Core Principles of Special and General Relativity

This 2004 textbook fills a gap in the literature on general relativity by providing the advanced student with practical tools for the computation of many physically interesting quantities. The context is provided by the mathematical theory of black holes, one of the most elegant, successful, and relevant applications of general relativity. Among the topics discussed are congruencies of timelike and null geodesics, the embedding of spacelike, timelike and null hypersurfaces in spacetime, and the Lagrangian and Hamiltonian formulations of general relativity. Although the book is self-contained, it is not meant to serve as an introduction to general relativity. Instead, it is meant to help the reader acquire advanced skills and become a competent researcher in relativity and gravitational physics. The primary readership consists of graduate students in gravitational physics. It will also be a useful reference for more seasoned researchers working in this field.
FUNDAMENTALS OF SPECIAL AND GENERAL RELATIVITY, Revised Edition

This book provides an accessible, yet thorough, introduction to special and general relativity, crafted and class-tested over many years of teaching. Suitable for advanced undergraduate and graduate students, this book provides clear descriptions of how to approach the mathematics and physics involved. It is also contains the latest exciting developments in the field, including dark energy, gravitational waves, and frame dragging. The table of contents has been carefully developed in consultation with a large number of instructors teaching courses worldwide, to ensure its wide applicability to modules on relativity and gravitation. Features: A clear, accessible writing style, presenting a sophisticated approach to the subject, that remains suitable for advanced undergraduate students and above Class-tested over many years To be accompanied by a partner volume on ‘Advanced Topics’ for students to further extend their learning

General Relativity

These lecture notes are intended for starting PhD students in theoretical physics who have a working knowledge of General Relativity. The four topics covered are: Surface charges as conserved quantities in theories of gravity; Classical and holographic features of three-dimensional Einstein gravity; Asymptotically flat spacetimes in four dimensions: BMS group and memory effects; The Kerr black hole: properties at extremality and quasi-normal mode ringing. Each topic starts with historical foundations and points to a few modern research directions.

Advanced General Relativity

Fans of Chris Ferrie's ABCs of Science, Organic Chemistry for Babies, and Quantum Physics for Babies will love this introduction to Einstein's most famous theory! Help your future genius become the smartest baby in the room! It only takes a small spark to ignite a child's mind. Written by an expert, General Relativity for Babies is a colorfully simple introduction to Einstein's most famous theory. Babies (and grownups!) will learn all about black holes, gravitational waves, and more. With a tongue-in-cheek approach that adults will love, this installment of the Baby University board book series is the perfect way to introduce basic concepts to even the youngest scientists. After all, it's never too early to become a quantum physicist! If you're looking for books similar to Baby Loves Science by Ruth Spiro, quantum information for babies, or infant
Where To Download Advanced General Relativity

science books, look no further! General Relativity for Babies offers fun early learning for your little quantum physicist!

**Introduction to General Relativity**

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

**Gravitation**

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.

**Manifolds, Tensors and Forms**

Vectors, tensors and functions -- Manifolds, vectors and differentiation -- Energy, momentum and Einstein's equations

**3+1 Formalism in General Relativity**

A textbook-neutral problems-and-solutions book that complements any relativity textbook at advanced undergraduate or masters level.

**General Relativity**

Aimed at advanced undergraduates with background knowledge of classical mechanics and electricity and magnetism, this textbook presents both the particle dynamics relevant to general relativity, and the field dynamics necessary to understand the theory. Focusing on action extremization, the book develops the structure and predictions of general relativity by analogy with familiar physical systems. Topics ranging from classical field theory to minimal surfaces and relativistic strings are covered in a homogeneous manner. Nearly 150 exercises
and numerous examples throughout the textbook enable students to test their understanding of the material covered. A tensor manipulation package to help students overcome the computational challenge associated with general relativity is available on a site hosted by the author. A link to this and to a solutions manual can be found at www.cambridge.org/9780521762458.

**Gravitation**

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.

**Special & General Relativity**

Relativity, apart from quantum mechanics, is the greatest wonder in science, unfolded single-handedly in the 20th century by Albert Einstein. The scientist developed general relativity as a logical sequel to special relativity. This comprehensive book presents explication of the conceptual evolution and mathematical derivations of the theories of special and general relativity. The book follows an Einsteinian approach while explaining the concepts and the theories of relativity. Divided into 14 chapters, the revised edition of the book covers elementary concepts of Special relativity, as well as the advanced studies on General relativity. The recent theories like Kerr geometry, Sagnac effect, Vaidya geometry, Raychaudhuri equation and Gravitation physics vis-à-vis Quantum physics are presented in easy-to-understand language and simple style. In addition to it, the book gives an in-depth analysis on the applications of advanced theories like Vaidya-Krori-Barua solution from author’s own research works. Apart from that, the book also discusses some of the isotropic and anisotropic cosmological models, in detail. The salient topics discussed in the revised edition of the book are extrinsic curvature, detection of gravitational waves, early
universe, evolution of a dead star into a white dwarf or a neutron star or a black hole, dark matter and dark energy. This book is intended for the undergraduate and postgraduate students of Physics and Mathematics. KEY FEATURES • Step-by-step derivation of equations • Easy demagogic approach • Review questions to widen the analytical understanding of the students

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

Covering all aspects of gravitation in a contemporary style, this advanced textbook is ideal for graduate students and researchers in all areas of theoretical physics. The 'Foundation' section develops the formalism in six chapters, and uses it in the next four chapters to discuss four key applications - spherical spacetimes, black holes, gravitational waves and cosmology. The six chapters in the 'Frontier' section describe cosmological perturbation theory, quantum fields in curved spacetime, and the Hamiltonian structure of general relativity, among several other advanced topics, some of which are covered in-depth for the first time in a textbook. The modular structure of the book allows different sections to be combined to suit a variety of courses. Over 200 exercises are included to test and develop the reader's understanding. There are also over 30 projects, which help readers make the transition from the book to their own original research.

A First Course in General Relativity

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

Modern General Relativity

A precise yet simple introduction to the foundations and main consequences of General Relativity. The first five chapters from Choquet-Bruhat's General Relativity and the Einstein Equations (2008) have been updated with new sections and chapters on black holes, gravitational waves, singularities and more to form this textbook.

General Theory of Relativity
This book discusses some of the open questions addressed by researchers in general relativity. Photons and particles play important roles in the theoretical framework, since they are involved in analyzing and measuring gravitational fields and in constructing mathematical models of gravitational fields of various types. The authors highlight this aspect covering topics such as the construction of models of Bateman electromagnetic waves and analogous gravitational waves, the studies of gravitational radiation in presence of a cosmological constant and the gravitational compass or clock compass for providing an operational way of measuring a gravitational field. The book is meant for advanced students and young researchers in general relativity, who look for an updated text which covers in depth the calculations and, equally, takes on new challenges. The reader, along the learning path, is stimulated by provocative examples interspersed in the text that help to find novel representations of the uses of particles and photons.

**Advanced General Relativity**

Student-friendly, well illustrated textbook for advanced undergraduate and beginning graduate students in physics and mathematics.

**General Relativity for Babies**

This book provides a concise introduction to both the special theory of relativity and the general theory of relativity. The format is chosen to provide the basis for a single semester course which can take the students all the way from the foundations of special relativity to the core results of general relativity: the Einstein equation and the equations of motion for particles and light in curved spacetime. To facilitate access to the topics of special and general relativity for science and engineering students without prior training in relativity or geometry, the relevant geometric notions are also introduced and developed from the ground up. Students in physics, mathematics or engineering with an interest to learn Einstein's theories of relativity should be able to use this book already in the second semester of their third year. The book could also be used as the basis of a graduate level introduction to relativity for students who did not learn relativity as part of their undergraduate training.

**Problem Book in Relativity and Gravitation**

These lecture notes are intended for starting PhD students in theoretical physics who have a working knowledge of General
Relativity. The four topics covered are: Surface charges as conserved quantities in theories of gravity; Classical and holographic features of three-dimensional Einstein gravity; Asymptotically flat spacetimes in four dimensions: BMS group and memory effects; The Kerr black hole: properties at extremality and quasi-normal mode ringing. Each topic starts with historical foundations and points to a few modern research directions.

The Theoretical Minimum

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.

Special and General Relativity

Geometric Relativity

"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
A Mathematical Introduction To General Relativity

Advanced General Relativity

Relativity is a triumph of the power of human thought and Einstein's greatest gift to mankind. It is a fascinating but difficult theory to understand. Mathematics is intimidating for a beginner. The popular books do not go into details of the subject and textbooks are just too hard for self-study. This book aims to bridge the gap between the two. The emphasis of this book is to explain the meaning and intuition behind concepts and mathematics. There is extensive use of analogies from daily life to develop visualization and intuition. This book is well suited for a beginner who has limited physics and mathematics background. The biggest barrier in learning relativity is the notation, which is a language onto itself. If the meaning behind notation is not clear, it's easy to get lost in the maze of indices used in relativity. This book tries to address the reason and meaning behind relativistic notation.

Introduction to General Relativity, Black Holes, and Cosmology

“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.

An Introduction to General Relativity and Cosmology

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.

**Mathematical Problems of General Relativity I**

The foundations are thoroughly developed together with the required mathematical background from differential geometry developed in Part III. The author also discusses the tests of general relativity in detail, including binary pulsars, with much space is devoted to the study of compact objects, especially to neutron stars and to the basic laws of black-hole physics. This well-structured text and reference enables readers to easily navigate through the various sections as best matches their backgrounds and perspectives, whether mathematical, physical or astronomical. Very applications oriented, the text includes very recent results, such as the supermassive black-hole in our galaxy and first double pulsar system.

**Spacetime and 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 Relativist's Toolkit**

A self-contained introduction to advanced general relativity.

**General Relativity: A First Examination (Second Edition)**

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 spacelike 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.

**300 Problems in Special and General Relativity**

Concise treatment, based on ideas of Einstein and Minkowski, geared toward advanced undergraduates and graduate students of physics. Topics include old physics, new geometry, special relativity, curved space, and general relativity. 1950 edition.

**General Relativity Without Calculus**

The book covers mainstream topics at research level involving gravitational waves, spinning particles, and black holes, suitable for graduates and early postgraduates exploring avenues into research in general relativity.

**Frontiers in General Relativity**

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.

**Advanced Lectures on General Relativity**

A Wall Street Journal Best Book of 2013 If you ever regretted not taking physics in college--or simply want to know how to think like a physicist--this is the book for you. In this bestselling introduction, physicist Leonard Susskind and hacker-scientist George Hrabovsky offer a first course in physics and associated math for the ardent amateur. Challenging, lucid, and concise, The Theoretical Minimum provides a tool kit for amateur scientists to learn physics at their own pace.

**General Relativity**

Based on a course taught for years at Oxford, this book offers a concise exposition of the central ideas of general relativity. The focus is on the chain of reasoning that leads to the relativistic theory from the analysis of distance and time measurements in the presence of gravity, rather than on the underlying mathematical structure. Includes links to recent developments, including theoretical work and observational evidence, to encourage further study.

**Advanced Lectures on General Relativity**

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.

**Introduction to General Relativity**

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

**Mathematics of Relativity**

This textbook is suitable for a one-semester introduction to General Relativity for advanced undergraduates in physics and engineering. The book is concise so that the entire material can be covered in the one-semester time frame. Many of the calculations are done in detail, without difficult mathematics, to help the students. Though concise, the theory development is lucid and the readers are exposed to possible analytic calculations. In the second edition, the famous twin paradox with acceleration is solved in full from the accelerated observer's frame. The findings of the Event Horizon Telescope (EHT) collaboration, who captured the first ever image of a black hole, are discussed in detail. The geodetic and frame drag precessions of gyroscopes in orbit about a rotating Earth are worked out and the Gravity Probe B (GPB) experiment is discussed. Also in the second edition are some new exercise problems. Resources are provided to instructors who adopt this textbook for their courses. Adopting instructors can print and copy portions of these resources solely for their teaching needs. All instructional resources are furnished for informational use only, and are subject to change without notice.
Surveys in Geometric Analysis and 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.

Advanced Mechanics and General Relativity

Einstein's general theory of relativity requires a curved space for the description of the physical world. If one wishes to go beyond superficial discussions of the physical relations involved, one needs to set up precise equations for handling curved space. The well-established mathematical technique that accomplishes this is clearly described in this classic book by Nobel Laureate P.A.M. Dirac. Based on a series of lectures given by Dirac at Florida State University, and intended for the advanced undergraduate, General Theory of Relativity comprises thirty-five compact chapters that take the reader point-by-point through the necessary steps for understanding general relativity.

A Student's Guide to General Relativity
The domain of application of Einstein's general relativity theory is astronomical systems. One of the mathematical methods analyzed and exploited in the present volume is an extension of Noether's fundamental principle connecting symmetries to conserved quantities. This book is intended for advanced students and researchers seeking an introduction into the methods and applications of general relativity.

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