The Mathematics Of Minkowski Space Time With An Introduction To Commutative Hypercomplex Numbers Frontiers In Mathematics

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Space--time--matter - Hermann Weyl 1922

The Universal Force - Louis Girifalco 2008
This book describes the growth of our understanding of gravity and the science on which it is based, from the early Greeks to Einstein's grand insights of curved space-time. Showing that science searches for the ultimate roots of natural phenomena and therefore pursues a kind of mysticism, the mysteries it unfolds are strange and enthralling.
Galileo Unbound - David D. Nolte 2018-07-12
Galileo Unbound traces the journey that brought us from Galileo's law of free fall to today's geneticists measuring evolutionary drift, entangled quantum particles moving among many worlds, and our lives as trajectories traversing a health space with thousands of dimensions. Remarkably, common themes persist that predict the evolution of species as readily as the orbits of planets or the collapse of stars into black holes. This book tells the history of spaces of expanding dimension and increasing abstraction and how they continue today to give new insight into the physics of complex systems. Galileo published the first modern law of motion, the Law of Fall, that was ideal and simple, laying the foundation upon which Newton built the first theory of dynamics. Early in the twentieth century, geometry became the cause of motion rather than the result when Einstein envisioned the fabric of space-time warped by mass and energy, forcing light rays to bend past the Sun. Possibly more radical was Feynman's dilemma of quantum particles taking all paths at once — setting the stage for the modern fields of quantum field theory and quantum computing. Yet as concepts of motion have evolved, one thing has remained constant, the need to track ever more complex changes and to capture their essence, to find patterns in the chaos as we try to predict and control our world.
Scientific Principles of Time, Space, and Perception - stephen h jarvis 2020-06-30
Any theory of physical reality is like a map; not just a map, yet a map of our human perception capability, successfully navigating the idea of space through time, understanding how all of that works. It is like travelling around the world; taking photos, gaining a greater understanding of how the world works, how the world lives, and how it breathes. To achieve that as a pure theory of physics in exploring space and time, from the basis of human perception, the travelling experience there is identifying a set of successful patterns of data that have been proven experimentally through real means, as patterns of data that come together to form a fundamental property of definition for perception as a logos of reality, here as a logos of space and time. The eBook presented here accounts for such a process, detailing 18 consecutive physics papers on the subject of time and perception, and how perception holds the key in unlocking the mystery of time and space. One key logos regarding our perception with space and time is that to understand nature is to first trust it, to trust what is presented to our perception as real, and thus more fundamentally, to know our perception, to accept those fundamentals. Yet how is “trust” a part of science, and should it be? In some ways nature like our body is like a piano; we can play anything with it, yet knowing how it works is key to getting the most out of it. And surely to get the most out of reality using our perception, our greater ability to perceive and think is certainly required for our advancement in the physical arts and sciences. This eBook is about knowing how nature works by accepting how our perception works and how perception can be used to understand the scientific here and now components of time and space. The eBook presented here is such a focus, and the hope is that it is an insightful and rewarding process of study. The utility of this eBook is to position the already freely available papers (available at http://www.equusspace.com/index-2.htm) in the one word/phrase search facility for immediate word/phrase index search functionality. For instance, if one wants to find which paper Avogadro’s constant was derived, it can be found by typing in “Avogadro” in the eBook document search function. If one wants to find where the fine structure constant was derived, it can be found by typing “fine structure constant” in the e-book document search function. When those results come up, each of those results will point to which of the papers that subject word/phrase arises by where it exists in the eBook. Owing to the nature of needing to keep each chapter as true to publication as the papers, hyperlinks for references are not used in the eBook yet remain the function of the individual papers themselves. The eBook is compiled as chapters representative of the sequential order of the papers as per publishing date, from chapter 1 (paper 1) to chapter 18 (paper 18). Paper 18 represents a summary of all the papers to the level of defining the fundamental and principle features of time, space, and perception; it was logical to reach paper 18 as a follow-on from papers 1-17, as a summary of the findings, namely the complete and fundamental description of time, space, and perception and their common functionality. Chapter 18 therefore is a good starting point, owing to its overview nature, if one is uncertain about the how to approach the papers. Or, if at any time one finds themselves getting lost in the reading, head to chapter 18 to get that overall heads-up overview perspective of what is ultimately sought in the papers, namely the fundamental scientific principles of time, space, and perception.
The Large Scale Structure of Space-Time - S. W. Hawking 1975-02-27
Einstein's General Theory of Relativity leads to two remarkable predictions: first, that the ultimate destiny of many massive stars is to undergo gravitational collapse and to disappear from view, leaving behind a 'black hole' in space; and secondly, that there will exist singularities in space-time itself. These singularities are places where space-time begins or ends, and the presently known laws of physics break down. They will occur inside black holes, and in the past are what might be construed as the beginning of the universe. To show how these predictions arise, the authors discuss the General Theory of Relativity in the large. Starting with a precise formulation of the theory and an account of the necessary background of differential geometry, the significance of space-time curvature is discussed and the global properties of a number of exact solutions of Einstein's field equations are examined. The theory of the causal structure of a general space-time is developed, and is used to study black holes and to prove a number of theorems establishing the inevitability of singularities under certain conditions. A discussion of the Cauchy problem for General Relativity is also included in this 1973 book.

The Einstein-Klein-Gordon Coupled System - Alexandru D. Ionescu 2022-03-15
The main construction and outline of the proof -- Preliminary estimates -- The nonlinearities N^h/[infinity][beta] and n^[psi] -- Improved energy estimates -- Improved profile bounds -- The main theorems.
Complex General Relativity - Maria Rosaria D'Esposito 1995-02-28
This book is written for theoretical and mathematical physicists and mat- maticians interested in recent developments in complex general relativity and their application to classical and quantum gravity. Calculations are presented by paying attention to those details normally omitted in research papers, for pedagogical r- sons. Familiarity with fibre-bundle theory is certainly helpful, but in many cases I only rely on two-spinor calculus and conformally invariant concepts in gravitational physics. The key concepts the book is devoted to are complex manifolds, spinor techniques, conformal gravity, ?-planes, ?-surfaces, Penrose transform, complex 3 1 – – space-time models with non-vanishing torsion, spin- fields and spin-potentials. 2 2 Problems have been inserted at the end, to help the reader to check his und- standing of these topics. Thus, I can find at least four reasons for writing yet another book on spinor and twistor methods in general relativity: (i) to write a textbook useful to - ginning graduate students and research workers, where two-component spinor c- culus is the unifying mathematical language.
Space, Time, and Spacetime - Lawrence Sklar 1977-03-15
In this book, Lawrence Sklar demonstrates the interdependence of science and philosophy by examining a number of crucial problems on the nature of space and time—problems that require for their resolution the resources of philosophy and of physics. The overall issues explored are our knowledge of the geometry of the world, the existence of spacetime as an entity over and above the material objects of the world, the relation between temporal order and causal order, and the problem of the direction of time. Without neglecting the most subtle philosophical points or the most advanced contributions of contemporary physics, the author has taken pains to make his explorations intelligible to the reader with no advanced training in physics, mathematics, or philosophy. The arguments are set forth step-by-step, beginning from first principles; and the philosophical discussions are supplemented in detail by nontechnical expositions of crucial features of physical theories.
The Einstein Theory of Space-time Without Mathematics - Samuel Blankson 2005-07-01
SOFTCOVER PRINT VERSION This is a new monograph by the Ghanaian philosopher, Samuel K. K. Blankson, who gave us The Metaphysical Foundations For Physics. In less than a hundred pages, and without mathematics, he launches a blistering attach on Herman Minkowski, the foremost mathematical interpreter of Einstein's theory of Space-Time. He explains that space-time is a philosophical concept and that mathematicians are ill-equipped to interpret it properly, and gives his own interpretation of space-time as 'relation between points'. The book is written in plain language, and aimed at the intelligent general reader. There is no doubt that if Blankson is right then mathematicians have a major problem on their hands.
Deformed Spacetime - Fabio Cardone 2007-09-04
This volume provides a detailed discussion of the mathematical aspects and physical applications of a new geometrical structure of space-time, based on a generalization ("deformation") of the usual Minkowski space, as supposed to be endowed with a metric whose coefficients depend on the energy. This new five-dimensional scheme (Deformed Relativity in Five Dimensions, DR5) represents a true generalization of the usual Kaluza-Klein (KK) formalism.
Global Nonlinear Stability of Schwarzschild Spacetime under Polarized Perturbations - Jérémie Szeftel 2020-12-15
Essential mathematical insights into one of the most important and challenging open problems in general relativity—the stability of black holes One of the major outstanding questions about black holes is whether they remain stable when subject to small perturbations. An affirmative answer to this question would provide strong theoretical support for the physical reality of black holes. In this book, Sergiu Klainerman and Jérémie Szeftel take a first important step toward solving the fundamental black hole stability problem in general relativity by establishing the stability of nonrotating black holes—or Schwarzschild spacetimes—under so-called polarized perturbations. This restriction ensures that the final state of evolution is itself a Schwarzschild space. Building on the remarkable advances made in the past fifteen years in establishing quantitative linear stability, Klainerman and Szeftel introduce a series of new ideas to deal with the strongly nonlinear, covariant features of the Einstein equations. Most preeminent among them is the general covariant modulation (GCM) procedure that allows them to determine the center of mass frame and the mass of the final black hole state. Essential reading for mathematicians and physicists alike, this book introduces a rich theoretical framework relevant to situations such as the full setting of the Kerr stability conjecture.
The Geometry of Spacetime - James J. Callahan 2000
Hermann Minkowski recast special relativity as essentially a new geometric structure for spacetime. This book looks at the ideas of both Einstein and Minkowski, and then introduces the theory of frames, surfaces and intrinsic geometry, developing the main implications of Einstein's general relativity theory.
The Einstein-Klein-Gordon Coupled System - Alexandru D. Ionescu 2022-03-15
A definitive proof of global nonlinear stability of Minkowski space-time as a solution of the Einstein-Klein-Gordon equations This book provides a definitive proof of global nonlinear stability of Minkowski space-time as a solution of the Einstein-Klein-Gordon equations of general relativity. Along the way, a novel robust analytical framework is developed, which extends to more general matter models. Alexandru Ionescu and Benoît Pausader prove global regularity at an appropriate level of generality of the initial data, and then prove several important asymptotic properties of the resulting space-time, such as future geodesic completeness, peeling estimates of the Riemann curvature tensor, conservation laws for the ADM tensor, and Bondi energy identities and inequalities. The book is self-contained, providing complete proofs and precise statements, which develop a refined theory for solutions of quasilinear Klein-Gordon and wave equations, including novel linear and bilinear estimates. Only mild decay assumptions are made on the scalar field and the initial metric is allowed to have nonisotropic decay consistent with the positive mass theorem. The framework incorporates analysis both in physical and Fourier space, and is compatible with previous results on other physical models such as water waves and plasma physics.
Minkowski Spacetime: A Hundred Years Later - Vesselin Petkov 2010-03-11
Celebrating the one hundredth anniversary of the 1909 publication of Minkowski's seminal paper "Space and Time", this volume includes a fresh translation as well as the original in German, and a number of contributed papers on the still-controversial subject.
Special Relativity - Michael Tsamparlis 2010-05-17
Writing a new book on the classic subject of Special Relativity, on which numerous important physicists have contributed and many books have already been written, can be like adding another epicycle to the Ptolemaic cosmology. Furthermore, it is our belief that if a book has no new elements, but simply repeats what is written in the existing literature, perhaps with a different style, then this is not enough to justify its publication. However, after having spent a number of years, both in class and research with relativity, I have come to the conclusion that there exists a place for a new book. Since it appears that somewhere along the way, mathem- ics may have obscured and prevailed to the degree that we tend to teach relativity (and I believe, theoretical physics) simply using "heavier" mathematics without the inspiration and the mastery of the classic physicists of the last century. Moreover current trends encourage the application of techniques in producing quick results and not tedious conceptual approaches resulting in long-lasting reasoning. On the other hand, physics cannot be done a´ la carte stripped from philosophy, or, to put it in a simple but dramatic context A building is not an accumulation of stones! As a result of the above, a major aim in the writing of this book has been the distinction between the mathematics of Minkowski space and the physics of r- ativity.
Geometrical Physics in Minkowski Spacetime - E.G.Peter Rowe 2013-04-17
From the reviews: "This attractive book provides an account of the theory of special relativity from a geometrical viewpoint, explaining the unification and insights that are given by such a treatment. [...] Can be read with profit by all who have taken a first course in relativity physics." ASLIB Book Guide
3+1 Formalism in General Relativity - Éric Gourgoulhon 2012-02-29
This graduate-level, course-based text is devoted to the 3+1 formalism of general relativity, which also constitutes the theoretical foundations of numerical relativity. The book starts by establishing the

mathematical background (differential geometry, hypersurfaces embedded in space-time, foliation of space-time by a family of space-like hypersurfaces), and then turns to the 3+1 decomposition of the Einstein equations, giving rise to the Cauchy problem with constraints, which constitutes the core of 3+1 formalism. The ADM Hamiltonian formulation of general relativity is also introduced at this stage. Finally, the decomposition of the matter and electromagnetic field equations is presented, focusing on the astrophysically relevant cases of a perfect fluid and a perfect conductor (ideal magnetohydrodynamics). The second part of the book introduces more advanced topics: the conformal transformation of the 3-metric on each hypersurface and the corresponding rewriting of the 3+1 Einstein equations, the Isenberg-Wilson-Mathews approximation to general relativity, global quantities associated with asymptotic flatness (ADM mass, linear and angular momentum) and with symmetries (Komar mass and angular momentum). In the last part, the initial data problem is studied, the choice of spacetime coordinates within the 3+1 framework is discussed and various schemes for the time integration of the 3+1 Einstein equations are reviewed. The prerequisites are those of a basic general relativity course with calculations and derivations presented in detail, making this text complete and self-contained. Numerical techniques are not covered in this book.

Independent Axioms for Minkowski Space-Time - John W Schutz 1997-10-08

The primary aim of this monograph is to clarify the undefined primitive concepts and the axioms which form the basis of Einstein's theory of special relativity. Minkowski space-time is developed from a set of independent axioms, stated in terms of a single relation of betweenness. It is shown that all models are isomorphic to the usual coordinate model, and the axioms are consistent relative to the reals.

Exact Space-Times in Einstein's General Relativity - Jerry B. Griffiths 2009-10-15

Einstein's theory of general relativity is a theory of gravity and, as in the earlier Newtonian theory, much can be learnt about the character of gravitation and its effects by investigating particular idealised examples. This book describes the basic solutions of Einstein's equations with a particular emphasis on what they mean, both geometrically and physically. Concepts such as big bang and big crunch-types of singularities, different kinds of horizons and gravitational waves, are described in the context of the particular space-times in which they naturally arise. These notions are initially introduced using the most simple and symmetric cases. Various important coordinate forms of each solution are presented, thus enabling the global structure of the corresponding space-time and its other properties to be analysed. The book is an invaluable resource both for graduate students and academic researchers working in gravitational physics.

Time and the Application of Time - Samuel K K Blankson 2010-05-24

In this monograph, the Ghanaian philosopher, Samuel K. K. Blankson, takes up the question of time. He argues that time and the application of time are two different things in the mind, but often they are conflated in practice. For example, he says if you want to know the true nature of time you cannot rely on the clock, no matter how it is analysed. Under relativity there is no longer a universal time; therefore how we get our own peculiar earth time to programme into the clock is what you want to know. Also he claims that the merger of space and time in the Minkowski theory of "space-time" is tautology; it is not a new way of giving us our earth time as "space-time." To merge time with space means the time was there already! On the other hand, to argue that there is time already but has now been merged with space is logically untenable---man cannot use mathematics alone to alter natural entities physically.

The Geometry of Minkowski Spacetime - Gregory L. Naber 2011-12-01

This book offers a presentation of the special theory of relativity that is mathematically rigorous and yet spells out in considerable detail the physical significance of the mathematics. It treats, in addition to the usual menu of topics one is accustomed to finding in introductions to special relativity, a wide variety of results of more contemporary origin. These include Zeeman's characterization of the causal automorphisms of Minkowski spacetime, the Penrose theorem on the apparent shape of a relativistically moving sphere, a detailed introduction to the theory of spinors, a Petrov-type classification of electromagnetic fields in both tensor and spinor form, a topology for Minkowski spacetime whose homeomorphism group is essentially the Lorentz group, and a careful discussion of Dirac's famous Scissors Problem and its relation to the notion of a two-valued representation of the Lorentz group. This second edition includes a new chapter on the de Sitter universe which is intended to serve two purposes. The first is to provide a gentle prologue to the steps one must take to move beyond special relativity and adapt to the presence of gravitational fields that cannot be considered negligible. The second is to understand some of the basic features of a model of the empty universe that differs markedly from Minkowski spacetime, but may be recommended by recent astronomical observations suggesting that the expansion of our own universe is accelerating rather than slowing down. The treatment presumes only a knowledge of linear algebra in the first three chapters, a bit of real analysis in the fourth and, in two appendices, some elementary point-set topology. The first edition of the book received the 1993 CHOICE award for Outstanding Academic Title. Reviews of first edition: "... a valuable contribution to the pedagogical literature which will be enjoyed by all who delight in precise mathematics and physics." (American Mathematical Society, 1993) "Where many physics texts explain physical phenomena by means of mathematical models, here a rigorous and detailed mathematical development is accompanied by precise physical interpretations." (CHOICE, 1993) "... his talent in choosing the most significant results and ordering them within the book can't be denied. The reading of the book is, really, a pleasure." (Dutch Mathematical Society, 1993)

Minkowski Space - Joachim Schröter 2017-06-12

In Minkowski-Space the space-time of special relativity is discussed on the basis of fundamental results of space-time theory. This idea has the consequence that the Minkowski-space can be characterized by 5 axioms, which determine its geometrical and kinematical structure completely. In this sense Minkowski-Space is a prolegomenon for the formulation of other branches of special relativity, like mechanics, electrodynamics, thermodynamics etc. But these applications are not subjects of this book. Contents Basic properties of special relativity Further properties of Lorentz matrices Further properties of Lorentz transformations Decomposition of Lorentz matrices and Lorentz transformations Further structures on Ms Tangent vectors in Ms Orientation Kinematics on Ms Some basic notions of relativistic theories

Geometry of Minkowski Space-Time - Francesco Catoni 2011-05-07

This book provides an original introduction to the geometry of Minkowski space-time. A hundred years after the space-time formulation of special relativity by Hermann Minkowski, it is shown that the kinematical consequences of special relativity are merely a manifestation of space-time geometry. The book is written with the intention of providing students (and teachers) of the first years of University courses with a tool which is easy to be applied and allows the solution of any problem of relativistic kinematics at the same time. The book treats in a rigorous way, but using a non-sophisticated mathematics, the Kinematics of Special Relativity. As an example, the famous "Twin Paradox" is completely solved for all kinds of motions. The novelty of the presentation in this book consists in the extensive use of hyperbolic numbers, the simplest extension of complex numbers, for a complete formalization of the kinematics in the Minkowski space-time. Moreover, from this formalization the understanding of gravity comes as a manifestation of curvature of space-time, suggesting new research fields.

General Relativity Without Calculus - Jose Natario 2011-08-01

"General Relativity Without Calculus" offers a compact but mathematically correct introduction to the general theory of relativity, assuming only a basic knowledge of high school mathematics and physics. Targeted at first year undergraduates (and advanced high school students) who wish to learn Einstein's theory beyond popular science accounts, it covers the basics of special relativity, Minkowski space-time, non-Euclidean geometry, Newtonian gravity, the Schwarzschild solution, black holes and cosmology. The quick-paced style is balanced by over 75 exercises (including full solutions), allowing readers to test and consolidate their understanding.

Space-Time Algebra - David Hestenes 2015-04-25

This small book started a profound revolution in the development of mathematical physics, one which has reached many working physicists already, and which stands poised to bring about far-reaching change in the future. At its heart is the use of Clifford algebra to unify otherwise disparate mathematical languages, particularly those of spinors, quaternions, tensors and differential forms. It provides a unified approach covering all these areas and thus leads to a very efficient 'toolkit' for use in physical problems including quantum mechanics, classical mechanics, electromagnetism and relativity (both special and general) – only one mathematical system needs to be learned and understood, and one can use it at levels which extend right through to current research topics in each of these areas. These same techniques, in the form of the

‘Geometric Algebra’, can be applied in many areas of engineering, robotics and computer science, with no changes necessary – it is the same underlying mathematics, and enables physicists to understand topics in engineering, and engineers to understand topics in physics (including aspects in frontier areas), in a way which no other single mathematical system could hope to make possible. There is another aspect to Geometric Algebra, which is less tangible, and goes beyond questions of mathematical power and range. This is the remarkable insight it gives to physical problems, and the way it constantly suggests new features of the physics itself, not just the mathematics. Examples of this are peppered throughout ‘Space-Time Algebra’, despite its short length, and some of them are effectively still research topics for the future. From the Foreward by Anthony Lasenby

Spacetime: Minkowski's Papers on Spacetime Physics - Hermann Minkowski 2020-03-20

Not only the general public, but even students of physics appear to believe that the physics concept of spacetime was introduced by Einstein. This is both unfortunate and unfair. It was Hermann Minkowski (Einstein's mathematics professor) who announced the new four-dimensional (spacetime) view of the world in 1908, which he deduced from experimental physics by decoding the profound message hidden in the failed experiments designed to discover absolute motion. Minkowski realized that the images coming from our senses, which seem to represent an evolving three-dimensional world, are only glimpses of a higher four-dimensional reality that is not divided into past, present, and future since space and all moments of time form an inseparable entity (spacetime). Einstein's initial reaction to Minkowski's view of spacetime and the associated with it four-dimensional physics (also introduced by Minkowski) was not quite favorable: "Since the mathematicians have invaded the relativity theory, I do not understand it myself any more." However, later Einstein adopted not only Minkowski's spacetime physics (which was crucial for Einstein's revolutionary theory of gravity as curvature of spacetime), but also Minkowski's world view as evident from Einstein's letter of condolences to the widow of his longtime friend Besso: "Now Besso has departed from this strange world a little ahead of me. That means nothing. People like us, who believe in physics, know that the distinction between past, present and future is only a stubbornly persistent illusion." Besso left this world on 15 March 1955; Einstein followed him on 18 April 1955. This volume contains Hermann Minkowski's four works, which laid the foundations of spacetime physics: Space and Time, The Relativity Principle, The Fundamental Equations for Electromagnetic Processes in Moving Bodies and A Derivation of the Fundamental Equations for the Electromagnetic Processes in Moving Bodies from the Standpoint of the Theory of Electrons. These papers have never been published together either in German or English and the second and the last paper have not been translated into English so far.

The Geometry of Special Relativity - Tevian Dray 2021-06-15

This unique book presents a particularly beautiful way of looking at special relativity. The author encourages students to see beyond the formulas to the deeper structure. The unification of space and time introduced by Einstein’s special theory of relativity is one of the cornerstones of the modern scientific description of the universe. Yet the unification is counterintuitive because we perceive time very differently from space. Even in relativity, time is not just another dimension, it is one with different properties The book treats the geometry of hyperbolas as the key to understanding special relativity. The author simplifies the formulas and emphasizes their geometric content. Many important relations, including the famous relativistic addition formula for velocities, then follow directly from the appropriate (hyperbolic) trigonometric addition formulas. Prior mastery of (ordinary) trigonometry is sufficient for most of the material presented, although occasional use is made of elementary differential calculus, and the chapter on electromagnetism assumes some more advanced knowledge. Changes to the Second Edition The treatment of Minkowski space and spacetime diagrams has been expanded. Several new topics have been added, including a geometric derivation of Lorentz transformations, a discussion of three-dimensional spacetime diagrams, and a brief geometric description of "area" and how it can be used to measure time and distance. Minor notational changes were made to avoid conflict with existing usage in the literature. Table of Contents Preface 1. Introduction. 2. The Physics of Special Relativity. 3. Circle Geometry. 4. Hyperbola Geometry. 5. The Geometry of Special Relativity. 6. Applications. 7. Problems III. 8. Paradoxes. 9. Relativistic Mechanics. 10. Problems II. 11. Relativistic Electromagnetism. 12. Problems III. 13. Beyond Special Relativity. 14. Three-Dimensional Spacetime Diagrams. 15. Minkowski Area via Light Boxes. 16. Hyperbolic Geometry. 17. Calculus. Bibliography. Author Biography Tevian Dray is a Professor of Mathematics at Oregon State University. His research lies at the interface between mathematics and physics, involving differential geometry and general relativity, as well as nonassociative algebra and particle physics; he also studies student understanding of "middle-division" mathematics and physics content. Educated at MIT and Berkeley, he held postdoctoral positions in both mathematics and physics in several countries prior to coming to OSU in 1988. Professor Dray is a Fellow of the American Physical Society for his work in relativity, and an award-winning teacher.

Mathematics of Relativity - George Yuri Rainich 2014-11-19

Based on the ideas of Einstein and Minkowski, this concise treatment is derived from the author's many years of teaching the mathematics of relativity at the University of Michigan. Geared toward advanced undergraduates and graduate students of physics, the text covers old physics, new geometry, special relativity, curved space, and general relativity. Beginning with a discussion of the inverse square law in terms of simple calculus, the treatment gradually introduces increasingly complicated situations and more sophisticated mathematical tools. Changes in fundamental concepts, which characterize relativity theory, and the refinements of mathematical technique are incorporated as necessary. The presentation thus offers an easier approach without sacrifice of rigor. Dover (2014) republication of the edition published by John Wiley & Sons, New York, 1950. See every Dover book in print at www.doverpublications.com

Gauge Field Theory in Natural Geometric Language - Daniel Canarutto 2020-10-06

Gauge Field theory in Natural Geometric Language addresses the need to clarify basic mathematical concepts at the crossroad between gravitation and quantum physics. Selected mathematical and theoretical topics are exposed within a brief, integrated approach that exploits standard and non-standard notions, as well as recent advances, in a natural geometric language in which the role of structure groups can be regarded as secondary even in the treatment of the gauge fields themselves. In proposing an original bridge between physics and mathematics, this text will appeal not only to mathematicians who wish to understand some of the basic ideas involved in quantum particle physics, but also to physicists who are not satisfied with the usual mathematical presentations of their field.

The Global Nonlinear Stability of the Minkowski Space (PMS-41) - Demetrios Christodoulou 2014-07-14

The aim of this work is to provide a proof of the nonlinear gravitational stability of the Minkowski space-time. More precisely, the book offers a constructive proof of global, smooth solutions to the Einstein Vacuum Equations, which look, in the large, like the Minkowski space-time. In particular, these solutions are free of black holes and singularities. The work contains a detailed description of the sense in which these solutions are close to the Minkowski space-time, in all directions. It thus provides the mathematical framework in which we can give a rigorous derivation of the laws of gravitation proposed by Bondi. Moreover, it establishes other important conclusions concerning the nonlinear character of gravitational radiation. The authors obtain their solutions as dynamic developments of all initial data sets, which are close, in a precise manner, to the flat initial data set corresponding to the Minkowski space-time. They thus establish the global dynamic stability of the latter. Originally published in 1994. The Princeton Legacy Library uses the latest print-on-demand technology to again make available previously out-of-print books from the distinguished backlist of Princeton University Press. These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions. The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905.

Spacetime, Geometry and Gravitation - Pankaj Sharan 2009-11-18

This is an introductory book on the general theory of relativity based partly on lectures given to students of M.Sc. Physics at my university. The book is divided into three parts. The ?rst part is a preliminary course on general relativity with minimum preparation. The second part builds the ma- ematical background and the third part deals with topics where mathematics developed in the second part is needed. The ?rst chapter gives a general background and introduction. This is f- lowed by an introduction to curvature through Gauss’ Theorema Egregium. This theorem expresses the curvature of a two-dimensional surface in terms of intrinsic quantitiesrelatedtothein?nitesimaldistancefunctiononthesurface.Thestudent isintroducedtothemetrictensor,Christo?elsymbolsandRiemanncurvaturet- sor by elementary methods in the familiar and visualizable case of two dimensions. This early introduction to geometric quantities equips a student to learn simpler topics in general relativity like the Newtonian limit, red shift, the Schwarzschild solution, precession of the perihelion and bending of light in a gravitational ?eld. Part II (chapters 5 to 10) is an introduction to Riemannian geometry as - quired by general relativity. This is done from the beginning, starting with vectors and tensors. I believe that students of physics grasp physical concepts better if they are not shaky about the mathematics involved.

Relativity and Geometry - Roberto Torretti 2014-05-20

Relativity and Geometry aims to elucidate the motivation and significance of the changes in physical geometry brought about by Einstein, in both the first and the second phases of relativity. The book contains seven chapters and a mathematical appendix. The first two chapters review a historical background of relativity. Chapter 3 centers on Einstein's first Relativity paper of 1905. Subsequent chapter presents the Minkowskian formulation of special relativity. Chapters 5 and 6 deal with Einstein's search for general relativity from 1907 to 1915, as well as some aspects and subsequent developments of the theory. The last chapter explores the concept of simultaneity, geometric conventionalism, and a few other questions concerning space time structure, causality, and time.

Springer Handbook of Spacetime - Abhay Ashtekar 2014-09-01

The Springer Handbook of Spacetime is dedicated to the ground-breaking paradigm shifts embodied in the two relativity theories, and describes in detail the profound reshaping of physical sciences they ushered in. It includes in a single volume chapters on foundations, on the underlying mathematics, on physical and astrophysical implications, experimental evidence and cosmological predictions, as well as chapters on efforts to unify general relativity and quantum physics. The Handbook can be used as a desk reference by researchers in a wide variety of fields, not only by specialists in relativity but also by researchers in related areas that either grew out of, or are deeply influenced by, the two relativity theories: cosmology, astronomy and astrophysics, high energy physics, quantum field theory, mathematics, and philosophy of science. It should also serve as a valuable resource for graduate students and young researchers entering these areas, and for instructors who teach courses on these subjects. The Handbook is divided into six parts. Part A: Introduction to Spacetime Structure. Part B: Foundational Issues. Part C: Spacetime Structure and Mathematics. Part D: Confronting Relativity theories with observations. Part E: General relativity and the universe. Part F: Spacetime beyond Einstein.

The Geometry of Minkowski Spacetime - Gregory L. Naber 2003-01-01

This mathematically rigorous treatment examines Zeeman's characterization of the causal automorphisms of Minkowski spacetime and the Penrose theorem concerning the apparent shape of a relativistically moving sphere. Other topics include the construction of a geometric theory of the electromagnetic field; an in-depth introduction to the theory of spinors; and a classification of electromagnetic fields in both tensor and spinor form. Appendixes introduce a topology for Minkowski spacetime and discuss Dirac's famous "Scissors Problem." Appropriate for graduate-level courses, this text presumes only a knowledge of linear algebra and elementary point-set topology. 1992 edition. 43 figures.

Foundations of Special Relativity: Kinematic Axioms for Minkowski Space-Time - J. W. Schutz 1973-12-20

The aim of this monograph is to give an axiomatic development of Einstein's theory of special relativity from axioms which describe intuitive concepts concerning the kinematic behavior of inertial particles and light signals.

Introduction to Lorentz Geometry - Ivo Terek Couto 2021-01-05

Lorentz Geometry is a very important intersection between Mathematics and Physics, being the mathematical language of General Relativity. Learning this type of geometry is the first step in properly understanding questions regarding the structure of the universe, such as: What is the shape of the universe? What is a spacetime? What is the relation between gravity and curvature? Why exactly is time treated in a different manner than other spatial dimensions? Introduction to Lorentz Geometry: Curves and Surfaces intends to provide the reader with the minimum mathematical background needed to pursue these very interesting questions, by presenting the classical theory of curves and surfaces in both Euclidean and Lorentzian ambient spaces simultaneously. Features: Over 300 exercises Suitable for senior undergraduates and graduates studying Mathematics and Physics Written in an accessible style without loss of precision or mathematical rigor Solution manual available on www.routledge.com/9780367468644

The Mathematics of Minkowski Space-Time - Francesco Catoni 2008-06-29

This book arose out of original research on the extension of well-established applications of complex numbers related to Euclidean geometry and to the space-time symmetry of two-dimensional Special Relativity. The system of hyperbolic numbers is extensively studied, and a plain exposition of space-time geometry and trigonometry is given. Commutative hypercomplex systems with four unities are studied and attention is drawn to their interesting properties.

Special Relativity - N.M.J. Woodhouse 2012-12-06

This book provides readers with the tools needed to understand the physical basis of special relativity and will enable a confident mathematical understanding of Minkowski's picture of space-time. It features a large number of examples and exercises, ranging from the rather simple through to the more involved and challenging. Coverage includes acceleration and tensors and has an emphasis on space-time diagrams.

Space, Time, and Geometry - Patrick Suppes 1973-12-31

The articles in this volume have been stimulated in two different ways. More than two years ago the editor of Synthese, laakko Hintikka, an nounced a special issue devoted to space and time, and articles were solicited. Part of the reason for that announcement was also the second source of papers. Several years ago I gave a seminar on special relativity at Stanford, and the papers by Domotor, Harrison, Hudgin, Latzer and myself partially arose out of discussion in that seminar. All of the papers except those of Griinbaum, Fine, the second paper of Friedman, and the paper of Adams appeared in a special double issue of Synthese (24 (1972), Nos. 1-2). I am pleased to have been able to add the four additional papers mentioned in making the special issue a volume in the Synthese Library. Of these four additional articles, only the one by Fine has pre viously appeared in print (Synthese 22 (1971),448--481); its relevance to the present volume is apparent. In preparing the papers for publication and in carrying out the various editorIal chores of such a task, I am very much indebted to Mrs. Lillian O'Toole for her extensive assistance. INTRODUCTION The philosophy of space and time has been of permanent importance in philosophy, and most of the major historical figures in philosophy, such as Aristotle, Descartes and Kant, have had a good deal to say about the nature of space and time.

Spinors and Space-Time: Volume 2, Spinor and Twistor Methods in Space-Time Geometry - Roger Penrose 1984

In the two volumes that comprise this work Roger Penrose and Wolfgang Rindler introduce the calculus of 2-spinors and the theory of twistors, and discuss in detail how these powerful and elegant methods may be used to elucidate the structure and properties of space-time. In volume 1, Two-spinor calculus and relativistic fields, the calculus of 2-spinors is introduced and developed. Volume 2, Spinor and twistor methods in space-time geometry, introduces the theory of twistors, and studies in detail how the theory of twistors and 2-spinors can be applied to the study of space-time. This work will be of great value to all those studying relativity, differential geometry, particle physics and quantum field theory from beginning graduate students to experts in these fields.