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Calculus 13 interpret them):

($t' = \gamma (t - vx/c^2)$, $x' = \gamma (x - vt)$ where c represents the speed of light (about 300,000 kilometers per second) and $\gamma = 1/\sqrt{1 - v^2/c^2}$. The special theory of relativity, developed by Einstein in 1905, boils down to analyzing the consequences of these transformations.

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A researcher in optical networking technologies, Gannett has shown that the Lorentz transformations and velocity addition law can be derived without assuming the constancy of the speed of light, ...

~~Relativity Derived Without Calculus — Possibly Centuries Ago~~

General Relativity, at its core, is a mathematical model that describes the relationship between events in space-time; the basic finding of the theory is that the relationship between events in the same as the relationship between points on a manifold with

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curvature, and the geometry of that manifold is determined by sources of energy-momentum and their distribution in space-time.

~~The Maths of General Relativity — Markus Hanke~~
First general relativity is typically taught at a 4th year undergraduate level or sometimes even a graduate level, obviously this presumes a good undergraduate training in mathematics and physics. Personally, I'm more of the opinion that one should go and learn other physics before tackling general relativity.

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~~What are the prerequisites to studying general relativity?~~

ometry and general relativity require mathematical entities of still higher rank. The tools of vector analysis are simply incapable of allowing one to write down the governing laws in an invariant form, and one has to adopt a different mathematics from the vector analysis taught in the freshman and sophomore years. Tensor calculus is that ...

~~Tensor Calculus — SMU~~
Definition and basic properties. General

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relativity is a metric theory of gravitation. At its core are Einstein's equations, which describe the relation between the geometry of a four-dimensional pseudo-Riemannian manifold representing spacetime, and the energy-momentum contained in that spacetime.

~~General relativity~~

~~Wikipedia~~

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~~General relativity without calculus : a concise ...~~

In general relativity, Regge calculus is a formalism for producing simplicial approximations of spacetimes that are solutions to the Einstein field equation. The calculus was introduced by the Italian theoretician Tullio Regge in 1961. Overview. The starting point for Regge's work ...

~~Regge calculus — Wikipedia~~

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Manifolds Generally speaking, a manifold is a space that with curvature and complicated topology that locally looks like \mathbb{R}^n . Examples: \mathbb{R}^n itself. \mathbb{R} is a line and \mathbb{R}^2 a plane. The n -sphere, S^n ; that is, the locus of all points some fixed distance from the origin in \mathbb{R}^{n+1} . S^1 is a circle and S^2 sphere. The n -torus T^n . T^2 is the surface of a doughnut. A Riemann surface of genus g .

“General Relativity Without Calculus” offers a compact but mathematically correct introduction to the general

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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.

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introduces the reader to

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like Penrose diagrams, causality theory, singularity theorems, the Cauchy problem for the Einstein equations, the positive mass theorem, and the laws of black hole thermodynamics. It emerged from lecture notes originally conceived for a one-semester course in Mathematical Relativity which has been taught at the Instituto Superior Técnico (University of Lisbon, Portugal) since 2010 to Masters and Doctorate students in Mathematics and Physics. Mostly self-contained, and mathematically rigorous, this book can be appealing

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A concise introduction to
Mathematics or Physics
seeking specialization in
general relativity, geometry
or partial differential
equations. Prerequisites
include proficiency in
differential geometry and
the basic principles of
relativity. Readers who are
familiar with special
relativity and have taken a
course either in Riemannian
geometry (for students of
Mathematics) or in general
relativity (for those in
Physics) can benefit from
this book.

Differential Forms and the
Geometry of General
Relativity provides readers

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A concise introduction 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

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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.

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A Concise Introduction To

This book is an introduction to the theories of Special and General Relativity. The

target audience are

physicists, engineers and applied scientists who are looking for an

understandable introduction to the topic - without too much new mathematics. The

fundamental equations of Einstein's theory of Special and General Relativity are derived using matrix

calculus, without the help of tensors. This feature

makes the book special and a valuable tool for scientists and engineers with no

experience in the field of tensor calculus. In part I

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The foundations of Special Relativity are developed, part II describes the structure and principle of General Relativity. Part III explains the Schwarzschild solution of spherical body gravity and examines the "Black Hole" phenomenon. Any necessary mathematical tools are user friendly provided, either directly in the text or in the appendices.

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

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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

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A concise 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.

Suitable for a one-semester course in general relativity for senior undergraduates or beginning graduate students, this text clarifies the mathematical aspects of Einstein's theory of relativity without sacrificing physical understanding.

A straightforward, enjoyable guide to the mathematics of Einstein's relativity To

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really understand Einstein's theory of relativity – one of the cornerstones of modern physics – you have to get to grips with the underlying mathematics. This self-study guide is aimed at the general reader who is motivated to tackle that not insignificant challenge. With a user-friendly style, clear step-by-step mathematical derivations, many fully solved problems and numerous diagrams, this book provides a comprehensive introduction to a fascinating but complex subject. For those with minimal mathematical background, the first chapter gives a crash course

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in foundation mathematics. The reader is then taken gently by the hand and guided through a wide range of fundamental topics, including Newtonian mechanics; the Lorentz transformations; tensor calculus; the Einstein field equations; the Schwarzschild solution (which gives a good approximation of the spacetime of our Solar System); simple black holes, relativistic cosmology and gravitational waves. Special relativity helps explain a huge range of non-gravitational physical phenomena and has some strangely counter-intuitive consequences. These include

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time dilation, length contraction, the relativity of simultaneity, mass-energy equivalence and an absolute speed limit. General relativity, the leading theory of gravity, is at the heart of our understanding of cosmology and black holes. "I must observe that the theory of relativity resembles a building consisting of two separate stories, the special theory and the general theory. The special theory, on which the general theory rests, applies to all physical phenomena with the exception of gravitation; the general theory provides the law of gravitation and its

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relations to the other forces
of nature." – Albert
Einstein, 1919 Understand
even the basics of

Einstein's amazing theory
and the world will never
seem the same again.

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curvature tensor

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Bibliography
Acknowledgements January 2019. This third edition has been revised to make the material even more accessible to the enthusiastic general reader who seeks to understand the mathematics of relativity.

In the first decade of the twentieth century as Albert Einstein began formulating a revolutionary theory of gravity, the Italian mathematician Gregorio Ricci was entering the later stages of what appeared to be a productive if not particularly memorable career, devoted largely to what his colleagues regarded

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As the dogged development of a mathematical language he called the absolute differential calculus. In 1912, the work of these two dedicated scientists would intersect—and physics and mathematics would never be the same. Einstein's Italian Mathematicians chronicles the lives and intellectual contributions of Ricci and his brilliant student Tullio Levi-Civita, including letters, interviews, memoranda, and other personal and professional papers, to tell the remarkable, little-known story of how two Italian academicians, of widely divergent backgrounds and

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temperaments, came to provide the indispensable mathematical foundation—today known as the tensor calculus—for general relativity.

Einstein's general theory of relativity is introduced in this advanced undergraduate textbook. Without an over emphasis on the difficult mathematics of tensor analysis, the book presents the curved spacetime theory of gravitation. The phenomena of gravitational light deflection, the precession of a planet's orbit, and black holes are discussed with technical detail. The book has an

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A concise treatment of cosmology from primordial inflation, cosmic microwave background to the dark energy that propels an accelerating universe. The book is the undergraduate edition of the author's previous work, *Relativity, Gravitation and Cosmology: A Basic Introduction*, published as part of the Oxford Master Series in Physics. This college edition concentrates on the core elements of the subject making it suitable for a one-semester course at the undergraduate level. It can also serve as an accessible introduction to general relativity and cosmology for those readers

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who want to study the
subject on their own.

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