



Multi-Variable Calculus/Linear Algebra Scope & Sequence

Grading Period	Unit Title	Learning Targets
Throughout the School Year	*Apply mathematics to problems in everyday life *Use a problem-solving model that incorporates analyzing information, formulating a plan, determining a solution, justifying the solution and evaluating the reasonableness of the solution *Select tools to solve problems *Communicate mathematical ideas, reasoning and their implications using multiple representations *Create and use representations to organize, record and communicate mathematical ideas *Analyze mathematical relationships to connect and communicate mathematical ideas *Display, explain and justify mathematical ideas and arguments	
First Grading Period MULTIVARIABLE CALCULUS	Vectors in a plane and in space	Unit vectors, graphing and basic operations
	Dot products and cross products	Angles between vectors, orthogonality, projections, work
	Lines and Planes in space	Equations, intersections, distance
	Surfaces in Space	Cylindrical surfaces, quadric surfaces, surfaces of revolution, cylindrical and spherical coordinate
	Vector Valued Functions	Parameterization, domain, range, limits, graphical representation, continuity, differentiation, integration, smoothness, velocity, acceleration, speed, position for a projectile, tangent and normal vectors, principal unit normal, arc length and curvature.
	Functions of several variables	Graphically, level curves, delta neighborhoods, interior point, boundary point, closed regions, limits by definition, limits from various paths, continuity.

	Partial Derivatives	Definition, notation, evaluating, slope in x and y direction, rate of change, second partial derivatives, mixed partial derivatives, differentials, error analysis, differential approximation, chain rule, implicit differentiation, directional derivatives, finding gradients and using their properties, tangent planes and normal lines, relative extrema, second partials test, absolute extrema, optimization, Lagrange Multipliers
Second Grading Period MULTIVARIABLE CALCULUS	Iterated Integrals	Area in the plane, double integrals, volume of a solid, change in variable, center of variables, center of mass and moments of inertia for a lamina, surface area, triple integrals, center of mass and moments inertia for a solid, Jacobians
	Vector Fields	Conservative vector fields, velocity fields, gravitational fields, force field, potential functions, curl
	Line Integrals	Smooth piecewise curves, parameterization, mass of a spring, work done by a force, independence of path, fundamental theorem of line integrals.
	Green's Theorem	Simple curves, simply connected regions, using Green's theorem to evaluate line integrals and calculate work, line integral for area
	Parametric Surfaces	Sketching, parameterizing, normal vectors and tangent planes, area
	Surface Integrals	Evaluating, mass of a surface lamina, orientation, flux integrals
	Divergence Theorem	Using and verifying divergence theorem
	Stoke's Theorem	Understand and use Stoke's theorem, curl
Third Grading Period LINEAR ALGEBRA	Introduction to vectors	Components, linear combinations, length, dot product, matrices as a combination of column vectors, multiplication with matrices, linear equations
	Solving Linear Equations	Vectors and linear equations, elimination using matrices, matrix operations, inverse matrices, Gauss Jordan method, factorization $A=LU$, transposes and permutations

	Vector spaces and subspaces	Subspaces of vectors, column space, null space, complete solutions to $Ax=b$, independence, span, basis, dimension, linear independence, dimensions of the four subspaces, Fundamental Theorem of Linear Algebra
	Orthogonality	Orthogonality of the four subspaces, projections onto a line, projections onto a subspace, orthonormal bases, Gram-Schmidt process
Fourth Grading Period LINEAR ALGEBRA	Determinants	Properties of determinants, permutations, cofactors, formulas for determinants, Cramer's rule, inverses, areas using determinants
	Eigenvalues and Eigenvectors	Introduction, computation, trace, diagonalization, using diagonalization to find powers of the matrix A , similar matrices, Markov matrices, symmetric matrices, complex eigenvalues of real matrices, orthogonal eigenvectors, positive definite matrices.
	Linear Transformations	Introduction and properties, Linearity, using matrices to do linear transformations, choosing the best bases, Jordan form
	Complex Vectors and Matrices	Complex plane, polar form, Euler's formula, Hermitian and unitary matrices
	Applications	Image processing, graphs and networks, population and economics, linear programming, computer graphics, Fourier series, cryptography.