TIME IN SPECIAL RELATIVITY
NEW INSIGHTS AND HIDDEN PRINCIPLES

INTRODUCTION

If the ideas presented here are correct they represent an extremely important advance in our understanding of the universe; and I have an extremely high level of confidence they are correct. They've been exhaustively considered and tested from every possible angle over many months and appear to be completely consistent with accepted special relativity while greatly extending it to a truly universal theory, an integral part of my *Complete Theory of Everything*. I invite scientists and laymen alike to carefully consider it and I challenge anyone to falsify a single point. I can be contacted at EdgarLOwen@icloud.com.

Here in the introduction I present a brief summary of the major points of the theory and why they are so important. The universe they reveal is amazingly profound and beautiful. The theory explains both how relativity works with respect to time, and also why it works this way. Most treatments explain how relativity works with varying degrees of clarity but don't even attempt to explain why. But when we understand the little recognized fundamental principles of time and the universe, how and why it works the way it does becomes clear, natural and easy to understand.

NOTE: This document replaces treatments of special relativity in all my previous books and YouTube talks. It reflects a completely new understanding and corrects previous errors. While written for the general public a little simple math is used to ensure accuracy but wherever equations appear their meaning should be clear.

1. It's accepted science that everything continuously advances through spacetime (combined space and time) at the speed of light c. Einstein noted this and some modern physicists such as Brian Greene mention it in passing. In particular every observer sees everything including himself as advancing through combined space and time at the speed of light, approximately 300,000 km. or 186,000 mi/sec.
2. Amazingly however modern physicists seem blind to the fundamental importance of this principle and its profound implications and largely ignore it.
3. In fact this is one of the most important fundamental principles of the universe and should also be recognized as the fundamental principle of special relativity because it essentially explains everything about how time works in special relativity.
4. What this means is that everything in the universe is continually advancing 300,000 km./sec through time unless it's moving in space, in which case the distance it travels in time is reduced such that $d\tau = \sqrt{(d\lambda^2 - d\chi^2)}$. This is the standard Pythagorean formula for addition of vectors in different orthogonal dimensions where $d\tau$ is the distance advanced in time, $d\lambda$ the total spacetime distance advanced, and $d\chi$ the distance traveled in space.
5. For example if one twin traveled 3 light years through *space* while everything advanced 5 light years total through *spacetime*, his clock would advance only 4 years through *time* and he would age only 4 years while the other twin who stayed on Earth would age a full 5 years

since he traveled no distance in space (ignoring the non-relativistic distance Earth travels in its orbit).

6. The important point here is that because everything advances at the *same velocity c* through spacetime, everything must continuously advance the *same dλ distance as light travels* through combined space and time.
7. Now because distances and times have different perceived values in the frames of different observers it might seem that there would be no standard distance traveled that all observers could agree upon. And most physicists apparently get stuck here.
8. However note that everything advances the same total spacetime distance as light and the speed of light is the same in all frames for all observers. Thus the total spacetime distance everything advances must also be the same in all frames for all observers. It's only the *distribution of that total spacetime distance between space and time* that varies in the frames of different observers.
9. So everything continually advances the same total dλ distance through spacetime but may do so with different amounts of time passing on their clocks. Thus there are two distinct types of time. There is the time of the present moment, and there is clock or proper time. This is shown in relativity by the Twin's example in which one of two twins leaves Earth on a space trip and returns younger with less time having passed on his clock. *However both twins reunite in the exact same present moment*. This conclusively shows that proper time and present moment time are separate and distinct kinds of time. This confirms our common sense understanding of one of the most important experiences of our existence.
10. Thus the identical distance everything continually advances through spacetime is the time of the identical present moment. Because everything continually advances the same total spacetime distance dλ and always has, then everything must be at the same present moment time as everything else.
11. Everything that exists shares the same universal current present moment across the entire universe. In fact this is the only moment of existence that exists, and outside of this there is not even nothing. But depending on the amount of distance in space traveled, clocks may advance different distances through proper time as they all continually advance the same distance through present moment time.
12. Now if objects are in relative motion they see the identical total spacetime distance everything travels distributed differently between space and time. An object with greater relative velocity will appear to travel a greater distance through space and thus a lesser distance through proper time. This is standard special relativity where the equation for proper time is $d\tau = \sqrt{(dt^2 - dx^2)}$; that is the distance a relatively moving clock appears to advance through proper time is the square root of the square of the distance it advances through time in the frame of the observer, minus the square of the distance it travels through space due to its relative velocity.
13. This is however the apparent proper time seen from the frame of an arbitrary observer. The actual elapsed proper time of a clock *depends only on its own motion through spacetime*. Specifically as John Baez of Caltech says, " The time dilation of a moving clock is determined by its deviation from an inertial path."
14. Since a clock can have different relative velocities to different observers but only one actual elapsed proper time between two events, the true measure of the distance in space a clock travels is the distance it deviates from its own inertial path. This is the only spatial distance that is intrinsic to the clock itself and the only distance that can influence how far it actually advances in proper time.
15. This is a brief summary of a revolutionary new understanding of special relativity. It demonstrates that rather than some strange confusing and paradoxical theory, that special relativity is the completely natural, and astonishingly profound and beautiful expression of the fundamental principle of the universe; that the life of the universe expresses through the continuous advancement of everything that exists through combined space and time at the

speed of light. What we actually experience in every moment of our existence as the passage of time through the current present moment in which our consciousness and everything in the universe exists. Totally amazing and totally scientific!

Observers in relative motion see space and time differently because their relative spatial velocities seem to give spatial velocity to each other. Thus the velocities they appear to have through time are slowed relative to each other. Thus the distribution of time and space observers measure in their various coordinate systems or frames depends entirely on their relative motion.

The equations of standard special relativity describe this relativistic world of individual observers quite well. However they miss the amazing unity that underlies them. As a result, physicists tend to be stuck at this level where everything is relative and are unable to see why it works the way it does.

The insights I present here are completely consistent with standard special relativity. However there are major extensions based on the well established, but little recognized, principle that everything continually advances in spacetime through combined time and space at the speed of light. A surprising number of physicists don't understand that as a result, everything continually advances *the same total distance through spacetime as everything else including light,* and that *the current identical distance everything has traveled through spacetime is the current universal present moment of the entire universe*.

Such physicists typically insist that proper time, the distance advanced just through *time* along a world line, is the total distance along the world line when that's actually the vector sum of the distances through time and through space. This leads to other mistaken beliefs, for example that the distance between two events isn't the same over all paths because elapsed proper time differs over different paths, or that there is no actual universal current present moment, or 'now', because relativistic observers do measure it differently, without realizing that it's revealed when the original inertial path frames of observers are directly compared in the form in which they are created.

Some physicists even hold the delusional belief that a present moment doesn't even exist because all moments of time exist 'simultaneously', as if the entire history of a causal universe could somehow just pop into existence non-causally.

All such mistaken beliefs arise because relatively moving observers do see space and time distributed differently from the perspective of their coordinate systems and physicists haven't been able to see the hidden unity that underlies the relativity of it all. Only when the fundamental principle of the universe, that everything in existence continually advances the same distance through combined space and time in spacetime as light does at the speed of light, which is the same to all observers, will the true nature of relativity become clear. Hopefully this book can contribute to that understanding because the universe that's revealed is totally awesome, elegant, and immensely beautiful.

CONTENTS

CONVENTIONS

1. In relativity it's easy to form ambiguous statements unless repetitive details are included. Thus to avoid repetition and misunderstanding certain conventions are used in this document.
2. First when a frame is not explicitly specified the native frame is always assumed. Thus the statement "Inertial clocks always run at the same rate." Means they run at the same rates in their own frames. This should be obvious as they clearly run at different apparent rates in other frames.
3. In this discussion the transit time of light signals between clocks is largely ignored. The way observers in different frames view clocks in other frames is considered only in terms of the basic relativistic principles. The lag time and red or blue shifting of light signals is an entirely separate issue easily added if desired. This enables the discussion to be reduced to its relativistic essentials.
4. We often speak of how an observer 'sees' or 'views' a relatively moving clock. This again is an ideal view that ignores distances and light signal lags. It is the actual state of a moving clock an observer at rest would see if he could see it instantaneously ignoring the time it would take light to travel to him from the moving clock. It's how the time of moving clocks is calculated and actually experienced in a reference frame on purely relativistic principles ignoring the travel time of light.
5. The terms 'clocks', 'observers' and 'objects' are used loosely to more simply signify how one observer views the clock of another. Thus the phrase 'how clocks see other clocks' obviously means how an observers see the comoving clock of other observers in terms of his own comoving clock.

INTRODUCTORY GLOSSARY

We begin with a summary of the basic concepts used. These are all covered in detail in the text.

1. The fabric of our universe is *spacetime*, a 4-dimensional continuum consisting of the 3 familiar dimensions of space and one additional orthogonal (at 90°) dimension of time.
2. *Events* are points in spacetime labeled with (t, x, y, z) coordinates.
3. *Spacetime paths* or *world lines* are paths traveled between events in spacetime.
4. Because everything continually travels through spacetime at velocity c, everything continually creates a world line of the same length through spacetime as everything else. This length is the same distance light travels which is the same in all frames since the velocity of light is the same in all frames.
5. A *frame* is an inertial coordinate system relative to which events and world lines are measured from the perspective of that frame.
6. An *inertial frame or path* is one at rest or in constant motion that isn't experiencing any external forces or accelerations and maintains its current state of

motion. Thus its coordinate system with respect to which it measures other frames remains unchanged. Light beams also travel inertial paths.

7. A *reference frame* is the current rest frame being used to describe events, world lines, and moving clocks.
8. A *Minkowski or spacetime diagram* is a spacetime graph that displays the relationships among events and world lines from the perspective of a particular inertial frame and facilitates calculations of spacetime variables from the perspective of that frame.
9. Minkowski diagrams are 2-dimensional graphs with a vertical time t-axis, and a horizontal space x-axis representing the time and space coordinates of the reference frame being used. The lengths of spacetime paths in a Minkowski diagram are designated by dt and dx, their respective distances through time and space from the perspective of this frame's coordinate system.
10. The y and z-axes of a Minkowski diagram are normally suppressed with all spatial motion assumed to occur along the x-axis.
11. The t and x-axes of Minkowski diagrams are scaled by the speed of light c, by the distances light travels through time and space at the speed of light.
12. On Minkowski diagrams spacetime events are represented by points, and paths or world lines are represented by lines connecting these points.
13. *Total spacetime length* $d\lambda$ (Greek lower case lambda) is the total distance through spacetime along a world line. It is the vector sum of distance through time plus the actual distance through space of a world line.
14. *Proper time* is simply what any clock is currently reading. The presence of an observer is irrelevant though if there is a comoving observer he is aging at the same rate his clock is ticking, and the same rate he is traveling through time.
15. *Elapsed proper time* $d\tau$ (Greek lower case tau) is the distance through *time* along a world line. It's the total distance in time traveled along the world line.
16. *Spatial distance* $d\chi$ (Greek lower case chi) of a world line is the *deviation from an inertial path* of a world line. It is the proper measure of the actual distance traveled through space along a world line.
17. These three variables obey the usual Pythagorean theorem for vector addition and subtraction of lengths (distances) in different orthogonal dimensions. That is the total spacetime distance traveled along a world line is the vector sum of the distance in time and the distance (deviation from an inertial path) in space of a world line, $d\lambda = \sqrt{(d\tau^2 + d\chi^2)}$.
18. Thus the proper time, the distance traveled in time $d\tau = \sqrt{(d\lambda^2 - d\chi^2)}$, is the distance in space subtracted from the total spacetime distance.
19. And the distance traveled in space, the deviation from an inertial path, is $d\chi = \sqrt{(d\lambda^2 - d\tau^2)}$, the proper time distance subtracted from the total spacetime distance.
20. *Lorentz transformations* are used to convert the coordinates of events from one frame to another, to convert the view of spacetime from the perspective of one frame to that of another.
21. *Invariance* is when a variable has the same value from the perspective of all frames. The values of $d\lambda$, $d\tau$, and $d\chi$ between two events are all invariant and have the same values in all frames. That is the total spacetime distance, time distance,

and deviation from an inertial path in space distance between two specific events are the same in all frames. In this sense these values are absolute.

22. *Time dilation* is the apparent slowing of the velocity of time of a moving clock from the perspective of a stationary clock. This is a reciprocal effect in which each of two relatively moving clocks each see the other clock ticking slower than their own. This is not a contradiction but a matter of different perspectives on the same reality as explained below.

SPACETIME

1. Our intuitive view is there is an absolute time that progresses at a constant rate for everyone throughout the universe independent of their motion in space. But time and space are actually tightly interwoven and motion in space affects motion in time. Any velocity in space always reduces velocity through time so the total velocity through spacetime always remains equal to c.
2. The fabric of our universe is spacetime, a 4-dimensional continuum consisting of the 3 familiar dimensions of space and one additional orthogonal (at 90°) dimension of time.
3. We can easily confirm we live in a 4-dimensional universe with our own eyes as we continually see it from the inside. We see the 3 familiar dimensions of space around us and we see the past dimension of time as distance in every direction. Thus in every direction we look the further away anything is the further it is back in time. What we are actually seeing is called our *light cone*, which is our 3-dimensional view into the past through the 4-dimensions of spacetime from the singularity of our current location in space and time.
4. We see only the past dimension of time because that's all that exists. The future dimension of time doesn't exist because it hasn't yet been created. The singularity of the present moment in which we exist is the point at which the universe is continually computing the current present moment from the data state of the previous present moment.
5. Actually the past also doesn't actually exist because it has all been recomputed into the present. We seem to see the past dimension of time only because it takes time for light to travel through space to our eyes. So we actually see everything in the present moment, which is all that actually exists.

NATURAL UNITS.

1. To properly calculate distances and velocities in time and space, which are different dimensions of the same continuum, we must express time and space in equivalent units. This is typically done by multiplying times by c so they are converted to units of light distance. Typically then distances in both time and space are expressed in the same units such as light years; distances in space as the

distance light travels through space in a year, and distance in time as the distance light travels through time at the speed of light. In this way we can manipulate distances and velocities in time and space as compatible units of a single 4-dimensional continuum, which is what they actually are.

2. Also distances, times and velocities are often expressed as percentages of the speed of light by setting $c = 1$ in all equations. These are called *natural units*. We will use natural units in most cases as they simplify the equations of relativity and better express the basic concepts. However it should always be remembered that distances and velocities in both time and space are expressed in units of the speed of light.

EVENTS AND WORLD LINES

1. Just as points in the 3 dimensions of space are specified by 3 spatial coordinates (x, y, z), points in spacetime are specified by 4 spacetime coordinates (t, x, y, z) and called *events* whether there is anything actually happening at that time and place or not. However, just as with points in space, the particular coordinate values given to an event depend on the coordinate system being used; on where the ruler is placed and how the clock is set.
2. An event, though not its coordinate values, is the same place at the same time in an absolute or invariant sense. Events are often unambiguously defined by distinct physical occurrences such as two observers separating or meeting, which uniquely defines particular times and places in spacetime. However any point in spacetime can be designated as an event though it should be unambiguously defined by some actual occurrence. An event is an unambiguous point in spacetime that is agreed by all observers.
3. Due to its constant motion through spacetime at the speed of light every object that exists continually traces a *path* or *world line* through spacetime. And every object is always at one and only one current position on its path. This is the current event in space and time it is actually at.
4. The object's past world line consists of all the past events the object previously traversed through time and space. Each event on its world line can be uniquely identified by its invariant proper time $d\tau$ clock reading and total $d\lambda$ spacetime distance at the event. The τ and λ values of these events are invariant and the same to all observers, but relatively moving observers will assign different t and x values to them in terms of their own coordinate system.
5. Paths through spacetime are typically used to define events at the start, end, and changes in motion along the path. For example if two twins separate as one leaves on a space trip, and later they reunite, these two events are uniquely identified by these physical occurrences even though the two twins' clocks may read different times and they assign different t values to the reunion event.
6. So every object is currently positioned at the spacetime point of the current event along its world line. From its current event it can theoretically travel to any other future event if the interval between the events is *timelike*; that is if there is more

time than spatial distance separating the events, which is necessary to reach the event at a velocity less than the speed of light.

7. To reach the destination event from its current event an observer just needs to orient itself toward the other event, which can be in any direction in space, and use the necessary velocity profile to reach the destination event at the time of its occurrence.
8. This will generally require accelerations that divert the object from its current inertial path and result in it traveling a lesser distance through time.

RELATIVE, ABSOLUTE, AND ACTUAL MOTION

1. To understand relativity one must clearly understand the concepts of relative, absolute, and actual spatial motion.
2. Objects are often in *relative motion* to each other. This affects the apparent distribution of the total spacetime motion of other objects between space and time. However it doesn't affect the actual space and time of the objects themselves.
3. *Accelerations are absolute motions* that are actually felt by the objects that experience them. Relative motions are not felt by objects, and thus are only matters of perspective.
4. *Actual motions are deviations from motion along an inertial path produced by accelerations*. Only actual, not relative motions, affect the actual distribution of an object's total spacetime velocity between space and time; and thus only actual motion, the amount of deviation from an inertial path, reduces the actual distance through time traveled by an object.
5. There is no absolute coordinate system in spacetime in the usual sense. So whether an object is at rest or in inertial motion depends entirely on what frame is used to measure it. In fact there is no way for an object to tell if it's at rest or in inertial motion because these concepts have no absolute meaning. They have meaning only relative to other objects.
6. Whether an object is at rest or in inertial motion or not simply has no meaning or any effects in any absolute sense. It's entirely a matter of how it appears relative to other objects.
7. Thus an object may well have many different states of apparent motion in many different frames, all of which can obviously be true only in a relative rather than any absolute sense.
8. Because relative spatial motion has meaning only relative to another frame, the amount of relative motion is causal only in how one frame observes the time and space of other frames, not their actual values. The actual spacetime values of an object are due entirely to its own motion, not to how it's being observed.

INERTIAL AND NON-INERTIAL WORLD LINES

1. Objects that aren't being accelerated are said to be on an *inertial path*, or *geodesic*. This is true no matter what their motion or state of rest may be relative to other objects.
2. Thus inertial motion produces relative rather than absolute or actual spatial motion.
3. An *inertial path* or *geodesic* is the route taken through spacetime by a body in constant motion or rest not subject to any external forces or accelerations. Light beams also travel inertial paths because light's motion isn't subject to external forces and always travels the path of no resistance.
4. Material objects on continuous inertial paths have no actual motion in space, so all their constant spacetime distance is traveled entirely through the dimension of time. Thus even an object seemingly at rest is actually continually traveling through time at the speed of light.
5. An inertial path or geodesic is entirely through time because it has no actual velocity through space, and thus covers no actual distance through space in its own frame. This is true no matter what motion is may have relative to other objects.
6. However if an object deviates from an inertial path onto another inertial path the total path becomes non-inertial because an acceleration was required to produce the deviation. In such cases the total deviation from the original inertial path counts as actual spatial distance and reduces the actual distance traveled through time.
7. Inertial frames must be used as reference frames in Minkowski diagrams to calculate space and time because only inertial frames have coordinate systems not being changed by accelerations. Rulers and clocks that are not changing must be used to make consistent measurements.

DISTANCES THROUGH SPACE, TIME AND SPACETIME

1. The distance between two points in *space* is given by the Pythagorean theorem as dist $=\sqrt{(dx^2 + dy^2 + dz^2)}$. The distance between the points also specifies the direct and shortest possible path between the points. However there can be many alternate paths between two points in space. For example there are many different routes over different highways between cities on a map, each with a different distance, but no routes can be shorter than the direct distance.
2. In spacetime the total distance through space and time between two events is also given by the Pythagorean theorem as dist $=\sqrt{(dt^2 + dx^2 + dy^2 + dz^2)}$.
3. In space the distance between points in one dimension is the total distance between the points minus the distances in the other dimensions, for example dx $=\sqrt{(dist^2 - dy^2 - dz^2)}$.
4. Similarly the distance between events in the dimension of time (called the elapsed proper time) is the total distance between the events minus the distance in space.

So the elapsed proper time $d\tau = \sqrt{(d\lambda^2 - dx^2 - dy^2 - dz^2)}$, or if all spatial motion is assumed in the x dimension with two spatial dimensions suppressed, $d\tau = \sqrt{(d\lambda^2 - dx^2)}$ is the distance in *time* between the two events.

5. However there is an important difference between distances in space and distances in spacetime. In space the distance traveled between two points can vary from the minimum distance between them to any imaginable distance over any imaginable path over any imaginable time.
6. However because everything travels at the same constant speed of light and thus covers the same distance in spacetime, the total distance between two events in spacetime is the same no matter what path is taken.
7. As with space there can be many different routes through spacetime between two events, each with different distances in space and time, but the vector sum of the distance in space and the distance in time will always equal the same total spacetime distance $d\lambda$. The total spacetime distance between two specific events is invariant, the same in all frames.
8. This means that the greater distance a clock travels in space, the lesser distance it will travel in time. Thus the less elapsed time it will record and the less an observer moving with that clock will age. This is the basic reason why rapidly moving objects and space travelers age less. They travel a shorter distance through time because they traveled a greater distance through space. This is why the space-traveling twin comes back younger, because he traveled a greater distance through space than his Earth twin and thus a lesser distance through time.
9. Because everything travels through spacetime at the speed of light the total space plus time distance between two events is the same no matter what path is taken. There are many possible routes through time and space between two points, but in contrast to the distance between two points in space, the total distance through both space and time is the same over all possible paths.
10. Thus the route a clock takes through spacetime between two events determines the distance through space and thus the distance through time it takes. This distance through time is the amount of elapsed time on the clock, and the amount an observer traveling with that clock will age.
11. Now because an object's travel through spacetime is an actual physical process independent of how it's observed, its actual path through spacetime, and its distance in both space and elapsed proper time are invariant in the frames of all observers. They are determined entirely by the object's own path through spacetime rather than from what perspective they are observed. In particular proper times between events are invariant, and have the same values in all coordinate systems.
12. An inertial path between two events has no actual motion in space. Thus an inertial path has the maximum distance through time. Other (non-inertial) paths will have increased distances through space and thus shorter distances through time. Clocks traversing non-inertial paths will travel shorter distances through time and thus register less elapsed time, and space travelers traversing such paths will age less because they travel a shorter distance through time.
13. Motion through space is variable and often voluntary, but our motion through spacetime is continuous and always covers the same distance that light travels.

Thus that portion of our total spacetime distance traveled not traveled through space is always made up for by the remainder being traveled through time.

14. Inertial paths have all their spacetime velocity through time, and no actual motion through space. Thus the elapsed time along an inertial path is the maximum possible and the distance traveled through space is zero. For inertial paths the entire distance traveled through spacetime is traveled entirely through time.
15. So the maximum time distance is that for the shortest spatial path, i.e. a geodesic, a path with no acceleration, and therefore no actual spatial velocity. Accelerations produce deviations from an object's inertial path and result in longer actual spatial paths and a correspondingly shorter path through time.
16. So what is actually important when it comes to the distance through time traveled is how much its motion through space deviates from an inertial path.
17. However anything can have motion through space relative to other frames and thus the velocity through time will be reduced from the perspective of those frames.
18. So the apparent distribution of total spacetime distance traveled varies among frames, but the actual distribution depends entirely on an object's deviation from an inertial path. This will be clearer below with some examples.
19. Note that because our internal mental clocks always tick at (approximately) the same rate as our comoving physical clocks, we never notice any difference in the rate of the passage of time no matter how our much of our actual velocity through spacetime is through time or space. The space-traveling twin never notices that less of his velocity and distance traveled is through time until he is able to compare his age to that of his stay-at-home twin.
20. Thus all observers always experience all their constant spacetime motion as through time because no matter how fast or slow their actual velocity through time is, their brains are ticking at the same rate as their clocks. This is consistent with the apparent inability of anything to have any motion in space relative to itself, though of course if an observer is deviating from an inertial path he does have actual motion in space relative to that path that reduces his velocity through time.
21. So in this sense every observer always experiences all his own spacetime motion as through time at the speed of light.

FRAMES AND COORDINATE SYSTEMS

1. In relativity as in daily life there is no absolute coordinate system that everything is measured with respect to. The measurements we get depend on where we place our rulers and how we set our clocks. So everything must always be measured or calculated in terms of some chosen coordinate system. Often but not necessarily this is the coordinate system of a particular observer. In relativity a particular coordinate system is called a *frame* and because there is no absolute frame everything must always be measured from the perspective of some individual frame. The frame currently being used is called the *reference frame*.

2. Thus space and time must always be measured from some arbitrary coordinate system and the measurements obtained will depend on the coordinate system used. In relativity especially our view of events in the universe depends on our coordinate system.
3. Now to get valid results we must always measure things with respect to a coordinate system that isn't changing. We can't get good results if the length of our rulers or the tick rates of our clocks are changing. This means we have to measure from an *inertial frame*. Inertial frames are frames that aren't subject to acceleration. Accelerations change relative velocities and thus the perspective from which events in spacetime are viewed, and thus the results we get from measurements are inconsistent. Inertial frames can be moving relative to each other, just never subject to any external forces or acceleration.
4. An inertial state of motion is motion (or rest) that isn't subject to external forces such as acceleration. Light beams, free falling objects, and orbits follow inertial paths through spacetime. Inertial frames can be moving relative to each other so long as they aren't undergoing accelerations. An object's inertial velocity or rest in space is relative to that of other objects and has no absolute meaning.
5. Frames can be associated with a particular inertial observer or clock, but in general any inertial coordinate system can be used as a frame. We can think of spacetime as full of innumerable possible overlapping frames or perspectives in relative motion to each other. All are valid systems of measurement so long as they remain inertial. Every individual object has a 'native' frame associated with it in which it is at rest and much of relativity involves comparing events in frames from the perspective of other frames in relative motion.
6. So we always need to select some inertial frame in which to perform measurements and calculations. Typically we will want to choose the most convenient and meaningful frame in which to clarify relevant information. So whenever we measure or calculate anything in relativity we must always do so with respect to an appropriate inertial frame.
7. A frame is a particular perspective on spacetime including other frames. Many properties such as velocities, times, and positions, have different values in different frame perspectives but some don't. If a property has the same value from the perspective of all frames it's *invariant*. Invariants are phenomena that depend only on the thing itself rather than how it is viewed. For example the current time reading of a clock, the *proper time* of that clock, is invariant and the same in all frames because it depends only on the clock itself, not a relationship between the clock and the frame it's viewed from. However the rate at which time appears to be ticking on a clock, its *time dilation*, is not invariant and depends on the perspective of the frame in which it is viewed.

EVERYTHING TRAVELS THROUGH SPACETIME AT THE SPEED OF LIGHT

1. Everything that exists, including ourselves, continually moves through spacetime (combined space and time) at the same constant velocity of c, the speed of light in a vacuum, approximately 300,000 kilometers or 186,000 miles per second.
2. This is the *basic little recognized principle that explains how time works in special relativity*. Understanding this principle and its implications is essential to truly understanding relativity.
3. All our velocity through spacetime is preferentially through time unless we have some velocity through space, in which case our velocity through time is reduced so that our total velocity through spacetime remains equal to c.
4. Thus we are all continually traveling through time at the speed of light in our own frame in which we seem to have no velocity in space relative to ourselves. This is what we experience as the passage of time through the present moment.
5. This is expressed by the equation $c^2 v_{time}^2 + v_{space}^2 = c^2$. This can also be written as $c^2(d\tau/dt)^2 + (dx/dt)^2 = c^2$ where $d\tau/dt$ is the velocity in time of some clock relative to that of a reference clock, and dx/dt is velocity in space which is distance traveled per unit time. The terms are squared since to add velocities in different dimensions we must use the Pythagorean theorem for vector addition. In relativity velocities in time are generally expressed as percentages of the speed of light, which is why we must multiply the velocities of time by c in these equations.
6. *Because everything advances through spacetime at the speed of light everything always advances the same distance through spacetime as light does*. But while light travels all its spacetime distance entirely through space, material objects travel different distances in space and time so long as the vector sum equals c. And since *the distance we travel through time is the amount of time that passes on our clock and how much we age* this simple fact explains much of what happens with time in special relativity.
7. Everything travels at the same spacetime velocity of c, and the speed of light c is the same in all frames. Thus everything travels the same distance through spacetime as light does. This is why the axes of Minkowski spacetime diagrams are scaled by c. Thus everything constantly travels the same distance through spacetime as light does in every frame, and in every Minkowski diagram. Thus $d\lambda$, the total spacetime distance traveled by everything is invariant (has the same value) in every Minkowski diagram and in every frame.
8. For example we and everything else travel one light second per second through spacetime, and one light year per year, with distances through both time and space expressed in compatible units of light distances. And since we normally travel only minute actual distances through space almost all of this total spacetime distance traveled is through time. Thus we are almost always zipping through time at close to the speed of light.
9. It is only when an object's actual velocity through space becomes significant relative to the speed of light that the shorter distance we travel through time it produces becomes significant. However with atomic clocks we can measure the minute lesser distances that astronauts aboard the ISS travel through time. And the differences in the distance in time traveled by GPS satellites relative to clocks on Earth must be compensated for to ensure the accuracy of the GPS system.

10. However the constant distance in spacetime is apportioned differently between space and time in different coordinate systems due to their relative motion. In every frame this is done consistently so the total spacetime distance of all spacetime paths between the same t values and same events measured in that frame is the same.
11. Thus the actual values of total spacetime distance dλ, distance in time dτ, and actual distance in space dχ, are invariant and the same in all frames. This shows that the underlying coordinate scales of all frames are identical which is to be expected as they are all scaled by the speed of light and the distance it travels, and the speed of light is the same in all frames.
12. The fact that everything that exists is speeding through combined space and time at the speed of light is the ultimate source of all happening in the universe. It's the ultimate source of time, motion, energy, change, process, and the continuing evolution of the universe. This constant c velocity of everything through spacetime is what gives life to the universe and allows us and other creatures to be consciously aware.

1. It's intuitive that for everything I do in every tick of my clock that everyone else in the universe is doing something simultaneously. However physicists have struggled to prove this and many still reject the idea of a universal current present moment or 'now'. This is due to *the relativity of simultaneity* in which the present moment of moving clocks appears different in different frames.
2. The current total distance dλ everything has traveled through spacetime is the current universal present moment. This is the only moment that actually exists, and it's common to the entire universe. The current identical distance that everything has traveled through spacetime is the current universal present moment of the universe.
3. The future does not yet exist, and the past has been entirely recomputed into the current present moment. Only the current universal present moment exists and within it the universe and everything in it, included ourselves.
4. Every individual entity or observer in the universe is at the current event on its world line that is simultaneous with this current universal present moment. All entities in the universe exist only on the universal surface in the same 'now' in which the entire universe exists and which is all that exists.
5. Every entity in the universe has a unique current proper time reading on its clock in every current universal present moment. Thus there is a unique 1:1 invariant correlation between the current proper times of all clocks in the universe in every current present moment, which we all inhabit simultaneously. However these actual proper times and their intrinsic rates are different for observers in different states of motion.
6. All clocks have the same intrinsic tick rate, but some tick fewer ticks because they travel less distance in time due to the distance they travel in space. Clocks that travel the same distance in time such as inertial clocks that travel only through time, all tick the same number of ticks, and thus inertial clocks all record the same maximum passage of time.

7. Non-inertial clocks travel some of their total dλ spacetime distance through space and thus advance less distance through time depending on the amount of distance in space they deviate from an inertial path.
8. The actual elapsed proper time of non-inertial clocks can be read directly from a frame in which the original inertial path it deviated from is at rest, as in the case of the Twins example, which will be discussed later.
9. This 1:1 correlation among all the proper times of all clocks in the universe serves as an absolute present moment time coordinate for all clocks in the universe.
10. But in general observers in relative motion don't view the actual proper times of each other's clocks. That is a matter of perspective, and in general, relatively moving observers each view the time on each other's clocks ticking slower than their own. They don't see the actual 1:1 current present moment proper time correlations though they can always be calculated.
11. The current proper time on any object's clock depends entirely on its own path through spacetime, not on how it is being observed from any other frame. Specifically all the distance it travels through spacetime is through time if it's path is inertial. However the amount of deviation from an inertial path reduces the distance it travels through time. Whatever the result an object's current proper time at the current common distance it has traveled through spacetime is the proper time it has in the universal current present moment, the universal now.
12. So observers in relative motion don't actually see this absolute one-to-one proper time correlation. In general they see the actual states of other clocks as they were in the past since they only see a portion of the time of those clocks. So every other person is doing what it's actually doing in the common present moment but depending on its relative velocity an observer sees what it was doing in the past. This is similar to how we see astronomical events that occurred in the past in our present moment, and don't actually see what's going on in distant galaxies in their present moment which is what they are actually doing in the current universal now.
13. So there is always an actual common current universal present moment that can be calculated by any observer but not necessarily perceived.
14. A common universal present moment is necessary for a computational universe to continually simultaneously recompute the state of the entire universe from its previous state. This is required for a consistent computational universe, which is essential to my *Complete Theory of Everything*.

EXTENDED MINKOWSKI SPACETIME DIAGRAMS

1. Minkowski diagrams are the standard representation of the relationships between space and time in special relativity. *Extended Minkowski diagrams* are Minkowski diagrams with a couple of important extensions I've added to identify world lines in the native original inertial path frames in which they are actually created and extend the notion of invariance from proper time dτ to include proper distances dχ

and invariant total dλ spacetime distances. These extensions will become clear in the course of the discussion.

2. Minkowski spacetime diagrams are simple graphs that show clearly how space and time work in special relativity and make it easy to calculate the relationships among relatively moving clocks. These diagrams are essential to understanding space and time in special relativity, and drawing a Minkowski diagram is always the first step in solving a problem in special relativity.
3. A Minkowski diagram is a depiction of times, distances and velocities in time, space and spacetime and how they are related from the perspective of any chosen reference frame. Each Minkowski diagram represents the spacetime view of a particular inertial frame taken as at rest. Other objects in relative motion are thus depicted with spatial velocities relative to the reference frame.
4. Minkowski diagrams are two-dimensional graphs in which time is flowing upward along the vertical t-axis and any velocity in space is assumed to take place along the horizontal x-axis. The y and z dimensions of space are normally suppressed with all spatial motion assumed to be outward or inward along the x-axis.
5. Thus the paths or world lines of objects through spacetime relative to this frame are depicted as lines whose distance in time is measured against the vertical t-axis and distance through space against the horizontal x-axis. A Minkowski diagram represents the perspective of the chosen reference frame and how clocks moving with respect to it appear from its perspective. Thus the coordinate values of the two axes are those of the reference frame, and the space and time values of moving objects are calculated with respect to these coordinates.
6. The path of objects or clocks *at rest in the reference frame* are vertical lines with their spacetime velocity entirely through time along or parallel to the vertical time axis with no deviation along the x-axis since they have no spatial velocity in a frame in which they are at rest. But the path of an object or clock moving relative to the reference frame is a slanted line since it's moving in space as well as time from the perspective of the reference frame.
7. The values the reference frame calculates for moving frames are best understood as the projections of their actual values onto the coordinate axes of the reference frame. They are the view of the moving frames from the perspective of the reference frame.

1. The origin of a Minkowski diagram represents an arbitrary present moment start time from which present moment time along with the proper time of the comoving clock flows upward at a constant rate equal to the speed of light c. Thus the vertical axis is often labeled ct indicating it represents the distance time travels as it moves at the speed of light c.
2. By multiplying the vertical time axis by the speed of light c we put it into the same units of light distance as distance along the x-axis in space. Thus both axes are scaled by the speed of light; the vertical axis by the distance time travels at the speed of light, and the horizontal axis by the distance light travels at c; in light years for example.

3. Thus all Minkowski diagrams are scaled by the speed of light, and since the speed of light is the same in all frames the scaling of all Minkowski diagrams is the same; assuming they are using the same units such as light years.
4. So from the perspective of the reference frame the current present moment is a horizontal line that sweeps upward along the vertical time axis carrying all entities on the diagram along with it.
5. Thus clocks traveling along all world lines in the diagram sweep upward together at the same rate with the current present moment in the perspective of the reference frame as time flows upward. The current dt proper time reading of the frame's comoving clock rises upward as the local measure of the current present moment.
6. All other clocks on the diagram rise upward in time along with the present moment at the same rate. However if their paths are slanted at an angle to the vertical axis due to spatial velocity along the x-axis, then their clocks run at a slower rate so the combined space and time distance they travel covers the same overall spacetime distance as the reference clock.
7. The diagram allows us to easily calculate the lesser distances in time covered by clocks in relative motion using the standard equation for proper time $d\tau = \sqrt{(dt^2 - dx^2)}$. Elapsed proper time is the square root of the square of the distance in time along the vertical t-axis minus the square of the distance along the horizontal x-axis. This is the standard Pythagorean equation for calculating the lengths of vectors in orthogonal dimensions.
8. Using this very simple method as a basis the elapsed proper time over any world line of any complexity can be calculated in a Minkowski diagram.

1. Minkowski diagrams are primarily used to calculate and compare he proper times of clocks moving relative to the reference clock of the diagram. But when one understands them completely one can also calculate other important values as well.
2. The proper time equation correctly calculates both the proper time of the reference clock along the vertical t-axis and the paths of all clocks moving relative to it.
3. In the case of the frame's reference clock its path is vertical meaning it has no movement along the x-axis so $dx = 0$. So in this case $d\tau = \sqrt{(dt^2 - 0^2)} = dt$, meaning the elapsed proper time of the reference clock is simply its reading along the t-axis.
4. And since the total distance through spacetime $d\lambda = \sqrt{(dt^2 + dx^2)}$, and its $dx = 0$, the distance the reference clock travels through time will be its total distance through spacetime. The reference clock in any Minkowski diagram travels its entire $d\lambda$ spacetime distance through time since $d\lambda = dt = d\tau$ in its own frame.
5. On the other hand the path of a relatively moving clock will have a non-zero total dx distance through space in this frame so its total total distance through spacetime will be $d\lambda = \sqrt{(d\tau^2 + dx^2)}$, and since dt is the total distance $d\lambda$ of everything in this frame $d\lambda = \sqrt{(d\tau^2 + dx^2)} = dt$. Thus the total distance through spacetime of every path in the diagram will be $d\lambda = \sqrt{(dt^2 + dx^2)} = dt$.

6. This will be the same total spacetime distance traveled by all paths with the same dt in this diagram. Thus every path with the same vertical dt will be at the same current moment in the perspective of this diagram.
7. However in general the perspective view of a particular Minkowski diagram will not reflect the actual invariance of the current universal present moment. That is true only for paths in which $d\lambda = dt$, such as when the vertical axis is that of the inertial path a non-inertial path has deviated from, or for other comoving clocks,.

1. Proper time is the actual clock reading of any clock. The elapsed proper time is the amount of proper time that elapses on a clock between two events. The elapsed proper time is the distance the clock has traveled through time, and is the amount of aging a person comoving with that clock will experience.
2. The total elapsed proper time of a moving clock depends on its own path through spacetime. Specifically it depends on the amount of deviation from an inertial path, which is the path of greatest elapsed time. The greater the deviation from an inertial path the less proper time elapses, and thus the less ageing an observer traveling that path will experience. The deviation is the longer actual distance through space that produces the shorter distance through time traveled.
3. This because everything always travels at the same c velocity through spacetime, and thus everything always travels the same total space plus time distance per unit time. And since the coordinates of Minkowski diagrams are scaled by light, and light has the same constant velocity in all frames, everything always travels the same total spacetime distance per unit time t on any Minkowski diagram in any frame.
4. Minkowski diagrams enable us to easily calculate the elapsed proper time over an arbitrary path on a clock moving relative to a reference frame. It is simply $d\tau = \sqrt{(dt^2-dx^2)}$, the elapsed proper time of any moving clock is equal to the square root of dt the total spacetime distance of its path in this frame minus dx the apparent distance traveled in space in this frame.
5. This gives us the actual elapsed proper time of the moving clock. There is nothing hidden here. All observers view the exact same actual reality, just from their own individual perspectives. The elapsed proper time calculated for a moving clock is the reference frame's perspective view of the elapsed time of the actual clock. If the original setting of the clock is known the current proper time reading from the perspective of the reference frame is known as well.
6. The clock of a reference frame is at rest in its frame. Thus it has no spatial motion in the frame and its $dx = 0$. This means that all the total spacetime velocity and distance the reference clock travels is entirely through time in its own frame and equal to c*dt, its own time reading.
7. However a clock moving relative to this frame will have a $dx \neq 0$, and thus its elapsed distance through time $d\tau$ will be reduced by $d\tau = \sqrt{(dt^2-dx^2)}$. The proper time distance it travels through time will be equal to the total spacetime distance c*dt minus dx, the distance it travels through space in this reference frame; and the total proper time of any path is the sum of the proper times of all its segments.

8. So the total elapsed proper time of a moving clock between two events on its path through spacetime can be easily calculated from the perspective of any inertial reference frame including that of its own inertial segments. The total elapsed proper time is simply the sum of the proper times $d\tau = \sqrt{(dt^2 - dx^2)}$ along each inertial segment of its path between the start and end events. More generally for curved (accelerated thus non-inertial) paths it's the integral of proper time $\int\sqrt{(dt^2 - dx^2)}$ over the segment. (Integration is a mathematical procedure in calculus for dividing a curved path into minute straight lines of unlimited shortness and taking their sum so the principle is the same.)
9. Elapsed proper times can be calculated from the perspective of any frame and will be the same since proper time is invariant under Lorentz transformations used to convert from the perspective of one reference frame to another. For example one could convert to the frame of an inertial segment of the path of a moving clock and get the same elapsed proper times of all paths.

1. So in any Minkowski diagram we can calculate the time, space and spacetime distances of any world line, but only from the spacetime perspective of a comoving clock at rest in this frame.
2. However since these distances are due only to a clock's own path through spacetime, and not to how it's being observed, these values are invariant – they turn out to be the same in the perspective of all frames. They have the same invariant values in all Minkowski diagrams. (See Appendix A for a proof.)
3. But to see this we have to convert from one frame to another, from one Minkowski diagram to another and to do that we use Lorentz transformations to convert from one frame to another based on the relative velocities of the frames. How this is done is explained in the eponymous section and won't be repeated here.
4. So the beauty of Minkowski diagrams is that using the simple proper time equation one can calculate the elapsed proper time over any possible path or combination of paths in the perspective of any frame, and the distances along these paths will have the same invariant values for $d\lambda$, $d\tau$, and $d\chi$ in all frames.
5. While the actual total spacetime distance, proper time distance, and actual spatial deviation distance $d\lambda$, $d\tau$, and $d\chi$ values along every path are invariant and have the same values in every frame, the dt and dx time and space distances reflecting the current perspective are specific to the frame being used and will be different in different frames. Thus the (t, x) coordinate values of events, resulting path tilts and scales will be different while their invariant lengths remain the same.
6. Note also that the apparent current present moment along the t-axis of any frame is the perspective view of that frame and will be different in all relatively moving frames.
7. However there is a universal current present moment common to all frames that is simply the same current total $d\lambda$ spacetime distance everything in the universe has traveled. This too is invariant and can be calculated from any frame along with the invariant proper time reading of all clocks in that common current universal present moment. This is demonstrated in the upcoming twins example.

8. Thus every Minkowski diagram has same innate speed of light based scale, though not the same perspective scale. But within any frame its local dt, dx can be used to calculate the invariant dλ, dτ, and dχ values of any paths.
9. This frame invariance confirms all frames use the same innate c based scale even as they view it from the different perspectives of their particular frames.

SPACETIME REGIONS

1. Spacetime is divided into several distinct regions on a Minkowski diagram. It's important to understand that these regions and everything on a Minkowski diagram are all relative to the singularity of the reference frame's location and relative motion in time and space. They will have different dt and dx values in other frames with different spacetime locations and motions.
2. The area below the x-axis represents the past and the area above it represents current time starting from some arbitrary time at the origin.
3. The 45° paths of light from the vertical below the x-axis is the past light cone from the origin and the 45° paths of light fro the vertical above the horizontal axis the future light cone.
4. Our view along our past light cone is what we actually see as we look out into deep space, namely the past in all directions from our current point in space and time, specifically the singular point of the location of our current moment event. This is our view of our 4 dimensional hypersphere from the inside from our current location.
5. There are 3 categories of spacetime intervals shown on a Minkowski diagram, timelike, lightlike, and spacelike. *Timelike intervals* connect events at less than the speed of light, *lightlike intervals* connect events at the speed of light, and *spacelike intervals* connect events that can't be traversed because it would require faster than light travel.
6. Timelike intervals are represented by paths on Minkowski diagrams in which dt > dx and thus have slopes less than 45° from the vertical t-axis. Because of this it is theoretically possible for an object, clock, or causal influence to propagate from an earlier to later event in this region. A traveler beginning at the origin can theoretically reach an event anywhere within this upper quadrant of a Minkowski diagram (plus or minus less than 45° from the vertical axis) at less than the speed of light.
7. On the other hand if dx > dt between two events, the distance in space is greater than the distance in time and the interval is spacelike. It isn't possible to travel between events separated by a spacelike interval because it would require faster than light travel, which is impossible.
8. And because no 'causal' effect can propagate faster than the speed of light events separated by spacelike intervals can have no causal effects on each other.
9. The distance between spacelike events is important however in determining the distance relative to an inertial path an object travels. The distance or length of a

spacelike interval or path in a particular frame is $d\chi = \sqrt{(dx^2 - dt^2)}$, the vector distance in space minus the vector distance in time.

10. In a frame in which the ends of a spacelike interval are simultaneous this interval is simply the spatial distance between the events measured using standard rulers, or the length of an object with those endpoints.
11. Finally if $dt = dx$, the slope is 45° with equal distances in time and space, and in this case the interval is lightlike. This is the path light takes as it travels at c through spacetime. Note that the proper time of a lightlike interval is 0. Since all of light's spacetime velocity is entirely through space time doesn't pass on particles that travel at the speed of light Photons wouldn't age according to their comoving clocks if they had any. Photons express all their total spacetime velocity entirely as velocity through space. This is why light always travels at the same constant spatial velocity of c in all frames no matter how the frames may be moving relative to each other.

ELAPSED PROPER TIME AND TIME DILATION – A MATTER OF PERSPECTIVE

Of special interest in relativity are the differences in elapsed proper time between relatively moving fames, and time dilation where two relatively moving observers each view the other's clock ticking slower than their own. While this may initially seem like a logical contradiction it's actually a simple matter of perspective.

1. From the perspective of a reference frame in which an observer is at rest there are two time calculations of a moving clock that are aspects of the same effect.
2. The calculation of the actual (invariant) *elapsed proper time* of the moving clock is $d\tau = \sqrt{(dt^2 - dx^2)}$, and if we know the original setting of the clock, its actual clock time.
3. The calculation of the *time dilation* of the moving clock, the current slower rate the clock appears to be ticking from the perspective of the reference frame, $t' = t\sqrt{(1-v^2/c^2)}$. Or in natural units where $c=1$ and v is expressed as a percent of c, $t'=t\sqrt{(1-v^2)}$.

These are both aspects of the same effect since if we divide $d\tau = \sqrt{(dt^2 - dx^2)}$ by dt^2 we get $d\tau/dt = \sqrt{(dt^2/dt^2 - dx^2/dt^2)} = \sqrt{(1 - v^2)}$ since $dx/dt = v$, is velocity. So time dilation is the apparent slowing of the tick rate of a moving clock in a rest frame due to the perspective effect of the elapsed proper time calculation. It's not a separate effect.

These are both reciprocal effects. We have $dt' = dt\sqrt{(1-v^2/c^2)}$ along a path of constant x' from the perspective of the reference frame, but we also have $dt = dt'\sqrt{(1-v^2/c^2)}$ along a path of constant x from the perspective of the other frame. For two relatively moving clocks, each runs slow in terms of the inertial coordinates in which the other is at rest.

1. Thus in relativity when two clocks move relative to each other they both see each other's clock running slower due to time dilation, and thus they both see less time passing on the other's clock than their own.
2. This is easy to understand as a matter of perspective. A spatial analogy makes this clear.
3. Imagine two cars each traveling at the same 60 mph but on roads that are angled with respect to each other. Each measures the speed of the other and the distance it seems to travel in terms of a coordinate grid aligned with the road it's on. Each car travels entirely along the x-axis in its own coordinate system. Thus each driver sees the other car traveling some distance at some velocity along the y-axis.
4. Using the familiar Pythagorean formula this apparent motion along the y-coordinate reduces the other car's distance traveled along the x-axis by $dx' = \sqrt{(dx^2 - dy^2)}$ and thus its apparent velocity along the x-axis.
5. And the same is true from the perspective of the other car since both measure the other car's motion relative to their own x-axes, which are at an angle to each other.
6. Thus both drivers each see the other car traveling at a slower velocity and covering a lesser distance than their own though they are both actually moving the same distance at the same velocity in their own frames.
7. Thus both drivers are viewing the exact same invariant actual reality from the perspective of their respective coordinate systems.
8. The same is true with respect to time dilation and elapsed proper time. Again two relatively moving observers each see the other's clock ticking slower and covering a lesser distance through time than their own, and for the exact same reason of perspective.
9. Here too everything is moving at the same velocity, the speed of light. So if two clocks are moving with relative spatial velocity, each will see the other clock moving (ticking) slower and covering less distance in time.
10. Here again both observers measure motion through spacetime in terms of a coordinate system in which they are moving entirely through time with no velocity in space relative to themselves. But both observers see the other traveling with reciprocal velocity and distance along their own x-axis.
11. So using the same Pythagorean theorem, each sees the other's distance through time as $d\tau = \sqrt{(dt^2 - dx^2)}$, less than their own since they see some of the other's identical spacetime velocity as being through space rather than time.
12. But again it's important to understand that both observers are viewing the same actual reality just from the perspectives of their different coordinate systems. In particular they are seeing the actual clock readings of the other clock, and seeing the actual tick rates of each other's clocks, just from their own native perspective. Each sees the other from the perspective of the frame in which it's at rest.
13. But actually both are actually traveling the same distance at the same rate through time and have no immediate motion in space in their own coordinate system.
14. So even though observers in different frames may view the spacetime variables of other clocks differently how they are viewed doesn't affect their actual behavior

at all. The actual behavior of everything in spacetime depends entirely on its own path through spacetime.

15. Specifically its actual elapsed proper time depends entirely on how much it deviates from an inertial path, and not at all by how it's viewed by other clocks. However relativity enables us to calculate this invariant elapsed proper time from any inertial frame.
16. So all views in relativity are perspective views of actual events, but we only see that part of a moving clock's passage through time from our perspective that is not diminished by its relative motion in space. We all view everything entirely from the perspective of our own coordinate system.

LORENTZ TRANSFORMATIONS – SWITCHING FRAMES

1. However we can easily switch from the view of one frame to that of another; that is from the view of one clock to that of another moving relative to it.
2. This is done by applying Lorentz transformations to convert the coordinates of events in the first frame to that of the second frame. This results in switching the perspective view from that of one relatively moving clock to that of another, from a frame in which the first clock is at rest to the frame in which the other relatively moving clock is at rest.
3. Lorentz transformations allow us to convert from one frame that moves at a constant velocity to another. The (t, x) coordinates of each event in the first frame are converted to the (t', x') coordinate values they have in the second frame.

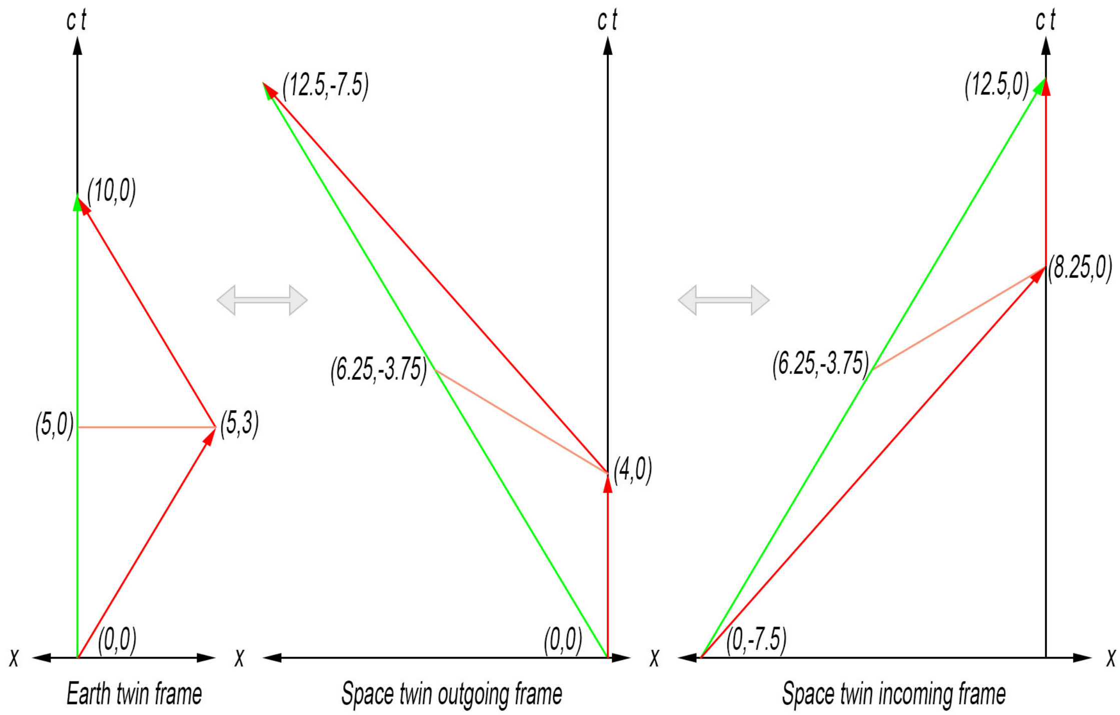
The Lorentz transformations are
$t' = \gamma\,(t - xv)$ in natural units, $t' = \gamma\,(t - x\,v/c^2)$ in non-natural units.
$x' = \gamma\,(x - tv)$ in natural units, $x' = \gamma\,(x - vt)$ in non-natural units.
where $\gamma = 1/\sqrt{(1-v^2)}$ is the Lorentz factor in natural units,
$\gamma = 1/\sqrt{(1-v^2/c^2)}$ is the Lorentz factor in non-natural units.

4. For example Lorentz transformations enable us to convert from the perspective of the Earth twin to that of the space-traveling twin in the frame of either of the leaving and returning legs of its trip.
5. Invariants such as the proper times of the various segments of world lines are preserved under the Lorentz transformations. See Appendix A for a proof.
6. Lorentz transformations also preserve the invariance of total spacetime distance $d\lambda$, and the spatial deviation from an inertial path $d\chi$, the distance in space that determines an actual lesser distance traveled in time.
7. Lorentz transformations are generally used to transform the events defining a moving inertial frame into a stationary inertial reference frame so it can be used as a reference frame. When this is done, invariances will be preserved.

THE TWINS – LESS ELAPSED PROPER TIME OVER NON-INERTIAL PATHS

1. The twins is a classic example from special relativity demonstrating how deviation from an inertial path in space results in less elapsed proper time and thus less aging of a space-traveling twin.
2. Two twins on Earth are each the same age and their clocks are synchronized.
3. One embarks on a trip to a nearby planet along the x-axis, turns around and returns to Earth only to find he has aged less than his Earth twin.
4. From our discussion so far it's easy to understand this is because the space-traveling twin diverged significantly from his original (approximately) inertial path on Earth while the twin who remained on Earth remained on Earth's inertial path and had no deviation from it.
5. We will analyze this example from the perspective of all three frames associated with the Earth, the outgoing leg of the space trip, and the return leg of the space trip to show that while they all view it from the different perspective of their own spatial motion, they all calculate the same invariant values for the total space, time and spacetime distances traveled, and thus they all agree on the different ages of the twins when they reunite.
6. It's important to understand that the lesser aging of the space-traveling twin is usually explained as due to the shorter distance through time he traveled, not because his clock ran slower. But compared to the Earth twin's clock it did run slower. Less of his total spacetime velocity was through time so his clock had fewer ticks on its path than Earth clocks on their path. Thus the space-traveling clock did in fact have a slower velocity through time relative to that of the Earth twin. A slower velocity in time results in a lesser distance through time. So these are equivalent explanations.
7. It may seem initially confusing that while the t and x coordinates of an event can have different coordinate values in different frames, that when frames are merged, as when the twins reunite, they can still have different t values reflected in the twins' different elapsed proper times, but the x values of the reunion event must be identical. The twins can reunite at different times on their clocks, but they must reunite at the same location.
8. Of course in reality they actually do reunite at the same time and the same place in the same event with the common coordinate values of their common frame, just with different elapsed proper times reflecting the different distances they traveled through time, and just as they have traveled different distances through space. If they both had odometers they would register the distances through space they traveled just as their clocks register the distances through time they traveled. And the vector sum of those two distances would be the total distance through spacetime they traveled which would be the same for both twins between their separation and reunion events.

FIGURE 1: xMINKOWSKI SPACETIME DIAGRAMS



Enhanced Minkowski spacetime diagrams

This figure illustrates the 3 frame views of the Twins where the space twin leaves the Earth at velocity v = 0.6c, travels 3 light years in 5 Earth years, turns around and returns. The 3 views can be interconverted using Lorentz transformations.

Green vectors are the Earth twin, red vectors the two legs of the space twin, and orange lines are the space twin's deviation from his original inertial Earth path.

In spite of the different shapes and coordinates of the events in the 3 frames, the proper times, deviation distances, and total spacetime distances of each path are the same, and the total spacetime distance between the separation and reunion events of both twins is the same. However, as a result of the space twin's deviation from his original inertial Earth path his clock only advances 8 years while the Earth clock progresses 10 years.

The Earth frame is the original inertial path of both twins thus it reflects the actual spacetime motion that determines both twin's own time dilation. And thus it also accurately shows the actual current present moment rising horizontally from the x-axis as the paths are created. Thus in this view the deviation from inertial dχ is the actual invariant proper distance of the space twin's path. Thus it's invariant in all frame views as are the elapsed proper times of all 3 paths.

xMinkowski diagrams show how frames actually see other spacetime paths but largely miss the actuality of paths shown in other types of diagrams.

CALCULATION OF TWINS EXAMPLE

Units of time are in years (multiplied by c so they are in the same units as space) and units of space are in light years. This example starts in Earth twin's frame with her path from events (0,0) to (10,0). The space twin's path is from events (0,0) to (5,3) to (10,0). Earth twin calculates the elapsed proper time of space twin at turnaround as 4, and over the entire trip as 8 while hers is 10, and 5 at space twin's turnaround.

Lorentz transformations are then use to convert to the frame of outgoing leg of space twin's path. Finally Lorentz transformations are used to convert to the frame of the return leg of the space twin's path.

Fractions are maintained to avoid rounding errors.

Calculations of time, space and spacetime distances in Earth frame
Events (0,0), (5,3), (10,0).
Earth inertial path. $d\tau = 10$, $d\chi = 0$, $d\lambda = 10$.
Space 1st leg. $d\tau = \sqrt{(5*5 - 3*3)} = \sqrt{16} = 4$
Space 2nd leg. $d\tau = \sqrt{(5*5 - 3*3)} = \sqrt{16} = 4$
Space path. $d\tau = 4 + 4 = 8$. $d\chi = 3 + 3 = 6$, $d\lambda = \sqrt{(6*6 + 8*8)} = \sqrt{(36 + 64)} = \sqrt{100} = 10$
So $d\lambda$ of both paths = 10 the same as expected.

Lorentz transformations to convert from Earth frame to outgoing frame of space twin:
$t' = \gamma\,(t-xv)$, $x' = \gamma\,(x-tv)$ where $\gamma = 1/\sqrt{(1-v^2)}$ and $v = 3/5$.
$\gamma = 1/\sqrt{(1-9/25)} = 1/\sqrt{(16/25)} = 1/(4/5) = 5/4$

Event (0,0) ->
$t'=0$,
$x'=0$

Event (5,3) ->
$t' = (5 - 3(3/5))(5/4) = (5 - 9/5)(5/4) = 16/5*5/4 = 4$,
$x' = (4- 5(4/5))(5/4) = 0(5/30 = 0$.

Event (10,0) ->
$t' = (10 - 0(3/5))(5/4) = 50/4 = 12.5$
$x' = (0 - 10(3/5))(5/4) = (-30/5)(5/4) = -30/4 = -7.5$

Confirmation of same invariant proper times of all 3 path segments in outgoing frame:
Earth inertial path. $d\tau = \sqrt{((12.5)^2 - (7.5)^2)} = \sqrt{(156.25 - 56.25)} = \sqrt{(100)} = 10$
Space 1st leg. $d\tau = \sqrt{(4^2 - (0))} = 4$
Space 2nd leg. $d\tau = \sqrt{((12.5 - 4)^2 - (-7.5)^2)} = \sqrt{(72.25 - 56.25)} = \sqrt{16} = 4$

Calculation of Earth time seen at turnaround in *outgoing space frame*.
In the frame of the space twin's first leg, Earth's path is from (0, 0) to (12.5, -7.5). So when the space twin's dt = 4 at turnaround the dx of Earth's path will be 4 (-7.5/12.5) = -2.4. So using $d\tau = \sqrt{(dt^2 - dx^2)}$ the apparent Earth time at turnaround will be $d\tau = \sqrt{(4^2 - -2.4^2)} = \sqrt{(16 - 5.76)} = 3.2$.

Transformation to frame of return leg of space twin:
The Lorentz transformation to the frame of an arbitrary path requires the start of the path be coincident with the origin. So prior to applying Lorentz transformations we first linearly transform the start of the 2nd leg path to the origin by subtracting its t, x values in the Earth frame from all events in the diagram.
Subtracting t = 5 and x = 3 the coordinates of the three points become
Event (0,0) -> (-5, -3)
Event (5,3) -> (0,0)
Event (10,0) -> (5,-3)

We can now apply Lorentz transformations to convert all 3 events from the Earth frame to the return leg frame of the space twin:
$t' = \gamma\,(t - xv)$, $x' = \gamma\,(x - tv)$ where $\gamma = 1/\sqrt{(1-v^2)}$ and $v = -3/5$.
$\gamma = 1/\sqrt{(1-9/25)} = 1/\sqrt{(16/25)} = 1/(4/5) = 5/4$

Event (0,0) -> (-5,-3) ->
$t' = (-5 - -3(-3/5))(5/4) = (-5 - 9/5)(5/4) = (-34/5)(5/4) = -34/4 = -8.5$,
$x' = (-3 - -5(-3/5))(5/4) = (-3 - 3)(5/4) = -7.5$

Event (5,3) -> (0,0) ->
$t' = (0 - 0(-3/5))(5/4) = 0$,
$x' = (0 - 0(-3/5))(5/4) = 0$.

Event (10,0) -> (5,-3) ->
$t' = (5 - -3(-3/5))(5/4) = (5 - 9/5)(5/4) = (16/5)(5/4) = 4$,
$x' = (-3 - 5(-3/5))(5/4) = (-3 + 15/5)(5/4) = 0$

To put the Minkowski diagram back into standard form we now reverse the linear transformation to raise the entire diagram (all 3 events) by adding t = 8.5 to bring the start of the twins' separation back to the origin at t = 0 in the 2nd leg frame.
Event (-8.5, -7.5) -> (0, -7.5)
Event (0, 0) -> (8.5, 0)
Event (4, 0) -> (12.5, 0)

Confirmation of same invariant proper times of 3 segments in return frame:

Earth inertial path. $d\tau = \sqrt{}(12.5^2 - 7.5^2) = \sqrt{}(156.25 – 56.25) = \sqrt{}100 = 10$.
Space 1st leg. $d\tau \sqrt{}((8.5)^2 –(-7.5)^2) = \sqrt{}(72.25 – 56.25) = \sqrt{}16 = 4$.
Space 2nd leg. $d\tau = \sqrt{}(4^2 - 0^2) = 4$.

Calculation of Earth time seen at turnaround in *incoming space frame*.
In the frame of the space twin's second leg, Earth's path is from (0, -75) to (12.5, 0). So when the space twin's 2nd leg dt = 8.5 at turnaround the dx of Earth's path will be 8.5 (-7.5/12.5) = -5.1. So using $d\tau =\sqrt{}(dt^2 –dx^2)$ the apparent Earth time at turnaround will be $d\tau =\sqrt{}(8.5^2 – -5.1^2) = \sqrt{}(72.25 – 26.01) = 6.8$.

Note that the Earth times are symmetrical when the space twin reverses direction to return to Earth. At turnaround in this example there is an apparent instantaneous symmetrical jump from Earth time 3.2 to Earth time 6.8 of 3.6 years due to the non-physical instantaneous acceleration assumed. This disappears when a physically possible acceleration-deceleration is used in which case the change sweeps continuously across the difference.

In this example we can also calculate dλ and dχ of both the Earth and space paths in all three frames and demonstrate their invariance simply since there is only the single deviation connecting the midpoints (same total dλ) of both paths. In the general case we would apply the Lorentz transformation to the events defining the deviation of each leg of a path and use these to calculate dχ in the other frames.

The proper times of all 3 inertial segments are invariant under Lorentz transformations as expected. The Earth path is an inertial path so its intrinsic proper deviation distance $d\chi = 0$ and its $d\lambda = \sqrt{}(d\tau^2 + d\chi^2) = \sqrt{}(100 + 0) = 10$ the same as its proper time since it has no actual spatial deviation. So the dλ and dχ of the Earth path as well as its dτ are all invariant.

In the frame of the first leg of the space twin the interval of spatial deviation of the space traveler's path from its turnaround point to the center point of the Earth path is the interval from (6.25, 3.75) – (4,0).

Since dx > dt this is a spacelike rather than a timelike interval and we subtract the distance in time from the total spacetime distance to get the spatial distance. This spatial distance is the invariant deviation from its inertial path of the traveling twin in the Earth twin's first leg frame.

So the deviation distance in space will be $d\chi_1 = \sqrt{}(dx^2 – dt^2) = \sqrt{}(3.75)^2 – (2.25)^2 = \sqrt{}(14.0625 – 5.0625) = \sqrt{}9 = 3$. And since this the deviation of both the in and out legs of the space traveler from his inertial path, his total deviation from the inertial Earth path for both legs of the trip $d\chi = d\chi_1 + d\chi_2 = 3 + 3 = 6$ the same invariant value it had in the original Earth frame.

And the total distance through both time and space of the space twin $d\lambda = \sqrt{(d\tau^2 + d\chi^2)} = \sqrt{(8^2 + 6^2)} = \sqrt{(64 + 36)} = 10$, the same total $d\lambda$ as the inertial Earth path. Thus both world lines between the separation and reunion events cover the same total distance through space and time, and this is true of all paths between any two events seen from all frames.

A similar calculation gives the same invariant results in the frame of the 2nd leg of the space path.

DETERMINING THE UNIVERSAL CURRENT PRESENT MOMENT

It must be stated up front that most physicists don't accept the idea of a universal current present moment or universal 'now' due to the relativity of simultaneity in which the time of the apparent present moment varies among frames. However we've seen that logic suggests there must be a universal present moment common to the entire universe. A universal present moment also enables a consistent model in which the data state of the entire universe is simultaneously recomputed. This section restates the argument for a universal current present moment, and shows how to find it.

1. We know that everything travels at the speed of light through combined time and space in the coordinates of every frame. This is accepted physics.
2. And everyone continually sees everything, including themselves, traveling through combined space and time at the speed of light. Also accepted physics.
3. Thus everything's world line must be continually extended the same total spacetime distance at the speed of light in every frame. Its total combined distance through space and time is continually extended the same total spacetime distance at the speed of light.
4. For any path in any frame standard relativity states that $d\tau^2 = (dt^2 - dx^2)$. This can be rewritten as $dt^2 = (d\tau^2 + dx^2)$. Dividing through by dt^2 we get $(d\tau/dt)^2 + (dx/dt)^2 = 1$ which is the speed of light in natural units. This says that the velocity in time plus velocity in space of anything along any path = c, the speed of light.
5. And the speed of light is the same in all frames. Also accepted science.
6. Thus $(d\tau'/dt')^2 + (dx'/dt')^2$ in frame 1 = c = $(d\tau/dt)^2 + (dx/dt)^2$ the combined velocities in space and time over all paths in all frames are the same. Thus the total space plus time distances over all paths per unit time are the same.
7. And since the ct and x axes of all Minkowski diagrams are scaled by the speed of light, which is the same in all frames, unit time is the same in all frames (presuming they are scaled in the same units such as light years). Thus the total space plus time distance per unit time of all paths is the same in all frames and all Minkowski diagrams.
8. So the total spacetime distance every world line is extended is the same in all frames. This is also accepted science.

9. However the apparent distribution between distance in space and distance in time can be different from frame to frame. This is due to the relative velocity among frames, which determines the apparent spatial velocity between frames thereby determining their relative velocity and distance through time.
10. Now the distance through time, the proper time, of any path is invariant and the same in all frames. Also accepted science.
11. Since the total distance every world line is extended through spacetime is the distance light travels and the same and the distance through spacetime of a world line is its combined distance in space and time, and the distance in time is invariant, then the distance is space must also be invariant for their vector sum to be equal to the invariant distance light travels.
12. Thus the actual distance through *space* $d\chi$, the proper distance, of any segment of a world line must also be invariant and the same in all frames so that the total distance $d\lambda$ through spacetime between the events defining the path will be the same as light travels along that path.
13. In any individual frame the total space plus time distance over an inertial path defined by two events is $d\lambda = \sqrt{(dt^2 + dx^2)} = dt$ since the total $d\lambda$ spacetime distance traveled of a path at rest in any frame is through time along the t-axis.
14. Using this equation it's easy to calculate that all paths between two events have the same total combined distance through space and time in any frame.
15. This must be true for two separate paths to leave one event in the same present moment and arrive at the second event at the same present moment.
16. This is the only way the total distance through combined space and time can also be the same for all world lines as it's created.
17. Thus by correlating the same step by step total spacetime distance along multiple world lines as they are created we can determine the common present moment and proper time correlations among them.
18. In this manner we can determine the single current universal present moment across all entities in the universe and the unique current proper time correlations they have in each current present moment.
19. *Because all paths advance at the same $d\lambda$ distance in spacetime as light the current universal present moment of all clocks is that in which they have all traveled the same $d\lambda$ distance through spacetime, the same combined distance in space and time $d\lambda= \sqrt{(d\tau^2 + d\chi^2)}$. This is the current location in space and time of all clocks and entities in the universe and the same universal current present moment across the entire universe.*
20. *And the current proper time reading on every clock in the universe in the current universal present moment is the unique proper time correlation among all proper times in this current present moment.*
21. This is because every world line in every frame is continually extended through combined space and time at the speed of light, and every world line in every frame is continually extended the same distance through combined space and time as light travels. Thus there is a unique one-to-one correlation of the proper times of all clocks across the entire universe. These proper times aren't identical but in every current present moment across the universe every clock will have one and

only one proper time. And all properly informed observers will agree on this correlation.

22. So the total combined space and time distance along any path must be invariant, since all paths are created by the same universal process that extends every frame at the same c rate over the same combined space plus time distance as light travels.
23. We know the proper times of all paths are invariant across frames, and the total spacetime distance $d\lambda = \sqrt{(dt^2 + dx^2)}$. Thus there must also be an *invariant proper distance in space* $d\chi$ for all paths since that is what produces its invariant elapsed proper time. An invariant proper distance is the only way the invariance of proper time can combine with it to produce an invariant total spacetime distance.
24. However there is an apparent problem. While the proper times of all paths are invariant across frames under Lorentz transformations, the associated spatial dx distances aren't invariant. This is because the paths themselves are distorted by the transformations. They now have different relative lengths and tilts, and the events defining them have different (t, x) coordinates in the transformed frame.
25. This is due to the relativity of simultaneity in which the view of space and time is skewed from frame to frame. One of the effects is that the apparent current present moment varies from frame to frame, as do the apparent present moment correlations among proper times along their paths.
26. This is why many physicists reject the idea of a universal present moment and proper time correlation. However that belief is illogical in light of the fact that everything travels the same velocity and distance in combined space and time. It also offers no apparent way for a consistent universe to be created or for a computational universe to be consistently created.
27. So here is the argument that I believe demonstrates a universal current present moment or 'now', an invariant proper time correlation of all clocks along their paths in this current present moment.
28. No doubt many physicists will disagree but for now I'll leave them to prove I'm wrong. My logic can of course be falsified by proving that it leads to contradictory results, or that the basic premise itself is wrong. And it may be that even if the premise is correct, and there is a universal present moment, that it may not always be possible to determine it.
29. Meanwhile all of reality including we and our consciousness continually evolves with this creative process of the universe and exists only in this current universal present moment. Thus everything that exists, exists only in the current universal present moment, which is all that actually exists.

DETERMINING THE CREATION FRAME OF A WORLD LINE

1. So everything sees everything including itself traveling through combined space and time at the speed of light over the same distance as light travels in any frame.
2. However if there is relative spatial velocity among clocks each sees this total spacetime distance distributed differently between space and time. The distance

through space due to the relative spatial velocity reduces the apparent distance through time so the total distance through spacetime always equals that traveled by light.

3. Thus changing relative velocity changes the distance in space and this changes the distance through time. And the distance through time determines the relative rate that time passes, clocks tick, and comoving persons age. This velocity and distance through time is the actual rate of progression through time of all comoving processes. It's the actual rate of time itself.
4. Now though the distribution of total $d\lambda$ between space and time depends on relative spatial velocity and the resulting distance in space, the actual elapsed proper time over any path defined by the interval between two events is invariant. The elapsed proper time along any path is simply $d\tau = \sqrt{(dt^2 - dx^2)}$ in any frame and has the same value in every frame.
5. However when one frame is transformed into another frame using a Lorentz transformation the perspective view on space and time is changed. The relative velocity is reversed and the elapsed proper times of all paths remains the same, but from the perspective of the new frame.
6. In the new perspective paths are all distorted in a specific manner. The coordinate values of the defining events have new values, and the figures are tilted and rescaled. But these changes are all such that the elapsed proper time values of the paths calculated by the proper time equation remain the same. We saw how this worked in the Twins example when we calculated the views from the Earth path, and the outgoing and incoming paths of the space-traveling twin.

1. Now since the $d\lambda$ total spacetime distance of all paths is the same, and the elapsed proper time across any path segment is invariant there must also be an invariant *proper distance* $d\chi$ associated with every path. This will be the actual distance in space that produces the actual elapsed proper time distance that combines to equal the total $d\lambda$ spacetime distance along the path.
2. But we know that the apparent dx spatial distance of any path depends on the relative spatial velocity and varies from frame to frame, so this dx cannot be the $d\chi$ we are seeking. So the question becomes how to determine the actual proper $d\chi$ spatial distance for any path.
3. Well since the actual elapsed proper time of any path depends entirely on its own motion in spacetime and not how it's observed, which varies from frame to frame, $d\chi$ must clearly be the dx in the frame that represents the path as it's actually created.
4. And since every clock tends to naturally travel an inertial path in which all its $d\lambda$ is through time, it is clear that it must be a clock's deviation from an inertial path that slows its velocity through time. A clock's *deviation from an inertial path* produces spatial motion relative to its own path and the amount of the deviation from its original inertial path produces the actual slower velocity and less distance through time. This deviation from an inertial path is what results in the lesser aging of the space-traveling twin because an inertial path is the path of maximum $d\tau$ distance in time.

5. To paraphrase renowned physicist John Baez of Caltech, “The time dilation of a moving clock is due to its deviation from an inertial path.”

1. So the actual elapsed proper time of any path is determined entirely by its own deviation from an inertial path. And on a Minkowski diagram this is shown as it’s actually created in the frame in which its original inertial path is at rest - in which its original inertial path is aligned with the t-axis.
2. So to find the actual creation frame of any path we simply use a Lorentz transformation to transform it to its creation frame in which its original inertial path is at rest and aligned with the t-axis.
3. For the Twins this is the frame in which the Earth is at rest. Here the Earth is considered to be traveling an inertial path so it’s in its original inertial path, and this is also the original inertial path from which the space-traveling twin’s path diverged. So in the Earth frame both twins are in their original inertial paths, which are identical.
4. Thus this frame shows the actual creation of the paths of both twins. Here the actual current present moment rises horizontally along both paths from separation to reunion, and the current present moment clock reading of both twin’s clocks is that along the horizontal line of the present moment as it rises upward.
5. And in this creation frame the actual proper distance is the deviation from an inertial path for both twins so $d\chi$ does equal dx, but only in this creation frame. Since the lesser elapsed proper time of the space twin was created in this frame dx is the proper measure of the deviation that produced its lesser elapsed proper time.
6. However this will not be the case if we use the Lorentz transformation to switch to the view from either of the legs of the space-twin’s path. Here the original inertial path of both paths along within the Earth path is tilted and the actual present moment line is tilted away from the horizontal. The *apparent present moment* line of this new frame again rises horizontally but it isn’t the *actual present moment* line of the original inertial path frame which is now tilted.
7. But as we saw in our calculation of the Twins the actual $d\chi$ proper distance found in the original inertial path frame once found is also invariant like the proper time under the Lorentz transformation and from these two invariant values we can determine the $d\lambda$ values along the transformed paths and reestablish their proper time correlations.
8. And since it’s the horizontal correlation of $d\lambda$ values that confirms we are in an actual creation frame that accurately displays the creation of multiple paths in the common present moment we confirm it was the original inertial path frame that is the creation frame.
9. So the rule is simple. To find the actual common current present moment and correlation of proper times in that present moment, we simply transform any path or pathset so its original inertial path is at rest in the reference frame. Only in this frame does the actual present moment rise horizontally at a constant rate across these frames, and only in the original inertial path frame are the actual proper time correlations of all clocks aligned with the current present moment as it advances upward in time with the creation of the paths at the speed of light.

COMBINING THE ROLES OF CREATION AND PERSPECTIVE

1. Now we've said that the elapsed proper time of a path is due only to its own motion through space, not to how it's observed, specifically to how much it deviates from its original inertial path.
2. However we also know that the elapsed proper time over any path is given by $d\tau = \sqrt{(dt^2 - dx^2)}$. And once that elapsed proper time is determined it's invariant in all frames. So it might seem that the first measurement of elapsed proper time, whatever it is from whatever frame is what actually determines its value. This would be in direct contradiction with the principle that it's entirely due to its own deviation from an inertial path. If that were true how could an initial measurement from any arbitrary frame of any arbitrary tilt produce a proper time value that then remains invariant in all subsequent frames?
3. Again in relativity the answer is simple but subtle. *The amount of elapsed proper time measured at any tilt is over a different portion of a path* than that created by a different tilt.
4. The actual space and time components of every path are created by its own motion through spacetime relative to its own original inertial path such that its $d\lambda = \sqrt{(d\tau^2 + d\chi^2)}$.
5. Consider a completely inertial path which has no $d\chi$ and whose total spacetime distance $d\lambda$ is entirely through time so that $d\lambda = d\tau$ in its own frame.
6. The path itself is created by its own progression through spacetime. But it can be viewed from any arbitrary reference frame with any relative velocity such that $0 \leq |v| < c$.
7. This frame view will see the original path with its space and time components redistributed by the relative spatial distance dx produced by its relative spatial velocity. The spatial distance dx produced by the relative velocity will appear to reduce some of the original path's distance through time so its total distance through spacetime $d\lambda$ remains the same.
8. Thus the reference frame will see the original path's space and time components redistributed as $d\tau = \sqrt{(dt^2 - dx^2)}$ where dx is the relative spatial distance and $d\tau$ is the reduced portion of the original $d\tau = d\lambda$ time along the original inertial path that remains in the view of the reference frame.
9. Now there can be any number of arbitrary reference frames with various relative velocities which each view the same original path from different angles with different apparent redistributions of its space and time components.
10. Because the actual elapsed proper time over the original path is its total spacetime length, the time lengths seen at different angles will be various shorter portions of the original path's total time length. They will be precisely that portion not seen as distance in space from their perspective.

1. So each different frame view sees the original all through time created path redistributed into space and time distances depending on its relative velocity to the created path.
2. And each different frame view measures its redistributed view of the original path in terms of the dt values of the start and stop events it uses to define the view. These events define the dx space and dτ time length of the viewed portion of the original time the new frame sees. These events define the dτ time length of the path portion seen.
3. So each frame view defines a new path having a new dτ time distance that is only its mapped portion of the actual time along the original created path. The frame view sees the entire original path, but from a perspective that sees part of its original distance in time replaced by the distance in space produced by its relative velocity.
4. So a new frame view sees only a reduced portion of the actual total elapsed proper time over the entire original path. It sees only that portion of time it doesn't see as the distance in space produced by its relative motion.
5. And this reduced portion of the total elapsed proper time of the original path seems to pass at a slower rate because it covers the same apparent present moment distance of the reference frame's clock as its own time. Less time on the original clock covers more time of the reference clock so it must pass at a slower rate over the same apparent present moment time.
6. So the start and stop events of the view of the reference frame of the reduced portion of the original elapsed proper time of the original path define a new view path, which is a partial path defined as only the lesser elapsed proper time.
7. Once defined by the view this shorter time piece of the path is invariant. In other words this particular shorter portion of the original path is invariant in the sense that the elapsed proper time over this shorter portion of the original path between the start and stop events that define it will have the same proper time distance in any frame.
8. Given the total dλ length of the original path which is all in time, the proper time length between any two points along that path must obviously be the same actual length in time since there is only one actual original path with its own actual time length along which actual time is passing at a constant rate. Thus the actual elapsed time between any two points on this path must always have the same value no matter who is viewing it. There is only one clock that actually exists creating the original path and it only has one actual clock time reading at every point along its path, and between any two events along the path.
9. So whatever shorter portion of that clock time the defining event points of any view, the dτ elapsed proper time between those two events will be invariant in all frames because they refer to actual points on the original path which has only one actual time progression.
10. So what the view of an arbitrary reference frame does is to define two event points along the time line of the original path and define that as a new portion, and the time it sees between these two events is invariant because it defines an actual portion of the original single path with its single actual time scale.

11. This is why once two events are used to define a specific set portion of the time along the original path, that same portion must have the same length in time in any frame no matter from what relative velocity it's observed. This $d\tau$ elapsed proper time length is something that is actually happening only along the original path. The view from another frame doesn't change the actual progression of time that is occurring only along the original path, it just selects a different portion of its total time. Specifically it selects the portion it didn't see as dx distance in space in its own view of the original path.
12. This is why the view of an arbitrary frame *may seem* to determine the actual lesser proper time of a path. It's actually not determining anything; it's just selecting the time part of the original path it doesn't see as dx spatial distance from its perspective. But once defined any portion of the actual time along a path will remain the same under the Lorentz transformation from frame view to frame view.
13. Since the original path and its elapsed proper time as created by its own motion through spacetime are fixed, any selected portion of that proper time must also remain fixed.
14. So every path is indeed created by its own motion through spacetime, but any arbitrary view of that original path selects the portion of it not seen as spatial distance, and as any portion, that portion of the original path is also invariant. This selected portion is then considered a new path that is also invariant since it's actually just a selected portion of the original invariant path.

1. This also explains the so-called '3rd twin'. The 3rd twin is a completely inertial clock that parallels the first leg of the space twin. As with all paths its actual elapsed proper time is determined entirely by its own spacetime path. In this case all its total $d\lambda$ spacetime distance is through time since it is always on its original inertial path and never deviates from it so its actual $d\tau = 0$.
2. However by the standard $d\tau$ equation it will have the exact same lesser elapsed proper time as the space twin in the Earth frame view. However there is no actual deviation from an inertial path as there is with the space twin.
3. This '3rd twin example', which has no acceleration since its inertial, is often used to claim the acceleration of the space twin don't actually produce its time dilation since there is no deviation from an inertial path for this clock. Thus getting the same results as the space twin's path, which does deviate, shows there is something more involved here than deviation.
4. As shown above this is just a case in which the perspective view matches the actual view. The Earth frame just selects the time portion of twin 3's path it doesn't see as distance and this just happens to be the same portion of the space twin 2 that is actually in time due to its own actual $d\chi$ being the same as the dx perceived distance of twin 3's path in this case.
5. But twin 3 has actually progressed 2 light years beyond the turnaround point of the space twin in its own frame since all its actual motion is inertial in time and it doesn't actually turn at the turnaround point.

6. So the space twin actually travels 3 light years in time and 4 in space during its outgoing leg, and then turns around. But during the same time twin 3 actually travels 5 light years in time along its original inertial path including 2 years beyond the turnaround point. Its time rate and distance to the turnaround was the same as the actual 3 light years of the space twin since its relative velocity was the same as the actual relative velocity of the space twin relative to its actual original inertial path which we recall is the same as the Earth path.
7. So in this case where the actual time length of one path is the same as the perceived time length of another path, the reference frame selects that portion of the actually longer time length of the inertial frame that matches the actual time length of the space twin's frame.
8. This is why the inertial 3rd twin appears to have the same proper time over the same path as that of the space twin. It is just a matter of the Earth frame selecting a matching proper time length from a longer time path.
9. This is the solution to the case of the 3rd twin.

1. Now if the original created path isn't inertial the process is essentially the same. In this case the original path will have an actual reduced elapsed proper time due to its own deviation from an original inertial path as in the case of the first leg of the space twin.
2. Now this path, like any path, can then be viewed from any arbitrary reference frame at any arbitrary angle depending on its relative velocity.
3. There are 3 cases here. Suppose the view angle of the reference frame is the same as that from the original path's original inertial path. In this case the apparent viewed reduction in total elapsed proper time will be the same as the actual reduction due to the original path's own deviation from its original inertial path. The selected path will be identical to the originally created path.
4. This is the case of the view from the Earth's reference frame of the legs of the space-traveling twin's path. The actual space and time distribution of the total $d\lambda$ spacetime distance of the space twin is due entirely to his own deviation from an inertial path. However the inertial path of the Earth is identical to the space twin's original inertial path. Thus the view of the elapsed proper times of the space twin is exactly the same as its actual elapsed proper times over the same paths.
5. However if the relative velocity of a reference frame is greater the apparent spatial distance will be greater and it will see only a smaller portion of the elapsed proper time of the first leg. The time interval seen will be only a shorter portion of the actual proper time of the full leg. And this shorter time, defined by the events of observation, is invariant because it's a fixed part of an actual elapsed proper time.
6. On the other hand if the relative velocity is less than that of the space twin's actual deviation from its original inertial path, then the view selected will be greater than the actual $d\tau$ along the first leg. In this case the $d\tau$ the view selected would be longer, and the proper time of this new longer path would theoretically extend past the turnaround event of the space twin's actual first leg.

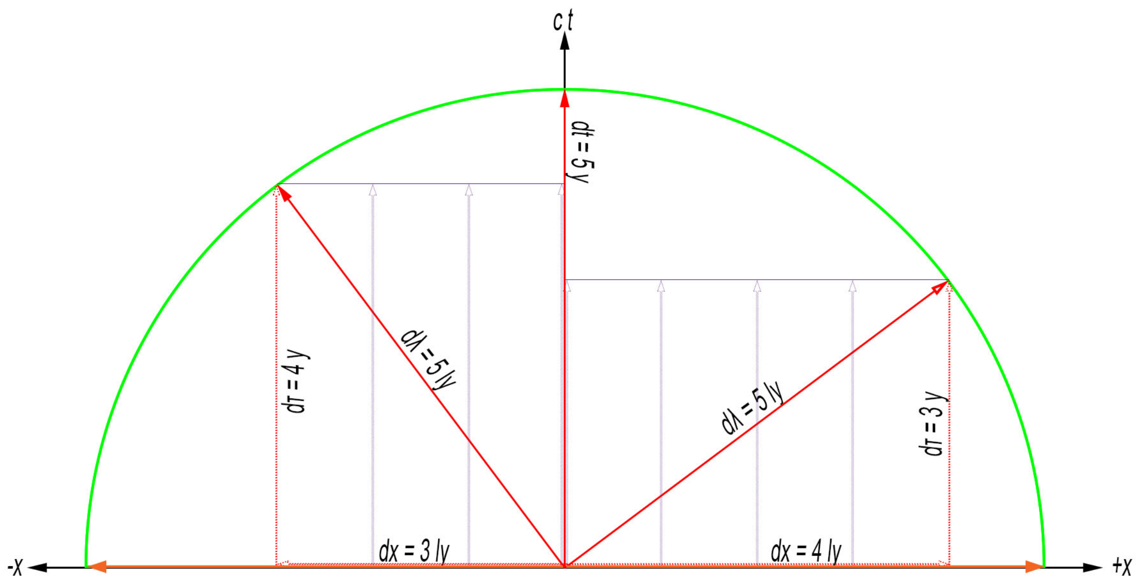
7. In actuality the corresponding dt of the reference frame is typically reduced so it coincides with the actual invariant dτ of the complete leg. We see this in our example when the Lorentz transformation from the Earth view to the view of the first leg of the space-twin frame ended up with a dt of only 3, the actual invariant proper time of the first leg. The corresponding dt of the reference frame was reduced from 5 in the Earth frame to only 3 in the first leg frame. And since all Minkowski diagrams have the same scale this is an actual reduction.
8. In general this is true of all Lorentz transformations. If the new reference frame saw only a portion of an original frame's invariant dτ over some path the transformed frame's dt will be reduced to that value.
9. And the reverse will occur when a Lorentz transformation takes us from the view of an actually shorter elapsed proper time due to its own deviation, such as the first space leg, to that of a frame with a greater elapsed proper time such as the inertial Earth path. In a Lorentz transformation from the first leg frame back to the Earth frame the dt would go from 3 back to 5 in the example.
10. So this clearly demonstrates how various frame views select portions of actual original time lengths that aren't seen as distance in space due to relative motion, and how these relate to the lesser proper time produced by actual spatial deviations from an original inertial path. All this is illustrated in Fig. 2, where the shorter portion of a path measured at some particular relative velocity is shown as it slides horizontally across the diagram in multiple frame views.

1. Lorentz transformations contribute to the confusion here. Every frame view in every Minkowski diagram shows the relative spatial distance and its effect on the viewed proper time of any path. However when we use the Lorentz transformation to convert to a new frame only the viewed dτ elapsed proper time of paths are kept invariant. The Lorentz transformation essentially disregards the dx spatial distance since that may be different from frame to frame, and calculates a new dx from the perspective of the new frame.
2. Thus only the dτ time length of the original path is transformed to its same invariant value in the new frame and the dx space length that produced it is ignored. Thus it may seem that the spatial distance and total spacetime distance aren't important since they aren't explicitly considered in the transformation. It just considers the dτ time portion of the whole actual dλ path.
3. But this enables us to see what's actually happening. When we transform to the view of the first leg we see its dt length is only 3 in the new frame rather than its actual dλ = 5 length in its own actual creation frame. So clearly its actual invariant dχ = 4 has been disregarded. So Lorentz transformations don't explicitly preserve the entire dλ spacetime lengths of the paths they transform, they consider only the invariant dτ time length seen in the frame view they are first measured in.
4. In spite of this the information is not lost and as we saw in the Twin's calculation, the total invariance of the entire original path is preserved and can be recovered.
5. We can visualize this by progressively applying Lorentz transformations from twin 3 along the original path of the first leg of the space twin through frame views with progressively less relative velocity until we reach the frame view of

the twin 3 path itself. The initial $d\tau = 3$ of the path defined by synchrony with the start and turnaround events is invariant and preserved as the diagram is tilted to vertical. However the initial apparent dx spatial distance of the path between these events is progressively lost until it vanishes as the path becomes vertical.

6. This shows how Lorentz transformations distort what actually occurs in favor of what changing frames actually see in their various perspective views. The original actual 5 light year path of twin 3 during the same 5 light year path of the Earth frame has been reduced to that of only its originally observed time distance. This shows that only a 3 year portion of the original 5 year path was selected and transformed from frame to frame.
7. We always need to remember the difference between what is actually happening to time in an original frame and how it's being seen or calculated from another frame. This becomes even clearer in Concentric diagrams.

FIGURE 2: CONCENTRIC DIAGRAMS



Concentric diagrams

Concentric diagrams show how all spacetime paths advance the same dλ spacetime distance while having different distances through space and time. Here the equal length red vectors show the paths of 5 different objects from a common origin event to the common current present moment surface of the universe in green. Because the objects are in relative motion they are seen with different distributions of motion in space and time determined by the spatial distances produced by their relative motion.

Here the ct time axis is vertical, and the x-axis is horizontal. The vertical red vector is that of the current inertial reference clock at rest in the diagram, since it has no spatial motion relative to itself The red orange paths from origin to the present moment surface along the x-axis are light beams which always travel all their total dλ spacetime distance as ct distance in space since they have no intrinsic advances in time.

The Pythagorean equation of all 5 spacetime paths is $d\lambda = \sqrt{(d\tau^2 + dx^2)}$, so that $d\tau = \sqrt{(d\lambda^2 - dx^2)}$, and $dx = \sqrt{(d\lambda^2 - d\tau^2)}$. Velocities of paths relative to the reference clock are $v = dx/d\lambda$, and obey the relativistic addition of velocities $v = (v' + u)/(1 + v'u/c^2)$ so that $0 < |v| < c$. Thus one frame is transformed to another simply by adding velocities.

Once a proper time is defined by a measurement between events on a world line it remains invariant in all frames since it's a fixed portion of the time. The actual distribution of the world line's time and space continue to vary in different frame views but the defined portion remains the same. This is shown by the identical dτ heights of the vertical purple lines under different relative velocities.

Concentric diagrams show how all clocks continuously advance the same dλ present moment time through spacetime as light, but due to their relative motion the perceived distribution of that distance between space and time varies.

CONCENTRIC DIAGRAMS - ACTUAL EQUAL LENGTH WORLD LINES

1. I've created what I call 'Concentric diagrams' to clearly illustrate the actual percentage relationships between space and time along a path and how they change with frame views. Concentric diagrams enable us to easily visualize the actual dλ total spacetime distance all paths travel and how the perceived distribution of space and time changes with relative velocity.
2. Concentric diagrams have the advantage of preserving the full total identical dλ spacetime lengths of all paths while simultaneously showing the distribution of that full dλ length into distance in time and distance in space in the view of any frame. Thus they clearly illustrate the underlying principle of how time actually works in special relativity.
3. Minkowski diagrams and Lorentz transformations are still needed to portray and calculate how different frames actually observe other paths.
4. A Concentric diagram represents spacetime paths beginning in an arbitrary common origin event with different relative velocities to the chosen reference frame which is aligned along the t-axis. As with Minkowski diagrams the ct axis is vertical and the x-axis is horizontal.
5. Since all paths actually advance at the speed of light all paths have the same radial length, representing the identical dλ distance they've traveled through spacetime. All paths have the same actual dλ total spacetime length. So the current present moment of the diagram is a concentric half circle expanding around the upper hemisphere at the speed of light from the origin. As the present moment expands it advances the current present moment point of each radial path along with it.
6. The equation of each radial path is $d\lambda = \sqrt{(d\tau^2 + dx^2)}$; the elapsed proper time $d\tau = \sqrt{(d\lambda^2 - dx^2)}$, and the distance $dx = \sqrt{(d\lambda^2 - d\tau^2)}$. This is just the Pythagorean theorem where dλ is the current identical space plus time radial length of all paths. dχ is its projected length along the x-axis, and dτ is the height of a line dropped from the end point to the x-axis. In Concentric diagrams as opposed to Minkowski diagrams the actual length of dτ is accurately shown. So each radial path has the same dλ total spacetime length, which is distributed among its distance in space and distance in time depending on its tilt from the t-axis, which is determined by its relative velocity. This is the true picture of spacetime paths from the perspective of a reference frame.
7. In Minkowski diagrams dτ is usually incorrectly shown along a path as if it were the actual total length of a path when it's actually only the *time length*. It should more properly be shown as its actual length rising from the x-axis towards the end point of the path. In Minkowski diagrams this partial length is implicitly lengthened up to the end point of the path to represent its shorter time length in the same apparent present moment time. This fudge is unnecessary in Concentric diagrams where actual dτ lengths are accurately portrayed.
8. The vertical path along the t-axis is the currently chosen reference frame, and the angles of all other paths relative to the t-axis are due to their relative velocities. Any chosen reference frame will see the paths of frames in relative motion advancing at an angle in spacetime to its own trajectory due to their relative velocities. Any relative velocity produces a distance in space that reduces the

apparent distance through time a path travels so they always vector sum to the same actual $d\lambda$ spacetime distance every path actually travels. A Concentric diagram shows all these aspects of special relativity accurately.

9. In a Minkowski diagram the relative velocity of any path relative to the reference frame is $v = dx/dt$, where v is expressed as a percentage of the speed of light c. This velocity produces an elapsed proper time of $d\tau = \sqrt{(dt^2 - dx^2)}$. The velocity that produces the same elapsed proper time in a Concentric diagram must be the same. To find the relative velocity of a path in a Concentric diagram we note that $d\lambda = dt$ along the t-axis in a Minkowski diagram because they both represent the total spacetime length of a path when it's all in time. Thus the relative velocity of a path in a Concentric diagram is $v = dx/d\lambda$.
10. [$dt^2 = dx^2 + d\tau^2$; $v = dx/dt$, so $v^2 = dx^2/dt^2 = dx^2/(dx^2 + d\tau^2) = dx^2/d\lambda^2$. Thus $v = dx/d\lambda$.]
11. Thus to draw a path with velocity v we simply draw a path of radius $d\lambda$ from the origin so its projected length along the x-axis is = dx.
12. As a result, and accurately showing that time and space are actual orthogonal dimensions at 90° to each other, radial timelike paths in Concentric diagrams can have any angle θ where $-90° < \theta < +90°$ from the vertical t-axis.
13. On Concentric diagrams light paths are horizontally aligned with the x-axis at 90° from the vertical t-axis, rather than at angles of 45° in Minkowski diagrams. This accurately reflects that light's total c velocity is exclusively through space, and has no velocity or distance through time. These horizontal paths are fixed in all rotations since light travels at the same constant c velocity through space in all frames, and has zero intrinsic temporal velocity. All its constant $d\lambda$ distance is through space, and if there could be a comoving clock it would never advance.

1. Now instead of the Lorentz transformations used to convert from one frame to another in Minkowski diagrams, in Concentric diagrams all we need to do is simply add or subtract velocities. However we must use the formula for addition of relativistic velocities.
2. This is $v = (v' + u)/(1 + v'u/ c^2)$ where v' is the current relative velocity of any path, u is the velocity added to each paths, c is the speed of light, and v is the resulting velocity of the path. Each resulting path has a $dx = v*d\lambda$ and can be drawn on this basis.
3. The equation above reduces to the standard addition of velocities $v = v' + u$ when velocities are low. However at relativistic velocities the resulting velocity can never quite reach or exceed c. For example, using velocities as a % of light, if $v'=.6$ and the added velocity $u = .5$ we have $v = (.5 + .6)/(1 + .5*.6/1) = 1.1/(1 + .3/1) = 1.1/1.3 = .846$ c.
4. Thus to convert from one reference frame to that of another with current relative velocity .5 we simply subtract u =.5 from all paths in the diagram. Thus the old reference frame will now have a relative velocity of -.5 and the new reference frame will of course have a relative velocity of 0.
5. In all transformations the correct values for elapsed proper time of all paths, as well as the reciprocal nature of time dilation are correctly portrayed on Concentric

diagrams. And we clearly see the determinative effect of relative velocity on this while also preserving the actual total equal dλ total spacetime length of all paths.

6. In Concentric diagrams it's of note that dτ = dλ*sin α and dx = dλ*cos α, where α is the angle of a path above the x-axis. dx values are of course negative in the upper left quadrant.

1. Now the beauty of Concentric diagrams is that as relative velocity changes and paths rotate around the origin we clearly see the actual distribution of their perceived dτ and dχ time and space components change as they actually do with changes in relative velocity. The percentage distribution of space and time distances, dτ*100/dλ in time, and dx*100/dλ in space, changes as the total dλ spacetime length of the path remains the same.
2. Now as we have seen on Minkowski diagrams each view of a path in relative motion selects a reduced dτ time portion of the total path defined by the start and stop events of the selection, basically its start and stop t values..
3. So suppose on a Concentric diagram where the common dλ radial length of all paths is 5 light years we view a path that is slanted so that its apparent distance in time dτ is 3 light years. Since this view it the path has a distance dx of 4, the reference frame only sees a distance in time of 3 instead of its total distance through time of 5.
4. So this view of that path defines a path with a reduced proper time length of 3 for this path, which has an actual length of 5 in time in its own frame.
5. On a Concentric diagram the proper time invariance of this dτ = 3 path with rotation is shown by merely sliding the vertical dτ =3 along the x-axis as we rotate all radial paths through any angle.
6. The apparent space and time distribution of the path's total dλ changes as the view is rotated but the invariant vertical dτ = 3 line of that view remains the same height as it slides across the diagram even as the viewed dτ of that path changes in height as its path is rotated.
7. As the relative velocity changes relative to the reference frame, the time portion of a selected path rises higher or lower along the current dτ rotation value. Again whatever dτ portion of the path is selected by a view it will also create a new invariant path whose invariance slides across the diagram from the t-axis to???. This shows how the apparent dχ and dτ of a path of fixed current length change with θ but the invariant dτ of any particular selected view maps to lesser or greater portions of it or is equal when the angle is that of its actual dτ in its own creation frame.
8. This is the portion of the actual proper time of a clock traversing that path that the reference frame actually sees due to the dx of the perspective view that it has of this clock. This is reflected in the slower apparent time dilation of a clock traversing that path. So this dτ= dλ-dx is the real actual proper time of a clock traversing that path with that dτ at that angle.
9. If the reference frame is the actual original inertial path a Concentric diagram shows the actual dτ and dχ of a path. Otherwise the dτ and dχ are those due to the relative motion with respect to the reference frame. In the case the relative motion

is the same as in the creation path, as in the case of the 3rd twin, these dτ's will be the same.

10. So to compare actual versus perceived effects, compare any path in its original inertial path reference frame with its view in any arbitrary frame and note how the perceived versus actual dτ's compare. In general the perceived dτ will be an identical or shorter portion of the actual dτ. However any selected portion of an invariant elapsed proper time proper time will itself be invariant since the identical portion of an invariant path must also be invariant.
11. Thus Concentric diagrams reveal the complete underlying relationship between relative velocity, and the distribution of spatial and temporal distances of paths which all have the same total distances through spacetime dλ.
12. While concentric diagrams show only paths that originate in a common origin, it is probably possible to show other paths by moving the origin to their start point. I'll leave this to others to explore.

GENERALIZING MINKOWSKI DIAGRMS

1. Minkowski diagrams correctly illustrate the actual frame views, and proper time and time dilation calculations of any number of world lines of any complexity, both inertial and non-inertial.
2. There are two general principles. The first principle is that the actual elapsed proper time of any clock depends entirely on its own path through space and time, specifically its amount of deviation from an inertial path.
3. The second is the principle describes how any frame views the space and time of any other frame. This depends entirely on the relative spatial velocity between the frames. We leave the issue of signal transit times between moving frames, an entirely separate issue, to its eponymous section.
4. The actual elapsed proper time of any clock depends entirely on its own motion through spacetime, not in the least on how it's being observed by any observer. However elapsed proper time is invariant and all observers will also see the same elapsed proper time in their frame. If a clock follows an inertial path all its constant spacetime distance traveled is through time. Thus (in flat spacetime) time passes at the same rate on all inertial clocks in their own frames. However to the extent it deviates from an inertial path a clock travels a shorter distance through time due to the distance it deviates from an inertial path in space. This is what happens to the space-traveling twin.
5. The easy way to calculate this is to plot the clock's path on a Minkowski diagram with its original inertial path aligned with the vertical t-axis. This makes its deviation from that inertial path easy to calculate as values of dx in the reference frame.
6. At every inflection of the path due to any change in spatial velocity extend a horizontal line from the inflection point to the x value of the previous inflection point. The length of that dx_i is the spatial deviation of that section of the path from

the inertial path, $dx_i = x_i - x_{i-1}$. The elapsed proper time along section i of the path will be $d\tau_i = \sqrt{(dt_i^2 - dx_i^2)}$.

7. The total elapsed proper time at any point along an arbitrary path will be the sum of the elapsed proper times of its inflected segments up to that point. The total elapsed proper time of any arbitrary world line of n segments will be $d\tau = \mathbf{\Sigma}^n_{i=1}\sqrt{(dt_i^2 - dx_i^2)}$.
8. This equation describes both inertial paths with no inflections and any non-inertial path or any combination of inertial and non-inertial segments because any non-inertial world line can be subdivided into inertial segments.
9. It's also true of curved segments produced by accelerations. In this case we just integrate over the curves to get the amount of spatial deviation from the inertial path of each segment i. This works on the same principle since integration essentially divides curved lines into straight sections of unlimited shortness.
10. So in the most general case we integrate over the entire path and have $d\tau = \int^n_{i=1}\sqrt{(dt_i^2 - dx_i^2)}$ for the total elapsed proper time of a clock over any arbitrary path to any arbitrary end point calculated in a frame in which the original inertial path the clock deviated from is at rest.
11. Though the choice of a start point is also arbitrary it should encompass the initial inertial path deviated from to correctly obtain the total elapsed proper time.
12. In addition if we know the actual clock setting at any point prior to or along the path then the clock reading of any point will be that setting plus or minus the elapsed proper time forwards or backwards from that point. If the original clock setting is known we can calculate the actual clock reading of the moving clock at any point along its path in addition to the elapsed proper time at that point.
13. Using the frame in which the original inertial path a world line deviated from is at rest and coincident with the vertical ct axis also provides a direct correlation of total spacetime distances traveled along the inertial and actual paths. In this frame equivalent t values of the two paths correspond to the same total spacetime distance traveled along them, and thus are the *same actual current present moments* along the two paths. This gives the absolute true one-to-one correspondence between the actual current proper times of the two paths, which is invariant in all frames. In the view of the frame in which the inertial path is at rest horizontal lines represent the current total spacetime distance of both paths as the present moment sweeps horizontally upward along the ct-axis. This is the case with the twins.

1. In the most general case the proper time of any arbitrary path or multiple paths through spacetime can be calculated from any arbitrary reference frame in the same manner. The only difference is the results will be the perspective view from the reference frame used rather than the inertial frame deviated from.
2. In this case the present moment correlations of the horizontal ct-axis will be those from the perspective of the reference frame and won't be those of the actual current universal present moment. Instead they will reflect the relativity of simultaneity between the frames.

3. However the proper times, deviated distances, and total spacetime distances are invariant and the same in all frames under Lorentz transformations. Thus they and the actual one-to-one present moment correlations can be calculated in any frame.
4. But only if the frame is that of the original inertial path of a world line will proper time correlations based on the ct-axis be actual and connect the same actual present moments of the frames.
5. However the actual universal current proper times can always be calculated in every frame when the current total dλ spacetime distance traveled along paths is known.
6. So the actual elapsed proper time of an arbitrary path can be most simply calculated from the frame in which the inertial path it has deviated from is at rest. And the view from any arbitrary inertial frame of the elapsed proper time of any arbitrary clock or clocks moving relative to it is calculated in exactly the same manner. But the result is always the view from the coordinate system of the inertial frame used. All frames view the same invariant proper time of all clocks, relative to that frame. But only If the inertial frame is that a world line has deviated from do equal dt values along the paths represent the actual same dλ traveled through spacetime and thus give the actual present moment correlations between the proper times of the two paths.
7. All frames view the exact same actual reality, but from the perspective of their own different coordinate system, whose space and time axes are tilted with respect to each other. Thus the values of the same space and time variables for any particular path will have different dx and dt values from frame to frame.
8. However since what happens to a clock depends only on its own path through spacetime and not how it's viewed, the actual elapsed proper time, deviations, and total spacetime distance of the segments of any spacetime path are invariant and the same in all frames, and can be recovered in any frame when actual dλ correlations can be established.

1. Because proper times are invariant in all frames under Lorentz transformations, so are the deviation distances from an inertial path and likewise the total spacetime distances traveled over any path.
2. However in frames in which the original inertial path deviated from is not the t-axis, the actual true proper time correlations and present moments are not represented by horizontal lines along the t-axis.
3. Instead one needs to calculate the corresponding actual total dλ total spacetime distances along the paths to determine correlations between the actual proper times of the common current present moments.
4. Using Lorentz transformations one just converts the coordinates of the end points of the deviation lines to their coordinate values in the new frame. As in the twin example these will lie along lines that join the same dλ values of the lines. For example in the twins example the line will connect the inflection point of the turnaround to the same dλ = dt value on the vertical axis in the Earth frame. However under Lorentz transformations this line joining the same dλ values will be tilted along with the path segments.

5. Because $dx > dt$ for these lines of deviation they are spacelike intervals so the invariant spatial distances across the deviations will be $d\chi = \sqrt{(dx^2 - dt^2)}$.
6. The total invariant spacetime distance along the inertial path deviated from will simply be its proper time length since that entire path is inertial $d\lambda^2 = d\tau^2 = d\tau^2 + d\chi^2$ where $d\chi = 0$.
7. To get $d\chi$ we could also just subtract the total $d\tau = d\lambda$ of its non-inertial path from the $d\tau$ of its inertial path.
8. The current total spacetime distance $d\lambda$ can also be calculated for any point along the non-inertial path as $d\lambda = \sqrt{(d\tau^2 + d\chi^2)}$, the elapsed proper time plus the sum of the deviations from the inertial path to that point.
9. At this point lines connecting identical $d\lambda$ total spacetime distance will correspond to the same actual spacetime distance traveled along the two paths and connect the actual proper times of the same universal present moments. In this way the actual proper times of any paths that correspond to the same universal current moment can be found.
10. So we can get the actual same $d\lambda$ present moment correlations between two paths in any frame. We simply need to draw a line between the same $d\lambda$ values of any two paths, and then calculate the $d\tau$ proper time values of those two points. These will be the actual proper time values along the two paths they had in that universal present moment.
11. Using this method we can get the *actual* proper time values of all clocks in the universe corresponding the same universal current present moment. Again this is NOT the apparent proper time correlation between moving and still clocks in the perspective of a particular frame, which obeys the relativity of simultaneity, in which proper times appear to occur in different present moments.

1. So proper times, deviation distances, and total spacetime distance along any path can be calculated from any frame and will all be invariant under the Lorentz transformation.
2. However these spacetime paths will have different dt and dx coordinate values of their start, end and inflection points, and will be tilted and scaled differently in the coordinate systems of individual frames. Thus the apparent simultaneity of events will differ in each frame, and thus the *apparent* proper time correlations will differ, as moving clocks appear to tick slower than that of clocks at rest in individual frames.
3. Thus frames don’t directly see the actual correlation of proper times in the same current present moment except when their original inertial paths are the same. However these correlations are invariant and can be calculated using the method described.
4. So everything is at the same current spacetime moment, but not with the same proper time reading. However there is always a current proper time reading on any clock. So the current proper time readings of all clocks in the same spacetime moment is the one-to-one correlation among all proper times for the current universal present moment.

1. It should be noted that frame views of proper time are somewhat similar to how we see past time at a distance in astronomy. We see the real state of affairs of a present moment, but at a past time. In astronomy this is due to the time it takes time to reach us from great distances.
2. How we see time on a relatively moving clock is somewhat similar. We see the actual state of the clock but with a shorter and slower time.. But in this case the reason isn't the speed of light but the fact that we only see that portion of the elapsed proper time of a path that is not through space in the perspective of our frame. So we see the actual present moment of a moving clock at a past time that doesn't reflect its actual current present moment in its own frame unless its own frame has an identical deviation from its own inertial path as that from the perspective of our frame. And this is reciprocally true of how the moving clock views our clock in its frame.
3. However when we add up these effects as for the space-traveling twin we find that the reduced times we see on his clock is his actual elapsed time because our perspective turns out to be identical with his own.
4. Only if we reunite in the same frame will our time dilation and rate of elapsing proper time become the same and can we directly compare our ages and proper time rates and will our time dilations vanish. Then we will both agree from our common perspective that the space-traveling twin has aged less than us because only his world line deviated actually from an inertial path.
5. Only when frames coincide in a common event are observers able to directly compare ages and elapsed proper times absent perspectives, or rather from a common perspective. In different frames observers will have perspective views of each other but all observers see the same total proper time of all paths.
6. So in general it seems possible to determine the $d\lambda$, $d\tau$, and $d\chi$ of any number of arbitrary paths in any arbitrary frame, and certainly the perspective dt, dx view of any number of paths in any arbitrary frame.
7. This general method works for all possible Minkowski diagrams with all possible world lines insofar as I know. For example it works for two twins separating and then meeting in another frame than they separated in. It also works it they never reunite at all or either or each unites with a new clock in its frame. And it works for any number of world lines with any number of inflections. Any imaginable possibility is covered by the simple proper time equation $d\tau = \sqrt{}(dt^2 - dx^2)$.
8. If there are other possibilities not covered please bring them to my attention.

1. The usual twins example assumes the twins reunite in the same frame at the end of the trip. But one can calculate any arbitrary end point anywhere on any world line. For any point on any path, it's the deviation from inertial to that point from an inertial start point that counts. No matter whether the twins ever reunite, or in their original frame or not, or in some other frame, we always use the same simple proper time equation to determine their elapsed proper times.

2. If there is a meeting clocks can compare their elapsed proper times directly. If no meeting they are each stuck in their perspective views of each other's proper times.
3. But in all cases in all frames the dλ, dτ, and dχ of all other frames will be invariant. As will be the current universal present moment of all frames. Because the scales of all Minkowski diagrams are all based on the same invariant speed and distance of light, the actual current present moment proper time correlations of all clocks in the universe will be seen the same in all frames. The relationships of all proper time readings for all clocks in the universe in the current universal present moment will be transitive. If A = B, and B= C, then A = C.
4. This can be confirmed by constructing Minkowski diagrams with 3 paths and using Lorentz transformations to calculate the views of all 3 paths. In all cases dλ correlations can be established the dλ's, dτ's and dχ's of any number of paths will have an invariant 1:1 correlation agreed by them all. Everything travels the same dλ through spacetime as everything else, and the proper times of those dλ's in the universal common current present moment, though different, will all maintain the same invariant relationship in every frame.

ACCOUNTING FOR LIGHT SIGNAL DELAYS BETWEEN MOVING CLOCKS

Till now we've considered the purely relativistic effects on how time is viewed by relatively moving clocks. But of course the actual view by one clock of another moving in space also depends on the time lag of light traveling from the observed clock to the observer. The light lag is an entirely separate effect and can be easily added to the previous relativistic results.

First we ignore the light lag completely and calculate the relativistic results using the previous method to calculate the proper times of moving clocks at any point in any frame using $d\tau = \sqrt{(dt^2 - dx^2)}$. Next the effect of light signal transit time can be simply added if we wish.

Just extend lines 45° upward from points on the world line of the moving path until they intersect the vertical ct axis of the reference frame. Since Minkowski diagrams are scaled by c, light travels 45° upward paths at c so each line will be the path that a light signal from the moving clock to the reference clock takes.

Thus the proper time τ where the line intersects the path of the moving clock is the time on the moving clock that will be seen at time t where the 45° line intersects the vertical t axis. In this manner one can calculate what proper time is seen at every reference time considering the time lag of light signals in addition to the purely relativistic perspective effects.

SURFACE DIAGRAMS - THE UNIVERSAL PICTURE

1. This brings us to Surface diagrams, in which all the world lines of all the objects in the universe are portrayed as they actually are in their own original inertial path creation frames as they are continually created in the common current present moment of the universe.
2. I developed Surface diagrams to show how every path appears in its own original true path format in the common universal surface in the form in which it's actually created in the universal current present moment.
3. Surface diagrams ignore relative velocity and dx values but borrow the common t-axis of all Minkowski diagrams. We can imagine individual paths sliding around the surface in relative motion to each other within their original inertial path frames to keep them vertical rather than tilting with respect to the currently chosen reference frame.
4. Any path in a Surface diagram can be copied and pasted back to a Minkowski diagram by aligning its vertical original inertial path with the t-axis of the Minkowski diagram.
5. Surface diagrams show all paths in the form in which they are actually created at the speed of light on the common universal present moment surface in their true creation paths, while Minkowski diagrams display one or more paths as they appear in a particular reference frame.
6. In a Surface diagram all paths are perpendicular to the universal surface in their own frames with their current actual present moment at the *universal processor time* surface. On this surface the past flows down through them all at the same rate as their paths extend into the past below the surface.
7. Each path continually extends as its past world line flows down into past time at the same $d\lambda$ rate. If inertial it flows straight down and all its total spacetime distance accumulates through proper time. If the path is non-inertial and there are bends or curves in its past those are the actual $d\chi$ deviations it has through space relative to its own original inertial path, which are what reduces the distance it travels through time. So the total $d\lambda$ spacetime distance is distributed between elapsed proper time and proper deviation in space so their vector sum always adds to c.
8. So the actual present moment is the current universal common present moment time surface. And actual proper time correlation between all paths is simply the current proper time of each path at the common surface. Elapsed proper time is calculated down the path curved or straight to some clock setting in the past. So the proper time reading of the clock on the common present moment surface is simply the proper time setting of the clock at some arbitrary point in the past plus the elapsed proper time from there up to the surface.
9. Thus the Surface diagram depicts all paths together in their own original inertial paths so their current present moments and proper times can be directly compared.
10. In their own frames all world lines are perpendicular to the surface where they are all being simultaneously created by the recomputation of the universe. See Fig. 4. As a result the past world lines of all frames trail down from the surface into the

past as they are created. Purely inertial world lines extend straight down into the past, but world lines whose paths change with accelerations extend down as bent or curved paths. Because of this they effectively have traveled in space with respect to themselves by their deviation distances from an inertial path and thus have traveled less distance in time.

11. Note however that acceleration doesn't change the total c spacetime velocity of a path. It just changes the distribution of that velocity between velocity in time and velocity in space.
12. Because all world lines continually cover the same total spacetime distance as light into the past, the total length along all world lines into the past to any other current present moment are the same. However because accelerated world lines have some of their distance sideways through space their total *vertical time length* down into the past is shorter. The amount of sideways deviation of a path from its current location on the surface produces a path that extends less distance straight down in time into the past because it deviates some distance sideways in space. However the past current present moment is at the same horizontal level for all world lines as always. It just is at a shorter *time* distance down because it took a circuitous sideways route in *space*.
13. Again as in actuality all world lines are created at the common surface with an identical dλ total distance being produced through spacetime and extending below into the past. Thus the identical past dλ lengths of all paths are the same but if there has been some actual non-inertial motion some of that distance through time has been replaced by distance through space.

1. This is the view of all frames in their own frames, however the view of other frames from any single frame chosen as a reference frame occurs when relative motion stops. Then the native frames stop moving and their motion is simulated by the other frames tilting as they are depicted in Minkowski diagrams. The actual relative motion stops and the reference frame views it as the dx distance in space it produces and the resulting relative tilt of the path.
2. In this case the angle at which the world line is viewed due to relative spatial velocity distributes the actual c velocity between velocity in time and velocity in space in the perspective of the viewing frame as previously described.
3. So individual frame views can be simulated within Surface diagram by pausing the relative motion of frames. Thus Surface diagrams are consistent with both individual frame views and Lorentz transformations by selecting which relative motions are paused, while preserving the frame independent surface view.

1. Surface diagrams work because we can model our 4D universe with one spatial dimension suppressed as the surface of a sphere. The two spatial dimensions are the x and y directions on the surface, and past time is the –ct radial dimension extending from every point on the surface back to the big bang at the center just as we actually see the past as distance back in time in every direction in space.

2. A Surface diagram models the entire universe as a single diagram populated by the world lines of all objects and clocks in the universe.
3. Note that the radial dimension of this universe is that of *present moment time (what I call processor time in my earlier books),* rather than ordinary relativistic proper time. The concept of processor time is explained in detail in my book *Universal Reality 2.0*. Processor, or present moment time, is the universal time in which the data state of the entire universe is recomputed in each tick including the distribution of the constant spacetime c velocity of everything between velocity in space and velocity in ordinary relativistic time.
4. In this manner a new universal current present moment is simultaneously computed for the entire universe in every tick of processor time including all local relativistic proper times.
5. So in every tick of present moment time the constant c spacetime velocity of everything in the universe advances the distance traveled through combined space and proper time of everything in the universe by the same amount that light travels. This is an unimaginably short distance at the scale of the granularity of spacetime that is required for even sub atomic processes to be computed.
6. So long as objects are inertial (assuming a flat special relativity universe) their proper times will all be advanced by the same amount vertically along with the surface in every tick.
7. Since time is an orthogonal dimension perpendicular to the 2-dimensional spatial surface these time distances take the form of vertical vectors perpendicular to the two-dimensional spatial surface in their own frames in which they are at rest.
8. While present moment time gives the universe a fundamental absolute vertical time dimension that produces the universal current present moment, the spatial surface has no absolute coordinate system in the ordinary sense. Within it all motion is relative to the apparent motion of other objects. There is no way to tell if anything is at rest or in motion except relative to other objects.
9. [There is actually a sense in which absolute motion in space does exist. For example in the absolute feeling of acceleration and in what rotation is relative to (Newton's bucket). This is motion relative to the aggregate structure of all particles in the universe. (In my CTOE computational universe this is called the entanglement network and described in *Universal Reality 2.0*.) For now we stick with the usual special relativity view of relative spatial motion among material objects.
10. Though we imagine this universe from the stationary perspective of our own inertial conceptual frame, the actual state of motion of the spatial surface of the universe is undefined. In space there is no absolute motion or absolute perspective. The entire spatial surface is fluid, neither moving nor stationary. From this perspective there is no way to tell if the surface or anything in it is in motion or not. Spatial motion has no absolute meaning, and has meaning only in relation to the motion of other objects.

1. Note that in the Surface diagram model with one spatial dimension suppressed the radial time dimension is clearly a separate orthogonal dimension.

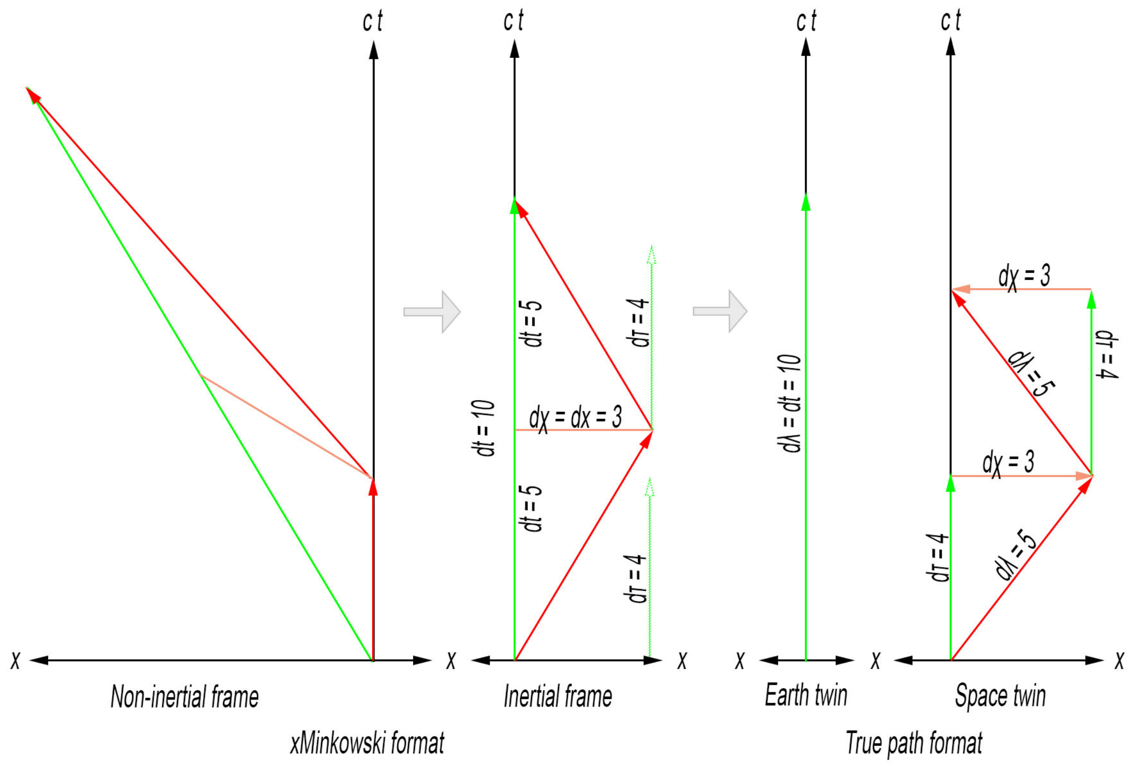
2. But just as the past is in every direction from any point in space in the actual 4-dimensional universe, the future is in every direction from the point in space a clock currently occupies.
3. Thus we intuitively imagine time as advancing in a single 'direction' for everything in the universe but this isn't true for a 3-D view inside a 4-D universe. Time for any clock actually seems to advance in every direction *from the successive points the clock occupies in space along its world line.*
4. So every clock travels through time and thus spacetime from the direction of its own world line. This is because it can't move in space relative to itself so all its motion through spacetime is through time in its own frame, though not in a reference frame in which it's in motion. So the fact a clock's proper time is along its world line reflects both of these realities. Though time is actually another orthogonal dimension, it doesn't appear that way from inside our 4-D universe.
5. This follows directly from the principle that everything continually travels through combined spacetime at the speed of light. If so then obviously it travels through time on the path it takes through spacetime just as it travels through space on the path it takes through spacetime. Everything continually travels through both space and time along the path of its world line.
6. Their relative inertial motions do not alter the fact that the same total spacetime distance $d\lambda$ of all objects advances entirely through time. In each of their own frames $dt = d\lambda$. In their own frames relative inertial motions don't count as actual spatial velocity that reduces the distance that paths travel through time.
7. Thus all objects on inertial paths have their identical common $d\lambda$ distance traveled entirely through time, and thus they travel the same distance through proper time in their own frame as all other inertial objects do. All inertial clocks travel at the same velocity and distance in time as all others do (in a flat spacetime universe).
8. But contrary to an inertial path in which there is no velocity in space in its own frame and thus no shorter distance in time, in an inflected non-inertial frame there is always a spatial deviation in every possible frame view. It's impossible to get rid of it no matter what frame is chosen. Thus in all frames there will be an intrinsic invariant $d\chi$, which is the bent path's spatial deviation from an inertial path, and this deviation from an inertial path will be the same in all frames. So it can be calculated in all frames and will always have the same value, though not the same perspective.
9. Thus in any frame view there must always be less elapsed proper time over an inflected path and there will be the same invariant lesser elapsed proper time in the view of all frames.
10. And since the perspective views of all frames are their actual experienced reality, the reality of the length of any path will be the same in all frames even from their different perspectives.
11. So all views in relativity are perspective views from some inertial frame. All these perspective views see the same invariant $d\lambda$, $d\tau$, and $d\chi$ as each other. But they all see them between the same events with different local dt, dx coordinate values, with different tilts, and different apparent relative scales.

1. *So everything here is simply a matter of perspective. But it's critically important to understand that the perspective view of every frame is its actual experience of reality!* It's not just how objects 'see' or calculate the space and time of other objects, it's how they are actually experienced.
2. *And this is equally true of how any non-inertial clock experiences its own reduced elapsed proper time.*
3. *All objects and clocks not only travel through spacetime at the speed of light. They also experience all other objects and clocks traveling through spacetime at the speed of light. All objects and clocks experience all objects and clocks, including themselves, as traveling through combined space and time at the speed of light, and thus all traveling the same distance through spacetime as light does.*
4. *And this experience of all objects and clocks is the actual reality of how the universe works with respect to time and space. Experience is reality, and experience is a matter of perspective relative to one's native comoving frame*
5. Consider the case of the outward and returning legs of the space-traveling twin with an addition. Now imagine two separate forever inertial clocks traveling alongside the clocks of the traveling twin on the outbound and inbound paths. Both pairs of comoving clocks will register the exact same times using the $d\tau$ equation. So these added comoving clocks will tick exactly the same as the traveling twin's clocks even though they have always been inertial. Thus the Earth frame calculates the exact same lesser elapsed proper time for this pair of added clocks as it does for the space twin's clock. So acceleration and deviation from an inertial path have nothing to do with the lesser proper time they register because there was no acceleration or deviation from an inertial path for these comoving clocks.
6. Thus everything is simply the way perspective views add up the same in all frames. The deviation from an inertial path is simply the value of the amount of proper time, not perhaps actually the cause.

1. *So not only does everything travel through spacetime at c, everything also experiences everything else as traveling through spacetime at c. Perspective is the actual reality of spacetime in the universe.*
7. Everything constantly experiences everything, itself and all other things, as constantly traveling through spacetime at c, and thus everything continually traveling the same $d\lambda$ distance through spacetime as light travels including light. And this $d\lambda$ distance is the same in all frames because the speed of light, and thus the distance it travels, is the same in all frames.
8. But this is all relative perspective of actual constant c spacetime velocity in time of inertial clocks of everything in its own frame. This is clearly actual reality in a clock's native frame as it's the actual proper time on its comoving clock and its actual aging. But the perspective view of relatively moving clocks is also totally actual. It's an actual view of the reality of the space and time of relatively moving clocks. In this sense all views of all frames of all clocks are equally actual. Actual reality is always being experienced in all cases. This is simply how the universe works!

9. So the *view* of every frame of all clocks in the universe is more properly what any clock *actually experiences* as the reality of those clocks. What it sees on its own clock is obviously what it actually experiences. What it sees on other clocks is its actual experience of those clocks also. Everything is actual.
10. Thus the space-traveling twin from the frame of either of its own legs actually experiences that some of its dλ was through space, not time. He doesn't just see or calculate this, he actually experiences it because it is actual and real.

FIGURE 3: CONSTRUCTING SURFACE DIAGRAMS



Constructing Original inertial Path Surface diagrams

Surface diagrams show how paths actually appear as they are ready to be created on the universal present moment surface of the universe. The actual process of creation is shown in Fig. 4. Surface diagrams can be drawn directly or they can be produced from xMinkowski diagrams as shown above.

Basically the process of converting an xMinkowski diagram to a surface diagram is to first convert each pathset into its original inertial path frame using a Lorentz transformation. Converted pathsets can then be copied and pasted into a single universal Surface diagram by separating out each path and converting it from the xMinkowski format into the True path format where the actual path followed is dλ rather than dt over all segments. This correctly generates the actual dλ total spacetime distance all clocks follow as they advance through spacetime at the same c velocity, as well as the correct dτ proper time and dχ proper deviation distances where $d\lambda = \sqrt{(d\tau^2 + dx^2)}$.

Since both xMinkowski diagrams and Surface diagrams are scaled by the speed of light the units will be the same. However individual paths must be aligned correctly along the ct axis of the Surface diagram by determining shared common present moment events among paths as explained in the text.

In this manner how all paths appear in their own original inertial path frames as they begin to be simultaneously created in the universal present moment surface of the universe becomes clear. See Fig. 4 for the actual creation process.

CONSTRUCTING SURFACE DIAGRAMS

1. Constructing a Surface diagram is basically a matter of transforming all world lines into their original inertial paths on a Minkowski diagram, then copying and pasting them into the surface diagram, and vertically aligning their current present moments along the t-axis. Or one can draw them directly if their information is known.
2. First one uses a Lorentz transformation in the Minkowski diagram to successively transform each pathset into its original inertial path frame. Then one copies and pastes each original inertial path into the Surface diagram with any intersection points horizontally aligned along the t-axis. This ensures that common t values are actual universal present moment values.
3. This produces a Surface diagram in which the current horizontal present moment of all world lines sweeps upward at the same universal c rate creating the same length of all world lines trailing down into the past from the current present moment surface at the speed of light.
4. The final step is to convert all paths from the Minkowski format to the *True path format* in which all paths actually exist.
5. Then we see a view of the actual world lines of everything in the universe, as they are being simultaneously created at the speed of light in the current universal present moment extending their world lines down into the past at the same common dλ rate.
6. Since each world line advances vertically in time in its own frame each world line must be individually graphed on a Surface diagram. Twin 1 and twin 2 and twin 3 would all be graphed side by side as individual world lines on a Surface diagram. So the paths of twin 1 and twin 2 would both be copied and pasted from their Earth frame view, and twin 3 would be first be rendered vertical using a Lorentz transformation into its original inertial path and copied and pasted in that orientation.
7. As long as world lines are copied and pasted from the same Minkowski diagram in their original inertial paths they all have the same current present moment alignment.
8. However they must also be correctly aligned along the t-axis of the Surface diagram on the basis of confirmed shared present moments. When world lines share a common event(s) such as the twins' separation and reunion events these are confirmed shared present moments with identical dλ values. So the separate world lines of the twins can now be aligned along the t-axis of a Surface diagram so common events occur at the same current present moments.

1. In this manner all paths that share common events on a single Minkowski diagram, like those of the twins, can be properly aligned along the t-axis on a Surface diagram.
2. Further since all non-parallel paths always intersect in one spatial dimension all non-parallel paths on a Minkowski diagram can be extended until they intersect in a common event and properly aligned on a Surface diagram on this basis. For

more than one spatial dimension common present moments can be determined by sending light signals between original inertial paths. I'll leave this to others to prove.

3. Since all world lines have an original inertial path, all world lines on any Minkowski diagram will have original inertial paths that either intersect at some point when extended or are parallel, so they can all be vertically aligned on a Surface diagram's t-axis on this basis.
4. On any Minkowski diagram if two or more pathsets share no common events first determine their original inertial paths. Then extend these original inertial paths until they meet in a common event.
5. Next successively transform each pathset to its original inertial path and copy and paste it on the Surface diagram so the common events are horizontally aligned along the t-axis.
6. If the original inertial paths on the Minkowski diagram are both vertical they are already co-aligned and can be directly copied and pasted onto the Surface diagram in this alignment.
7. This method provides absolute present moment correlations of all paths.
8. So multiple pathsets on a single Minkowski diagram can be connected simply by extending their original inertial paths until they intersect in a common event. This establishes a verified common present moment between the pathsets that enables them to be correctly aligned along the t-axis of the Surface diagram. When paths meet in a common event we can be assured they meet in the same present moment, no matter the perspective of the current reference frame.
9. Because the twins separate and meet in the same current present moments they must have both traveled the same $d\lambda$ total spacetime distance. Thus we can always determine the same present moment and proper time correlation along their paths unambiguously in a shared event.
10. In general multiple pasted paths may not rise to the same common present moment on a Surface diagram, which is fine since they now reflect their actual present moments and elapsed proper times which may differ. Of course the shorter ones will actually have continuing paths up to the actual current present moment whatever that may be. In any case the overlapping portions will be properly aligned. The diagrams are all relative to an arbitrary present moment anyway. The actual current present moment is arbitrary unless pegged to an actual point on one of the original inertial paths.
11. Their scales will automatically be the same since both Minkowski and Surface diagram axes are scaled by c. In this manner the same actual present moments and associated proper time correlations of all paths are produced on a Surface diagram.
12. We can also combine paths from multiple Minkowski diagrams since they all have identical light scaled axes (assuming their units are the same), but only if we can determine shared present moments from shared events across the diagrams. So it's always theoretically possible. The method works, even if we don't always have the necessary information.
13. This can be done if common events are known across Minkowski diagrams. For example if the same event is represented on paths of multiple Minkowski

diagrams. For example if a spaceship arrived at t = t' on one diagram and t= t" on another we can align both paths on that basis on a Surface diagram (or a single Minkowski diagram for that matter). In this manner all paths across all Minkowski diagrams can theoretically be aligned on a single Surface diagram.

14. It's also possible to add additional verified paths and branches to Minkowski diagrams to establish additional connection across them. Adding light signals is especially useful. Thus it's theoretically possible to determine the universal current present moment and one-to-one actual proper time correlation among all clocks in the universe. This ensures a single unique current present moment that is transitive and invariant among all observers, even though it differs in the perspective of individual frames.
15. To Lorentz transform a path that doesn't begin at the origin to its original inertial path frame, its start point must first be linearly transformed to the origin. Remember we did this before we could Lorentz transform the 2nd leg of the space twin's path. Then the linear transform can be reversed to restore the correct t-axis alignment.

1. Paths can be aligned along the *x-axis of a Surface diagram* on the basis of the relative motion among them. The dx distances are those simulated in Minkowski diagrams by the tilts of relatively moving frames. These mutual tilts are replaced by the relative motions of the actual comoving frames of each path with its original inertial path. When the frames stop sliding around the surface the original inertial path's tilt to simulate the distance from a static perspective, and vice versa.
2. However x-axis alignment is not so important as the main point of Surface diagram's is just to show each path side by side in its original inertial path as it's actually created on the universal current present moment surface of the universe.

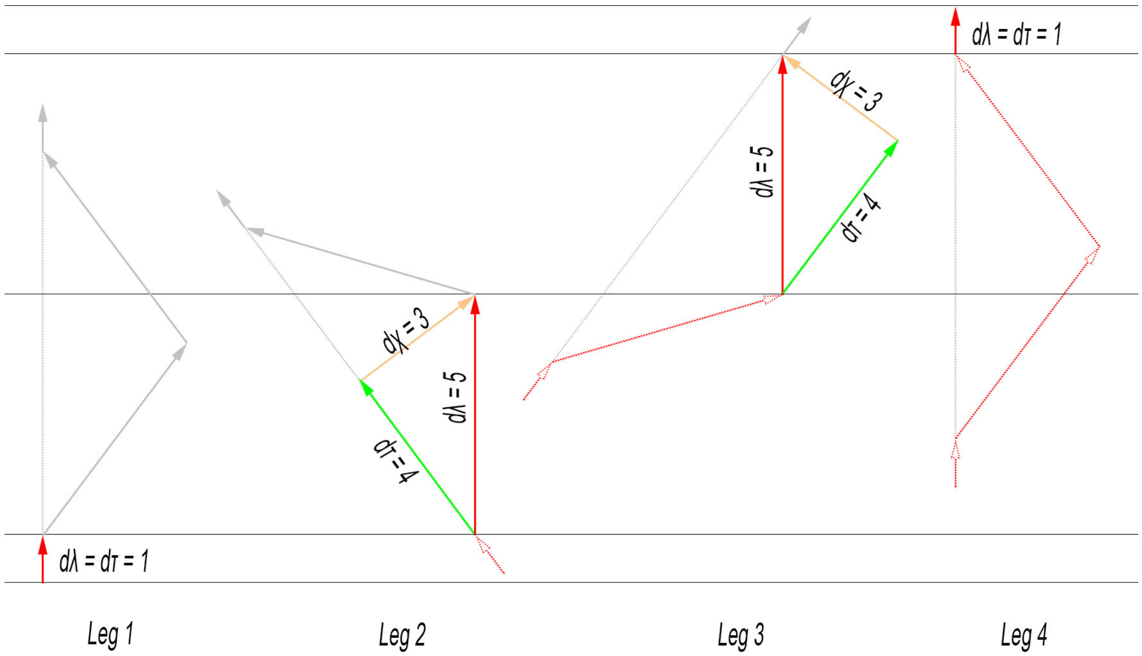
THE TRUE PATH FORMAT

1. The final step in creating a Surface diagram from Minkowski diagrams is to convert all paths into their True path format in which the dλ distances around all legs of a path are the actual spacetime distances traveled as the paths are created.
2. For example the legs of the space twin's path in a Minkowski diagram are merely the result of the dt and dx values of its apparent path in the perspective of the Earth frame rather than the actual dλ distance it travels through spacetime in its own frame.
3. In the True path format the first leg of the space twin's path is the actual dλ of that leg, the vertical projection of that leg on the t-axis is the actual dτ elapsed proper time, and the horizontal component the actual dχ deviation distance in space. This is shown in detail in Fig. 3 where it's compared with the values that leg has in the perspective of the Earth frame.

4. Basically we obtain the True path of the twin's first leg path by reducing the vertical height of a Minkowski representation which represents it from the perspective of the present moment time of the Earth frame. The height is reduced from the Earth's present moment time to its height in its own elapsed proper time. From 10 to 8 years in Fig. 3.
5. This gives us a complete and accurate representation of the True motion of the space twin's first leg because it shows how the complete dλ distance around the entire space twin's path is 10, the same as that along the Earth's inertial path since all paths advance the same distance. But the result of that 10 spacetime distance around its deviations is a vertical elapsed proper time of 8.
6. Finally Fig. 4 shows the actual creation of the space twin's path and shows exactly how motion around a deviated path produces the correct lesser distance in proper time as it's actually created in the same current present moment.

1. The True path format in a Surface diagram is the only representation in which the actual current present moment rises horizontally along all original inertial paths and actual non-inertial paths at the same rate in concert with the actual dλ spacetime distance along all paths. Only here is there a one-to-one correlation with dλ along all paths as they are actually created.
2. Thus this must be the actual view of the simultaneous creation of all paths with their actual dχ spatial deviations that produce their actual invariant dτ's. Only in this view do we see the actual creation process of the three invariants of every spacetime path, dλ, dτ, and dχ. And though there are apparent present moments in all frames this is the only view that accurately reflects the actual creation process, and thus the actual simultaneous creation of all paths in the same universal current present moments.
3. The Surface view with True path formats is a global view of all world line systems in their own original inertial path frames independent of the perspectives of other frames in a manner they can be directly compared as to common present moment and proper time correlations.
4. This is only possible when we understand that everything travels the same velocity and distance through spacetime as light does in every frame and the speed of light is the same in every frame.
5. Thus everything must travel the same velocity and distance as light does, the same actual total spacetime distance as light in all frames. And the total spacetime distance of any path between two events must be an invariant across all frames, as must be its dχ and dτ components.
6. Thus the surface model in the True path format correctly portrays the true picture of the creation of all world lines in the universe, and their relationships.

FIGURE 4: TRUE PATH SURFACE DIAGRAMS



Space twin creation True path Surface diagram

This figure shows the 4 successive legs of a non-inertial path through spacetime as they are created and flow down into the past from the current present moment surface of the universe. The legs are shown in the true path view in which the distance along their original inertial path is in proper time, and the distance around the deviated path is in present moment time. Thus the clock creating the path continually stays on the current present moment surface while present moment time advances 12 units but proper time only advances 10 units. The true path Surface diagram shows exactly how this happens and why everything continually covers the same dλ total spacetime distance but different dτ proper time distances.

As the path deviates from the inertial it travels distance in space relative to its original inertial path, which results in deviated dχ distances of 3 units in legs 2 and 3. These deviated distances reduce the distances in proper time covered to dτ = 4 in each leg. But in each leg the actual spacetime distance dλ advanced is 5 units since $d\lambda = \sqrt{(d\tau^2 + dx^2)}$.

Note if the bends of a non-inertial path are straightened we get a straight vertical inertial path in which the present moment length and proper time length are the same. On the other hand if we put deviations into a straight inertial path the width of the deviations shorten the vertical proper time of the path while its overall length in present moment time remains the same.

Solid red vectors are the current leg being traversed, dotted red vectors previous legs, solid grey vectors legs yet to be traveled. Green vectors are proper times produced by the orange vectors, which are spatial deviations from the original inertial path, which is represented by dotted grey lines. Horizontal black lines are universal current present moment times where changes in motion occur.

True path diagrams show how all paths are actually created at the same rate in present moment time at the common present moment surface of the universe. But if non-inertial they end up with less elapsed proper time due to their deviation in space from their original inertial path during their creation. Notice how the deviation always occurs in the past as the path always turns perpendicular at the surface.

THE SURFACE DIAGRAM CREATION VIEW

1. Though non-inertial paths can be modeled as clocks moving relative to their original inertial path and this works fine, everything must actually advance along its own path that it actually creates by its passage. So in their own frame on a Surface diagram world lines are more properly depicted as their articulated paths continually advancing vertically upward perpendicular at the surface as their articulations continually deviate from the vertical below the surface.
2. In this more accurate view the original inertial path continually deviates as the articulations are created.
3. So the measurements come out the same. The $d\chi$'s created are still the deviations produced by lines from the current position at the surface that intersect the original inertial path at a 90 angle.
4. For example the path of twin 2 initially rises along its original inertial path along with that of the Earth.
5. As it leaves the Earth it continues vertically but the previous segment tilts to the right so that its original inertial path extension now slants to the left of its actual creating clock. Here again the $d\chi$ gradually increases as the space path deviates from its original inertial path.
6. And then when it turns around back toward the Earth its path continues vertically but its past path now tilts toward the right below its current moment point. the $d\chi$ deviation this produces is now given by a line from its intersection with the surface to the now right tilted original inertial path. All in all it all comes out the same as before when we modeled it with the original inertial path rising vertically from the surface.
7. The actual distance in time is still given by the advancing deviation distance in space relative to its own past original inertial path.
8. So in this actual creation view all clocks create their past paths simultaneously at the common spacetime surface, and if there are deviations this produces bends with $d\chi$ spatial deviations relative to their past paths. Otherwise all inertial paths rise at the same rate exclusively through time. In any case all paths are created at the same rate of c relative to their own clocks (since their perceptual time is equal to their local clock time rate) even if they are both slowed, and their same actual $d\lambda$ extension rates of their world lines are all the same, that of the distance light and everything else advances in combined spacetime.

9. Everything actually experiences all of its total dλ in time since nothing can actually move with respect to itself. However if there is acceleration then they have actually moved with respect to their own original inertial path so some of their dλ has actually been in space. So all clocks experience all their constant spacetime velocity in time at c since the perceptual time rate is the same as their actual time rate even if actually have slower velocity in proper time because some of their actual dλ was spatial deviation.
10. Thus everything exists only in the common universal current present moment of continuous creation, and the actual proper times clocks have in this common universal current present moment form a universal invariant one-to-one transitive correlation with which all properly informed observers agree.

THE DEEP HISTORICAL VIEW

1. We can assume as a first approximation that the paths of all particles and particulate objects have original inertial paths dating back to the big bang, and that all world lines in the universe have continually advanced the same distance as light everywhere in the universe since then. Thus there must have always been a universal current present moment in which everything in the universe currently existed, a universal common current moment surface of the universe in which everything that exists was continually recomputed. This universal current present moment is the moment of all existence, reality and consciousness, in which everything that exists does exist. Outside this moment not even nothing exists.
2. The vast majority of objects in the universe will have low relativistic velocities relative to their original inertial paths, and in general will tend to revert to velocities close to that of their original inertial paths through continuing interactions. Thus in general most objects in the universe will have relatively low elapsed proper time deviations from the inertial.
3. However it is reasonable to assume that during the initial inflationary expansion of the universe that everything was moving with respect to everything else at very high relativistic velocities, and as a result proper time in general was advancing at an extremely slow rate. In fact this suggests a new and much more reasonable explanation for cosmic inflation as explained in my *Universal Reality 2.0*.
4. If time throughout the universe was advancing at an incredibly slow rate then the apparent near instantaneous initial expansion could have actually taken much longer and even occurred subluminally. If that is true the universe could also be much much older in current time than we currently assume.

INCORPORATING GENERAL RELATIVITY

1. This new understanding of time in special relativity can be readily extended to general relativity. I won't repeat what I believe the best model of general relativity is here but will briefly mention how it's naturally compatible.

2. The most immediate difference is in the 'Big Picture' when we add gravitation is that gravitation fields are modeled as fields of intrinsic spatial velocity. These fields are 'felt' by objects and clocks within them as spatial velocity that reduces their proper time velocity accordingly; so again the total vector spacetime velocity including the intrinsic spatial velocity of gravitation fields remains equal to c. All the rest follows naturally as this intrinsic spatial velocity is entirely equivalent to linear spatial velocity in its effect on elapsed proper time. In this way time dilation in both special relativity and general relativity are seen as results of the exact same fundamental principle of the constant spacetime velocity and spatial distance traveled.
3. Because the mechanism of gravitational time dilation is the same the results are the same and $d\lambda$, $d\tau$, and $d\chi$ all remain invariant in all inertial frames. And taking this into account the perspective views of different frames work in a similar manner.
4. This entirely new model of mass as fields of intrinsic spatial velocity in the form of hyper-fine vibrations of space itself very naturally explains several unanswered problems in relativity such as *how* the presence of mass-energy curves spacetime.
5. And it also leads to a much simpler but mathematically equivalent flat geometry of spacetime in general relativity in the form of a vibrationally densified flat space. This model portrays spacetime in the way we actually see it, as a flat spacetime through which light curves and objects tend to follow the same curved gravitational geodesics. In this model spacetime itself isn't curved but the paths of geodesics through it are curved along gradients of intrinsic spatial velocity.
6. This model is explained in detail in my book *Universal Reality 2.0*.

SPATIAL VELOCITY = MASS/ENERGY = SPATIAL VELOCITY

1. One of the most profound insights of the Complete Theory of Everything is that energy, and also mass, which is a form of energy are simply different forms of spatial velocity.
2. In this view all forms of energy including mass are simply different forms of spatial velocity, and all types of spatial velocity are always forms of mass/energy.
3. Thus the constant speed of light velocity of everything that exists through spacetime is expressed either as velocity in time, or velocity in space, which is always some form of mass or energy.
4. Specifically masses are fields of intrinsic spatial velocity that reduce the velocity of time within them.
5. Thus the entire fabric of the universe is a single field of greater or lesser combined spatial and temporal velocity whose vector sum equals the speed of light c for all things within spacetime and at all points in spacetime.
6. And the fundamental principle that everything travels through combined space and time at the speed of light c is extended to everything in the universe continually travels through combined space and time at the speed of light c, and all velocity in space manifests as some form of energy including the intrinsic

spatial velocity fields of gravitational mass. Everything in the universe is either velocity in time or mass-energy, which is velocity in space!

7. This original model very simply explains the underlying reason for the conservation of mass and all forms of energy. The conservation of mass-energy is simply the conversion of one form of spatial velocity to an equivalent amount of another form of spatial velocity!
8. How this all plays out is explained in considerable detail in my book *Universal Reality 2.0*.

THE DIFFERENCE BETWEEN SPACE AND TIME

1. Space and time are both orthogonal dimensions of a single spacetime continuum. However there are major differences.
2. Distances in time are actual changes to the thing itself. Distance in space doesn't change the thing itself. It just changes its location not its actual state. Velocity in space is voluntary and reversible. Distance in time is involuntary and always goes only in one direction and isn't reversible. They are both orthogonal dimensions but fundamentally different in nature.
3. This is why $d\tau$ is invariant, because it's an actual irreversible change in a thing itself produced by the continuous irreversible recomputation of everything that exists in terms of its elementary particle interactions. Distances in space are just changes in location of particles and particulate objects relative to the background fabric of the universe or more accurately other particulate objects.
4. Thus clock time only began when the fabric of spacetime gave birth to particles in the big bang. Only separate particles can move with respect to the background fabric and each other. Thus only they can observe each other in the changes their interactions make to their own states.
5. This fundamental mechanism of observation is developed in higher biological organisms through specialized mechanisms to detect, record organize and remember into their simulation world views of their environment. This entire process as well as other differences in space and time are described in detail in my book *Universal Reality 2.0*.

SPACE AND TIME TRAVEL

1. The possibilities of space and time travel are described in *Universal Reality 2.0* in more detail but a brief summary is appropriate here.
2. First because all that exists is the current universal present moment there simply can be no time travel to an actual past or future since neither actually exists.
3. All that exists is the common current universal actual present moment in which everything in the entire universe exists, and is continually recomputed.

4. This completely eliminates the possibility of any time travel paradoxes such as going back in time and killing your own parents before you were born. Reality cannot be logically contradictory.
5. Unfortunately it also eliminates the possibility of going back in time and viewing dinosaurs or changing history for the better. The past is simply gone forever recomputed into the present.
6. So the only possible 'time travel' possible is traveling through the present moment at different velocities and distances in one's own current proper time. This possibility has been extensively confirmed by experiment.
7. Thus an ancient Greek with a spaceship could theoretically have embarked on a trip through space a couple thousand years ago and return to Earth today not too much older than when he departed. And you or I could embark on a similar space journey today and return at some chosen time either near or far in the future not much older than we are now. However this isn't true time travel in the usual sense but just traveling through the continuing present moment at a much slower velocity in time than clocks here on Earth so as to end up in the common present many years from now.
8. And for the same reason very extensive space travel is theoretically possible well within a human lifetime. See the Wikipedia entry *Space travel using constant acceleration* for the amazing distances one could theoretically travel in space at a just a constant 1g acceleration.
9. In any case whatever the details, we and everything else in the universe is always forever traveling at the speed of light c through combined space and time in the current universal present moment. There is simply no getting around this and no other possibility whatsoever.

HOW THE UNIVERSE COMPUTES RELATIVITY

1. A proper computational theory of reality must not only accurately describe how space and time interact in relativity, but also how the universe itself computes that interaction. Observers can compute the relationships between time and space according to relativity, but how does a computational universe actually produce them?
2. In my other books and talks I've extensively described the most promising model of a computational universe and won't repeat them here. However the basic idea is that at the fundamental level the universe actually exists in a pre-dimensional computational space in the same sense as the data of a virtual reality exists in the non-dimensional memory of a game controller, and only appears as a 3-dimensional virtual world active in time in the headset of the VR viewer.
3. In the simplest, and I think most likely model, the actual computational universe exists only as the current data state of all its elementary particles and their entanglement relationships. And at every tick of processor time its entire state is simultaneously recomputed by a universal processor whose ticks each create a new current universal present moment for the entire universe.

4. What observers then interpret as an encompassing universal spacetime is their brain's simulation and reification of the results of their dimensional interactions as a particulate object with other particulate objects as the universe is recomputed in the present moment.
5. A corollary to this view is that the universe must compute how space and time appear in relativity entirely from its immediately prior data state, which consists entirely of the dimension interrelationships among elementary particles. The universe has no historical memory of the previous history of world lines, accelerations, frame views, or deviations from inertial paths and cannot use those to compute its current data state.
6. However the immediately prior states of relative motion, acceleration and relative times is encoded in the current states of elementary particles due to their entanglements produced by the conservation of particle components including their energy and momentums. This data is store in the form one what I call the entanglement network. This data is encoded in the actual current values of the particle components of the particles themselves.
7. Thus the universe must compute the distribution of the constant incremental distance through spacetime entirely on the basis of its immediately previous state in interaction with local forces on the particle scale.
8. The most obvious explanation is the universe just uniformly increments the proper time of all objects and clocks by the same amount in their own frame in the next current present moment. And that the perspective views of frames are emergent views constructed by intelligent observers who are able to recall historical views of other frames in the over time simulations their brains are able to produce of the actual instantaneous universe.
9. The result is the Minkowski diagram big picture described in the previous section. However again it must be emphasized that this model is an emergent mental model that exists in observer brains and most importantly *is thus the actual experience of relativistic spacetime* of human observers. It is the actual experience of the reality of relatively moving clocks whether the observer understands relativity or not.

1. So the current data state of the universe is continually recomputed at the elementary particle level in terms of individual particle interactions. These produce entanglement relationships stored in the particle component values of all particles relative to the other particles they have interacted with.
2. Thus the elemental program that computes universe in terms of its particle interactions knows the relative space and time velocities of all particles relative to those they have interacted with in their last interaction.
3. It can now calculate the velocity in time and space of all particles on a local relative basis.
4. As explained in detail in my book *Universal Reality 2.0* everything in the universe is simultaneously computed in computational space at the elementary particle level using a fixed number of processor cycles in each tick of processor time. The

velocity in space is first calculated and the particle is relatively relocated in computational space on that basis.

5. Then the remaining processor cycles from this tick are used to compute the evolution of its internal processes, which are its velocity in time. In this manner the elemental program continually implements the fundamental principle that everything continually advances at the speed of light through the same distance through spacetime that light travels. Due to the fixed (extremely large) number of processor cycles it uses to compute all processes it computes the same total spacetime distance traveled through spacetime for everything. It is this fixed number of processor cycles that determines the actual value of the speed of light.
6. So the immediate spatial position and velocity of everything is relative to every particle's immediate computational environment.
7. But he big picture model is the emergent result of an observer's interaction with huge numbers of particulate objects as a particulate object himself.
8. As explained in *Universal Reality 2.0* dimensional spacetime is an *emergent phenomenon* that is not computed directly by the elemental program but exists only in the views and experiences of observers whose own particles continually interact with objects composed of multitudes of other particles. The result of these interactions is an aggregate view of the dimensional relationships among millions of particles that is then mentally graphed and reified in the form of an encompassing spacetime within which the observer and the objects of his experience seem to exist on the basis of their consistent dimensional interrelationships.

1. The result of all these calculations at the particle level are the *emergent domains* we call objects, including ourselves, consisting of more strongly interrelated particles and their dimensional relationships at an aggregate level. The dimensional relationships in aggregate form increasingly extensive dimensional fragments out of which observers construct mental simulations of particulate objects in a single encompassing spacetime that obeys relativistic rules at the classical level.
2. In particular the preponderance of dimensional relationships within the domain are relative to the dimensional fragment of the domain itself.
3. Thus the resultant processor allocation of spatial and temporal velocities to the domain in aggregate tend to result in an inertial motion of the domain itself since their minimal relative velocities tend to cancel each other out at the local level.
4. Thus the domain itself coalesces into a single inertial entity with a single inertial world line as depicted in the *Big Picture* section.
5. From there, its perspective views of other entities emerge naturally on the basis of the relativistic relationships among classical scale entities.
6. This computational model at the particle level is explained more extensively and in much greater detail in the section on quantum theory in *Universal Reality 2.0*.
7. In this manner, as explained in detail in *Universal Reality 2.0*, *CTOE* is consistent with quantum theory at the particle level and also with general relativity at the classical level.

APPENDIX A: PROOF OF THE INVARIANCE OF PROPER TIME

In calculating the proper time of a set path between two events the frame we choose is completely irrelevant. The frame itself has nothing to do with the result and doesn't influence the result in any way. So the aging of the space twin is completely independent of the other twin or the Earth or the frame in which we calculate it. This is because its value is invariant and is the same for all frames under a Lorentz transformation.

Proof proper time is invariant under a Lorentz transformation from one frame to another with arbitrary relative velocity v:

The equation for proper time is $\tau = \sqrt{(dt^2-dx^2)}$. If proper time is invariant under the Lorentz transform then $(dt'^2-dx'^2) = (dt^2-dx^2) = \tau^2$.

The Lorentz transformations are
$t' = \gamma\,(t- x\,v/c)$ in natural units, $\gamma\,(t-x\,v/c^2)$ in non-natural units.
$x' = \gamma\,(x- t\,v/c)$ in natural units, $\gamma\,(x-vt)$ in non-natural units.
where $\gamma = 1/\sqrt{(1-v^2)}$ is the Lorentz factor in natural units, or $\gamma = 1/\sqrt{(1-v^2/c^2)}$ in non-natural units. Natural units are used in the proof below.

Substituting in the proper time equation
$\tau^2 = \gamma^2(dt-dx\,v/c)^2 - \gamma^2(dx-dt\,v/c)^2$
$= \gamma^2((dt-dx\,v/c)^2 - (dx-dt\,v/c)^2)$
squaring the binomials
$= \gamma^2(dt^2 - 2\,dt\,dx\,v/c + dx^2\,v^2/c^2 - (dx^2 - 2\,dx\,dt\,v/c + dt^2\,v^2/c^2))$
removing parentheses
$= \gamma^2(dt^2 - 2\,dt\,dx\,v/c + dx^2\,v^2/c^2 - dx^2 + 2\,dx\,dt\,v/c - dt^2\,v^2/c^2)$
canceling equal and opposite terms
$= \gamma^2(dt^2 + dx^2\,v^2/c^2 - dx^2 - dt^2\,v^2/c^2)$
rearranging
$= \gamma^2(dt^2 - dx^2 \quad + dx^2\,v^2/c^2 - dt^2\,v^2/c^2)$
$= \gamma^2(dt^2 - dx^2 \quad + v^2/c^2(dx^2 - dt^2))$
factoring
$= \gamma^2(1- v^2/c^2)(dt^2 - dx^2)$ [confirming the factoring $= dt^2 - dx^2 - dt^2\,v^2/c^2 + dx^2\,v^2/c^2$]
But $\gamma^2(1 - v^2/c^2) = (1-v^2/c^2)/(1-v^2/c^2) = 1$
So $= (dt^2 - dx^2)$
And $(dt'^2 - dx'^2) = (dt^2 - dx^2) = \tau^2$

Thus proper time is proven invariant under an arbitrary Lorentz transformation.