and decomposition through programming. LACS.PAR.7.15

7.16 Program a Fast Fourier Transform to store a sequence of amplitude samples. LACS.PAR.7.16

7.17 Apply the Rank Theorem to demonstrate the simple authentication scheme. LACS.PAR.7.17

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8 **Solve contextual, mathematical problems using eigenvalues and eigenvectors to explain real-life phenomena.** LACS.PAR.8

8.1 Evaluate the determinant of a matrix along any row or column and use a recursive procedure for evaluating a determinant for matrices larger than 3-by-3. LACS.PAR.8.1

8.2 Justify properties of the determinant. LACS.PAR.8.2

8.3 Calculate the determinant of the product of two matrices; calculate the determinant of the transpose of a matrix. LACS.PAR.8.3

8.4 Determine if a matrix has a nonzero determinant and extend the nonzero determinant property to problems involving linear dependency, rank, and matrix inverses. LACS.PAR.8.4

8.5 Extend the definition and geometric interpretation of the cross product to n – 1 vectors in n dimensions. LACS.PAR.8.5

8.6 Use Cramer's Rule to solve a system of linear equations. LACS.PAR.8.6

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.7 Find the characteristic polynomial of a matrix and interpret the characteristic polynomial geometrically. LACS.PAR.8.7

8.8 Find the eigenvalues and eigenvectors of a matrix and interpret them geometrically. LACS.PAR.8.8

8.9 Use a basis of eigenvectors to create a change of basis matrix. LACS.PAR.8.9

8.10 Find the dimension of the eigenspace corresponding to the eigenvalues of a symmetric matrix. LACS.PAR.8.10

8.11 Determine an orthogonal matrix that diagonalizes a given matrix. LACS.PAR.8.11

8.12 Apply eigenvalues and eigenvectors to problems in context. LACS.PAR.8.12

Probabilistic Reasoning

6 Using probabilistic and quantitative reasoning, solve contextual, mathematical problems using Markov chains to explain real-life phenomena. LACS.PR.6

6.1 Model a finite random process using transition matrices in a Markov chain. LACS.PR.6.1

6.2 Simulate the different stages of a Markov chain using random numbers. LACS.PR.6.2

6.3 Use matrix algebra to calculate the probability of future states of a Markov chain. LACS.PR.6.3

6.4 Determine the attractor for a regular Markov chain. LACS.PR.6.4

6.5 Use transition matrices to identify absorbing states of a Markov chain. LACS.PR.6.5

6.6 Apply Markov chains in context. LACS.PR.6.6

6.7 Write a program to model the probabilities of real-life phenomena using a Markov chain. LACS.PR.6.7