Special Relativity Found on the Web

References by Type

Online Articles, Lecture Notes, Video Lectures, Multimedia Presentations and Movies, Interactive Simulations

Online Articles

Brief Mathematical Explanation of Special Relativity
Useful for understanding basic math behind Special Relativity. The article, however, does not provide a detailed mathematical derivation or an in-depth explanation of various scientific terms referenced in the article. External links are given for advanced terms such as Lorentz contraction, time dilation, and relativistic gamma, but information in external links is not inclusive. *This reference should only be used to get a general overview of Special Relativity. Those who are planning to use this reference should not expect to gain a comprehensive knowledge of Special Relativity.*
Required Math: High school algebra and matrices as linear transformations are minimum requirements to understand basics in this article.
Required Physics: A basic familiarity with classical mechanics is required to understand the article. External links for advanced physics terms are also provided.

x	Inertial Frames of Reference
x	Measuring Length and Times in Inertial Frames
x	Time Dilation

x	Mass of a System

Four-momentum

The article defines four-momentum as a four-vector in spacetime, and says how to calculate the Minkowski norm as well as discusses the relation to four-velocity.

Math Required: Linear algebra

Physics Required: Relativistic physics

X	Postulates of Special Relativity
X	Spacetime Intervals
X	Invariance of Spacetime Interval
X	Invariance of Relative Velocity of Frames of Reference
X	Lorentz Transformations
X	Momentum, Energy, and Four Momentum
X	Mass of a System
X	Four Force and Relativistic form of Newton's 2nd Law
X	Conservation of Four Momentum

Special Relativity - the wikipedia article - Comprehensive, not for Absolute Beginners

Most useful as a review article and for many references to sub topics and other learning resources. This is a comprehensive but dense general article. Readers unfamiliar with Special Relativity and Classical Mechanics will need more discussion, math, and examples to understand large parts of this article. The article has plentiful references to the history and experimental verifications of special relativity as well as the theory. Most topics in Special Relativity are discussed in one of the linked references. Perhaps the best thing about the article are the links to subtopics and to other learning resources.
This article is probably <u>not </u>most useful a first exposure to the subject.

Required Math: High school algebra and matrices as linear transformations are minimum requirements to understand basics in this article with more advanced math (calculus, tensor algebra, and index notation) needed for more than half. Ambitious readers can follow links to some math topics but the article is weak in these kinds of references.

Required Physics: A basic familiarity with classical mechanics including calculus (length, time, position measurement, quantitative description of motion, forces, energy, and momentum, etc.) is required to understand the core of this article. Familiarity with electrodynamics and waves is required for later parts. Ambitious readers can follow links to wikipedia articles describing most of the required physics prerequisites.

Found By: *John Dell QED 1,2*
Found Date: 2/16/2013

Verified By: James Jang and Pedram Pejman

http://en.wikipedia.org/wiki/Special_relativity

Wikipedia - Inertial Frames of Reference

This article describes the physical properties of inertial frames of reference and describes how the properties of spacetime are described by the lorentz transformation

Math Required: High school algebra

Physics Required: Newtonian mechanics

X	Inertial Frames of Reference
X	Isotropy and Homogeneity of Space
X	Measuring Length and Times in Inertial Frames
X	Postulates of Special Relativity

X	Invariance of the Speed of Light

Found By: *Sreenath Are and Ivy Ren, pd 1*
Found Date: 2/19/20

Verified By: Will Lewitus and David Guo

The Link: http://en.wikipedia.org/wiki/Inertial_frame_of_reference

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Wolfram Mathworld Lorentz Transform

This article describes the Lorentz Transform using index notation and tensors. Useless as a first introduction to the subject.

Math Required: Tensor Algebra, Index Notation

Physics Required: Special Relativity. This page is mostly useless unless you already know everything on it.

Found By: *Owen Gray 1 & Sarthak Sahu 1*
Found Date: 2/16/13

Verified By: Venkat Manne & Dan Kim, Ed Lee & Thomas Lee

The Link: http://mathworld.wolfram.com/LorentzTransformation.html

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Relativistic Mass—Philip Gibbs and Jim Carr

Usenet article about mass in special relativity. The use of this concept is debated, but the article demonstrates its usefulness in the study of physics.

Required Math: Basic calculus (derivatives, center of mass); matrix algebra is discussed at the end but the solution is given.

Required Physics: Basic familiarity with Newton's Second Law. The postulates of special relativity e.g. length contraction are discussed, but at a level that does not require any previous familiarity.

X	Postulates of Special Relativity
X	Length Contraction
X	Momentum, Energy, and Four Momentum

X	Mass of a System
X	Four Force and Relativistic form of Newton's 2nd Law

Foundations -- Greg Egan

It assumes no knowledge of physics, and derives all relevant equations. The original publication was a science fiction magazine, but it goes into some detail. It covers special relativity, general relativity, black holes, and some quantum mechanics.

Math Required: High school algebra and geometry

Physics Required: little to none

X	Inertial Frames of Reference
X	Measuring Length and Times in Inertial Frames
X	Synchronization of Clocks
X	Postulates of Special Relativity
X	Time Dilation
X	Length Contraction
X	Simultaneity and Desynchronization
X	Lorentz Transformations
X	Doppler Shifts
X	The Twin Paradox
X	Light Cone
X	Momentum, Energy, and Four Momentum
X	Mass of a System

X	Conservation of Four Momentum

Found By: *Austin Ralls and Alec Grieser,* Period 1
Found Date: 2/19/2013

Verified By: Will Lewitus and David Guo, Sarah Khatry & Hannah Rudin

The Link: http://www.gregegan.net/FOUNDATIONS/

The Day the Universe Went All Funny

Starts out by explaining Galilean Relativity, then introduces the fact that the speed of light is the same in all reference frames. Goes through reference frames and explains how special relativity explains things that seem unintuitive.

Math Required: The ability to subtract 2 thousand from 5 thousand (or 1/4 from 1).

Physics Required: None

X	Inertial Frames of Reference
X	Invariance of Relative Velocity of Frames of Reference
X	The Twin Paradox

Found By: *Collin Berman and Cody Silverman QED 1*
Found Date: 2/19/2013

Verified By: James Jang and Pedram Pejman, Hannah Rudin & Sarah Khatry

The Link: http://www4.ncsu.edu/unity/lockers/users/f/felder/public/kenny/papers/relativity.html

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Headline : The Postulates of Special Relativity

Abstract: *This article lists the postulates of Special Relativity and further elaborates on them.*

Math Required: There is no specific math required, but one should understand the concept of multidimensional space learned in multivariable calculus.

Physics Required: Newtonian Mechanics.

Four-momentum

The article defines four-momentum as a four-vector in spacetime, and describes how to calculate the Minkowski norm as well as discusses the relation to four-velocity.

Math Required: Linear algebra

Physics Required: Relativistic physics

X	Postulates of Special Relativity
X	Spacetime Intervals
X	Invariance of Spacetime Interval
X	Invariance of Relative Velocity of Frames of Reference
X	Lorentz Transformations
X	Momentum, Energy, and Four Momentum
X	Mass of a System
X	Four Force and Relativistic form of Newton's 2nd Law
X	Conservation of Four Momentum

The Pole-Barn Paradox

This article explores how events that appear to be simultaneous in one reference frame are

not necessarily simultaneous in another reference frame.	
Required Math: High School Algebra and Graphs	
Required Physics: Advanced Newtonian Mechanics	

X	Inertial Frames of Reference
x	Synchronization of Clocks
X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Invariance of Relative Velocity of Frames of Reference
X	Length Contraction
X	Simultaneity and Desynchronization
X	The Pole and Barn Paradox

Found By: *Steven Kool period 1* **Found Date:** 2/19/2013
Verified By: James Jang and Pedram Pejman, Hannah Rudin & Sarah Khatry
The Link: http://hyperphysics.phy-astr.gsu.edu/hbase/relativ/polebarn.html

Lecture Notes from Courses and Classes

Comprehensive Lecture Notes on Special Relativity from Macquaire University
Detailed explanation of Special Relativity. From Chapter 1: Frames of References to Chapter 6: Electrodynamics in Special Relativity
Math Required: High school Algebra and Graphs, Linear Algebra and Matrices, Calculus, MultiVariable Calculus, Tensors Algebra, Differential Geometry
Physics Required: Some Newtonian Mechanics, Conservation Laws in Mechanics, Advanced Newtonian Mechanics, Electricity and Magnetism, Electromagnetic Waves

x	Inertial Frames of Reference
x	Measuring Length and Times in Inertial Frames
x	Postulates of Special Relativity
x	Invariance of the Speed of Light
x	Time Dilation
x	Lorentz Transformations
x	Mass of a System
x	Transformation Properties of Electric and Magnetic Fields under Lorentz Transformation

Found By: *Ed Lee and Thomas Lee*
   QED 1
Found Date: 2/19/13

Verified By: Will Lewitus and David Guo, Sarah Khatry & Hannah Rudin

http://physics.mq.edu.au/~jcresser/Phys378/LectureNotes/VectorsTensorsSR.pdf

Virginia Tech - Special Relativity - Newton's Second Law

Explains basic concepts of special relativity

Math Required: High School Algebra

Physics Required: Newtonian Mechanics

X	Inertial Frames of Reference
X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Invariance of Relative Velocity of Frames of Reference
X	Simultaneity and Desynchronization

David Hogg's Lecture Notes on Special Relativity

A compact but complete set of notes taking the reader from foundation through many of the major applications in mostly classical physics. Unfortunately the notes end with apparent optical effects before getting to applications to Electrodynamics and a promised introduction to General Relativity. The author does a good job working up step by step from postulates / assumptions to the Lorentz transformations and beyond.

Required Math: High school geometry and algebra until about midway through; then calculus is required.

Required Physics: None really, the notes are fairly well self contained.

http://cosmo.nyu.edu/hogg/sr/

Spacetime Diagrams and Bondi k-Calculus

A compact set of notes explaining Bondi's K-Calculus and Spacetime Diagrams

Required Math: Geometry and Calculus

Required Physics: Mechanics

x	Doppler Shifts
x	Spacetime Diagrams
x	Bondi's k-Calculus
x	Light Cone

Found By: *Venkat Manne & Dan Kim* **Found Date:** 2/19/2013
Verified By: Owen Gray 1 & Sarthak Sahu 1, Kathy Wu
http://www.math.ku.edu/~lerner/m291/SR_Lecture2.pdf

Headline : Covariance of Maxwell's Equations
Abstract: Goes through the derivation of the covariance of maxwell's equations
Math Required: Algebra, Matrices, Calculus
Physics Required: Newtonian, Electricity and Magnetism,
Found By: *David Guo and Will Lewitus* **Found Date:** 2/19/13
Verified By: James Jang and Pedram Pejman, Takeshi Mochida and Remy Lee
The Link: http://www.physics.sun.ac.za/~weigel/teach/SR09/covariance.pdf

Special Relativity from David Tong's Lectures on Dynamics and Relativity
This is just one part of a complete set of course notes for his introductory course on Newtonian Mechanics and Special Relativity (url for the whole set and more : http://www.damtp.cam.ac.uk/user/tong/relativity.html) . The notes cover these topics starting from scratch: "Lorentz Transformations; Spacetime Diagrams; Simultaneity; Causality; Time Dilation; Length Contraction; Addition of Velocities; The Geometry of Spacetime; The Lorentz Group; Kinematics; Particle Physics ". Tong does a good job developing the component qualitative kinematic phenomena before assembly into full Lorentz transformations.
Required Math: Highs school algebra and geometry for the basics (first ⅓) then some calculus, vectors, and linear transformations.
Required Physics: Familiarity with the prior notes in the series (Newtonian Mechanics) at the college level are needed after about half way through the special relativity notes.
Found By: *John Dell QED 1,2* **Found Date:** 2/16/2013
Verified By: Will Lewitus and David Guo
http://www.damtp.cam.ac.uk/user/tong/relativity/eight.pdf

Time Dilation
Abstract: *This is a lecture note on time dilation that elaborates on the concept of time dilation and also explains the Twin Paradox, a huge part of time dilation.*
Math Required: Multivariable Calculus
Physics Required: Basic understanding of relativity
Found By: *Gene Gonzalez and David Shin Period 1* **Found Date:** 2/19/13
Verified By: Kathy Wu, Nalini Singh
The Link: http://www.lecture-notes.co.uk/susskind/special-relativity/lecture-4/time-dilation/

Lecture Notes on the Doppler Effect
A lecture that mathematically analyzes the Doppler Effect
Required Math: Algebra, Geometry, and knowing a little calculus won't hurt
Required Physics: Mechanics
Found By: *Sarthak Sahu & Owen Gray* **Found Date:** 2/19/2013
Verified By: Venkat Manne & Dan Kim
http://www.physics.mcgill.ca/~guymoore/ph224/notes/lecture17.pdf

Lecture Notes: Simple relativistic kinematics
Explores simple relativistic kinematics with relativistic kinematics and four-momentum conservation, orientation with respect to an axis (the beam axis), and Mandelstam variables.
Math Required: High school Algebra and Graphs, Linear Algebra and Matrices, Calculus
Physics Required: Understanding of the basic physics identities and four-vectors.

X	Momentum, Energy, and Four Momentum
X	Mass of a System
X	Conservation of Four Momentum

Found By: *Kathy Wu*
Found Date: 2/19/13

Verified By: Alec Grieser and Austin Ralls

The Link: http://www.ippp.dur.ac.uk/~krauss/Lectures/QuarksLeptons/Basics/Kin_1.html

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PHY2061 Enriched Physics 2 Lecture Notes: Relativity 4

A set of lecture notes meant to be a study guide for Dr. Darin Acosta of the University of Florida covering relativistic momentum, force, and energy as well as touching on the relationship between energy and momentum, the invariant mass, and binding and reaction energy. These notes can be a little sparse at times, and they may not be the best at introducing the concepts of special relativity, but they should be a good reference for those wishing to review.

Required Math: This reference requires Calculus including knowledge of differentiation, integration, and Taylor series (or the binomial theorem for non-integer powers) as well as high school algebra.

Required Physics: This requires a basic knowledge of time dilation, velocity addition, and Lorentz transformations as a prerequisite as well as knowledge of the classical versions of the concepts covered.

X	Momentum, Energy, and Four Momentum
X	Four Force and Relativistic form of Newton's 2nd Law

Found By: *Alec Grieser and Austin Ralls QED 1*
Found Date: 2/19/2013

Verified By: Owen Gray 1 & Sarthak Sahu 1, Andrew Tao, Michael Nguyen

www.phys.ufl.edu/~acosta/phy2061/lectures/Relativity4.pdf

MIT OpenCourseWare - Some Special Relativity Formulas

A set of formulas meant to be used along with the MIT OpenCourseWare special relativity

class. It doesn't go through their derivations, but it's a nice list.	

Math Required: Algebra

Physics Required: Some Newtonian Mechanics

X	Time Dilation
X	Length Contraction

Found By: *Collin Berman and Cody Silverman QED 1*
Found Date: 2/19/2013

Verified By: Kathy Wu

The Link: http://ocw.mit.edu/high-school/courses/excitatory-topics-in-physics/lecture-notes/sr.pdf

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Notes on Special Relativity, UC Berkeley

These lecture notes from the University of California Berkeley detail some aspects of special relativity, including Gallilean space and time, Michaelson-Morley experiment, Lorentz transformation, four-vector notation, energy and momentum four-vector, Doppler Shift, and natural unit.

Math Required: Linear Algebra and Matrices, Calculus, Multivariable Calculus, Tensors Algebra, Differential Geometry

Physics Required: Some Newtonian
Mechanics, Conservation Laws in Mechanics, Advanced Newtonian Mechanics,
Electricity and Magnetism, Electromagnetic Waves

X	Measuring Length and Times in Inertial Frames
X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Time Dilation
X	Lorentz Transformations
X	Doppler Shifts

X	Mass of a System
X	Transformation Properties of Electric and Magnetic Fields under Lorentz Transformation
X	Covariance of Maxwell's Equations

Found By: *Will Lewitus, David Guo QED 1*
Found Date: 2/19/2013

Verified By: Alec Grieser and Austin Ralls

The Link: http://hitoshi.berkeley.edu/129A/relativity.pdf

The Pole-Barn Paradox

This article explores how events that appear to be simultaneous in one reference frame are not necessarily simultaneous in another reference frame.

Required Math: Calculus

Required Physics: Advanced Newtonian Mechanics

X	Inertial Frames of Reference
X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Invariance of Relative Velocity of Frames of Reference
X	Length Contraction
X	Simultaneity and Desynchronization
X	The Pole and Barn Paradox

Found By: *Steven Kool period 1*
Found Date: 2/19/2013

Verified By:

The Link: http://www2.warwick.ac.uk/fac/sci/physics/current/teach/module_home/px436/notes/lecture3.pdf

Video: Lectures

	Richard Feynman Lecture on Quantum Electrodynamics: QED
	Richard Feynman introduces Quantum electrodynamics.
	Math Required: Linear algebra and multivariable calculus
	Physics Required: Relativistic physics, classical physics, quantum mechanics, Maxwell's equations

X	Inertial Frames of Reference
X	Measuring Length and Times in Inertial Frames
X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Spacetime Intervals
X	Invariance of Spacetime Interval
X	Time Dilation
X	Length Contraction
X	Covariance of the Laws of Physics
X	Doppler Shifts
X	Covariance of Maxwell's Equations

Found By: *Sarah Khatry and Hannah Rudin,* Period 1
Found Date: 2/19/2013

Verified By: *Andrew Tao, Michael Nguyen, Bakhtiar Chaudry*

The Link: http://www.youtube.com/watch?v=LPDP_8X5Hug

Modern Physics: Special Relativity - Stanford Prof. Leonard Susskind's Lectures

Lenny Susskind is an accomplished theoretical physicist and Professor of physics at Stanford University. In this collection, Prof. Susskind delivers three substantial lectures on Special Relativity and later Classical Field Theory, mostly E&M. His lectures do not require any deep background knowledge to start and yet they touch on all the fundamental ideas in Special Relativity developed from scratch. Susskind embraces , understands, and uses special relativity in understanding the world. This puts him at the head of the class of video lecturers on this subject. Highly recommended. The links to the YouTube video series on Modern Phyziks, the first three of which are about Special Relativity. There are associated lecture notes here : http://www.lecture-notes.co.uk/susskind/special-relativity/

Required Math: High school algebra. Calculus will help.

Required Physics: None, but some familiarity with classical mechanics will help.

Found By: *John Dell QED 1,2*
Found Date: 2/16/2013

Verified By: Alec Grieser and Austin Ralls

http://www.youtube.com/watch?v=AbrSKDvRTro&list=PLCCD6C043FEC59772

Modern Physics: Yale University: Introduction to Relativity

This is the first of a series of lectures on relativity. The lecture begins with a historical overview and goes into problems that aim to describe a single event as seen by two independent observers. Maxwell's theory, as well as the Galilean and Lorentz transformations are also discussed.

Required Math: High school algebra. Calculus, maxwell.

Required Physics: Classical mechanics and some electrodynamics.

Found By: *Dan Kim and Venkat Manne QED 1*
Found Date: 2/19/2013

Verified By: *Bakhtiar Chaudry*

http://www.youtube.com/watch?v=pHfFSQ6pLGU

Geometry in Special Relativity

University of New South Wales Professor N.J. Wildberger gives a brief introduction into the

geometry in Special Relativity. This lecture is part of his series on the applications of trigonometry.

Required Math: High school algebra and basic trigonometry.

Required Physics: Basic

X	Measuring Length and Times in Inertial Frames
X	Spacetime Intervals
X	Time Dilation

Found By: *Ivy Ren and Sreenath Are*
Found Date: 2/19/2013

Verified By: Steven Kool, Takeshi Mochida and Remy Lee

http://www.cosmolearning.com/video-lectures/einsteins-special-relativity-an-introduction-12085/

Exploring Black Holes: General Relativity & Astrophysics: Selected Video Lectures

This course from MIT OpenCourseware contains several video lectures spanning a variety of topics in relativistic physics and astrophysics.

Required Math: Basic tensor algebra, some differential geometry

Required Physics: Special relativity is a prerequisite for this course

X	Inertial Frames of Reference
X	Measuring Length and Times in Inertial Frames
X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Spacetime Intervals
X	Lorentz Transformations
X	Momentum, Energy, and Four Momentum

Physics for Future Presidents, Lecture 22: Relativity

This is a lecture from a class offered at U. C. Berkely designed to teach some of the most "interesting and important" concepts in physics from a less-technical, less math based approach that places importance in the current applications and implications. This particular lecture is given by Dr. Richard A. Muller in 2006 and covers topics in relativity including time dilation, synchronization, length contraction, velocity addition, energy, and photon mass. Because it is designed for non-physicists, he often interrupts himself by saying that something will be difficult to follow or not on the test, but it is interesting for the concepts and general sketch of proof anyway without gory details of the derivation.

Required Math: High school algebra. Knowledge of the binomial theorem or Taylor series is helpful but not required.

Required Physics: Basic classical mechanics.

X	Invariance of the Speed of Light
X	Time Dilation
X	Length Contraction
X	Simultaneity and Desynchronization
X	The Pole and Barn Paradox

Lecture on Special Relativity

Lecture on special relativity by Professor Peter Fisher .
Required Math: None to start, some with High school Algebra and Geometry and some without
Required Physics: None to start if consumed in order of appearance in list.
Found By: *Takeshi Mochida & Remy Lee QED 1* **Found Date:** 2/19/2013
Verified By: Owen Gray 1 & Sarthak Sahu 1
http://video.mit.edu/watch/peter-fisher-lecture-on-special-relativity-22211-10613/

Multimedia Presentations & Movies

EinsteinLight:The finer points of relativity in less time than it takes to eat a sandwich
Compiled by faculty at the University of New South Wales, this is a collection of multimedia demonstrating most of the fundamental phenomena associated with special relativity. Lots of fun stuff here broken into small, digestible, multimedia pieces. They have a rating system that indicates if there is any math involved in any particular piece.
Required Math: None to start, some with High school Algebra and Geometry and some without
Required Physics: None to start if consumed in order of appearance in list.
Found By: *John Dell QED 1,2* **Found Date:** 2/16/2013
Verified By: Sreenath Are, Ivy Ren
http://www.phys.unsw.edu.au/einsteinlight/

Modern Physics: Spacetime and the Twins Paradox

Dr Physics has a BSc (physics) and PhD (nuclear physics) from King's College, London. In this Video, he discusses the relationship between space, time and motion. Objects and communication cannot exceed the speed of light. He uses many clear diagrams and pictures that help explain the paradox.

Required Math: High school algebra, basic geometry. Calculus will help.

Required Physics: None, but some familiarity with classical mechanics will help.

X	Inertial Frames of Reference
X	Measuring Length and Times in Inertial Frames
X	Synchronization of Clocks
X	Spacetime Intervals
X	Invariance of Spacetime Interval
X	Time Dilation
X	Simultaneity and Desynchronization
X	Spacetime Diagrams
X	The Twin Paradox

Found By: *Venkat Manne & Dan Kim QED 1*
Found Date: 2/19/2013

Verified By:

http://www.youtube.com/watch?v=KdjQkuGTBMo

Short Introduction to the Basics of Special Relativity

This video provides a basic introduction into the world of Special Relativity for beginners.

Required Math: Basic

Required Physics: Basic

Found By: *Ivy Ren and Sreenath Are* **Found Date:** 2/19/2013
Verified By: Owen Gray 1 & Sarthak Sahu 1, Kathy Wu
http://science.discovery.com/video-topics/space-videos/time-special-relativity.htm

Stephen Hawking-Time Dilation
This is a video of Stephen Hawking explaining Time Dilation
Required Physics: Not much
Found By: *Sarthak Sahu 1, Owen Gray 1* **Found Date:** 2/16/2013
Verified By: *Sreenath Are, Ivy Ren*
http://www.youtube.com/watch?v=02tchltLm3c

Al's Relativistic Adventures
Interactive presentation that introduces special relativity in 5 minutes.
Required Math: Not much
Required Physics: Basic understanding of mechanics
Found By: *Takeshi Mochida & Remy Lee* QED 1 **Found Date:** 2/19/2013
Verified By: *Michael Nguyen, Bakhtiar Chaudry*
http://www.onestick.com/relativity/

The Twin Paradox
shows how the dilation factor (beta) we needed to introduce predicts that someone who makes a spaceflight will age more slowly than someone who stays on Earth.
Required Math: Algebra

Required Physics: Basic understanding of relativity	

X	Inertial Frames of Reference
X	Synchronization of Clocks
X	Spacetime Intervals
X	Time Dilation
X	Spacetime Diagrams
X	The Twin Paradox

Found By: *Willie Nuckols and Raynor Kuang*
Found Date: 2/19/2013

Verified By: *Bakhtiar Chaudry*

http://www.youtube.com/watch?v=txZO_ELt_S8

Time Dilation | Einstein's Relativity

An explanation of time dilation from ScienceTV that starts with the result from Maxwell's equations that the speed of light is constant and then expands on that to show how a light clock would be affected by relative motion. This is supposed to show a conceptual rather than a quantitative understanding of the physics.

Math Required: Little math except for a conceptual understanding of elementary geometry. There are no calculations.

Physics Required: Intuitive understanding of Galilean relativity.

Found By: Alec Grieser and Austin Ralls QED1
Found Date: 2/20/2013

Verified By:

http://youtu.be/G-R8LGy-OVs

A Simple Introduction to Special Relativity

This is a presentation on the basics of special relativity that includes numerous images. It is a

good source to learn or review the key concepts and fundamentals.

Math Required: High school Algebra and Graphs

Physics Required: Some Newtonian Mechanics

X	Postulates of Special Relativity
X	Invariance of the Speed of Light
X	Spacetime Intervals
X	Invariance of Spacetime Interval
X	Invariance of Lengths Measured Perpendicular to Relative Motion
X	Time Dilation
X	Length Contraction

Found By: *Kalki Seksaria* (Period 1)
Found Date: February 22, 2013

Verified By:

The Link: http://amalfi.colorado.edu/~rosalba/astro2030/SpecialRelativity.pdf

Interactive Simulations

Twin Paradox Simulation
This simulation demonstrates the twin paradox, and has a well written explanation.
Math Required: None
Physics Required: None
Found By: *Sreenath Are and Ivy Ren, pd 1* **Found Date:** 2/19/2013
Verified By:
The Link: http://www.pbs.org/wgbh/nova/einstein/hotsciencetwin/index.html

Relativistic Aberration and Doppler Shift
Use the aberration formula to transform the reference frames between stationary and moving. The Doppler factor is defined as the ratio between the emitted wavelength from the light source and the wavelength measured by the (moving) observer. The demonstration allows the user to change the scaled velocity of the observer and the number of rays emitted from the light source.
Math Required: High school algebra and graphs
Physics Required: Newtonian Mechanics, waves, and some relativistic physics.
Found By: *Sarah Khatry and Hannah Rudin,* Period 1 **Found Date:** 2/19/2013
Verified By: Sreenath Are, Ivy Ren
The Link: http://demonstrations.wolfram.com/RelativisticAberrationAndDopplerShift/

Real Time Relativity - View from StarShip Moving at Relativistic Speeds (MAC & PC)

Download this application (20 + Megabytes) to take a ride on a relativistic rocket under your control. Users get a high quality "Virtual Reality" simulated view from a spaceship moving at relativistic speeds in a number of scenarios, including through the solar system. Thoughtful students who are willing to analyze their experience in the simulated scenarios can get a lot out using this program. The controls take some getting used to but this is a high quality ray-traced simulation. Some learning materials come with the app. Long on experience but relatively short on analysis in the app itself. This is one of the highest quality relativistic ray tracing apps available on the web. Available in OSX and WINDOWS versions. Your computer will need a decent but not outrageous graphics card to run this app comfortably. There is an associated paper describing the program here: http://arxiv.org/abs/physics/0607223

Required Math: None to experience the simulation, lots to understand it. Even more if you want to understand how they made it.

Required Physics: None to experience the simulation, lots to understand it.

Found By: *John Dell QED 1,2*
Found Date: 2/16/2013

Verified By:

http://realtimerelativity.org/

A Slower Speed of Light (MAC & PC) - Somewhat Accurate Simulation

Download this application (20 + Megabytes) to play a game that incorporates much relativistic physics, including doppler shift and the lorentz transformation. May aid in getting an intuitive understanding for relativistic effects, but is not perfectly accurate and includes no math.

Required Math: None to experience the simulation, lots to understand it. Even more if you want to understand how they made it.

Required Physics: None to experience the simulation, lots to understand it.

Found By: *Owen Gray 1 & Sarthak Sahu 1*
Found Date: 2/16/2013

Verified By: Sreenath Are, Steven Kool, Ivy Ren

http://gamelab.mit.edu/games/a-slower-speed-of-light/

TheLarge - Special Relativity Simulator (Linux & PC)

Simulates relativistic motion of bodies. Helpful in understanding length contraction, time dilation and acceleration distortions. View is given in 2D top-down view, but simulator contains 3D-capable engines.

Required Math: None to experience the simulation, lots to understand it. Even more if you want to understand how they made it.

Required Physics: "TheLarge has been written as a tool to help develop intuitive understanding of space-time physics. However, some prior knowledge of special relativity is necessary to understand the simulation in full."

Found By: *Takeshi Mochida & Remy Lee QED 1*
Found Date: 2/19/2013

Verified By: Venkat Manne & Dan Kim, Owen Gray 1 & Sarthak Sahu 1, Sreenath Are, Ivy Ren, William Nuckols, Raynor Kuang

http://thelarge.org/

StarStrider—3D planetarium program (W, includes relativistic physics

Abstract: *Primarily a 3D planetarium software for mapping stars and such. (30-day free trial version available). Includes "optional relativistic aberration and Doppler-shift effects."*

Math Required: None

Physics Required: None

Found By: *Cody Silverman, Collin Berman QED 1*
Found Date: 02/19/13

Verified By:

The Link: http://www.starstrider.com/

Doppler Shift Demonstrator

Abstract: *This is an interactive stimulator of the Doppler Effect.*
Math Required: None.
Physics Required: None.
Found By: *Gene Gonzalez and David Shin Period 1* **Found Date:** 2/19/13
Verified By: Alec Grieser and Austin Ralls
The Link: http://astro.unl.edu/classaction/animations/light/dopplershift.html

Lorentz Transformation Animations
This website contains a Java applet that goes through 6 thought experiments related to special relativity. There is also the option to create your own simulation and watch it run as well as two scenarios that attempt to demonstrate the difference between light and two other media, sound and a water fountain. There is an explanation of each scenario on the page as well as a brief mathematical description of the transformation. The applet was put together by Prasenjit Saha of the Institute for Theoretical Physics at the University of Zurich.
Math Required: None for the applet itself. Elementary high school algebra is needed for the description of the transformation.
Physics Required: Some knowledge of classical mechanics is needed to understand the explanations of the thought experiments.
Found By: Austin Ralls and Alec Grieser QED 1 **Found Date:** 2/20/2013
Verified By: Steven Kool
The Link: http://www.physik.uzh.ch/~psaha/sr/

Headline : Adding Velocities in Special Relativity
Abstract: *This article describes how velocities in special relativity. It highlights the differences between adding velocities non-relativistically and using special relativity. It shows how adding velocities becomes more similar to the non-relativistic theory as the speeds get smaller.*
Math Required: High school math, hyperbolic trigonometric functions
Physics Required: Newtonian Mechanics

Found By: *Anand Prasanna and Brandon Zhang* **Found Date:** 2/19/13
Verified By: William Nuckols and Raynor Kuang
The Link: http://math.ucr.edu/home/baez/physics/Relativity/SR/velocity.html

Headline : Space Travel
Abstract: *Applet shows the twin paradox and length contraction.*
Math Required: None
Physics Required: None
Found By: *William Nuckols and Raynor Kuang* **Found Date:** 2/19/13
Verified By: James Jang and Pedram Pejman
The Link: http://chair.pa.msu.edu/applets/travel/a.htm

Exploration 1: The Pole and Barn "Paradox"
This demonstrates the difference in length as measured from the frame of the pole and of the barn, and clearly demonstrates the difference in opinion as to whether or not the pole will fit inside the barn.
Required Math: None
Required Physics: None
Found By: *Steven Kool period 1* **Found Date:** 2/19/2013
Verified By: Alec Grieser and Austin Ralls
The Link: http://webphysics.davidson.edu/physlet_resources/special_relativity/ex1b.html

Lecture 1: Modern Physics: Special Relativity

This lecture explored the essential theoretical foundations of modern physics. The topics covered in this course focus on classical mechanics.
Required Math: Calculus
Required Physics: Quantum Mechanics
Found By: *James Jang and Pedram Pejman Period 2* **Found Date:** 2/19/2013
Verified By: Takeshi Mochida and Remy Lee
The Link: http://www.youtube.com/watch?v=BAurgxtOdxY

Lecture Notes on Relativity
This lecture on MIT Opencourseware introduces students to various topics in relativity.
Required Math: Single Variable Calculus, Multivariable Calculus.
Required Physics: First year in Physics.
Found By: *Takeshi Mochida & Remy Lee QED 1* **Found Date:** 2/20/2013
Verified By:
http://ocw.mit.edu/courses/physics/8-033-relativity-fall-2006/syllabus/

Special Relativity
This online article outlines some of the fundamental topics, methods and illustrations related to special relativity.
Required Math: Calculus
Required Physics: First year in Physics
Found By: *Takeshi Mochida & Remy Lee QED 1* **Found Date:** 2/20/2013
Verified By:

http://www.physics.nyu.edu/hogg/sr/sr.pdf