

## *Spacetime And Geometry An Introduction To General Relativity Solutions*

General Relativity is a beautiful geometric theory, simple in its mathematical formulation but leading to numerous consequences with striking physical interpretations: gravitational waves, black holes, cosmological models, and so on. This introductory textbook is written for mathematics students interested in physics and physics students interested in exact mathematical formulations (or for anyone with a scientific mind who is curious to know more of the world we live in), recent remarkable experimental and observational results which confirm the theory are clearly described and no specialised physics knowledge is required. The mathematical level of Part A is aimed at undergraduate students and could be the basis for a course on General Relativity. Part B is more advanced, but still does not require sophisticated mathematics. Based on Yvonne Choquet-Bruhat's more advanced text, *General Relativity and the Einstein Equations*, the aim of this book is to give with precision, but as simply as possible, the foundations and main consequences of General Relativity. The first five chapters from *General Relativity and the Einstein Equations* have been updated with new sections and chapters on black holes, gravitational waves, singularities, and the Reissner-Nordstrom and interior Schwarzschild solutions. The rigour behind this book will provide readers with the perfect preparation to follow the great mathematical progress in the actual development, as well as the ability to model, the latest astrophysical and cosmological observations. The book presents basic General Relativity and provides a basis for understanding and using the fundamental theory.

Einstein's general theory of relativity -- currently our best theory of gravity -- is important not only to specialists, but to a much wider group of physicists. This short textbook on general relativity and gravitation offers students glimpses of the vast landscape of science connected to general relativity. It incorporates some of the latest research in the field. The book is aimed at readers with a broad range of interests in physics, from cosmology, to gravitational radiation, to high energy physics, to condensed matter theory. The pedagogical approach is "physics first": readers move very quickly to the calculation of observational predictions, and only return to the mathematical foundations after the physics is established. In addition to the "standard" topics covered by most introductory textbooks, it contains short introductions to more advanced topics: for instance, why field equations are second order, how to treat gravitational energy, and what is required for a Hamiltonian formulation of general relativity. A concluding chapter discusses directions for further study, from mathematical relativity, to experimental tests, to quantum gravity. This is an introductory text, but it has also been written as a jumping-off point for readers who plan to study more specialized topics.

One of the most exciting aspects is the general relativity prediction 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.

"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*

Second edition of a widely-used textbook providing the first step into general relativity for undergraduate students with minimal mathematical background.

An Introduction

Exploring Black Holes

The Geometry of Physics

Black Holes, Gravitational Waves, and Cosmology

The Geometry of Minkowski Spacetime

An Introduction to Special and General Relativity

**Differential Geometry and Relativity Theory: An Introduction approaches relativity as a geometric theory of space and time in which gravity is a manifestation of space-time curvature, rather than a force. Uniting differential geometry and both special and general relativity in a single source, this easy-to-understand text opens the general theory of relativity to mathematics majors having a background only in multivariable calculus and linear algebra. The book offers a broad overview of the physical foundations and mathematical details of relativity, and presents concrete physical interpretations of numerous abstract concepts in Riemannian geometry. The work is profusely illustrated with diagrams aiding in the understanding of proofs and explanations. Appendices feature important material on vector analysis and hyperbolic functions. Differential Geometry and Relativity Theory: An Introduction serves as the ideal text for high-level undergraduate courses in mathematics and physics, and includes a solutions manual augmenting classroom study. It is an invaluable reference for mathematicians interested in differential and Riemannian geometry, or the special and general theories of relativity**

**A working knowledge of Einstein's theory of general relativity is an essential tool for every physicist today. This self-contained book is an introductory text on the subject aimed at first-year graduate students, or advanced undergraduates, in physics that assumes only a basic understanding of classical Lagrangian mechanics. The mechanics problem of a point mass constrained to move without friction on a two-dimensional surface of arbitrary shape serves as a paradigm for the development of the mathematics and physics of general relativity.**

After reviewing special relativity, the basic principles of general relativity are presented, and the most important applications are discussed. The final special topics section guides the reader through a few important areas of current research. This book will allow the reader to approach the more advanced texts and monographs, as well as the continual influx of fascinating new experimental results, with a deeper understanding and sense of appreciation.

An essential resource for learning about general relativity and much more, from four leading experts Important and useful to every student of relativity, this book is a unique collection of some 475 problems--with solutions--in the fields of special and general relativity, gravitation, relativistic astrophysics, and cosmology. The problems are expressed in broad physical terms to enhance their pertinence to readers with diverse backgrounds. In their solutions, the authors have attempted to convey a mode of approach to these kinds of problems, revealing procedures that can reduce the labor of calculations while avoiding the pitfall of too much or too powerful formalism. Although well suited for individual use, the volume may also be used with one of the modern textbooks in general relativity.

An accessible introductory textbook on general relativity, covering the theory's foundations, mathematical formalism and major applications.

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 first part is a preliminary course on general relativity with minimum preparation. The second part builds the mathematical background and the third part deals with topics where mathematics developed in the second part is needed. The first chapter gives a general background and introduction. This is followed by an introduction to curvature through Gauss' Theorema Egregium. This theorem expresses the curvature of a two-dimensional surface in terms of intrinsic quantities related to the infinitesimal distance function on the surface. The student is introduced to the metric tensor, Christoffel symbols and Riemann curvature tensor 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 field. Part II (chapters 5 to 10) is an introduction to Riemannian geometry as required 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.

**The Geometry of Spacetime**

**Modern General Relativity**

**3+1 Formalism in General Relativity**

**Spacetime, Geometry, Cosmology**

**Spacetime**

**Quantum Field Theory and the Standard Model**

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. Special Relativity (SR) is essentially grounded on the properties of space-time, i.e. isotropy of space and homogeneity of space and time (as a consequence of the equivalence of inertial frames) and on the Galilei principle of relativity.

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.

Spacetime and Geometry Cambridge University Press

“ 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.

General Relativity Without Calculus

Spacetime Physics

An Introduction to Twistor Theory

A First Course in General Relativity

An Introduction to Einstein's General Relativity

Visual Differential Geometry and Forms

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.

An inviting, intuitive, and visual exploration of differential geometry and forms Visual Differential Geometry and Forms fulfills two principal goals. In the first four acts, Tristan Needham puts the geometry back into differential geometry. Using 235 hand-drawn diagrams, Needham deploys Newton’s geometrical methods to provide geometrical explanations of the classical results. In the fifth act, he offers the first undergraduate introduction to differential forms that treats advanced topics in an intuitive and geometrical manner. Unique features of the first four acts include: four distinct geometrical proofs of the fundamentally important Global Gauss-Bonnet theorem, providing a stunning link between local geometry and global topology; a simple, geometrical proof of Gauss’s famous Theorema Egregium; a complete geometrical treatment of the Riemann curvature tensor of an  $n$ -manifold; and a detailed geometrical treatment of Einstein’s field equation, describing gravity as curved spacetime (General Relativity), together with its implications for gravitational waves, black holes, and cosmology. The final act elucidates such topics as the unification of all the integral theorems of vector calculus; the elegant reformulation of Maxwell’s equations of electromagnetism in terms of 2-forms; de Rham cohomology; differential geometry via Cartan’s method of moving frames; and the calculation of the Riemann tensor using curvature 2-forms. Six of the seven chapters of Act V can be read completely independently from the rest of the book. Requiring only basic calculus and geometry, Visual Differential Geometry and Forms provocatively rethinks the way this important area of mathematics should be considered and taught.

This excellent textbook offers a unique take on relativity theory, setting it in its historical context. Ideal for those interested in relativity and the history of physics, the book contains a complete account of special relativity that begins with the historical analysis of the reasons that led to a change in our view of space and time. Its aim is to foster a deep understanding of relativistic spacetime and its consequences for Dynamics.

Einstein's theory of general relativity is a cornerstone of modern physics. It also touches upon a wealth of topics that students find fascinating – black holes, warped spacetime, gravitational waves, and cosmology. Now reissued by Cambridge University Press, this ground-breaking text helped to bring general relativity into the undergraduate curriculum, making it accessible to virtually all physics majors. One of the pioneers of the 'physics-first' approach to the subject, renowned relativist James B. Hartle, recognized that there is typically not enough time in a short introductory course for the traditional, mathematics-first, approach. In this text, he provides a fluent and accessible physics-first introduction to general relativity that begins with the essential physical applications and uses a minimum of new mathematics. This market-leading text is ideal for a one-semester course for undergraduates, with only introductory mechanics as a prerequisite.

The Geometry of Special Relativity provides an introduction to special relativity that encourages readers to see beyond the formulas to the deeper geometric structure. The text treats the geometry of hyperbolas as the key to understanding special relativity. This approach replaces the ubiquitous  $\gamma$  symbol of most standard treatments with the appropriate hyperbolic trigonometric functions. In most cases, this not only simplifies the appearance of the formulas, but also emphasizes their geometric content in such a way as to make them almost obvious. Furthermore, many important relations, including the famous relativistic addition formula for velocities, follow directly from the appropriate trigonometric addition formulas. The book first describes the basic physics of special relativity to set the stage for the geometric treatment that follows. It then reviews properties of ordinary two-dimensional Euclidean space, expressed in terms of the usual circular trigonometric functions, before presenting a similar treatment of two-dimensional Minkowski space, expressed in terms of hyperbolic trigonometric functions. After covering special relativity again from the geometric point of view, the text discusses standard paradoxes, applications to relativistic mechanics, the relativistic unification of electricity and magnetism, and further steps leading to Einstein’s general theory of relativity. The book also briefly describes the further steps leading to Einstein's general theory of relativity and then explores applications of hyperbola geometry to non-Euclidean geometry and calculus, including a geometric construction of the derivatives of trigonometric functions and the exponential function.

Foundations of General Relativity and Differential Geometry

Problem Book in Relativity and Gravitation

A Mathematical Drama in Five Acts

Introduction To General Relativity And Cosmology

An Introduction for Physicists

Gravitational Curvature

Einstein's general theory of relativity is widely considered to be one of the most elegant and successful scientific theories ever developed, and it is increasingly being taught in a simplified form at advanced undergraduate level within both physics and mathematics departments. Due to the increasing interest in gravitational physics, in both the academic and the public sphere, driven largely by widely-publicised developments such as the recent observations of gravitational waves, general relativity is also one of the most popular scientific topics pursued through self-study. Modern General Relativity introduces the reader to the general theory of relativity using an example-based approach, before describing some of its most important applications in cosmology and astrophysics, such as gamma-ray bursts, neutron stars, black holes, and gravitational waves. With hundreds of worked examples, explanatory boxes, and end-of-chapter problems, this

textbook provides a solid foundation for understanding one of the towering achievements of twentieth-century physics.

Evolving from graduate lectures given in London and Oxford, this introduction to twistor theory and modern geometrical approaches to space-time structure will provide graduate students with the basics of twistor theory, presupposing some knowledge of special relativity and differential geometry.

General relativity is a cornerstone of modern physics, and is of major importance in its applications to cosmology. Plebanski and Krasinski are experts in the field and in this book they provide a thorough introduction to general relativity, guiding the reader through complete derivations of the most important results. Providing coverage from a unique viewpoint, geometrical, physical and astrophysical properties of inhomogeneous cosmological models are all systematically and clearly presented, allowing the reader to follow and verify all derivations. For advanced undergraduates and graduates in physics and astronomy, this textbook will enable students to develop expertise in the mathematical techniques necessary to study general relativity.

A modern introduction to quantum field theory for graduates, providing intuitive, physical explanations supported by real-world applications and homework problems.

This unique book offers a concise, introductory overview of general relativity and black holes, motivating students to become active participants in carrying out their own investigations. To this end, the book uses calculus and algebra, rather than tensors, to make general relativity accessible to sophomores and juniors. Five chapters introduce basic concepts, and seven projects require the reader to apply these basic concepts to real astronomical applications.

Space, Time, and Motion

An Introduction to Einstein's Theory

Space-time

Bases of Numerical Relativity

A Mathematical Introduction To General Relativity

***Learning quantum field theory doesn't have to be hard What if there were a book that allowed you to see the whole picture and not just tiny parts of it? Thoughts like this are the reason that No-Nonsense Quantum Field Theory now exists. What will you learn from this book? Get to know all fundamental concepts — Grasp what a quantum field is, why we use propagators to describe its behavior, and how Feynman diagrams help us to make sense of field interactions. Learn to describe quantum field theory mathematically — Understand the meaning and origin of the most important equations: the Klein-Gordon equation, the Dirac equation, the Proca equation, the Maxwell equations, and the canonical commutation/anticommutation relations. Master important quantum field theory interactions — Read fully annotated, step-by-step calculations and understand the general algorithm we use to particle interactions. Get an understanding you can be proud of —Learn about advanced topics like renormalization and regularization, spontaneous symmetry breaking, the renormalization group equations, non-perturbative phenomena, and effective field models. No-Nonsense Quantum Field Theory is one the most student-friendly book on quantum field theory ever written. Here's why. First of all, it's nothing like a formal university lecture. Instead, it's like a casual conversation with a more experienced student. This also means that nothing is assumed to be "obvious" or "easy to see". Each chapter, each section, and each page focuses solely on the goal to help you understand. Nothing is introduced without a thorough motivation and it is always clear where each equation comes from. The book ruthlessly focuses on the fundamentals and makes sure you'll understand them in detail. The primary focus on the readers' needs is also visible in dozens of small features that you won't find in any other textbook In total, the book contains more than 100 illustrations that help you understand the most important concepts visually. In each chapter, you'll find fully annotated equations and calculations are done carefully step-by-step. This makes it much easier to understand what's going on. Whenever a concept is used that was already introduced previously there is a short sidenote that reminds you where it was first introduced and often recites the main points. In addition, there are summaries at the beginning of each chapter that make sure you won't get lost.***

***Following the approach of Lev Landau and Evgenii Lifshitz, this book introduces the theory of special and general relativity with the Lagrangian formalism and the principle of least action. This method allows the complete theory to be constructed starting from a small number of assumptions, and is the most natural approach in modern theoretical physics. The book begins by reviewing Newtonian mechanics and Newtonian gravity with the Lagrangian formalism and the principle of least action, and then moves to special and general relativity. Most calculations are presented step by step, as is done on the board in class. The book covers recent advances in gravitational wave astronomy and provides a general overview of current lines of research in gravity. It also includes numerous examples and problems in each chapter. INSTANT NEW YORK TIMES BESTSELLER "A porthole into another world."—Scientific American "Brings science dissemination to a new level."—Science The most trusted explainer of the most mind-boggling concepts pulls back the veil of mystery that has too long cloaked the most valuable building blocks of modern science. Sean Carroll, with his genius for making complex notions entertaining, presents in his uniquely lucid voice the fundamental ideas informing the modern physics of reality. Physics offers deep insights into the workings of the universe but those insights come in the form of equations that often look like gobbledygook. Sean Carroll shows that they are really like meaningful poems that can help us fly over sierras***

**to discover a miraculous multidimensional landscape alive with radiant giants, warped space-time, and bewilderingly powerful forces. High school calculus is itself a centuries-old marvel as worthy of our gaze as the Mona Lisa. And it may come as a surprise the extent to which all our most cutting-edge ideas about black holes are built on the math calculus enables. No one else could so smoothly guide readers toward grasping the very equation Einstein used to describe his theory of general relativity. In the tradition of the legendary Richard Feynman lectures presented sixty years ago, this book is an inspiring, dazzling introduction to a way of seeing that will resonate across cultural and generational boundaries for many years to come. 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.**

**This classic text and reference monograph applies modern differential geometry to general relativity. A brief mathematical introduction to gravitational curvature, it emphasizes the subject's geometric essence and stresses the global aspects of cosmology. Suitable for independent study as well as for courses in differential geometry, relativity, and cosmology. 1979 edition.**

**A Course for Undergraduate Students of Physics**

**A Student-Friendly Introduction**

**Differential Geometry and Relativity Theory**

**A Concise Introduction to the Geometry of Relativity**

**An Introduction to the Mathematics of the Special Theory of Relativity**

**Gravity**

This book provides a working knowledge of those parts of exterior differential forms, differential geometry, algebraic and differential topology, Lie groups, vector bundles and Chern forms that are essential for a deeper understanding of both classical and modern physics and engineering. Included are discussions of analytical and fluid dynamics, electromagnetism (in flat and curved space), thermodynamics, the Dirac operator and spinors, and gauge fields, including Yang-Mills, the Aharonov-Bohm effect, Berry phase and instanton winding numbers, quarks and quark model for mesons. Before discussing abstract notions of differential geometry, geometric intuition is developed through a rather extensive introduction to the study of surfaces in ordinary space. The book is ideal for graduate and advanced undergraduate students of physics, engineering or mathematics as a course text or for self study. This third edition includes an overview of Cartan's exterior differential forms, which previews many of the geometric concepts developed in the text.

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.

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.

Collaboration on the First Edition of Spacetime Physics began in the mid-1960s when Edwin Taylor took a junior faculty sabbatical at Princeton University where John Wheeler was a professor. The resulting text emphasized the unity of spacetime and those quantities (such as proper time, proper distance, mass) that are invariant, the same for all observers, rather than those quantities (such as space and time separations) that are relative, different for different observers. The book has become a standard introduction to relativity. The Second Edition of Spacetime Physics embodies what the authors have learned during an additional quarter century of teaching and research. They have updated the text to reflect the immense strides in physics during the same period and modernized and increased the number of exercises, for which the First Edition was famous. Enrichment boxes provide expanded coverage of intriguing topics. An enlarged final chapter on general relativity includes new material on gravity waves, black holes, and cosmology. The Second Edition of Spacetime Physics provides a new generation of readers with a deep and simple overview of the principles of relativity.

Written for advanced undergraduate and graduate students, this is a clear mathematical introduction to Einstein's theory of general relativity and its physical applications. Concentrating on the theory's physical consequences, this approachable textbook contains over 300 exercises to illuminate and extend the discussion.

Spacetime and Singularities

Gravitation

An Introduction to General Relativity and Cosmology

Energy and Geometry

The Biggest Ideas in the Universe

An Introduction to Spacetime Physics

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.

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.

Introduction to General Relativity and Cosmology gives undergraduate students an overview of the fundamental ideas behind the geometric theory of gravitation and spacetime. Through pointers on how to modify and generalise Einstein's theory to enhance understanding, it provides a link between standard textbook content and current research in the field. Chapters present complicated material practically and concisely, initially dealing with the mathematical foundations of the theory of relativity, in particular differential geometry. This is followed by a discussion of the Einstein field equations and their various properties. Also given is analysis of the important Schwarzschild solutions, followed by application of general relativity to cosmology. Questions with fully worked answers are provided at the end of each chapter to aid comprehension and guide learning. This pared down textbook is specifically designed for new students looking for a workable, simple presentation of some of the key theories in modern physics and mathematics.

Spacetime physics -- Physics in flat spacetime -- The mathematics of curved spacetime -- Einstein's geometric theory of gravity -- Relativistic stars -- The universe -- Gravitational collapse and black holes -- Gravitational waves -- Experimental tests of general relativity -- Frontiers

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

An Introduction to Einstein's Theory of Gravity

Spacetime and Geometry

Einstein's Space-Time

General Relativity

An Introduction to Deformed Special Relativity

No-Nonsense Quantum Field Theory

This book, suitable for interested post-16 school pupils or undergraduates looking for a supplement to their course text, develops our modern view of space-time and its implications in the theories of gravity and cosmology. While aspects of this topic are inevitably abstract, the book seeks to ground thinking in observational and experimental evidence where possible. In addition, some of Einstein's philosophical thoughts are explored and contrasted with our modern views. Written in an accessible yet rigorous style, Jonathan Allday, a highly accomplished writer, brings his trademark clarity and engagement to these fascinating subjects, which underpin so much of modern physics. Features: Restricted use of advanced mathematics, making the book suitable for post-16 students and undergraduates Contains discussions of key modern developments in quantum gravity, and the latest developments in the field, including results from the Laser Interferometer Gravitational-Wave Observatory (LIGO) Accompanied by appendices on the CRC Press website featuring detailed mathematical arguments for key derivations

Elementary Theory

Quantum Mechanics in the Geometry of Space-Time

Curvature of Space and Time, with an Introduction to Geometric Analysis

Relativity

A Concise Introduction

The Geometry of Special Relativity