Differential Geometry And Relativity A Volume In Honour Of Andri 1 2 Lichnerowicz On His 60th Birthday Mathematical Physics And Applied Mathematics

Differential Geometry and RelativityA Volume in Honour of André Lichnerowicz on His 60th BirthdaySpringer Science & Business Media

The aim of this book is to provide a short but complete exposition of the logical structure of classical relativistic electrodynamics written in the language and spirit of coordinate-free differential geometry. The intended audience is primarily mathematicians who want a bare-bones account of the foundations of electrodynamics written in language with which they are familiar and secondarily physicists who may be curious how their old friend looks in the new clothes of the differential-geometric viewpoint which in recent years has become an important language and tool for theoretical physics. This work is not intended to be a textbook in electrodynamics in the usual sense; in particular no applications are treated, and the focus is exclusively the equations of motion of charged particles. Rather, it is hoped that it may serve as a bridge between mathemat ics and physics. Many non-physicists are surprised to learn that the correct equation to describe the motion of a classical charged particle is still a matter of some controversy. The most mentioned candidate is the Lorentz-Dirac equation t . However, it is experimentally unverified, is known to have no physically reasonable solutions in certain circumstances, and its usual derivations raise serious foundational issues. Such difficulties are not extensively discussed in most electrodynamics texts, which quite naturally are oriented toward applying the well-verified part of the subject to con crete problems.

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.

This book is an exposition of semi-Riemannian geometry (also called pseudo-Riemannian geometry)--the study of a smooth manifold furnished with a metric tensor of arbitrary signature. The principal special cases are Riemannian geometry, where the metric is positive definite, and Lorentz geometry. For many years these two geometries have developed almost independently: Riemannian geometry reformulated in coordinate-free fashion and directed toward global problems, Lorentz geometry in classical tensor notation devoted to general relativity. More recently, this divergence has been reversed as physicists, turning increasingly toward invariant methods, have produced results of compelling mathematical interest.

Visual Differential Geometry and Forms
MATHEMATICS OF DIFFERENTIAL GEOMETRY AND RELATIVITY
Differential Geometry and Mathematical Physics
An Introduction to Special and General Relativity
Geometrical Methods of Mathematical Physics
From Riemann to Differential Geometry and Relativity

An introduction to geometrical topics used in applied mathematics and theoretical physics.

An explanation of the mathematics needed as a foundation for a deep understanding of general relativity or quantum field theory. Physics is naturally expressed in mathematical language. Students new to the subject must simultaneously learn an idiomatic mathematical language and the content that is expressed in that language. It is as if they were asked to read Les Misérables while struggling with French grammar. This book offers an innovative way to learn the differential geometry needed as a foundation for a deep understanding of general relativity or quantum field theory as taught at the college level. The approach taken by the authors (and used in their classes at MIT for many years) differs from the conventional one in several ways, including an emphasis on the development of the covariant derivative and an avoidance of the use of traditional index notation for tensors in favor of a semantically richer language of vector fields and differential forms. But the biggest single difference is the authors' integration of computer programming into their explanations. By programming a computer to interpret a formula, the student soon learns whether or not a formula is correct. Students are led to improve their program, and as a result improve their understanding.

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

This book lays the mathematical foundations required to understand the majestic grandeur and essence of General Relativity (GR). This book provides a basic introduction to Differential Geometry required for studying GR. It's unique pictorial and analogy-driven approach provides a vivid experience to the reader. This book is for the highly-motivated undergraduate students of maths or physics who want to learn advanced concepts of maths and it's applications in physics in a unique and intuitive way. The mathematical level of the seven chapters of the book is that of undergraduates of mathematics or physics. The book assumes the reader to possess a fair knowledge of Special Relativity and Electromagnetism and aims at communicating the concepts as intuitively as possible, constantly promoting the avant-garde and consciously avoiding the vicissitudes one faces in the conventionalist approach to physics and the labyrinthine choice of words in archaic texts.

Methods of Local and Global Differential Geometry in General Relativity

Spacetime
Semi-Riemannian Geometry With Applications to Relativity
Techniques of Differential Topology in Relativity
The Beemfest Advances in Differential Geometry and General Relativity on the Occasion of Professor John Beem's Retirement, May 10-11, 2003, University of Missouri-Columbia

Acquaints the specialist in relativity theory with some global techniques for the treatment of space-times and will provide the pure mathematician with a way into the subject of general relativity.

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 ? 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.

The principal aim of analysis of tensors is to investigate those relations which remain valid when we change from one coordinate system to another. This book on Tensors requires only a knowledge of elementary calculus, differential equations and classical mechanics as pre-requisites. It provides the readers with all the information about the tensors along with the derivation of all the tensorial relations/equations in a simple manner. The book also deals in detail with topics of importance to the study of special and general relativity and the geometry of differentiable manifolds with a crystal clear exposition. The concepts dealt within the book are well supported by a number of solved examples. A carefully selected set of unsolved problems is also given at the end of each chapter, and the answers and hints for the solution of these problems are given at the end of the book. The applications of tensors to the fields of differential geometry, relativity, cosmology and electromagnetism is another attraction of the present book. This book is intended to serve as text for postgraduate students of mathematics, physics and engineering. It is ideally suited for both students and teachers who are engaged in research in General Theory of Relativity and Differential Geometry.

An introduction to semi-Riemannian geometry as a foundation for general relativity Semi-Riemannian Geometry: The Mathematical Language of General Relativity is an accessible exposition of the mathematics underlying general relativity. The book begins with background on linear and multilinear algebra, general topology, and real analysis. This is followed by material on the classical theory of curves and surfaces, expanded to include both the Lorentz and Euclidean signatures. The remainder of the book is devoted to a discussion of smooth manifolds, smooth manifolds with boundary, smooth manifolds with a connection, semi-Riemannian manifolds, and differential operators, culminating in applications to Maxwell's equations and the Einstein tensor. Many worked examples and detailed diagrams are provided to aid understanding. This book will appeal especially to physics students wishing to learn more differential geometry than is usually provided in texts on general relativity.

Differential Geometry and Relativity Theory
Advances in Differential Geometry and General Relativity
A Volume in Honour of Andre Lichnerowicz on His 60th Birthday
Foundations and Philosophy of Science and Technology Series
Manifolds, Tensors and Forms
An Introduction to Riemannian Geometry

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.

Starting from an undergraduate level, this book systematically develops the basics of • Calculus on manifolds, vector bundles, vector fields and differential forms, • Lie groups and Lie group actions, • Linear symplectic algebra and symplectic geometry, • Hamiltonian systems, symmetries and reduction, integrable systems and Hamilton-Jacobi theory. The topics listed under the first item are relevant for virtually all areas of mathematical physics. The second and third items constitute the link between abstract calculus and the theory of Hamiltonian systems. The last item provides an introduction to various aspects of this theory, including Morse families, the Maslov class and caustics. The book guides the reader from elementary differential geometry to advanced topics in the theory of Hamiltonian systems with the aim of making current research literature accessible. The style is that of a mathematical textbook,with full proofs given in the text or as exercises. The material is illustrated by numerous detailed examples, some of which are taken up several times for demonstrating how the methods evolve and interact.

This volume presents a collection of problems and solutions in differential geometry with applications. Both introductory and advanced topics are introduced in an easy-to-digest manner, with the materials of the volume being self-contained. In particular, curves, surfaces, Riemannian and pseudo-Riemannian manifolds, Hodge duality operator, vector fields and Lie series, differential forms, matrix-valued differential forms, Maurer–Cartan form, and the Lie derivative are covered. Readers will find useful applications to special and general relativity, Yang–Mills theory, hydrodynamics and field theory. Besides the solved problems, each chapter contains stimulating supplementary problems and software implementations are also included. The volume will not only benefit students in mathematics, applied mathematics and theoretical physics, but also researchers in the field of differential geometry. Request Inspection Copy

This is a book about physics, written for mathematicians. The readers we have in mind can be roughly described as those who: I. are mathematics graduate students with some knowledge of global differential geometry 2. have had the equivalent of freshman physics, and find popular accounts of astrophysics and cosmology interesting 3. appreciate mathematical elarity, but are willing to accept physical motiva tions for the mathematics in place of mathematical ones 4. are willing to spend time and effort mastering certain technical details, such as those in Section 1. 1. Each book disappoints so me readers. This one will disappoint: 1. physicists who want to use this book as a first course on differential geometry 2. mathematicians who think Lorentzian manifolds are wholly similar to Riemannian ones, or that, given a sufficiently good mathematical back ground, the essentials of a subject !ike cosmology can be learned without so me hard work on boring detaiis 3. those who believe vague philosophical arguments have more than historical and heuristic significance, that general relativity should somehow be "proved," or that axiomatization of this subject is useful 4. those who want an encyclopedic treatment (the books by Hawking-Ellis [1], Penrose [1], Weinberg [1], and Misner-Thorne-Wheeler [1] go further into the subject than we do; see also the survey article, Sachs-Wu [1]). 5. mathematicians who want to learn quantum physics or unified field theory (unfortunately, quantum physics texts all seem either to be for physicists, or merely concerned with formal mathematics).

A Mathematical Drama in Five Acts
Spacetime and Geometry
An Introduction
Methods of local global differential geometry in general relativity
Differential Geometry, Gauge Theories, and Gravity
Gravitational Curvature

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.

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.

This book explores the work of Bernhard Riemann and its impact on mathematics, philosophy and physics. It features contributions from a range of fields, historical expositions, and selected research articles that were motivated by Riemann ' s ideas and demonstrate their timelessness. The editors are convinced of the tremendous value of going into Riemann ' s work in depth, investigating his original ideas, integrating them into a broader perspective, and establishing ties with modern science and philosophy. Accordingly, the contributors to this volume are mathematicians, physicists, philosophers and historians of science. The book offers a unique resource for students and researchers in the fields of mathematics, physics and philosophy, historians of science, and more generally to a wide range of readers interested in the history of ideas.

On the occasion of the sixtieth birthday of Andre Lichnerowicz a number of his friends, many of whom have been his students or coworkers, decided to celebrate this event by preparing a jubilee volume of contributed articles in the two main fields of research marked by Lichnerowicz's work, namely differential geometry and mathematical physics. Limitations of space and time did not enable us to include papers from all Lichnerowicz's friends nor from all his former students. It was equally impossible to reflect in a single book the great variety of subjects tackled by Lichnerowicz. In spite of these limitations, we hope that this book reflects some of the present trends of fields in which he worked, and some of the subjects to which he contributed in his long - and not yet finished - career. This career was very much marked by the influence of his masters, Elie Cartan who introduced him to research in mathematics, mainly in geometry and its relations with mathematical physics, and Georges Darmois who developed his interest for mechanics and physics, especially the theory of relativity and electromagnetism. This par ticular combination, and his personal talent, made of him a natural scientific heir and continuator of the French mathematical physics school in the tradition of Henri Poincare. Some of his works would even be best qualified by a new field name, that of physical ma thematics: branches of pure mathematics entirely motivated by physics.

Foundations of General Relativity and Differential Geometry
Differential Geometry and Relativity
General Relativity for Mathematicians
Relativity and Geometry
Izaak Walton's The Compleat Angler
Semi-Riemannian Geometry

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.

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.

This volume consists of expanded versions of invited lectures given at The Beemfest: Advances in Differential Geometry and General Relativity (University of Missouri-Columbia) on the occasion of Professor John K. Beem's retirement. The articles address problems in differential geometry in general and in particular, global Lorentzian geometry, Finsler geometry, causal boundaries, Penrose's cosmic censorship hypothesis, the geometry of differential operators with variable coefficients on manifolds, and asymptotically de Sitter spacetimes satisfying Einstein's equations with positive cosmological constant. The book is suitable for graduate students and research mathematicians interested in differential geometry.

Many problems in general relativity are essentially geometric in nature, in the sense that they can be understood in terms of Riemannian geometry and partial differential equations. This book is centered around the study of mass in general relativity using the techniques of geometric analysis. Specifically, it provides a comprehensive treatment of the positive mass theorem and closely related results, such as the Penrose inequality, drawing on a variety of tools used in this area of research, including minimal hypersurfaces, conformal geometry, inverse mean curvature flow, conformal flow, spinors and the Dirac operator, marginally outer trapped surfaces, and density theorems. This is the first time these topics have been gathered into a single place and presented with an advanced graduate student audience in mind; several dozen exercises are also included. The main prerequisite for this book is a working understanding of Riemannian geometry and basic knowledge of elliptic linear partial differential equations, with only minimal prior knowledge of physics required. The second part of the book includes a short crash course on general relativity, which provides background for the study of asymptotically flat initial data sets satisfying the dominant energy condition.

The Language of General Relativity
Problems and Solutions in Differential Geometry, Lie Series, Differential Forms, Relativity and Applications
Differential Geometry and Lie Groups for Physicists
Proceedings of the Regional Conference on Relativity Held at the University of Pittsburgh, Pittsburgh, Pennsylvania, July 13-17, 1970
An Introduction to Einstein's Theory
Relativistic Electrodynamics and Differential Geometry

Differential geometry plays an increasingly important role in modern theoretical physics and applied mathematics. This textbook gives an introduction to geometrical topics useful in theoretical physics and applied mathematics, covering: manifolds, tensor fields, differential forms, connections, symplectic geometry, actions of Lie groups, bundles, spinors, and so on. Written in an informal style, the author places a strong emphasis on developing the understanding of the general theory through more than 1000 simple exercises, with complete solutions or detailed hints. The book will prepare readers for studying modern treatments of Lagrangian and Hamiltonian mechanics, electromagnetism, gauge fields, relativity and gravitation. Differential Geometry and Lie Groups for Physicists is well suited for courses in physics, mathematics and engineering for advanced undergraduate or graduate students, and can also be used for active self-study. The required mathematical background knowledge does not go beyond the level of standard introductory undergraduate mathematics courses.

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.

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.

In recent years the methods of modern differential geometry have become of considerable importance in theoretical physics and have found application in relativity and cosmology, high-energy physics and field theory, thermodynamics, fluid dynamics and mechanics. This textbook provides an introduction to these methods - in particular Lie derivatives, Lie groups and differential forms - and covers their extensive applications to theoretical physics. The reader is assumed to have some familiarity with advanced calculus, linear algebra and a little elementary operator theory. The advanced physics undergraduate should therefore find the presentation quite accessible. This account will prove valuable for those with backgrounds in physics and applied mathematics who desire an introduction to the subject. Having studied the book, the reader will be able to comprehend research papers that use this mathematics and follow more advanced pure-mathematical expositions.

Functional Differential Geometry
TENSORS
Part I. Manifolds, Lie Groups and Hamiltonian Systems
The Art of Recreation
The Geometry of Spacetime
Essential Differential Geometry

Unlike many other texts on differential geometry, this textbook also offers interesting applications to geometric mechanics and general relativity. The first part is a concise and self-contained introduction to the basics of manifolds, differential forms, metrics and curvature. The second part studies applications to mechanics and relativity including the proofs of the Hawking and Penrose singularity theorems. It can be independently used for one-semester courses in either of these subjects. The main ideas are illustrated and further developed by numerous examples and over 300 exercises. Detailed solutions are provided for many of these exercises, making An Introduction to Riemannian Geometry ideal for self-study.

Emphasizing the applications of differential geometry to gauge theories in particle physics and general relativity, this work will be of special interest for researchers in applied mathematics or theoretical physics.

Spacetime and Geometry is an introductory textbook on general relativity, specifically aimed at students. Using a lucid style, Carroll first covers the foundations of the theory and mathematical formalism, providing an approachable introduction to what can often be an intimidating subject. Three major applications of general relativity are then discussed: black holes, perturbation theory and gravitational waves, and cosmology. Students will learn the origin of how spacetime curves (the Einstein equation) and how matter moves through it (the geodesic equation). They will learn what black holes really are, how gravitational waves are generated and detected, and the modern view of the expansion of the universe. A brief introduction to quantum field theory in curved spacetime is also included. A student familiar with this book will be ready to tackle research-level problems in gravitational physics.

Comprehensive treatment of the essentials of modern differential geometry and topology for graduate students in mathematics and the physical sciences.

The Mathematical Language of General Relativity
Differential Geometry and General Relativity
With Applications to Mechanics and Relativity
Curvature of Space and Time, with an Introduction to Geometric Analysis
Differential Geometry and Relativity Theories
Geometric Relativity