

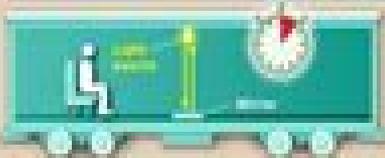
# EINSTEIN'S THEORY OF RELATIVITY

There are two Theories of Relativity: the Special and the General. The Special Theory shows that movement over a straight line at a constant speed is always relative to any observer. The General Theory extends the Special Theory from uniform to accelerated motion, movement at a changing speed or over a non-straight path.

## SPECIAL THEORY OF RELATIVITY

Based in a basic assumption: the speed of light is always the same regardless of the speed of the light source or observer. This fact has unexpected and astonishing ramifications.

### RELATIVITY OF TIME



1 A man is riding on a moving train. He is shining a ray of light that travels from a source in the ceiling to a mirror in the floor and back to the ceiling. From his point of view the light source and the mirror are stationary, so the light travels directly down and up in perfectly vertical lines.

2 From the point of view of a stationary observer standing outside the train, the light source and the mirror are moving, so the light follows a path in the shape of a V. This path is longer than the one observed by the man on the train. Since light travels at the same speed for any observer, from the stationary point of view the ray takes longer than from the perspective of the man on the train. Or, in other words, time passes slower for the man in the train than for the stationary observer. So, there is no meaning to the concept of absolute time. Time is relative to the observer.



### RELATIVITY OF LENGTH



3 The man in the train is now trying to measure the length of the car by sending a ray of light from one end to the other, knowing the speed of light and the time the ray takes to reach the other and he can calculate the length of the car.



4 From the point of view of the stationary observer the end of the train is moving to meet the ray of light, so it has to travel a shorter distance. The stationary observer will calculate a shorter length for the car than the man in the train. So, there is no meaning to the concept of absolute length. Length is relative to the observer.

### HISTORY'S FAMOUS EQUATION

Another important idea of the Special Theory of Relativity is the equivalence of mass and energy: mass can be converted into energy and vice versa. This relationship is expressed in the equation:

$$E = mc^2$$

The energy ( $E$ ) contained in any quantity of mass (mass) is directly proportional to the square of the speed of light ( $c$ ) multiplied by it. Here,  $c^2$  is an enormous number, which is why a little bit of mass contains a tremendous amount of energy. A dramatic example of the power of mass and energy is provided in the atomic bomb, which converts into energy a tiny mass of uranium.

## GENERAL THEORY OF RELATIVITY

The theory asserts that accelerated motion is relative to the observer, as the Special theory did for the uniform motion. It shows that inertia (the force that presses you against the back of your seat when your car accelerates) and gravity are equivalent forces, two sides of the same phenomenon.

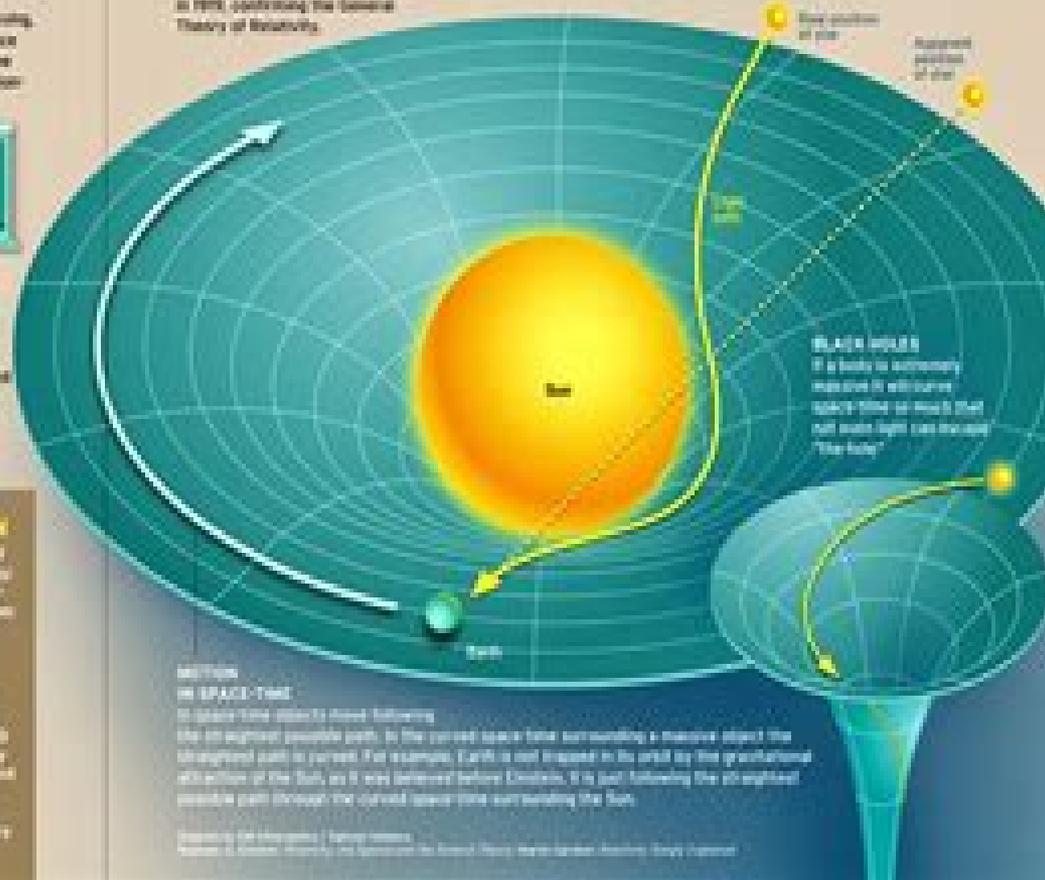
### THE EQUIVALENCE OF GRAVITY AND ACCELERATION

A man is inside an elevator that is accelerating upwards at a constant rate. The forces he experiences (that pressing on the floor) and the way objects fall are indistinguishable from those produced by gravity.



### THE CURVATURE OF SPACE-TIME BY MASSIVE BODIES

According to Einstein gravity is not a force at all. It is a distortion or curvature of the space-time (a four-dimensional compound of the three dimensions of space plus time) that occurs around any massive body (for example, the Sun). It's like a rubber sheet being bent by a weight placed in its center. Even light curves when passing close to a massive body. Thus the position of a star appears displaced if its light passes close to the Sun. This effect was observed in 1919, confirming the General Theory of Relativity.



**BLACK HOLES**  
If a body is extremely massive it will curve space-time so much that not even light can escape "the hole".

### TRAJECTORIES IN SPACE-TIME

In space-time objects don't travel following the straight possible path, in the curved space-time surrounding a massive object the straightest path is curved. For example, Earth is not trapped in its orbit by the gravitational attraction of the Sun, as it was believed before Einstein. It is just following the straightest possible path through the curved space-time surrounding the Sun.

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# Theory Of Relativity

**Hendrik Antoon Lorentz, Albert  
Einstein, Hermann Minkowski, Hermann  
Weyl**

## **Theory Of Relativity:**

**Relativity** Albert Einstein, 2004 Albert Einsteins Relativity The Special and the General Theory 1920 is a cornerstone of modern physics Einstein intended this book for those readers who from a general scientific and philosophical point of view are interested in the theory but who are not conversant with the mathematical apparatus Indeed within the vast literature on the philosophy of space and time Einsteins Relativity shall remain an illuminable and intelligible exposition highly quotable as one of the most lucid presentations of the subject matter and a launching pad for any further inquiry on the fascinating features of our universe

**The Special Theory of Relativity** David Bohm, 1996 The book presents the theory of relativity as a unified whole By showing that the concepts of this theory are interrelated to form a unified totality David Bohm supplements some of the more specialist courses which have tended to give students a fragmentary impression of the logical and conceptual nature of physics as a whole

**The Meaning of Relativity** Albert Einstein, 2014-10-26 In 1921 five years after the appearance of his comprehensive paper on general relativity and twelve years before he left Europe permanently to join the Institute for Advanced Study Albert Einstein visited Princeton University where he delivered the Stafford Little Lectures for that year These four lectures constituted an overview of his then controversial theory of relativity Princeton University Press made the lectures available under the title The Meaning of Relativity the first book by Einstein to be produced by an American publisher As subsequent editions were brought out by the Press Einstein included new material amplifying the theory A revised version of the appendix Relativistic Theory of the Non Symmetric Field added to the posthumous edition of 1956 was Einstein s last scientific paper

**Einstein's General Theory of Relativity** Øyvind Grøn, Sigbjørn Hervik, 2007-05-04 This book introduces the general theory of relativity and includes applications to cosmology The book provides a thorough introduction to tensor calculus and curved manifolds After the necessary mathematical tools are introduced the authors offer a thorough presentation of the theory of relativity Also included are some advanced topics not previously covered by textbooks including Kaluza Klein theory Israel s formalism and branes Anisotropic cosmological models are also included The book contains a large number of new exercises and examples each with separate headings The reader will benefit from an updated introduction to general relativity including the most recent developments in cosmology

**The Physical and Mathematical Foundations of the Theory of Relativity** Antonio Romano, Mario Mango Furnari, 2019-09-25 This unique textbook offers a mathematically rigorous presentation of the theory of relativity emphasizing the need for a critical analysis of the foundations of general relativity in order to best study the theory and its implications The transitions from classical mechanics to special relativity and then to general relativity are explored in detail as well helping readers to gain a more profound and nuanced understanding of the theory as a whole After reviewing the fundamentals of differential geometry and classical mechanics the text introduces special relativity first using the physical approach proposed by Einstein and then via Minkowski s mathematical model The authors then address the relativistic

thermodynamics of continua and electromagnetic fields in matter topics which are normally covered only very briefly in other treatments in the next two chapters The text then turns to a discussion of general relativity by means of the authors unique critical approach underlining the difficulty of recognizing the physical meaning of some statements such as the physical meaning of coordinates and the derivation of physical quantities from those of space time Chapters in this section cover the model of space time proposed by Schwarzschild black holes the Friedman equations and the different cosmological models they describe and the Fermi Walker derivative Well suited for graduate students in physics and mathematics who have a strong foundation in real analysis classical mechanics and general physics this textbook is appropriate for a variety of graduate level courses that cover topics in relativity Additionally it will interest physicists and other researchers who wish to further study the subtleties of these theories and understand the contemporary scholarly discussions surrounding them

**General Theory of Relativity** C. W. Kilmister,2013-10-22 General Theory of Relativity deals with the general theory of relativity and covers topics ranging from the principle of equivalence and the space theory of matter to the hypotheses which lie at the bases of geometry along with the effect of gravitation on the propagation of light The motion of particles in general relativity theory is also discussed This book is comprised of 14 chapters and begins with a review of the principle of equivalence paying particular attention to the question of the existence of inertial frames in Newtonian mechanics The beginnings and foundations of general relativity are then considered together with modern developments in the field Subsequent chapters explore the general notion of multiply extended magnitudes the space theory of matter the effect of gravitation on light propagation gravitational waves and the motion of particles in general relativity theory and homogeneity and covariance An invariant formulation of gravitational radiation theory is also presented The last three chapters examine continued gravitational contraction a spinor approach to general relativity and gravitational red shift in nuclear resonance This monograph will be of interest to physicists and mathematicians **Relativity** Albert Einstein,Robert W.

Lawson,2001-01-01 This book contains the great physicist s own explanation of both the special and general theories of relativity Written for readers interested in the theory but not conversant with the mathematical apparatus of theoretical physics it presents the ideas in their simplest most intelligible form **Relativity** Albert Einstein,2022 **Relativity** Albert Einstein,2009-01 The theory of relativity explained by the greatest mind of the 20th century Albert Einstein discusses the special and general theories of relativity and the core concepts of modern cosmology including time dilation the spacetime continuum and the energy mass relationship in simple non mathematical terms The Principle of Relativity Hendrik Antoon Lorentz,Albert Einstein,Hermann Minkowski,Hermann Weyl,1952 Here are the 11 papers that forged the general and special theories of relativity seven papers by Einstein plus two papers by Lorentz and one each by Minkowski and Weyl A thrill to read again the original papers by these giants School Science and Mathematics 1923 edition *The Theory of Relativity and a Priori Knowledge* Hans Reichenbach,1965 **Theory of Relativity** Albert Einstein,2015-06-02 Theory of

Relativity The Foundation by Albert Einstein The theory which is sketched in the following pages forms the most wide going generalization conceivable of what is at present known as the theory of Relativity this latter theory I differentiate from the former Special Relativity theory and suppose it to be known The generalization of the Relativity theory has been made much easier through the form given to the special Relativity theory by Minkowski which mathematician was the first to recognize clearly the formal equivalence of the space like and time like co ordinates and who made use of it in the building up of the theory The mathematical apparatus useful for the general relativity theory lay already complete in the Absolute Differential Calculus which were based on the researches of GAUSS RIEMANN and CHRISTOFFEL on the non Euclidean manifold and which have been shaped into a system by RICCI and LEVI CIVITA and already applied to the problems of theoretical physics

**Gravitation and Cosmology** Steven Weinberg,2013-08-12 A leading physicist delves into relativity and experimental applications Gravitation and Cosmology Principles and Applications of the General Theory of Relativity offers a Nobel laureate s perspectives on the wealth of data technological developments have brought to expand upon Einstein s theory Unique in basing relativity on the Principle of Equivalence of Gravitation and Inertia over Riemannian geometry this book explores relativity experiments and observational cosmology to provide a sound foundation upon which analyses can be made Covering special and general relativity tensor analysis gravitation curvature and more this book provides an engaging insightful introduction to the forces that shape the universe

**Relativity** Albert Einstein,1954 The special theory of relativity The general theory of relativity Considerations on the universe as a whole

**Theory of Relativity** W. Pauli,2013-04-15 Nobel Laureate s brilliant early treatise on Einstein s theory consists of his original 1921 text plus retrospective comments 35 years later Concise and comprehensive it pays special attention to unified field theories

**Relativity** Albert Einstein,2013-03-27 How better to learn the Special Theory of Relativity and the General Theory of Relativity than directly from their creator Albert Einstein himself In Relativity The Special and the General Theory Einstein describes the theories that made him famous illuminating his case with numerous examples and a smattering of math nothing more complex than high school algebra Einstein s book is not casual reading but for those who appreciate his work without diving into the arcana of theoretical physics Relativity will prove a stimulating read The present book is intended Einstein wrote in 1916 as far as possible to give an exact insight into the theory of Relativity to those readers who from a general scientific and philosophical point of view are interested in the theory but who are not conversant with the mathematical apparatus of theoretical physics

**The Meaning of Relativity** a Einstein,2013-03-09 BY W H MCCREA F R S THE only justification for our concepts and system of concepts is that they serve to represent the complex of our experiences beyond this they have no legitimacy So Einstein writes on page 2 of this book Most present day physicists would agree and many before Einstein must have held the same opinion Einstein however put the opinion into practice to better purpose than any physicist before him And for Einstein it evidently meant what it means for most of us today a theory is the construction of a

theoretical model of the world of physics all the mathematical discussion applies to the model the model embodies the system of concepts and it serves to represent the complex of our experiences if the experience of the theoretical observer in the theoretical model can be put into satisfactory correspondence with the experience of the actual observer in the actual physical world Classical mechanics and classical electromagnetism provide models that are good representations of two sets of actual experiences As Einstein was the first fully to appreciate however it is not possible to combine these into a single self consistent model The construction of the simplest possible self consistent model is the achievement of Einstein's theory of special relativity The theory is found in particular to give a satisfactory representation of the electromagnetic interaction between charged particles through its use of the concept of the electromagnetic field

*Einstein's Theory of Relativity* Max Born, 1962-01-01 A Nobel Prize winning physicist explains the historical background and scientific principles of Einstein's famous theory

**Relativity** Albert Einstein, 2010-06-20 Einstein's classic work explaining his theories of relativity and gravitation to the non specialist

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