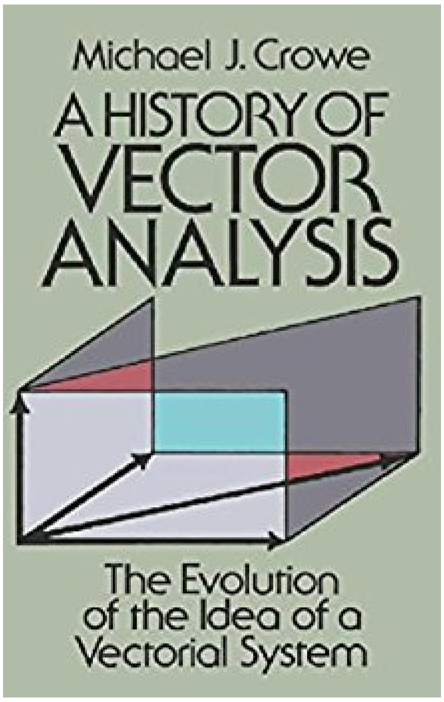
A History Of Vector Analysis: The Evolution Of The Idea Of A Vectorial System



Michael J. Crowe

A HISTORY OF VECTOR ANALYSIS

The Evolution of the Idea of a Vectorial System

Synopsis

On October 16, 1843, Sir William Rowan Hamilton discovered quaternions and, on the very same day, presented his breakthrough to the Royal Irish Academy. Meanwhile, in a less dramatic style, a German high school teacher, Hermann Grassmann, was developing another vectorial system involving hypercomplex numbers comparable to quaternions. The creations of these two mathematicians led to other vectorial systems, most notably the system of vector analysis formulated by Josiah Willard Gibbs and Oliver Heaviside and now almost universally employed in mathematics, physics and engineering. Yet the Gibbs-Heaviside system won acceptance only after decades of debate and controversy in the latter half of the nineteenth century concerning which of the competing systems offered the greatest advantages for mathematical pedagogy and practice.This volume, the first large-scale study of the development of vectorial systems, traces he rise of the vector concept from the discovery of complex numbers through the systems of hypercomplex numbers created by Hamilton and Grassmann to the final acceptance around 1910 of the modern system of vector analysis. Professor Michael J. Crowe (University of Notre Dame) discusses each major vectorial system as well as the motivations that led to their creation, development, and acceptance or rejection.The vectorial approach revolutionized mathematical methods and teaching in algebra, geometry, and physical science. As Professor Crowe explains, in these areas traditional Cartesian methods were replaced by vectorial approaches. He also presents the history of ideas of vector addition, subtraction, multiplication, division (in those systems where it occurs) and differentiation. His book also contains refreshing portraits of the personalities involved in the competition among the various systems.Teachers, students, and practitioners of mathematics, physics, and engineering as well as anyone interested in the history of scientific ideas will find this volume to be well written, solidly argued, and excellently documented. Reviewers have described it a s "a fascinating volume," "an engaging and penetrating historical study" and "an outstanding book (that) will doubtless long remain the standard work on the subject." In 1992 it won an award for excellence from the Jean Scott Foundation of France.

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Customer Reviews

We take for granted mankind’s current ability to fly across continents without error. The landing on the moon, made possible only by the ability of NASA computers to predict changing orbits between two celestial objects, has become ancient history. But, just how did this revolution in applied mathematical thinking occur? Two hundred years ago no one but Issaic Newton and God had even imagined what this would require in navigational artistry.The Mathematics of Geometry has been around for a very long time. Pythagoras created a society based on the relationships of sacred numbers around 300 B.C. And we now know the Egyptians had been keeping it safe for thousands of years. Yet, it is taught primarily as an intellectual exercise in Universities, I should know. Something happened to make this dusty exercise come alive and serve our loftiest ambitions. And it happened suddenly around 1843.One man by the name of William Hamilton had an idea while strolling across a bridge. He was wrestling with a problem in multiplying vectors, basically the same ones postulated by Euclid. But he was doing it in three-space and the irksome things tended to reverse themselves at odd points. He had been trying to use three element vectors to solve the problem, but they didn’t behave themselves. On this walk he had an inspiration, use four item vectors and the mathematics worked flawlessly. The Quaternion was born and one hundred and seventy years of debate over the use of them has now occurred.This is the book about the subject of Vector Analysis that may be considered to have raised mankind out of pounding along the ground and sent him off to travel among the stars. Vector Analysis provides the basis for electromagnetic field computations, understanding the physics of rotating systems, as well as what type of spaceflight maneuvering it will take to place a man on another planet and bring him back successfully. Even flight simulator computer games require this concept to work.This book is about how mankind began to think like the Gods of old. It was not a simple process, it almost was hijacked out of existence. This concept took over a hundred years of argument and development to become fully evolved. So read about the idea that gave support to Tesla's design for the electric grid that supports the machine this review is being written on. Read about the competing concepts and people that contributed to modern civilization that depends on electricity, radio, airlines, world navigation, and GPS satellites to exist. And thank your lucky stars that someone saw a need to make this idea practical.

Lessons we learn early become so much a part of our thinking that we cannot imagine the world otherwise. So it is with arithmetic and yes, vector analysis too. Yet logic forces us to admit that there once was a time without arithmetic or vector analysis. Crowe's carefully written and well researched book makes clear that that time for vector analysis was not so long ago. Prior to vector analysis, the description of commonplace processes such as the movement of an object was done by Cartesian analysis. So, if one wanted to describe the motion of a particle, separate equations were written for the particle's motion in each of the three spatial dimensions. Thus Newton's deceptively simple force law, F=ma becomes three equations, one for the x-axis, a second for the y-axis and a third for the z-axis. With vector analysis, these three equations collapse into one, (vector F) = (mass)x(vector a), and, it is this simplicity of expression, which is much more evident when bold fonts are available to the reviewer, that makes vectors so appealing.Crowe opens by taking us back to a time before vector analysis and provides a view of its origins in the parallelogram of forces, the geometrical interpretation of complex numbers, and the early ruminations of Leibniz on space analysis. After an enlightening discussion of complex number geometry, he eases us into the invention of quaternions by Sir W. R. Hamilton and Hamilton's intellectual struggles preceding the invention of these hypercomplex numbers. For us who are not mathematicians by trade, this struggle is instructive, for, not only do we learn something about the creative process and the history of mathematical thought, we also, if we care to retain it, learn some math. Furthermore, we are reminded of Hamilton's genius as a theoretical physicist. I, for one, knew nothing of his work in geometrical optics and his exciting prediction, later experimentally verified, of conical diffraction.From quaternions Crowe leads us into a mind opening discussion of various efforts to describe geometrical objects in three dimensions. Here we discover not only some of the storied names of nineteenth century mathematics but also, if we are alert and receptive, some, perhaps, wholly unexpected mathematical ideas, for example the multiplication of points to obtain a line. Rightly so, it is the work of Hermann Grassmann, that commands the most attention here. Regrettably, Grassmann's product was so involved, so monumental even, that Crowe left this reader wishing for more, a wish that could only be satisfied by other books.Then we meet Gibbs and Heaviside, those two splendid scientists, who, standing on the shoulders of those two giants Hamilton and Grassmann, created the practical system of vector analysis that we all learn today in beginning calculus, or if not there, then in beginning mechanics or electricity and magnetism. Here we see the clash of the physicists' pragmatism with the mathematicians desire for logical unity, a clash that reverberated for years. Eventually, in the realm of the physical sciences, Gibbs and Heaviside carry the day but not without controversy and struggle. It is during this period in the late nineteenth century that we discover once again that intellectuals are just people subject to the same passions as anyone else. In fact, with the play "Copenhagen" in mind which provides a marvelous fictional portrayal of scientists in conflict, I suggest that the struggles over vector analysis have all the elements of good fiction within them.In this book, Crowe traces in detail, the history of the thought processes that led to our modern system of vector analysis. Though the reading may be dry, there is great excitement lurking just below the surface and between the lines. If you have ever wondered how we got where we are vector wise, you can find out here. Crowe includes biographical sketches that humanize the leading figures in this story. And, if you enjoy footnotes, Crowe is masterful with some of his. This book is the product of prodigious intellectual effort and self discipline and will greatly reward the patient reader.

Michael J. Crowe's account of the evolution of our modern system of vector analysis was first published in 1967 but the history it refers to is a good bit older. The book traces the idea of a vectorial system from beginnings with the notion of the composition of velocities, known to the ancient Greeks. It continues through attempts to find a mathematics of position by Leibniz and others, through the realization of the vectorial interpretation of complex numbers, through attempts to extend complex numbers to model 3-dimensional physical space culminating in Hamilton's discovery of quaternions, and eventually to the modern system worked out by Gibbs and Heaviside. The book gives a detailed account of the relative degrees of influence of Hamilton's quaternion system and the profound but less known and more algebraic system devised by Hermann Grassmann. The role of physical science in motivating developments, or not, in the emerging mathematics of vectors is explored particularly in the work of Maxwell in electromagnetic theory, leading to the modifications of Hamilton's system by Oliver Heaviside and Josiah Gibbs. Crowe's history is very thorough. It is eminently readable with flashes of humour and a clear style but readers might not want to take in the full detail of the story, at least on a first reading.

A nice and accessible read for a scientist who uses vectors and is interested to know how they developed. Note this is in a pdf format, so it is not so convenient on a kindle, but it does keep the equations looking good

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