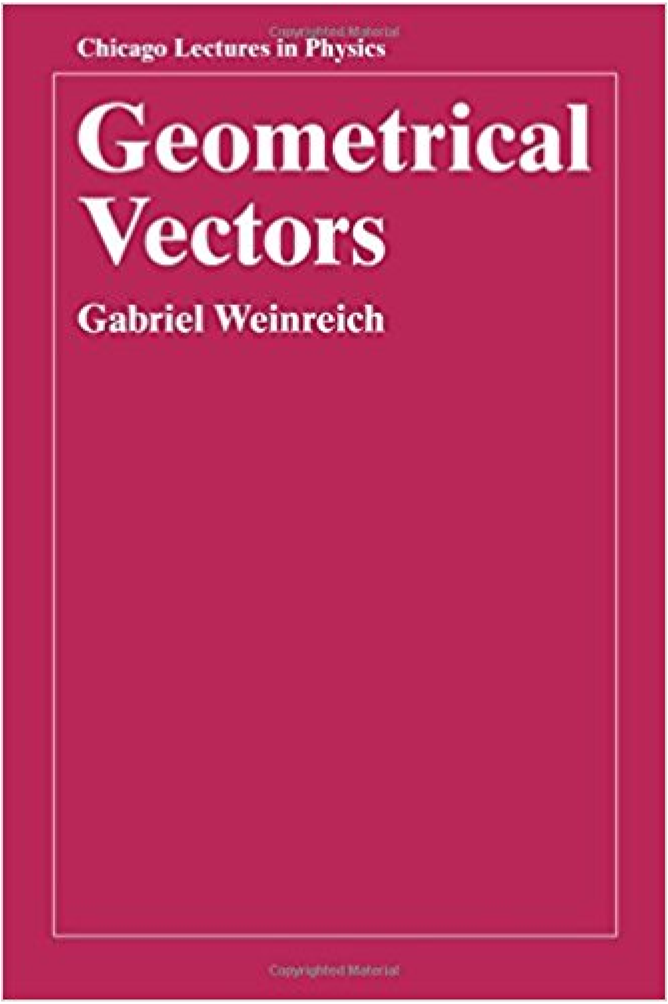
Geometrical Vectors (Chicago Lectures In Physics)



Synopsis

Every advanced undergraduate and graduate student of physics must master the concepts of vectors and vector analysis. Yet most books cover this topic by merely repeating the introductory-level treatment based on a limited algebraic or analytic view of the subject.Geometrical Vectors introduces a more sophisticated approach, which not only brings together many loose ends of the traditional treatment, but also leads directly into the practical use of vectors in general curvilinear coordinates by carefully separating those relationships which are topologically invariant from those which are not. Based on the essentially geometric nature of the subject, this approach builds consistently on students' prior knowledge and geometrical intuition.Written in an informal and personal style, Geometrical Vectors provides a handy guide for any student of vector analysis. Clear, carefully constructed line drawings illustrate key points in the text, and problem sets as well as physical examples are provided.

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Customer Reviews

Physics/MathematicsEvery advanced undergraduate and graduate student of physics must master the concepts of vectors and vector analysis. Yet most textbooks cover this topic by merely repeating the introductory-level treatment based on a limited algebraic or analytic view of the subject.By contrast, Geometrical Vectors introduces a more sophisticated approach, which not only brings together many loose ends of the traditional treatment, but also leads directly into the practical use of vectors in general curvilinear coordinates by carefully separating those relationships which are topologically invariant from those which are not. Based on the essentially geometric nature of the subject, this approach builds consistently on students' prior knowledge and geometrical intuition.Written in an informal and personal style, Geometrical Vectors provides a handy guide for any student of vector analysis. Clear, carefully constructed line drawings illustrate key points in the text, and a set of problems is provided at the end of each chapter (except the Epilogue) to deepen understanding of the material presented. Pertinent physical examples are cited to show how geometrically informed methods of vector analysis may be applied to situations of special interest to physicists.

I have to admit, when I first started reading the book, I was ready to dismiss it all as nonsense...I mean really, vectors are arrows, not a stack or thumbtack or any of the other "flavors" of vectors that are introduced in the book. I kept reading, and eventually the light clicked on...maybe I'm slow. Or maybe I simply still bear the bruises from my high school physics teacher beating the whole "arrow: magnitude and direction" aspect of vectors into me.Weinreich discusses vectors, in their many forms (contravariant, covariant, etc), almost entirely divorced from anything to do with physical laws. Relying on our natural human intuition and perception capabilities, this book explores the definition and manipulation of vectors and vector fields as simple geometric objects existing in three dimensional space where rulers are forbidden. Along the way, we learn about the simplicity, power, and if I may dare say, the beauty, of the branch of mathematics known as vector analysis.This is a great book to accompany a course or a more traditional book on the topic (e.g.Ã Â Gravitation). I found the book to be easy to read and comprehend (and I am an engineer, not a physicist or mathematician). I think some of the figures could have used a little work, seeing how the whole book is based on geometry arguments.

This book is deep! While lacking the formal rigor of vector analysis or exterior calculus this book attempts to remedy the lack of intuition that often accompanies such treatments (read the preface of the book).In this book the author sneaks in clifford algebra, forms and applications to physics, he gives us a method of calculation that opens up the vector calculus you already knew and gives a great way to 'draw' many phenomenon in physics.The author has an important agenda in this volume and that is to distinguish between objects that naturally behave differently. It has been the legacy of Gibbs and Heaviside for us to flounder in the 3-d application/misapplication of Hamiliton's quaternions. The reader is led to realize that identifying everything with contravariant vectors (arrows) is wrong and damaging to our intuition of phenomenon.I highly recommend this book. It may seem hokey at first with odd names like thumbtack and swarm but it portrays deep mathematics in a beautiful manner. Work hard on it, apply it to physics and mathematics and be surprised at what you find! This sort of geometrical analysis is hard to find (try Gravitation by MTW or Applied Differential Geometry by Burke) at this level.Remember it is meant to be an affordable companion to courses on vector and tensor analysis, and what a companion it is!

A fresh look at what can be a dusty subject, demonstrates simple yet powerful unifying concepts. This book is a treat.

I actually have a few complaints about this book, but the core material is so helpful and instructive that they don’t much matter.This book explains vector and the beginnings of tensor analysis with new visual metaphors for vectors: lines, sheaves, thumbtacks, stacks. The dot and cross products can be visualized with these metaphors, and the various forms of Stokes/Gauss theorems proven visually.This is great stuff for anyone going beyond the basics in vector analysis -- which would be anyone in pure math or physics, and some engineers.You do need to use this as an adjuct to a conventional text or course.This is the more sophisticated and general version of "Div, Grad, Curl and All That".

The concept of a field got its first geometrical incarnation thanks to Michael Faraday’s line drawings. Since, its treatment and interpretations have been progressively analytical as the sophistication of physical description has necessitated its abstraction. Gabriel Weinreich has convinced me through his wonderful little monograph that there is more than meets the eye if one cared to look and extend geometrical reasoning to those vector concepts that can be understood by our everyday intuition.The primary strength of his method, at least initially, lies in a description of vector relationships in rubbery space. The raison d’etre is twofold, as the author points out quite early. One appeals to the pedagogical advantage of exploiting the capacity of our brain to extrapolate 3D data from what is essentially a 2D image on the retina (in conjunction with the stereoscopic nature of vision, of course), and hence lending itself to think in topologically invariant terms. The other leaves the forms of relationships invariant in this rubber space geometry, which potentially saves some nightmare calculations from their tedium.Weinreich hints, however, that this formulation might not represent `interesting’ physical laws, but that there is a lot to be gained from this perspective. Like a well-told story, what exactly is gained emerges with an elegant lucidity only toward the end of the book, where he motivates the definition of the metric through topological reasoning. He does this by first demonstrating the problems faced when representing physical laws, like Maxwell's equations, using his invariant formulation, then introduces a coordinate representation that is necessitated by the need for this metric. Ultimately, he provides an alternative to his invariant formulation by introducing a scaling factor for orthogonal basis vectors which is represented in terms of a Cartesian system. This is but one of the infinite possibilities, making the definition of the metric independent of a Cartesian or orthogonal basis.In the present development, from the earliest arguments about invariance, one thing I did find missing was any mention about fundamental and derived quantities, which would have provided support for arguments about space distortions. A case in point being the example of the capacitor field. At the same time, I cannot help but wonder if the omission was deliberate, so the author could emphasize that particular physical systems did not affect topological invariance. If one were oblivious to dimensional analysis, this would be understandable, but given that the audience of this book is primarily students of physics, I don't think it would be easy to turn that blind an eye.Weinreich builds his invariant scaffolding by creating four types of vectors to facilitate his intuitive outlook, dividing them into `plane' and `line' types. In addition, he introduces three types of scalars. If that didn't seem fanciful enough, he draws out his hat both a polar and an axial sense to each. That leaves us to juggle fourteen objects and their relationships!However, he offers an accurate picture for each, and goes on to define how they satisfy closure properties, and then extends his arguments and constructions to vector operations. One could get lost in the myriad permutations if he hadn't brought it all together, reasoning why his exotic vectors don't spawn an unending array of objects of increasing complexity. The finiteness of the flavors, both for scalars and vectors, turns out a be a consequence of the simplicity of their representation. Weinreich is quite straightforward in his justification: either constructed objects can be drawn, or they need to make sense from a invariance viewpoint, which is to say that the response to space transformations is linear. This is where a remarkably consistent description emerges, and it comes as quite a surprise to see how he even blends the three flavors of scalars he introduces to the coherent set of rules between vector and scalar quantities. Newer objects mushroom but can be appropriately classified and unruly objects are politely but firmly discarded, keeping the balance - nothing unnecessary, and nothing insufficient.The introduction of the gradient, divergence and curl, in addition to the vector integral relations, Stokes' and the Gauss's theorem, have a wonderfully elegant geometrical construction and interpretation, and I think this where the simplicity of the approach reaps its benefits. If one were to visualize fields in terms of lines or surfaces, gleaning these limiting relations in so direct a manner would have possibly moved the man who taught us how to think in terms of fields at the first place - Michael Faraday. If one were to reminisce about a middle school essay involving a hypothetical meeting with a historical character, it doesn't get better than this.After fabricating and floating around in rubber space, and having defined field operations, Weinreich comfortably descends into a coordinate system, albeit general, where he grounds his vectors in a basis. The interesting thing is that he derives the basis from the idea of a scalar field, and defines it so. When I thought back about this approach in retrospect, I realized that he had introduced the idea of a reciprocal lattice through this definition. This was the most pleasant shock! Maybe it is my sheer naivete, but I hadn't come across this concept except through the conventional condensed matter treatment - the wave vector approach. In fact, I had to rub my eyes again to see that if the basis was defined in terms of the field, and its reciprocal basis was defined in terms of the gradient, this was symbolically obvious even in the differential notation! So here was a new perspective to reciprocity.That said, I felt there was an element lacking in the treatment of the abstract vector quantities introduced for constructions. What I would have liked to see was a discussion of dependent and independent variables threaded through the topics. It would have provided some of the geometric transformations a physical context, especially when differential operations and formation of the basis are discussed. Again, I understand that this point is debatable, and any discussion of dependent quantities would have to be associated with the physical system at hand, and may not have kept the discussion as general as the author had intended it to be.The development of vector differential relations in his terms of the generalized basis follows, and we see how, true to its promise of invariance, its forms are exactly the ubiquitous and familiar Cartesian differentials. After this, Weinreich demonstrates how his house of cards almost collapses the moment Maxwell's equations are introduced. This underlines the need for a metric and we are back to our conventional Cartesian system, but now with the knowledge that it represents just one basis and metric, and we can express other bases in terms of it. The idea of orthogonal bases is then motivated from a proportionality relation between reciprocal bases and we see how this leads to an alternative representation of a basis in terms of unit vector and position-dependent scale factors. Finally, comfortable switching bases, and representing the differential operators in these, we realize there isn't anything special about Rene Descarte, and we close with a generic definition of a metric, as a stepping stone to understanding more abstract geometries.Summarizing, the topological route that Weinreich follows ultimately frees the representation of basis vectors in Cartesian terms, and defines the metric in terms of invariant basis vectors. This approach motivates the idea of a metric from a geometrical viewpoint but inspired by the form of a physical law. We get to see how the means itself can lead to a somewhat different end.The author succinctly points out at the end of this book how his approach could be a victim of its own success. He is acutely aware of it limitations, and doesn't mince his words in spelling them out. The most obvious shortcoming is also the prima forte of the approach, in the sense that our intuition is sometimes a dysfunctional radar as we seek out physical laws, and demanding simple geometric representation may be too simplistic a demand. Further, the approach works very well for 3D space, but the objects need to be redefined when we step down to flatland. This is typically contrary to methods of generalization, where expanding the scope of arguments leaves existing structures intact. Lastly, the ease with which we could shift the form of operators between bases assumed that it could be expressed in Cartesian terms, thereby implying the underlying space was flat. Obviously, this argument doesn't hold water for curved spaces with a different metric.Geometrical vectors, in effect, gives us in all its visual self-sufficiency, what H. M. Schey's Div, grad, curl and all that offered for the symbolic understanding of vector differential and integral calculus. One can only guess why Dr Weinreich is somewhat recalcitrant about introducing a similar book on tensors. He might be losing sleep worrying if it will live up to the standards of this one.

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