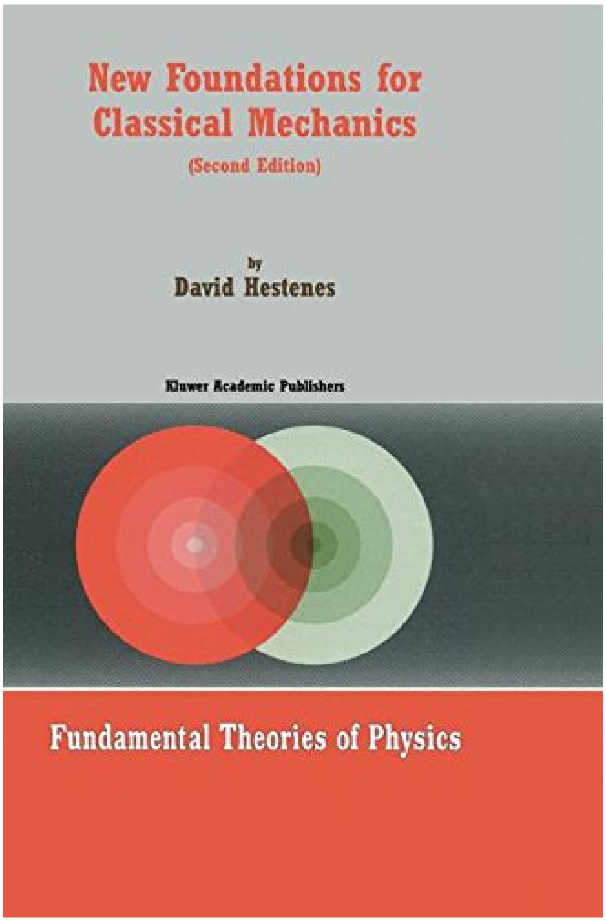
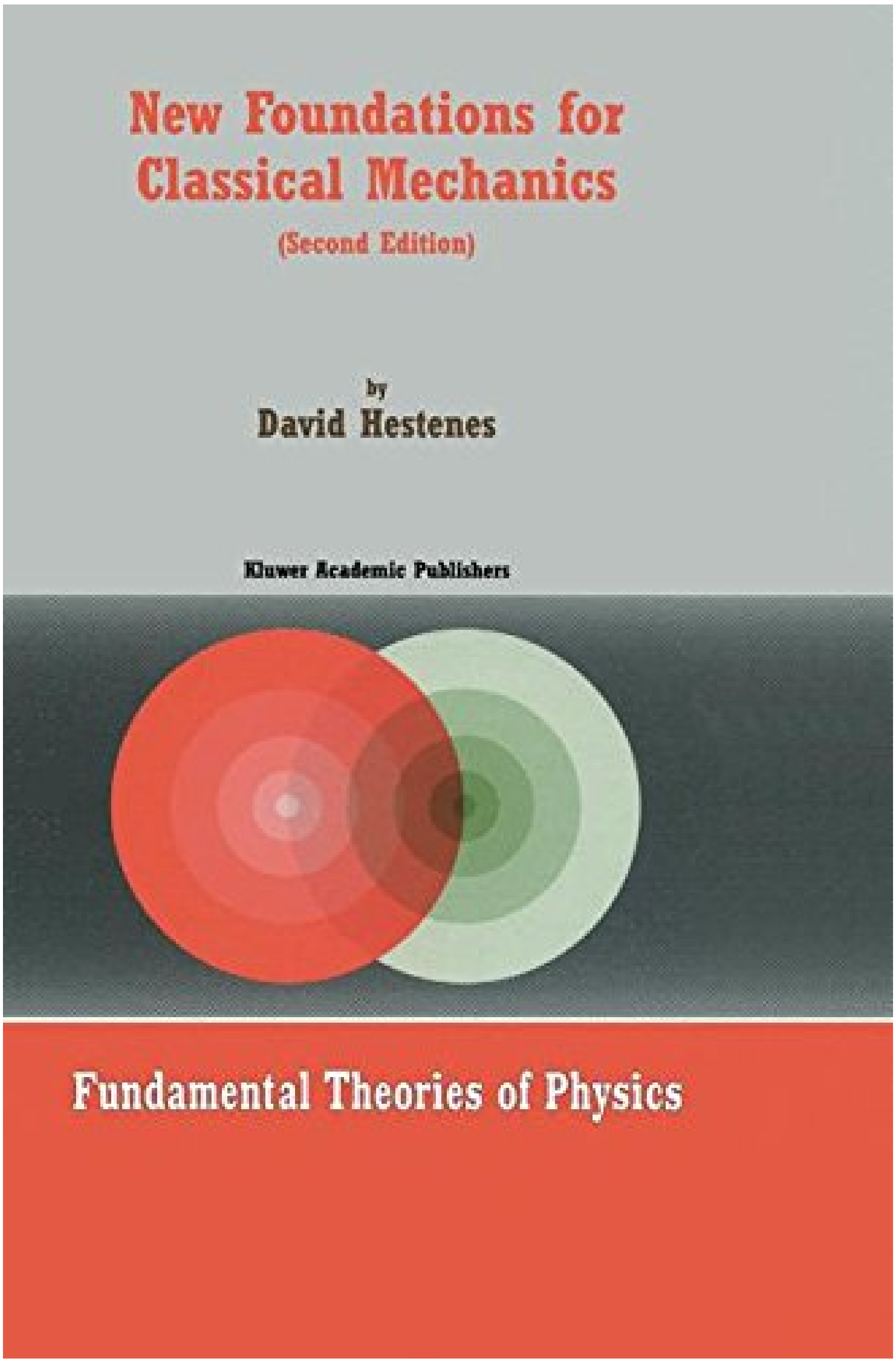
NEW FOUNDATIONS FOR CLASSICAL MECHANICS (FUNDAMENTAL THEORIES OF PHYSICS) BY DAVID HESTENES




New Foundations for
Classical Mechanics
(Second Edition)
by
David Hestenes
Kluwer Academic Publishers
Fundamental Theories of Physics

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About the Author
David Hesteness is awarded the Oersted Medal for 2002.
The Oersted Award recognizes notable contributions to the teaching of physics. It is the most prestigious award conferred by the American Association of Physics Teachers.

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(revised) This is a textbook on classical mechanics at the intermediate level, but its main purpose is to serve as an introduction to a new mathematical language for physics called geometric algebra. Mechanics is most commonly formulated today in terms of the vector algebra developed by the American physicist J. Willard Gibbs, but for some applications of mechanics the algebra of complex numbers is more efficient than vector algebra, while in other applications matrix algebra works better. Geometric algebra integrates all these algebraic systems into a coherent mathematical language which not only retains the advantages of each special algebra but possesses powerful new capabilities. This book covers the fairly standard material for a course on the mechanics of particles and rigid bodies. However, it will be seen that geometric algebra brings new insights into the treatment of nearly every topic and produces simplifications that move the subject quickly to advanced levels. That has made it possible in this book to carry the treatment of two major topics in mechanics well beyond the level of other textbooks. A few words are in order about the unique treatment of these two topics, namely, rotational dynamics and celestial mechanics.

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About the Author
David Hesteness is awarded the Oersted Medal for 2002.
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Most helpful customer reviews

47 of 48 people found the following review helpful.
A problem with relativistic mechanics...
By Prof C. R. PAIVA
David Hestenes is a forerunner of the modern development of Clifford algebra. His current research activities can be followed in the site [...] Probably his most important book until now (written with Garret Sobczyk) was "Clifford Algebra to Geometric Calculus: A Unified Language for Mathematics and Physics" (Dordrecht: Kluwer Academic Publishers, 1984) also available at Amazon.com. This book on the new

foundations for classical mechanics (second edition) was written as an introduction to geometric algebra. The term "geometric algebra" was coined to stress that this formulation of Clifford algebra is a unified language for physics and mathematics; it is not a matrix algebra (as used in quantum mechanics in the disguised forms of Pauli and Dirac matrices) as it uses a new property, the contraction, which makes it different from other associative algebras. A recent book on geometric algebra is "Geometric Algebra for Physicists" by Chris Doran and Anthony Lasenby (Cambridge: Cambridge University Press, 2003) - see the site [...]

Geometric algebra is a graded algebra based on the geometric product of vectors which reduces to the inner product (a scalar) when the two vectors are parallel and to the outer product (a bivector) when the two vectors are orthogonal. The geometric product is associative and can be used in spaces with any dimension (as opposed to the cross product of vectors which is not associative and can only be used in three or seven dimensions). Therefore, the geometric product is able to generate several graded algebras: (i) in two dimensions we recover the complex numbers as elements of a real algebra, not as elements of a field; (ii) in three dimensions we get a geometric algebra that is far better than the Gibbsian approach mainly due to the geometric role of rotors is reflections and rotations; (iii) in four dimensions we obtain the so-called spacetime algebra which is perfect for Minkowski spacetime within the context of special relativity - see the paper from Hestenes in American Journal of Physics (vol. 71, pp. 691-714, June 2003). Hamilton's quaternions are properly understood. Even as a new gauge theory of gravity on flat spacetime Hestenes' geometric algebra plays a very important role - see the paper from Hestenes in Foundations of Physics (vol. 25, pp. 903-970, June 2005). The clear and insightful approach that geometric algebra can bring to the Dirac equation is also remarkable.

My only problem with this book is due to Chapter 9 on relativistic mechanics. In this chapter Hestenes takes the usual approach that can be found in traditional four-vectors, by representing an event as a paravector, i.e., as a sum of a scalar and a three-dimensional vector (in Euclidean space). This kind of approach doesn't take advantage of geometric algebra (as in his article on spacetime algebra for Am. J. Phys.) because spatial vectors are not directly linked to an observer (and to its proper time) as they are in spacetime algebra where the so-called space-time split clearly leads to an invariant and proper formulation of physics. In Chapter 9, indeed, these paravectors induce a relativistic approach and not a proper approach. Nevertheless, apart from this remark, my overall comment on this book is very positive.

33 of 36 people found the following review helpful.
Great for physicists, okay for others
By Thouis Jones
This is a great introduction to the Geometric (Clifford) Algebra. It's fundamentally a physics textbook, however. Those readers whose only desire is to learn the Geometric Algebra might feel some frustration at having to separate out the Geometric Algebra from the physics. Readers that prefer learning by exploring applications and examples will like this book; those that prefer explanations in the abstract will still enjoy many sections, but will have to make it through the more applied sections to get the full story.
Reading the book and working through the problems gives a firm grounding in the use of the Geometric Algebra and teaches classical mechanics besides. I could easily recommend this book as a physics textbook on its merits in that area alone.

10 of 10 people found the following review helpful.
Can Geometric Algebra be Taught in High School?
By Pdecordoba
Update, 9 December 2012: Don't miss Alan Macdonald's Linear and Geometric Algebra, which is recommended enthusiastically by Hestenes.

Although New Foundations for Classical Mechanics (NFCM) is primarily a physics book, it's also intended to demonstrate the usefulness of geometric algebra (GA) in solving any sort of problem whose data and unknowns can be formulated as vectors.

Several previous reviewers were more qualified than I to discuss the advanced aspects of this book. I review it from the viewpoint of someone who was considering Hestenes' advice, expressed elsewhere, to employ geometric algebra in high-school classes. Of course I didn't expect that New Foundations would be suitable for high schoolers. Instead, I wanted to decide whether GA might save students enough time in college to be worth introducing in high school. To that end, I worked many of the problems in the first 3-1/2 chapters, then skipped to chapter 5, where I have worked on only the first section. I also attempted, with mixed results,* to solve classic geometry problems via GA, especially those involving construction of circles tangent to other objects.

That amount of experience is probably necessary to decide about trying GA in high schools. My own decision is a cautious "yes", with some caveats regarding both GA itself, and this book.

First, NFCM is definitely not a stand-alone textbook. Although Hestenes' explanations of many topics are not only lucid, but genuinely thought-provoking, few people who tackle NFCM on their own will find it easy. But then, Hestenes never said it would be. As he noted on p. 39 of his Oersted Medal paper (see first comment, below, for all references in this review),

"... I had to design [New Foundations] as a multipurpose book, including a general introduction to GA and material of interest to researchers, as well as problem sets for students. It is not what I would have written to be a mechanics textbook alone. Most students need judicious guidance by the instructor to get through it."

By the way, anyone who's considering teaching GA anywhere should read that paper to learn from Hestenes' own travails.

Since I had no instructor to give me judicious guidance, I read several papers on GA by Hestenes and others. The lectures and problem sets from Cambridge University were helpful up to the point where they became too advanced for me. Another good reference was Ramon Gonález Calvet's "Treatise of Plane Geometry through Geometric Algebra". The chapters from the previous edition of NFCM that Hestenes maintains online offered many valuable perspectives.

However, all of those resources couldn't make up for the lack of a good solutions manual, with plenty of additional worked-out examples. If I could make just one suggestion to Hestenes for facilitating adoption of GA, this would be it. Ideally, the manual would also show how to explore GA using computer software such as GAViewer, or even CaRMetal (which I plunked along with). I suspect Hestenes would agree with all of these recommendations.

IN SUMMARY
This is a good book for learning to use GA, if used as Hestenes intended. I'm convinced that GA is worth trying to teach at the high school level. I don't expect that it would be any easier to teach than the geometry and trig that it would replace, but it should pay off better down the road.

Please note that Hestenes and his colleagues have also done extensive research on teaching physics. The "Modeling Instruction in Physics" method they developed has given good results. (See links.)

* EDIT 1 August 2014: Geometric Algebra actually works quite well for solving "construction" problems. When I wrote this review in 2010, I hadn't yet learned to frame the problems as needed to make use of GA's

strengths. The contrasts between how to frame problems for solution via GA and via "ruler-and-compass" are thought-provoking. See the link "Classical vs GA Solutions" in the first comment.

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