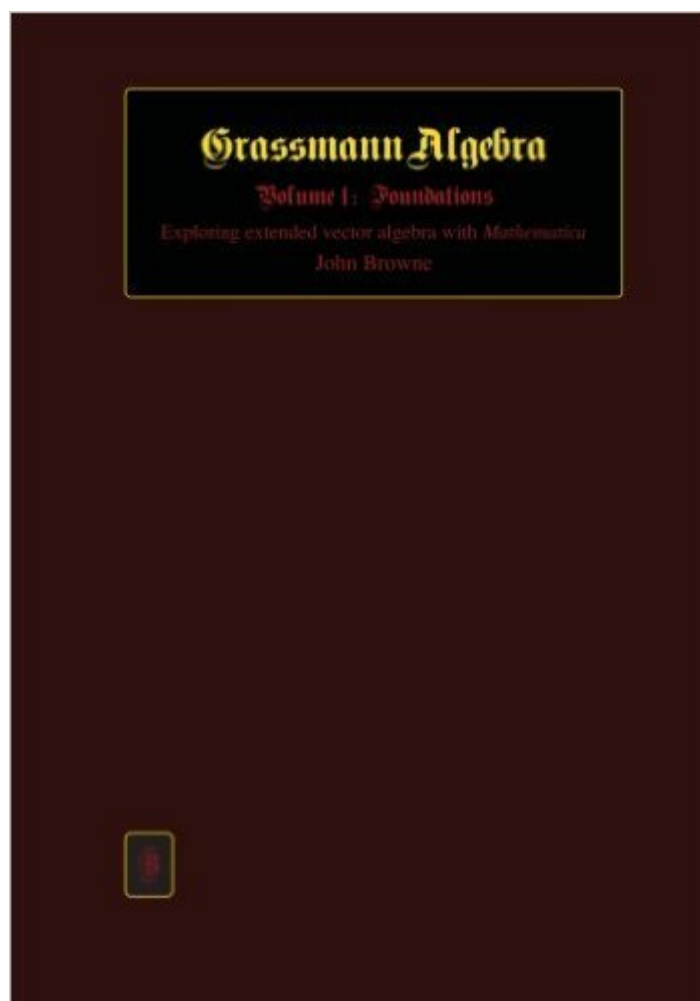# Grassmann Algebra Volume 1: Foundations: Exploring Extended Vector Algebra With Mathematica

Synopsis

Grassmann Algebra Volume 1: Foundations Exploring extended vector algebra with Mathematica Grassmann algebra extends vector algebra by introducing the exterior product to algebraicize the notion of linear dependence. With it, vectors may be extended to higher-grade entities: bivectors, trivectors, ... multivectors. The extensive exterior product also has a regressive dual: the regressive product. The pair behaves a little like the Boolean duals of union and intersection. By interpreting one of the elements of the vector space as an origin point, points can be defined, and the exterior product can extend points into higher-grade located entities from which lines, planes and multiplanes can be defined. Theorems of Projective Geometry are simply formulae involving these entities and the dual products. By introducing the (orthogonal) complement operation, the scalar product of vectors may be extended to the interior product of multivectors, which in this more general case may no longer result in a scalar. The notion of the magnitude of vectors is extended to the magnitude of multivectors: for example, the magnitude of the exterior product of two vectors (a bivector) is the area of the parallelogram formed by them. To develop these foundational concepts, we need only consider entities which are the sums of elements of the same grade. This is the focus of this volume. But the entities of Grassmann algebra need not be of the same grade, and the possible product types need not be constricted to just the exterior, regressive and interior products. For example quaternion algebra is simply the Grassmann algebra of scalars and bivectors under a new product operation. Clifford, geometric and higher order hypercomplex algebras, for example the octonions, may be defined similarly. If to these we introduce Clifford's invention of a scalar which squares to zero, we can define entities (for example dual quaternions) with which we can perform elaborate transformations. Exploration of these entities, operations and algebras will be the focus of the volume to follow this. There is something fascinating about the beauty with which the mathematical structures that Hermann Grassmann discovered describe the physical world, and something also fascinating about how these beautiful structures have been largely lost to the mainstreams of mathematics and science. He wrote his seminal Ausdehnungslehre (Die Ausdehnungslehre. Vollständig und in strenger Form) in 1862. But it was not until the latter part of his life that he received any significant recognition for it, most notably by Gibbs and Clifford. In recent times David Hestenes' Geometric Algebra must be given the credit for much of the emerging awareness of GrassÂ- mann's innovation. In the hope that the book be accessible to scientists and engineers, students and professionals alike, the text attempts to avoid any terminology which does not make an essential contribution to an understanding of the basic concepts. Some familiarity with basic linear algebra may however be useful. The book is written using Mathematica, a powerful

system for doing mathematics on a computer. This enables the theory to be cross-checked with computational explorations. However, a knowledge of Mathematica is not essential for an appreciation of Grassmann's beautiful ideas.

Book Information

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Customer Reviews

The publication of this book, Grassmann Algebra by John Browne, is a watershed event. According to the author, "the focus of these books [a second volume on applications is in preparation] is to provide a readable account in modern notation of Grassmann's major algebraic contributions to mathematics and science." I believe that the author has succeeded in realizing his goal. The only background required is linear algebra.For those who have never heard of Grassmann Algebra, let me address this question: as a subject, is Hermann Grassmann's algebra worth studying? Gauging by its influence, I would say `most definitely'. For instance, the vector calculus used in physics and engineering is a tailoring (by Gibbs and Heaviside) of Grassmann's algebra ([...]). Geometric Algebra, used in physics, engineering and computer science, was developed by William Clifford and based on the work of Grassmann ([...]). The list goes on. Here is an interesting biography of Elie Cartan that refers to Hermann Grassmann ([...]).If Hermann Grassmann's work is so influential why haven't you heard of him or his work? Unfortunately, Grassmann's mathematical work was generally unappreciated in his life. To quote Wikipedia, "The Die Lineale Ausdehnungslehre (1844) by Hermann Grassmann was a revolutionary text, too far ahead of its time to be appreciated [...])." In the end, is seems that those who did understand Grassmann's work, had to adapt it into various forms that were more accessible to the larger mathematical community. The adaptations became the primary sources. This resulted in Grassmann's work being forgotten except by a few specialists.

Recent interest in Geometric Algebra has had the side effect of increasing interest in Grassmann Algebra.

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