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Space, Time, and Geometry Nov 29 2019 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 editorlal 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.
General Relativity and Gravitation May 04 2020 Explore spectacular advances in contemporary physics with this unique celebration of the centennial of Einstein's discovery of general relativity.
The Geometry of Special Relativity Apr 14 2021 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.

Orthogonality and Spacetime Geometry Apr 26 2022 This book examines the geometrical notion of orthogonality, and shows how to use it as the primitive concept on which to base a metric structure in affine geometry. The focus of the book is on geometries having lines which are self-orthogonal, or even singular (orthogonal to all lines). The most significant examples concern the four-dimensional spacetime of special relativity, however no knowledge of physics is presumed. An initial chapter has been included which explains the physical interpretation of the different orthogonality relations. The mathematical background needed is basic abstract and linear algebra.

General Relativity Jul 06 2020 Solutions and hints to selected exercises

The Geometry of Spacetime Jan 04 2023 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.

Differential Geometry and Relativity Theory Jun 16 2021 Differentilil Geometry and Relativity Theory: An Introduction approaches relativity asa geometric theory of space and time in which gravity is a manifestation of space-timecurvature, rathe1 than a force. Uniting differential geometry and both special and generalrelativity in a single source, this easy-to-understand text opens the general theory of relativityto mathematics majors having a backgr.ound only in multivariable calculus and linearalgebra.The book offers a broad overview of the physical foundations and mathematical details ofrelativity, and presents concrete physical interpretations of numerous abstract concepts inRiemannian geometry. The work is profusely illustrated with diagrams aiding in the understandingof proofs and explanations. Appendices feature important material on vectoranalysis and hyperbolic functions.Differential Geometry and Relativity Theory: An Introduction serves as the ideal textfor high-level undergraduate couues in mathematics and physics, and includes a solutionsmanual augmenting classroom study. It is an invaluable reference for mathematicians interestedin differential and IUemannian geometry, or the special and general theories ofrelativity

Space, Time, and Spacetime Dec 23 2021 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.

Spinors and Space-Time: Volume 2, Spinor and Twistor Methods in Space-Time Geometry May 16 2021 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.

General Relativity Mar 02 2020 "Wald's book is clearly the first textbook on general relativity with a totally modern point of view; and it succeeds very well where others are only partially successful. The book includes full discussions of many problems of current interest which are not treated in any

extant book, and all these matters are considered with perception and understanding."—S. Chandrasekhar "A tour de force: lucid, straightforward, mathematically rigorous, exacting in the analysis of the theory in its physical aspect."—L. P. Hughston, Times Higher Education Supplement "Truly excellent. . . . A sophisticated text of manageable size that will probably be read by every student of relativity, astrophysics, and field theory for years to come."—James W. York, Physics Today

The Shape of Inner Space Nov 09 2020 Argues that geometry is fundamental to string theory--which posits that we live in a 10-dimensional existence--as well as the very nature of the universe, and explains where mathematics will take string theory next.

Spacetime, Geometry, Cosmology Mar 26 2022 Novel interpretation of the relationship between space, time, gravitation, and their cosmological implications; based on author's discovery of a value in gravitation overlooked by both Newton and Einstein. 1982 edition.

Space – Time – Matter Oct 09 2020 This monograph describes some of the most interesting results obtained by the mathematicians and physicists collaborating in the CRC 647 "Space – Time – Matter", in the years 2005 - 2016. The work presented concerns the mathematical and physical foundations of string and quantum field theory as well as cosmology. Important topics are the spaces and metrics modelling the geometry of matter, and the evolution of these geometries. The partial differential equations governing such structures and their singularities, special solutions and stability properties are discussed in detail. Contents Introduction Algebraic K-theory, assembly maps, controlled algebra, and trace methods Lorentzian manifolds with special holonomy – Constructions and global properties Contributions to the spectral geometry of locally homogeneous spaces On conformally covariant differential operators and spectral theory of the holographic Laplacian Moduli and deformations Vector bundles in algebraic geometry and mathematical physics Dyson–Schwinger equations: Fix-point equations for quantum fields Hidden structure in the form factors ofN = 4 SYM On regulating the AdS superstring Constraints on CFT observables from the bootstrap program Simplifying amplitudes in Maxwell-Einstein and Yang-Mills-Einstein supergravities Yangian symmetry in maximally supersymmetric Yang-Mills theory Wave and Dirac equations on manifolds Geometric analysis on singular spaces Singularities and long-time behavior in nonlinear evolution equations and general relativity

Asymptotic Behavior of Mass and Spacetime Geometry Aug 26 2019

Space-Time Algebra Aug 07 2020 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

Minkowski Geometry Dec 31 2019 Minkowski geometry is a non-Euclidean geometry in a finite number of dimensions that is different from elliptic and hyperbolic geometry (and from the Minkowskian geometry of spacetime). Here the linear structure is the same as the Euclidean one but distance is not "uniform" in all directions. Instead of the usual sphere in Euclidean space, the unit ball is a general symmetric convex set. Therefore, although the parallel axiom is valid, Pythagoras' theorem is not. This book begins by presenting the topological properties of Minkowski

spaces, including the existence and essential uniqueness of Haar measure, followed by the fundamental metric properties - the group of isometries, the existence of certain bases and the existence of the Lowner ellipsoid. This is followed by characterizations of Euclidean space among normed spaces and a full treatment of two-dimensional spaces. The three central chapters present the theory of area and volume in normed spaces. The author describes the fascinating geometric interplay among the isoperimetrix (the convex body which solves the isoperimetric problem), the unit ball and their duals, and the ways in which various roles of the ball in Euclidean space are divided among them. The next chapter deals with trigonometry in Minkowski spaces and the last one takes a brief look at a number of numerical parameters associated with a normed space, including J. J. Schaffer's ideas on the intrinsic geometry of the unit sphere. Each chapter ends with a section of historical notes and the book ends with a list of 50 unsolved problems. Minkowski Geometry will appeal to students and researchers interested in geometry, convexity theory and functional analysis.

Geometric Flows and the Geometry of Space-time Jun 28 2022 This book consists of two lecture notes on geometric flow equations (O. Schnürer) and Lorentzian geometry - holonomy, spinors and Cauchy Problems (H. Baum and T. Leistner) written by leading experts in these fields. It grew out of the summer school "Geometric flows and the geometry of space-time" held in Hamburg (2016) and provides an excellent introduction for students of mathematics and theoretical physics to important themes of current research in global analysis, differential geometry and mathematical physics

Spacetime Jul 30 2022 One of the most of exciting aspects is the general relativity pred- tion of black holes and the Such Big Bang. predictions gained weight the theorems through Penrose. singularity pioneered In various by te- books on theorems general relativity singularity are and then presented used to that black holes exist and that the argue universe started with a To date what has big been is bang. a critical of what lacking analysis these theorems predict-' We of really give a proof a typical singul- theorem and this ity use theorem to illustrate problems arising through the of possibilities violations" and "causality weak "shell very crossing These singularities". add to the problems weight of view that the point theorems alone singularity are not sufficient to the existence of predict physical singularities. The mathematical theme of the book In order to both solid gain a of and intuition understanding good for any mathematical theory, one,should to realise it as model of try a a fam- iar non-mathematical theories have had concept. Physical an especially the important on of and impact development mathematics, conversely various modern theories physical rather require sophisticated mathem- ics for their formulation. both and mathematics Today, physics are so that it is often difficult complex to master the theories in both very s- in the of jects. However, case differential pseudo-Riemannian geometry or the general relativity between and mathematics relationship physics is and it is therefore especially close, to from interd- possible profit an ciplinary approach.

Relativity and Geometry Mar 14 2021 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.

The Geometry of Minkowski Spacetime Nov 02 2022 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.

Geometry, Relativity and the Fourth Dimension Jan 12 2021 Exposition of fourth dimension, concepts of relativity as Flatland characters continue adventures. Topics include curved space time

as a higher dimension, special relativity, and shape of space-time. Includes 141 illustrations.

The Geometry of Spacetime Oct 21 2021 This book systematically develops the mathematical foundations of the theory of relativity and links them to physical relations. For this purpose, differential geometry on manifolds is introduced first, including differentiation and integration, and special relativity is presented as tensor calculus on tangential spaces. Using Einstein's field equations relating curvature to matter, the relativistic effects in the solar system including black holes are discussed in detail. The text is aimed at students of physics and mathematics and assumes only basic knowledge of classical differential and integral calculus and linear algebra.

Geometry of Minkowski Space-Time Aug 31 2022 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.

Spacetime and Geometry Sep 19 2021 Why is the universe so symmetrical? / Dennis Sciama -- Null congruences and Plebanski-Schild spaces / Ivor Robinson -- Linearization stability / Dieter Brill -- Nonlinear model field theories based on harmonic mappings / Charles W. Misner -- Gravitational fields in general relativity / Roy F. Kerr -- On the potential barriers surrounding the Schwarzschild black hole / S. Chandrasekhar -- The initial value problem and beyond / James W. York, Jr. and Tsvi Piran.

Spacetime and Singularities Oct 28 2019 An elementary introduction to the geometrical methods and notions used in special and general relativity. Emphasizes the ideas concerned with structure of space-time that play a role in Penrose-Hawking singularity theorems.

A Mathematical Introduction To General Relativity Aug 19 2021 The book aims to give a mathematical presentation of the theory of general relativity (that is, spacetime-geometry-based gravitation theory) to advanced undergraduate mathematics students. Mathematicians will find spacetime physics presented in the definition-theorem-proof format familiar to them. The given precise mathematical definitions of physical notions help avoiding pitfalls, especially in the context of spacetime physics describing phenomena that are counter-intuitive to everyday experiences.In the first part, the differential geometry of smooth manifolds, which is needed to present the spacetime-based gravitation theory, is developed from scratch. Here, many of the illustrating examples are the Lorentzian manifolds which later serve as spacetime models. This has the twofold purpose of making the physics forthcoming in the second part relatable, and the mathematics learnt in the first part less dry. The book uses the modern coordinate-free language of semi-Riemannian geometry. Nevertheless, to familiarise the reader with the useful tool of coordinates for computations, and to bridge the gap with the physics literature, the link to coordinates is made through exercises, and via frequent remarks on how the two languages are related.In the second part, the focus is on physics, covering essential material of the 20th century spacetime-based view of gravity: energy-momentum tensor field of matter, field equation, spacetime examples, Newtonian approximation, geodesics, tests of the theory, black holes, and cosmological models of the universe.Prior knowledge of differential geometry or physics is not assumed. The book is intended for self-study, and the solutions to the (over 200) exercises are included.

M-Theory and Quantum Geometry Dec 11 2020 The fundamental structure of matter and spacetime at the shortest length scales remains an exciting frontier of basic research in theoretical physics. A unifying theme in this area is the quantisation of geometrical objects. The majority of contributions to this volume cover recent advances in superstring theory, which is the leading candidate for a unified description of all known elementary particles and interactions. The geometrical concept of one-dimensional extended objects (strings) has always been at the core of superstring theory, but recently the focus has shifted to include higher-dimensional objects (D-

branes), which play a key role in non-perturbative dynamics of the theory. Related developments are also described in M-theory, our understanding of quantum effects in black-hole physics, gauge theory of the strong interaction, and the dynamic triangulation construction of the quantum geometry of spacetime.

Quantum Mechanics in the Geometry of Space-Time May 28 2022 This book continues the fundamental work of Arnold Sommerfeld and David Hestenes formulating theoretical physics in terms of Minkowski space-time geometry. We see how the standard matrix version of the Dirac equation can be reformulated in terms of a real space-time algebra, thus revealing a geometric meaning for the "number i" in quantum mechanics. Next, it is examined in some detail how electroweak theory can be integrated into the Dirac theory and this way interpreted in terms of space-time geometry. Finally, some implications for quantum electrodynamics are considered. The presentation of real quantum electromagnetism is expressed in an addendum. The book covers both the use of the complex and the real languages and allows the reader acquainted with the first language to make a step by step translation to the second one.

Geometrical Physics in Minkowski Spacetime Jul 18 2021 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

Space-time-matter Jan 30 2020 Albert Einstein, together with Theodor Kaluza and Oskar Klein, realized that extra dimensions can be used to unify the different fields of physics, as well as unifying the fields with their material sources. In fact, it was Einstein's dream to transpose the a base wooda of the matter term in his field equations to the ?marble? of the geometrical term. During his lifetime, this kind of unified theory achieved only partial success. But the modern approach, outlined in this bestseller, is elegant and agrees with all the classical tests. The basic idea is to unify the source and its field using the rich algebra of higher-dimensional Riemannian geometry. In other words, space, time and matter become parts of geometry."

Spacetime, Geometry and Gravitation Oct 01 2022 This introductory textbook on the general theory of relativity presents a solid foundation for those who want to learn about relativity. The subject is presented in a physically intuitive, but mathematically rigorous style. The topic of relativity is covered in a broad and deep manner. Besides, the aim is that after reading the book a student should not feel discouraged when she opens advanced texts on general relativity for further reading. The book consists of three parts: An introduction to the general theory of relativity. Geometrical mathematical background material. Topics that include the action principle, weak gravitational fields and gravitational waves, Schwarzschild and Kerr solution, and the Friedman equation in cosmology. The book is suitable for advanced graduates and graduates, but also for established researchers wishing to be educated about the field.

The Shape of Inner Space Apr 02 2020 String theory says we live in a ten-dimensional universe, but that only four are accessible to our everyday senses. According to theorists, the missing six are curled up in bizarre structures known as Calabi-Yau manifolds. In The Shape of Inner Space, Shing-Tung Yau, the man who mathematically proved that these manifolds exist, argues that not only is geometry fundamental to string theory, it is also fundamental to the very nature of our universe. Time and again, where Yau has gone, physics has followed. Now for the first time, readers will follow Yau's penetrating thinking on where we've been, and where mathematics will take us next. A fascinating exploration of a world we are only just beginning to grasp, The Shape of Inner Space will change the way we consider the universe on both its grandest and smallest scales.

Relativity Sep 07 2020 Provides the essential principles and results of special relativity as required by undergraduates. The text uses a geometric interpretation of space-time so that a general theory is seen as a natural extension of the special theory. Although most results are derived from first principles, complex and distracting mathematics is avoided and all mathe

The Mathematics of Minkowski Space-Time Feb 10 2021 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.

Spacetime Jan 24 2022 This textbook is for mathematicians and mathematical physicists and is mainly concerned with the physical justification of both the mathematical framework and the foundations of the theory of general relativity. Previous knowledge of the relevant physics is not assumed. This book is also suitable as an introduction to pseudo-Riemannian geometry with emphasis on geometrical concepts. A significant part of the text is devoted to the discussion of causality and singularity theorems. The insights obtained are applied to black hole astrophysics, thereby making the connection to current active research in mathematical physics and cosmology.
Spacetime and Geometry Dec 03 2022 An accessible introductory textbook on general relativity, covering the theory's foundations, mathematical formalism and major applications.
Deformed Spacetime Feb 22 2022 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.
The Large Scale Structure of Space-Time Jun 04 2020 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 singualarities under certain conditions. A discussion of the Cauchy problem for General Relativity is also included in this 1973 book.
Curvature of Space and Time, with an Introduction to Geometric Analysis Nov 21 2021 This book introduces advanced undergraduates to Riemannian geometry and mathematical general relativity. The overall strategy of the book is to explain the concept of curvature via the Jacobi equation which, through discussion of tidal forces, further helps motivate the Einstein field equations. After addressing concepts in geometry such as metrics, covariant differentiation, tensor calculus and curvature, the book explains the mathematical framework for both special and general relativity. Relativistic concepts discussed include (initial value formulation of) the Einstein equations, stress-energy tensor, Schwarzschild space-time, ADM mass and geodesic incompleteness. The concluding chapters of the book introduce the reader to geometric analysis: original results of the author and her undergraduate student collaborators illustrate how methods of analysis and differential equations are used in addressing questions from geometry and relativity. The book is mostly self-contained and the reader is only expected to have a solid foundation in multivariable and vector calculus and linear algebra. The material in this book was first developed for the 2013 summer program in geometric analysis at the Park City Math Institute, and was recently modified and expanded to reflect the author's experience of teaching mathematical general relativity to advanced undergraduates at Lewis & Clark College.
Differential Forms and the Geometry of General Relativity Sep 27 2019 Differential Forms and the Geometry of General Relativity provides readers with a coherent path to understanding relativity. Requiring little more than calculus and some linear algebra, it helps readers learn just enough differential geometry to grasp the basics of general relativity. The book contains two intertwined but distinct halves. Designed for advanced undergraduate or beginning graduate students in mathematics or physics, most of the text requires little more than familiarity with calculus and linear algebra. The first half presents an introduction to general relativity that describes some of the surprising implications of relativity without introducing more formalism than necessary. This nonstandard approach uses differential forms rather than tensor calculus and minimizes the use of "index gymnastics" as much as possible. The second half of the book takes a more detailed look at the mathematics of differential forms. It covers the theory behind the mathematics used in the first

half by emphasizing a conceptual understanding instead of formal proofs. The book provides a language to describe curvature, the key geometric idea in general relativity.