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Contents; Preface; Acknowledgements; 1. Introduction; 1.1 A Vector Space Approach to Euclidean Geometry and A Gyrovector Space Approach to Hyperbolic Geometry; 1.2 Gyrolanguage; 1.3 Analytic Hyperbolic Geometry; 1.4 The Three Models; 1.5 Applications in Quantum and Special Relativity Theory; 2. Gyrogroups; 2.1 Definitions; 2.2 First Gyrogroup Theorems; 2.3 The Associative Gyropolygonal Gyroaddition; 2.4 Two Basic Gyrogroup Equations and Cancellation Laws; 2.5 Commuting Automorphisms with Gyroautomorphisms; 2.6 The Gyrosemidirect Product Group; 2.7 Basic Gyration Properties; 3. Gyrocommutative Gyrogroups; 3.1 Gyrocommutative Gyrogroups; 3.2 Nested Gyroautomorphism Identities; 3.3 Two-Divisible Two-Torsion Free Gyrocommutative Gyrogroups; 3.4 From M obius to Gyrogroups; 3.5 Higher Dimensional M obius Gyrogroups; 3.6 M obius gyrations; 3.7 Three-Dimensional M obius gyrations; 3.8 Einstein Gyrogroups; 3.9 Einstein Coaddition; 3.10 PV Gyrogroups; 3.11 Points and Vectors in a Real Inner Product Space; 3.12 Exercises; 4. Gyrogroup Extension; 4.1 Gyrogroup Extension; 4.2 The Gyroinner Product, the Gyronorm, and the Gyroboost; 4.3 The Extended Automorphisms; 4.4 Gyrotransformation Groups; 4.5 Einstein Gyrotransformation Groups; 4.6 PV (Proper Velocity) Gyrotransformation Groups; 4.7 Galilei Transformation Groups; 4.8 From Gyroboosts to Boosts; 4.9 The Lorentz Boost; 4.10 The $(p : q)$ -Gyromidpoint; 4.11 The $(p_1 : p_2 : \dots : p_n)$ -Gyromidpoint; 5. Gyrovectors and Cogyrovectors; 5.1 Equivalence Classes; 5.2 Gyrovectors; 5.3 Gyrovector Translation; 5.4 Gyrovector Translation Composition; 5.5 Points and Gyrovectors; 5.6 The Gyroparallelogram Addition Law; 5.7 Cogyrovectors; 5.8 Cogyrovector Translation; 5.9 Cogyrovector Translation Composition; 5.10 Points and Cogyrovectors; 5.11 Exercises; 6. Gyrovector Spaces; 6.1 Definition and First Gyrovector Space Theorems; 6.2 Solving a System of Two Equations in a Gyrovector Space; 6.3 Gyrolines and Cogyrolines; 6.4 Gyrolines; 6.5 Gyromidpoints; 6.6 Gyrocovariance; 6.7 Gyroparallelograms; 6.8 Gyrogeodesics; 6.9 Cogyrolines; 6.10 Carrier Cogyrolines of Cogyrovectors; 6.11 Cogyromidpoints; 6.12 Cogyrogeodesics; 6.13 Various Gyrolines and Cancellation Laws; 6.14 M obius Gyrovector Spaces; 6.15 M obius Cogyroline Parallelism; 6.16 Illustrating the Gyroline Gyration Transitive Law; 6.17 Turning the M obius Gyrometric into the Poincar e Metric; 6.18 Einstein Gyrovector Spaces; 6.19 Turning Einstein Gyrometric into a Metric; 6.20 PV(Proper Velocity) Gyrovector Spaces; 6.21 Gyrovector Space Isomorphisms; 6.22 Gyrotriangle Gyromedians and Gyrocentroids; 6.22.1 In Einstein Gyrovector Spaces; 6.22.2 In M obius Gyrovector Spaces; 6.22.3 In PV Gyrovector Spaces; 6.23 Exercises; 7. Rudiments of Differential Geometry; 7.1 The Riemannian Line Element of Euclidean Metric; 7.2 The Gyroline and the Cogyroline Element; 7.3 The Gyroline Element of M obius Gyrovector Spaces; 7.4 The Cogyroline Element of M obius Gyrovector Spaces

This book presents a powerful way to study Einstein's special theory of relativity and its underlying hyperbolic geometry in which analogies with classical results form the right tool. It introduces the notion of vectors into analytic hyperbolic geometry, where they are called *gyrovectors*. Newtonian velocity addition is the common vector addition, which is both commutative and associative. The resulting vector spaces, in turn, form the algebraic setting for the standard model of Euclidean geometry. In full analogy, Einsteinian velocity addition is a gyrovector addition, which is both