

The Mathematical Theory Of Special And General Relativity

[#mathematical relativity](#) [#special relativity](#) [#general relativity](#) [#relativity theory](#) [#theoretical physics](#)

The Mathematical Theory of Special and General Relativity explores the profound principles governing the fabric of spacetime, energy, and gravitation. It encompasses Einstein's groundbreaking insights into the constant speed of light, time dilation, length contraction, and the curvature of spacetime induced by mass and energy, all underpinned by rigorous mathematical frameworks crucial for understanding the universe's fundamental workings.

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The Mathematical Theory Of Special And General Relativity

The Maths of General Relativity (1/8) - Spacetime and Worldlines - The Maths of General Relativity (1/8) - Spacetime and Worldlines by ScienceClic English 309,144 views 3 years ago 6 minutes, 35 seconds - In this series, we build together the **theory**, of **general relativity**,. This first video focuses on the notions of worldline, proper time, and ...

Introduction

Example

Conclusion

The General Theory of Relativity: Its Faulty Mathematical Foundations - The General Theory of Relativity: Its Faulty Mathematical Foundations by Sky Scholar 24,976 views 1 year ago 18 minutes - G. Ricci-Curbastro, T. Levi-Civita, Matematiche Annalen 1901, B54, 162. S.J. Crothers, On the **General**, Solution to Einstein's ...

Deriving Einstein's most famous equation: Why does energy = mass x speed of light squared? -

Deriving Einstein's most famous equation: Why does energy = mass x speed of light squared? by Physics Explained 1,509,717 views 3 years ago 36 minutes - Along the way we will also touch upon some of the most fascinating features of Einstein's **theory of special relativity**,, including time ...

Einstein's most

The Principle of Relativity

The Problem with Light

Time Dilation

Relativistic Energy

Massless particles

Energy and Momentum

What does this mean?

Einstein's General Theory of Relativity | Lecture 1 - Einstein's General Theory of Relativity | Lecture 1 by Stanford 7,067,642 views 15 years ago 1 hour, 38 minutes - Lecture 1 of Leonard Susskind's

Modern Physics concentrating on **General Relativity**,. Recorded September 22, 2008 at Stanford ...

Newton's Equations

Inertial Frame of Reference

The Basic Newtonian Equation

Newtonian Equation

Acceleration

Newton's First and Second Law

The Equivalence Principle

Equivalence Principle

Newton's Theory of Gravity Newton's Theory of Gravity

Experiments

Newton's Third Law the Forces Are Equal and Opposite

Angular Frequency

Kepler's Second Law

Electrostatic Force Laws

Tidal Forces

Uniform Acceleration

The Minus Sign There Look As Far as the Minus Sign Goes all It Means Is that every One of these Particles Is Pulling on this Particle toward It as Opposed to Pushing Away from It It's Just a Convention Which Keeps Track of Attraction Instead of Repulsion Yeah for the for the Ice Master That's My Word You Want To Make Sense but if You Can Look at It as a Kind of an in Samba Wasn't about a Linear Conic Component to It because the Ice Guy Affects the Jade Guy and Then Put You Compute the Jade Guy When You Take It Yeah Now What this What this Formula Is for Is Supposing You Know the Positions or All the Others You Know that Then What Is the Force on the One

This Extra Particle Which May Be Imaginary Is Called a Test Particle It's the Thing That You'Re Imagining Testing Out the Gravitational Field with You Take a Light Little Particle and You Put It Here and You See How It Accelerates Knowing How It Accelerates Tells You How Much Force Is on It in Fact It Just Tells You How It Accelerates and You Can Go Around and Imagine Putting It in Different Places and Mapping Out the Force Field That's on that Particle or the Acceleration

It's the Thing That You'Re Imagining Testing Out the Gravitational Field with You Take a Light Little Particle and You Put It Here and You See How It Accelerates Knowing How It Accelerates Tells You How Much Force Is on It in Fact It Just Tells You How It Accelerates and You Can Go Around and Imagine Putting It in Different Places and Mapping Out the Force Field That's on that Particle or the Acceleration Field since We Already Know that the Force Is Proportional to the Mass Then We Can Just Concentrate on the Acceleration

And You Can Go Around and Imagine Putting It in Different Places and Mapping Out the Force Field That's on that Particle or the Acceleration Field since We Already Know that the Force Is Proportional to the Mass Then We Can Just Concentrate on the Acceleration the Acceleration all Particles Will Have the Same Acceleration Independent of the Mass so We Don't Even Have To Know What the Mass of the Particle Is We Put Something over There a Little Bit of Dust and We See How It Accelerates Acceleration Is a Vector and So We Map Out in Space the Acceleration of a Particle at every Point in Space either Imaginary or Real Particle

And We See How It Accelerates Acceleration Is a Vector and So We Map Out in Space the Acceleration of a Particle at every Point in Space either Imaginary or Real Particle and that Gives Us a Vector Field at every Point in Space every Point in Space There Is a Gravitational Field of Acceleration It Can Be Thought of as the Acceleration You Don't Have To Think of It as Force Acceleration the Acceleration of a Point Mass Located at that Position It's a Vector It Has a Direction It Has a Magnitude and It's a Function of Position so We Just Give It a Name the Acceleration due to All the Gravitating Objects

If Everything Is in Motion the Gravitational Field Will Also Depend on Time We Can Even Work Out What It Is We Know What the Force on the Earth Particle Is All Right the Force on a Particle Is the Mass Times the Acceleration So if We Want To Find the Acceleration Let's Take the Ayth Particle To Be the Test Particle Little Eye Represents the Test Particle over Here Let's Erase the Intermediate Step Over Here and Write that this Is in $\mathbf{a}_i$ Times $\mathbf{a}_i$ but Let Me Call It Now Capital $\mathbf{a}$ the Acceleration of a Particle at Position $\mathbf{x}$

And that's the Way I'M GonNa Use It Well for the Moment It's Just an Arbitrary Vector Field a It Depends on Position When I Say It's a Field the Implication Is that It Depends on Position Now I Probably Made It Completely Unreadable a of $\mathbf{x}$ Varies from Point to Point and I Want To Define a Concept Called the Divergence of the Field Now It's Called the Divergence because One Has To

Do Is the Way the Field Is Spreading Out Away from a Point for Example a Characteristic Situation Where We Would Have a Strong Divergence for a Field Is if the Field Was Spreading Out from a Point like that the Field Is Diverging Away from the Point Incidentally if the Field Is Pointing Inward The Field Is the Same Everywhere as in Space What Does that Mean that Would Mean the Field That Has both Not Only the Same Magnitude but the Same Direction Everywhere Is in Space Then It Just Points in the Same Direction Everywhere Else with the Same Magnitude It Certainly Has no Tendency To Spread Out When Does a Field Have a Tendency To Spread Out When the Field Varies for Example It Could Be Small over Here Growing Bigger Growing Bigger Growing Bigger and We Might Even Go in the Opposite Direction and Discover that It's in the Opposite Direction and Getting Bigger in that Direction Then Clearly There's a Tendency for the Field To Spread Out Away from the Center Here the Same Thing Could Be True if It Were Varying in the Vertical

It Certainly Has no Tendency To Spread Out When Does a Field Have a Tendency To Spread Out When the Field Varies for Example It Could Be Small over Here Growing Bigger Growing Bigger Growing Bigger and We Might Even Go in the Opposite Direction and Discover that It's in the Opposite Direction and Getting Bigger in that Direction Then Clearly There's a Tendency for the Field To Spread Out Away from the Center Here the Same Thing Could Be True if It Were Varying in the Vertical Direction or Who Are Varying in the Other Horizontal Direction and So the Divergence Whatever It Is Has To Do with Derivatives of the Components of the Field

If You Found the Water Was Spreading Out Away from a Line this Way Here and this Way Here Then You'd Be Pretty Sure that some Water Was Being Pumped In from Underneath along this Line Here Well You Would See It another Way You Would Discover that the X Component of the Velocity Has a Derivative It's Different over Here than It Is over Here the X Component of the Velocity Varies along the X Direction so the Fact that the X Component of the Velocity Is Varying along the Direction There's an Indication that There's some Water Being Pumped in Here Likewise

You Can See the In and out the in Arrow and the Arrow of a Circle Right in between those Two and Let's Say that's the Bigger Arrow Is Created by a Steeper Slope of the Street It's Just Faster It's Going Fast It's Going Okay and because of that There's a Divergence There That's Basically It's Sort of the Difference between that's Right that's Right if We Drew a Circle around Here or We Would See that More since the Water Was Moving Faster over Here than It Is over Here More Water Is Flowing Out over Here Then It's Coming in Over Here

It's Just Faster It's Going Fast It's Going Okay and because of that There's a Divergence There That's Basically It's Sort of the Difference between that's Right that's Right if We Drew a Circle around Here or We Would See that More since the Water Was Moving Faster over Here than It Is over Here More Water Is Flowing Out over Here Then It's Coming In over Here Where Is It Coming from It Must Be Pumped in the Fact that There's More Water Flowing Out on One Side Then It's Coming In from the Other Side Must Indicate that There's a Net Inflow from Somewheres Else and the Somewheres Else Would Be from the Pump in Water from Underneath

Water Is an Incompressible Fluid It Can't Be Squeezed It Can't Be Stretched Then the Velocity Vector Would Be the Right Thing To Think about Them Yeah but You Could Have no You're Right You Could Have a Velocity Vector Having a Divergence because the Water Is Not because Water Is Flowing in but because It's Thinning Out Yeah that's that's Also Possible Okay but Let's Keep It Simple All Right and You Can Have the Idea of a Divergence Makes Sense in Three Dimensions Just As Well as Two Dimensions You Simply Have To Imagine that all of Space Is Filled with Water and There Are some Hidden Pipes Coming in Depositing Water in Different Places

Having a Divergence because the Water Is Not because Water Is Flowing in but because It's Thinning Out Yeah that's that's Also Possible Okay but Let's Keep It Simple All Right and You Can Have the Idea of a Divergence Makes Sense in Three Dimensions Just As Well as Two Dimensions You Simply Have To Imagine that all of Space Is Filled with Water and There Are some Hidden Pipes Coming in Depositing Water in Different Places so that It's Spreading Out Away from Points in Three-Dimensional Space in Three-Dimensional Space this Is the Expression for the Divergence All Right and You Can Have the Idea of a Divergence Makes Sense in Three Dimensions Just As Well as Two Dimensions You Simply Have To Imagine that all of Space Is Filled with Water and There Are some Hidden Pipes Coming in Depositing Water in Different Places so that It's Spreading Out Away from Points in Three-Dimensional Space in Three-Dimensional Space this Is the Expression for the Divergence if this Were the Velocity Vector at every Point You Would Calculate this Quantity and that Would Tell You How Much New Water Is Coming In at each Point of Space so that's the Divergence Now There's a Theorem Which

The Divergence Could Be Over Here Could Be Over Here Could Be Over Here Could Be Over Here in Fact any Ways Where There's a Divergence Will Cause an Effect in Which Water Will Flow out of

this Region Yeah so There's a Connection There's a Connection between What's Going On on the Boundary of this Region How Much Water Is Flowing through the Boundary on the One Hand and What the Divergence Is in the Interior the Connection between the Two and that Connection Is Called Gauss's Theorem What It Says Is that the Integral of the Divergence in the Interior That's the Total Amount of Flow Coming In from Outside from underneath the Bottom of the Lake

The Connection between the Two and that Connection Is Called Gauss's Theorem What It Says Is that the Integral of the Divergence in the Interior That's the Total Amount of Flow Coming In from Outside from underneath the Bottom of the Lake the Total Integrated and Now by Integrated I Mean in the Sense of an Integral the Integrated Amount of Flow in that's the Integral of the Divergence the Integral over the Interior in the Three-Dimensional Case It Would Be $\int_V \text{Divergence} \, dx \, dy \, dz$ over the Interior of this Region of the Divergence of a

The Integral over the Interior in the Three-Dimensional Case It Would Be $\int_V \text{Divergence} \, dx \, dy \, dz$ over the Interior of this Region of the Divergence of a if You Like To Think of a Is the Velocity Field That's Fine Is Equal to the Total Amount of Flow That's Going Out through the Boundary and How Do We Write that the Total Amount of Flow That's Flowing Outward through the Boundary We Break Up Let's Take the Three-Dimensional Case We Break Up the Boundary into Little Cells each Little Cell Is a Little Area

So We Integrate the Perpendicular Component of the Flow over the Surface That's through the Sigma Here That Gives Us the Total Amount of Fluid Coming Out per Unit Time for Example and that Has To Be the Amount of Fluid That's Being Generated in the Interior by the Divergence this Is Gauss's Theorem the Relationship between the Integral of the Divergence on the Interior of some Region and the Integral over the Boundary Where Where It's Measuring the Flux the Amount of Stuff That's Coming Out through the Boundary Fundamental Theorem and Let's Let's See What It Says Now And Now Let's See Can We Figure Out What the Field Is Elsewhere outside of Here So What We Do Is We Draw a Surface Around There We Draw a Surface Around There and Now We're Going To Use Gauss's Theorem First of all Let's Look at the Left Side the Left Side Has the Integral of the Divergence of the Vector Field All Right the Vector Field or the Divergence Is Completely Restricted to some Finite Sphere in Here What Is Incidentally for the Flow Case for the Fluid Flow Case What Would Be the Integral of the Divergence Does Anybody Know if It Really Was a Flue or a Flow of a Fluid

So What We Do Is We Draw a Surface Around There We Draw a Surface Around There and Now We're Going To Use Gauss's Theorem First of all Let's Look at the Left Side the Left Side Has the Integral of the Divergence of the Vector Field All Right the Vector Field or the Divergence Is Completely Restricted to some Finite Sphere in Here What Is Incidentally for the Flow Case for the Fluid Flow Case What Would Be the Integral of the Divergence Does Anybody Know if It Really Was a Flue or a Flow of a Fluid It'll Be the Total Amount of Fluid That Was Flowing

Why because the Integral over that There Vergence of a Is Entirely Concentrated in this Region Here and There's Zero Divergence on the Outside So First of All the Left Hand Side Is Independent of the Radius of this Outer Sphere As Long as the Radius of the Outer Sphere Is Bigger than this Concentration of Divergence Iya so It's a Number Altogether It's a Number Let's Call that Number M I'M Not Evan Let's Just Qq That's the Left Hand Side and It Doesn't Depend on the Radius on the Other Hand What Is the Right Hand Side Well There's a Flow Going Out and if Everything Is Nice and Spherically Symmetric Then the Flow Is Going To Go Radially Outward

So a Point Mass Can Be Thought of as a Concentrated Divergence of the Gravitational Field Right at the Center Point Mass the Literal Point Mass Can Be Thought of as a Concentrated Concentrated Divergence of the Gravitational Field Concentrated in some Very Very Small Little Volume Think of It if You like You Can Think of the Gravitational Field as the Flow Field or the Velocity Field of a Fluid That's Spreading Out Oh Incidentally of Course I've Got the Sign Wrong Here the Real Gravitational Acceleration Points Inward Which Is an Indication that this Divergence Is Negative the Divergence Is More like a Convergence Sucking Fluid in So the Newtonian Gravitational

Or There It's a Spread Out Mass this Big As Long as You're outside the Object and As Long as the Object Is Spherically Symmetric in Other Words As Long as the Object Is Shaped like a Sphere and You're outside of It on the Outside of It outside of Where the Mass Distribution Is Then the Gravitational Field of It Doesn't Depend on whether It's a Point It's a Spread Out Object whether It's Denser at the Center and Less Dense at the Outside Less Dense in the Inside More Dense on the Outside all It Depends on Is the Total Amount of Mass the Total Amount of Mass Is like the Total Amount of Flow

Whether It's Denser at the Center and Less Dense at the Outside Less Dense in the Inside More Dense on the Outside all It Depends on Is the Total Amount of Mass the Total Amount of Mass Is like

the Total Amount of Flow through Coming into the that Theorem Is Very Fundamental and Important to Thinking about Gravity for Example Supposing We Are Interested in the Motion of an Object near the Surface of the Earth but Not So near that We Can Make the Flat Space Approximation Let's Say at a Distance Two or Three or One and a Half Times the Radius of the Earth

It's Close to this Point that's Far from this Point That Sounds like a Hellish Problem To Figure Out What the Gravitational Effect on this Point Is but Know this Tells You the Gravitational Field Is Exactly the Same as if the Same Total Mass Was Concentrated Right at the Center Okay That's Newton's Theorem Then It's Marvelous Theorem It's a Great Piece of Luck for Him because without It He Couldn't Have Couldn't Have Solved His Equations He Knew He Meant but It May Have Been Essentially this Argument I'M Not Sure Exactly What Argument He Made but He Knew that with the 1 over R Squared Force Law and Only the 1 over R Squared Force Law Wouldn't Have Been Truth Was One of Our Cubes 1 over R to the Fourth 1 over R to the 7th

But He Knew that with the 1 over R Squared Force Law and Only the 1 over R Squared Force Law Wouldn't Have Been Truth Was One of Our Cubes 1 over R to the Fourth 1 over R to the 7th with the 1 over R Squared Force Law a Spherical Distribution of Mass Behaves Exactly as if All the Mass Was Concentrated Right at the Center As Long as You're outside the Mass so that's What Made It Possible for Newton To To Easily Solve His Own Equations That every Object As Long as It's Spherical Shape Behaves as if It Were Appoint Appointments

But Yes We Can Work Out What Would Happen in the Mine Shaft but that's Right It Doesn't Hold It a Mine Shaft for Example Supposing You Dig a Mine Shaft Right Down through the Center of the Earth Okay and Now You Get Very Close to the Center of the Earth How Much Force Do You Expect that We Have Pulling You toward the Center Not Much Certainly Much Less than if You Were than if All the Mass Will Concentrate a Right at the Center You Got the It's Not Even Obvious Which Way the Force Is but It Is toward the Center

... an Analogue of this in the **General Theory, of Relativity**, ...

General Relativity Explained in 7 Levels of Difficulty - General Relativity Explained in 7 Levels of Difficulty by minutephysics 1,547,038 views 3 years ago 6 minutes, 9 seconds - This video covers the General **theory**, of Relativity, developed by Albert Einstein, from basic simple levels (it's **gravity**,, curved ...

General Relativity explained in 7 Levels

Spacetime is a pseudo-Riemannian manifold

General Relativity is curved spacetime plus geodesics

Matter and spacetime obey the Einstein Field Equations

Level 6.5 General Relativity is about both gravity AND cosmology

Final Answer: What is General Relativity?

General Relativity is incomplete

Discovery That Changed Physics! Gravity is NOT a Force! - Discovery That Changed Physics! Gravity is NOT a Force! by Destiny 1,976,167 views 1 year ago 11 minutes, 16 seconds - Gravity, is one of the four fundamental forces of nature in the Universe. But of the four forces of nature, it stands alone as different.

THE SHORTEST

DAVID SCOTT NASA ASTRONAUT

WARPED SPACE-TIME

Does the Past Still Exist? - Does the Past Still Exist? by Sabine Hossenfelder 5,104,843 views 1 year ago 16 minutes - Albert Einstein taught us that space and time belong together to a common entity: space-time. This means that time becomes a ...

Intro

Space-time

Space-time diagrams

Special Relativity

The Relativity of Simultaneity

The Block Universe

The if's and but's

Sponsor Message

The secrets of Einstein's unknown equation – with Sean Carroll - The secrets of Einstein's unknown equation – with Sean Carroll by The Royal Institution 570,178 views 4 months ago 53 minutes - Did you know that Einstein's most important equation isn't $E=mc^2$? Find out all about his equation that expresses how spacetime ...

Einstein's most important equation

Why Newton's equations are so important

The two kinds of relativity

Why is it the geometry of spacetime that matters?

The principle of equivalence

Types of non-Euclidean geometry

The Metric Tensor and equations

Interstellar and time and space twisting

The Riemann tensor

A physical theory of gravity

How to solve Einstein's equation

Using the equation to make predictions

How its been used to find black holes

Theoretical Physicist Brian Greene Explains Time in 5 Levels of Difficulty | WIRED - Theoretical

Physicist Brian Greene Explains Time in 5 Levels of Difficulty | WIRED by WIRED 2,172,295 views

10 months ago 31 minutes - Time: the most familiar, and most mysterious quality of the physical universe. Theoretical physicist Brian Greene, PhD, has been ...

What Actually Are Space And Time? - What Actually Are Space And Time? by History of the

Universe 9,840,474 views 1 year ago 1 hour, 15 minutes - AND check out his Youtube channel:

<https://www.youtube.com/c/AlasLewisAndBarnes> Incredible thumbnail art by Ettore Mazza, ...

Introduction

What Is Space?

What Is Time?

New Space

New Time

Quantum Spacetime

Fundamentals of Quantum Physics. Basics of Quantum Mechanics Lecture for Sleep & Study -

Fundamentals of Quantum Physics. Basics of Quantum Mechanics Lecture for Sleep & Study by

LECTURES FOR SLEEP & STUDY 2,124,335 views 1 year ago 3 hours, 32 minutes - In this lecture,

you will learn about the prerequisites for the emergence of such a science as quantum physics, its foundations, and ...

The need for quantum mechanics

The domain of quantum mechanics

Key concepts in quantum mechanics

Review of complex numbers

Complex numbers examples

Probability in quantum mechanics

Probability distributions and their properties

Variance and standard deviation

Probability normalization and wave function

Position, velocity, momentum, and operators

An introduction to the uncertainty principle

Key concepts of quantum mechanics, revisited

How Einstein Thought of the Theory of Relativity - How Einstein Thought of the Theory of Relativity

by Beeyond Ideas 1,365,536 views 2 years ago 9 minutes, 5 seconds - This means that at that point,

he knew how to unify his **theory of special**, relativity with **gravity**,. Luckily, he didn't stop there. He did ...

Simplest Explanation of $E=MC^2$ for Beginners | $E=mc^2$ explained - Simplest Explanation of $E=MC^2$ for

Beginners | $E=mc^2$ explained by Klonusk 435,875 views 2 years ago 9 minutes - $E=mc^2$ Explanation:

The equation $E = mc^2$ means "energy equals mass times the speed of light squared." It shows that energy (E) ...

Most Popular Scientific Equation

Michael Faraday

A Moving Object Has Energy

Einstein's Universe: Understand Theory of General Relativity - Einstein's Universe: Understand

Theory of General Relativity by Best Documentary 494,335 views 10 months ago 1 hour, 57 minutes

- A documentary produced in 1979 by WGBH and the BBC to celebrate the centenary of the birth of Albert Einstein. Narrated and ...

Einstein's Relativity - Einstein's Relativity by ScienceChannel9000 217,815 views 11 years ago 4

minutes, 55 seconds - Brian Cox discusses Einstein's **theory**, of **relativity**, and how it is used in

GPS. Full lecture can be viewed here: ...

WSU: Space, Time, and Einstein with Brian Greene - WSU: Space, Time, and Einstein with Brian Greene by World Science Festival 7,003,841 views 3 years ago 2 hours, 31 minutes - Join Brian Greene, acclaimed physicist and author, on a wild ride into the mind of Albert Einstein, revealing deep aspects of the ...

Start

The Special Theory of Relativity

Speed

The Speed of Light

Relativity of Simultaneity

Time in Motion

How Fast Does Time Slow?

Time Dilation: Experimental Evidence

The Reality of Past, Present, and Future

Time Dilation: Intuitive Explanation

Motion's Effect on Space

The Pole in the Barn: Quantitative Details

The Twin Paradox

Implications for Mass

Special Relativity

What is the difference between Special and General Relativity? - What is the difference between Special and General Relativity? by World Science U 23,207 views 9 years ago 55 seconds - Subscribe to our YouTube Channel for all the latest from World Science U. Visit our Website: <http://www.world-scienceu.com/> Like ...

Albert Einstein and Theory of relativity Full Documentary HD - Albert Einstein and Theory of relativity Full Documentary HD by Science Corner 297,079 views 5 years ago 1 hour, 29 minutes - albert einstein (academic),documentary (tv genre),the extraordinary genius of albert einstein,albert einstein,**theory**, of **relativity**, ...

The Maths of General Relativity (7/8) - The Einstein equation - The Maths of General Relativity (7/8) - The Einstein equation by ScienceClic English 117,801 views 3 years ago 7 minutes, 29 seconds - In this series, we build together the **theory**, of **general relativity**,. This seventh video focuses on the Einstein equation, the key ...

PART 7 The Einstein equation

Technical Point Alternative formulation

EXAMPLE of a concrete situation

Your Daily Equation #26: Einstein's General Theory of Relativity: The Essential Idea - Your Daily Equation #26: Einstein's General Theory of Relativity: The Essential Idea by World Science Festival 147,685 views 3 years ago 34 minutes - Episode 26 #YourDailyEquation: Albert Einstein's **General Theory**, of **Relativity**,, phrased in terms of warps and curves in space ...

Intro

Context

The Third Axis

The Force of Gravity

Newtons Law in Action

Einsteins Reasoning

Newtons Law

Einsteins Goal

The General Idea

How Einstein Came to This Idea

The Happiest Thought

Freefall

Acceleration

Circle is not flat

The equation

General Relativity & Mathematical Reality - General Relativity & Mathematical Reality by Mathe-matikoid 39,916 views 8 years ago 1 minute, 38 seconds - Yet another anecdote that (in my opinion) suggest that **mathematics**, is the basis of our reality: Inside Einstein's Mind — PBS Nova ...

WSU: Special Relativity with Brian Greene - WSU: Special Relativity with Brian Greene by World Science Festival 1,069,925 views 3 years ago 11 hours, 29 minutes - Physicist Brian Greene takes

you on a visual, conceptual, and **mathematical**, exploration of Einstein's spectacular insights into ...

Introduction

Scale

Speed

The Speed of Light

Units

The Mathematics of Speed

Relativity of Simultaneity

Pitfalls: Relativity of Simultaneity

Calculating the Time Difference

Time in Motion

How Fast Does Time Slow?

The Mathematics of Slow Time

Time Dilation Examples

Time Dilation: Experimental Evidence

The Reality of Past, Present, and Future

Time Dilation: Intuitive Explanation

Motion's Effect On Space

Motion's Effect On Space: Mathematical Form

Length Contraction: Travel of Proxima Centauri

Length Contraction: Disintegrating Muons

Length Contraction: Distant Spaceflight

Length Contraction: Horizontal Light Clock In Motion

Coordinates For Space

Coordinates For Space: Rotation of Coordinate Frames

Coordinates For Space: Translation of Coordinate Frames

Coordinates for Time

Coordinates in Motion

Clocks in Motion: Examples

Clocks in Motion: Length Expansion From Asynchronous Clocks

Clocks in Motion: Bicycle Wheels

Clocks in Motion: Temporal Order

Clocks in Motion: How Observers Say the Other's Clock Runs Slow?

The Lorentz Transformation

The Lorentz Transformation: Relating Time Coordinates

The Lorentz Transformation: Generalizations

The Lorentz Transformation: The Big Picture Summary

Lorentz Transformation: Moving Light Clock

Lorentz Transformation: Future Baseball

Lorentz Transformation: Speed of Light in a Moving Frame

Lorentz Transformation: Sprinter

Combining Velocities

Combining Velocities: 3-Dimensions

Combining Velocities: Example in 1D

Combining Velocities: Example in 3D

Spacetime Diagrams

Spacetime Diagrams: Two Observers in Relative Motion

Spacetime Diagrams: Essential Features

Spacetime Diagrams: Demonstrations

Lorentz Transformation: As An Exotic Rotation

Reality of Past, Present, and Future: Mathematical Details

Invariants

Invariants: Spacetime Distance

Invariants: Examples

Cause and Effect: A Spacetime Invariant

Cause and Effect: Same Place, Same Time

Intuition and Time Dilation: Mathematical Approach

The Pole in the Barn Paradox

The Pole in the Barn: Quantitative Details

The Pole in the Barn: Spacetime Diagrams
 Pole in the Barn: Lock the Doors
 The Twin Paradox
 The Twin Paradox: Without Acceleration
 The Twin Paradox: Spacetime Diagrams
 Twin Paradox: The Twins Communicate
 The Relativistic Doppler Effect
 Twin Paradox: The Twins Communicate Quantitative
 Implications of Mass
 Force and Energy
 Force and Energy: Relativistic Work and Kinetic Energy
 $E=MC^2$
 Course Recap
 General Relativity Explained simply & visually - General Relativity Explained simply & visually by Arvin Ash 5,702,731 views 3 years ago 14 minutes, 4 seconds - Albert Einstein was ridiculed when he first published his **theory**,. People thought it was too weird and radical to be real. Einstein ...
 The Maths of General Relativity (2/8) - Spacetime velocity - The Maths of General Relativity (2/8) - Spacetime velocity by ScienceClic English 190,210 views 3 years ago 7 minutes, 19 seconds - In this series, we build together the **theory**, of **general relativity**,. This second video focuses on the notions of velocity, vector ...
 PART 2 Spacetime velocity
 Technical Point The Einstein notation
 EXAMPLE of a concrete situation
 Relativity 107f: General Relativity Basics - Einstein Field Equation Derivation (w/ sign convention) - Relativity 107f: General Relativity Basics - Einstein Field Equation Derivation (w/ sign convention) by eigenchris 79,712 views 2 years ago 36 minutes - 0:00 Overview of Derivation 6:42 Metric Compatibility + Cosmological Constant term 12:53 Contracted Bianchi Identity 20:54 ...
 Overview of Derivation
 Metric Compatibility + Cosmological Constant term
 Contracted Bianchi Identity
 Solving for Kappa (Einstein Constant)
 Trace-Reversed Form
 Sign Conventions
 Summary
 Simple Relativity - Understanding Einstein's Special Theory of Relativity - Simple Relativity - Understanding Einstein's Special Theory of Relativity by Vinit Masram 4,921,007 views 9 years ago 5 minutes, 56 seconds - Simple **Relativity**, is a 2D short educational animation film. The film is an attempt to explain Albert Einstein's **Special Theory**, of ...
 How we know that Einstein's General Relativity can't be quite right - How we know that Einstein's General Relativity can't be quite right by Sabine Hossenfelder 2,343,319 views 4 years ago 5 minutes, 28 seconds - Einstein's **theory**, of **General Relativity**, tells us that **gravity**, is caused by the curvature of space and time. It is a remarkable **theory**, ...
 Introduction
 What is General Relativity
 The problem with General Relativity
 Double Slit Problem
 Singularity
 Search filters
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 General
 Subtitles and closed captions
 Spherical videos