



Tevian Dray

THE GEOMETRY OF SPECIAL RELATIVITY

Second Edition



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100 YEARS OF SPECIAL RELATIVITY

The Geometry Of Special Relativity

**Wladimir-Georges Boskoff, Salvatore
Capozziello**



The Geometry Of Special Relativity:

The Geometry of Special Relativity - a Concise Course Norbert Dragon, 2012-08-01 In this concise primer it is shown that with simple diagrams the phenomena of time dilatation length contraction and Lorentz transformations can be deduced from the fact that in a vacuum one cannot distinguish physically straight and uniform motion from rest and that the speed of light does not depend on the speed of either the source or the observer The text proceeds to derive the important results of relativistic physics and to resolve its apparent paradoxes A short introduction into the covariant formulation of electrodynamics is also given This publication addresses in particular students of physics and mathematics in their final undergraduate year

The Geometry of Special Relativity Tevian Dray, 2021-06-10 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

The Geometry of Minkowski Spacetime Gregory L. Naber, 2003-01-01 This mathematically rigorous

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

Callahan,2013-03-09 In 1905 Albert Einstein offered a revolutionary theory special relativity to explain some of the most troubling problems in current physics concerning electromagnetism and motion Soon afterwards Hermann Minkowski recast special relativity essentially as a new geometric structure for spacetime These ideas are the subject of the first part of the book The second part develops the main implications of Einstein's general relativity as a theory of gravity rooted in the differential geometry of surfaces The author explores the way an individual observer views the world and how a pair of observers collaborates to gain objective knowledge of the world He has tried to encompass both the general and special theory by using the geometry of spacetime as the unifying theme of the book To read it one needs only a first course in linear algebra and multivariable calculus and familiarity with the physical applications of calculus *The Geometry of Spacetime*

Rainer Oloff,2023-04-21 This book systematically develops the mathematical foundations of the theory of relativity and links them to physical relations For this purpose differential geometry on manifolds is introduced first including differentiation and integration and special relativity is presented as tensor calculus on tangential spaces Using Einstein's field equations relating curvature to matter the relativistic effects in the solar system including black holes are discussed in detail The text is aimed at students of physics and mathematics and assumes only basic knowledge of classical differential and integral calculus and linear algebra **The Geometry of Special Relativity** Mahtab Ghafoori,2009 **Geometry and Quantum Features of**

Special Relativity Norbert Dragon,2025-06-17 This second edition of *The Geometry of Special Relativity* a Concise Course offers more than just corrections and enhancements It includes a new chapter on four velocities and boosts as points and straight lines of hyperbolic geometry Quantum properties of relativistic particles are derived from the unitary representations of the Poincaré group Notably the massless representation is related to the concept of a Hopf bundle Scattering theory is developed analogously to the non relativistic case relying on proper symmetry postulates Chapters on quantum fields reflections of charge space and time and the necessary gauge symmetry of quantized vector fields complete the foundation for evaluating Feynman graphs An extended appendix covers more than a dozen additional topics The first half of this edition refines the first edition using simple diagrams to explain time dilation length contraction and Lorentz transformations based on the invariance of the speed of light The text derives key results of relativistic physics and resolves apparent paradoxes Following a presentation of the action principle Noether's theorem and relativistic mechanics the book

covers the covariant formulation of electrodynamics and classical field theory The groups of rotations and Lorentz transformations are also examined as a transition to relativistic quantum physics This text is aimed at graduate students of physics and mathematics seeking an advanced introduction to special relativity and related topics Its presentation of quantum physics aims to inspire fellow researchers Energy And Geometry: An Introduction To Deformed Special Relativity Fabio Cardone,Roberto Mignani,2004-08-10 This book discusses in detail the mathematical aspects and physical applications of a new geometrical structure of space time It is based on a generalization deformation of the usual Minkowski space supposedly endowed with a metric whose coefficients depend on the energy Energy and Geometry Geometrical Description of Interactions is suitable for researchers academics and students in mathematical and theoretical physics This book has been selected for coverage in CC Physical Chemical Earth Sciences Index to Scientific Book Contents ISBC

General Relativity Without Calculus Jose Natario,2011-07-30 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

Relativity Albert Einstein,2005 The Nobel Prize winning physicist presents his views on the special and general theory of relativity and the universe as a whole in an accessible introduction to his seminal theories written for the non scientist

Geometry of Minkowski Space-Time Francesco Catoni,Dino Boccaletti,Roberto Cannata,Vincenzo Catoni,Paolo Zampetti,2011-05-07 This book provides an original introduction to the geometry of Minkowski space time A hundred years after the space time formulation of special relativity by Hermann Minkowski it is shown that the kinematical consequences of special relativity are merely a manifestation of space time geometry The book is written with the intention of providing students and teachers of the first years of University courses with a tool which is easy to be applied and allows the solution of any problem of relativistic kinematics at the same time The book treats in a rigorous way but using a non sophisticated mathematics the Kinematics of Special Relativity As an example the famous Twin Paradox is completely solved for all kinds of motions The novelty of the presentation in this book consists in the extensive use of hyperbolic numbers the simplest extension of complex numbers for a complete formalization of the kinematics in the Minkowski space time Moreover from this formalization the understanding of gravity comes as a manifestation of curvature of space time suggesting new research fields

Differential Forms and the Geometry of General Relativity Tevian Dray,2014-10-20 Requiring little more than calculus and some linear algebra this book provides readers with a coherent path to understanding relativity It helps readers learn just enough differential geometry to grasp the basics of general relativity The first half of the book describes some of

the surprising implications of relativity without introducing more formalism than necessary The second half takes a more detailed look at the mathematics of differential forms showing how they are used to describe key geometric ideas in general relativity

A Mathematical Journey to Relativity Wladimir-Georges Boskoff, Salvatore Capozziello, 2020-06-01 This book opens with an axiomatic description of Euclidean and non Euclidean geometries Euclidean geometry is the starting point to understand all other geometries and it is the cornerstone for our basic intuition of vector spaces The generalization to non Euclidean geometry is the following step to develop the language of Special and General Relativity These theories are discussed starting from a full geometric point of view Differential geometry is presented in the simplest way and it is applied to describe the physical world The final result of this construction is deriving the Einstein field equations for gravitation and spacetime dynamics Possible solutions and their physical implications are also discussed the Schwarzschild metric the relativistic trajectory of planets the deflection of light the black holes the cosmological solutions like de Sitter Friedmann Lemaître Robertson Walker and Gödel ones Some current problems like dark energy are also sketched The book is self contained and includes details of all proofs It provides solutions or tips to solve problems and exercises It is designed for undergraduate students and for all readers who want a first geometric approach to Special and General Relativity

Relativity : An Introduction To The Special Theory Asghar Qadir, 1989-11-01 The most important feature in this book is the simple presentation with details of calculations It is very easy to follow Fairly sophisticated calculations are developed very rapidly The presentation is logical and the detailed coverage makes this book very readable and useful The contents develop Relativity as a modern theory of motion starting by placing it in historical perspective and proceeding to show its logical necessity The development of the Lorentz transformation is given using only one assumption rather than two Right away in Chapter 3 geometry as required in Special Relativity for extension to General Relativity is introduced This enables the use of the four vector formalism of Minkowski By the end of Chapter 4 the general Lorentz transformations for three dimensional motion and their relation to four dimensional boosts have already been explained In Chapter 5 applications of relevance in Physics are provided After a brief introduction to elementary electromagnetic theory it is reformulated as a theory in four dimensions using tensors in Chapter 6 Finally in Chapter 7 the theory is extended to deal with accelerated motion as corrections to Special Relativity

Relativity and Geometry Roberto Torretti, 1996-01-01 Early in this century it was shown that the new non Newtonian physics known as Einstein's Special Theory of Relativity rested on a new non Euclidean geometry which incorporated time and space into a unified chronogeometric structure This high level study elucidates the motivation and significance of the changes in physical geometry brought about by Einstein in both the first and the second phase of Relativity After a discussion of Newtonian principles and 19th century views on electrodynamics and the aether the author offers illuminating expositions of Einstein's electrodynamics of moving bodies Minkowski spacetime Einstein's quest for a theory of gravity gravitational geometry the concept of simultaneity time and causality and other topics

An important Appendix designed to define spacetime curvature considers differentiable manifolds fiber bundles linear connections and useful formulae Relativity continues to be a major focus of interest for physicists mathematicians and philosophers of science This highly regarded work offers them a rich historico critical exposition emphasizing geometrical ideas of the elements of the Special and General Theory of Relativity *Geometry: from Isometries to Special Relativity* Nam-Hoon Lee,2020-04-28 This textbook offers a geometric perspective on special relativity bridging Euclidean space hyperbolic space and Einstein s spacetime in one accessible self contained volume Using tools tailored to undergraduates the author explores Euclidean and non Euclidean geometries gradually building from intuitive to abstract spaces By the end readers will have encountered a range of topics from isometries to the Lorentz Minkowski plane building an understanding of how geometry can be used to model special relativity Beginning with intuitive spaces such as the Euclidean plane and the sphere a structure theorem for isometries is introduced that serves as a foundation for increasingly sophisticated topics such as the hyperbolic plane and the Lorentz Minkowski plane By gradually introducing tools throughout the author offers readers an accessible pathway to visualizing increasingly abstract geometric concepts Numerous exercises are also included with selected solutions provided *Geometry from Isometries to Special Relativity* offers a unique approach to non Euclidean geometries culminating in a mathematical model for special relativity The focus on isometries offers undergraduates an accessible progression from the intuitive to abstract instructors will appreciate the complete instructor solutions manual available online A background in elementary calculus is assumed *Spacetime and Geometry* Sean M. Carroll,2019-08-08 An accessible introductory textbook on general relativity covering the theory s foundations mathematical formalism and major applications *The Special Theory of Relativity* Farook Rahaman,2014-10-07 The book expounds the major topics in the special theory of relativity It provides a detailed examination of the mathematical foundation of the special theory of relativity relativistic mass relativistic mechanics and relativistic electrodynamics As well as covariant formulation of relativistic mechanics and electrodynamics the book discusses the relativistic effect on photons Using a mathematical approach the text offers graduate students a clear concise view of the special theory of relativity Organized into 14 chapters and two appendices the content is presented in a logical order and every topic has been dealt with in a simple and lucid manner To aid understanding of the subject the book provides numerous relevant worked examples in every chapter The book s mathematical approach helps students in their independent study and motivates them to research the topic further

Flat and Curved Space-times George Francis Rayner Ellis,Ruth M. Williams,2000 The present book explains special relativity and the basics of general relativity from a geometric viewpoint Space time geometry is emphasised throughout and provides the basis of understanding of the special relativity effects of time dilation length contraction and the relativity of simultaneity Bondi s K calculus is introduced as a simple means of calculating the magnitudes of these effects and leads to a derivation of the Lorentz transformation as a way of unifying these results The invariant interval of flat space time is

generalised to that of curved space times and leads to an understanding of the basic properties of simple cosmological models and of the collapse of a star to form a black hole The appendices enable the advanced student to master the application of four tensors to the relativistic study of energy and momentum and of electromagnetism In addition this new edition contains up to date information on black holes gravitational collapse and cosmology

Very Special Relativity

Sander Bais, 2007 Einstein's Special Theory of Relativity first published in 1905 radically changed our understanding of the world Familiar notions of space and time and energy were turned on their head and our struggle with Einstein's counterintuitive explanation of these concepts was under way The task is no easier today than it was a hundred years ago but in this book Sander Bais has found an original and uniquely effective way to convey the fundamental ideas of Einstein's Special Theory Bais's previous book *The Equations* was widely read and roundly praised for its clear and commonsense explanation of the math in physics *Very Special Relativity* brings the same accessible approach to Einstein's theory Using a series of easy to follow diagrams and employing only elementary high school geometry Bais conducts readers through the quirks and quandaries of such fundamental concepts as simultaneity causality and time dilation The diagrams also illustrate the difference between the Newtonian view in which time was universal and the Einsteinian in which the speed of light is universal Following Bais's straightforward sequence of simple commonsense arguments readers can tinker with the theory and its great paradoxes and finally arrive at a truly deep understanding of Einstein's interpretation of space and time An intellectual journey into the heart of the Special Theory the book offers an intimate look at the terms and ideas that define our reality

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