The Unified Theory Of Relativity

A unified description of acceleration that doesn't distinguish between straight geodesic worldlines in curved spacetime and curved worldlines in flat spacetime, thereby simplifying and unifying the special and the general theories of relativity.

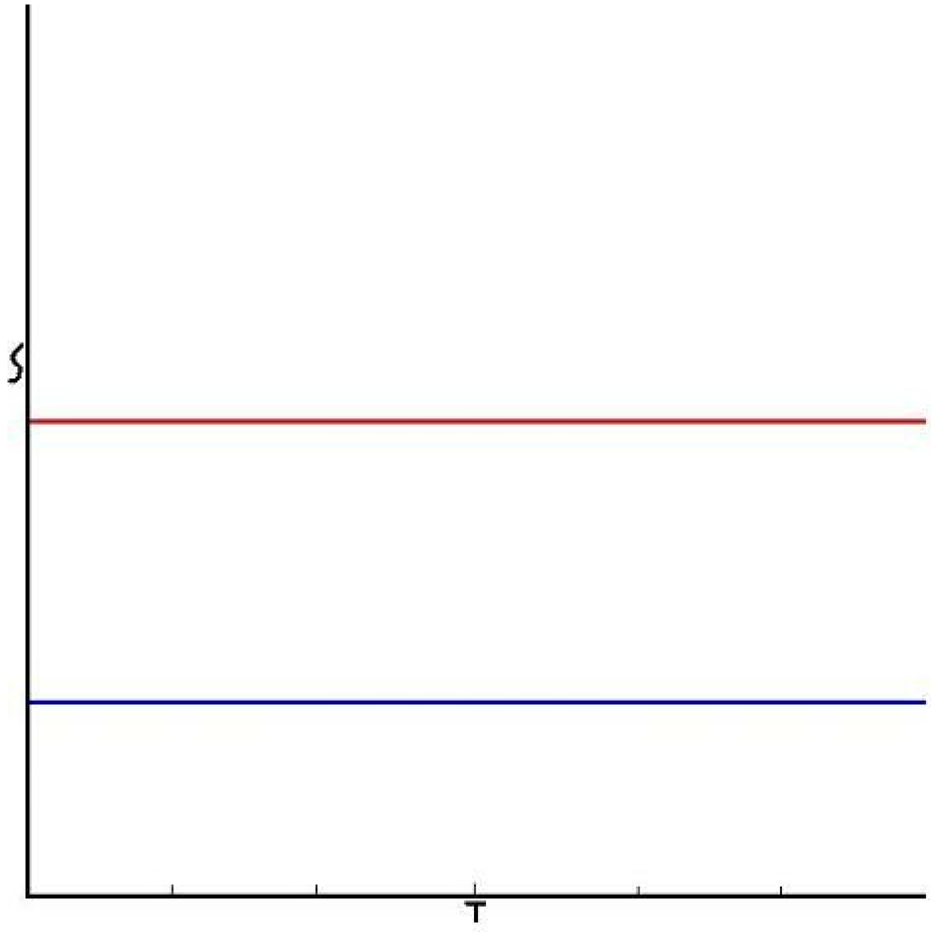
Summary

Special relativity describes acceleration as objects following curved paths through flat spacetime while general relativity describes acceleration as objects following straight paths through flat space time but these are entirely interchangeable and equivalent because the curvature of spacetime can only ever be measured in principle by measuring the curvature of worldlines.

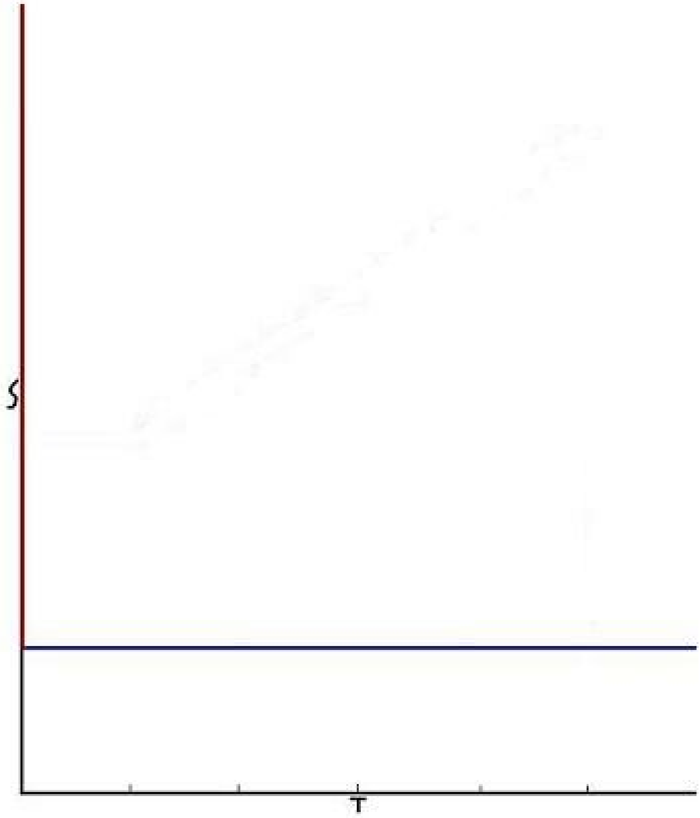
Energy causes an outward negative curvature away from the source and mass causes an inwards positive curvature towards the source. Because of the high energy to mass equivalence ratio, gravity is a comparatively weak force.

World Lines

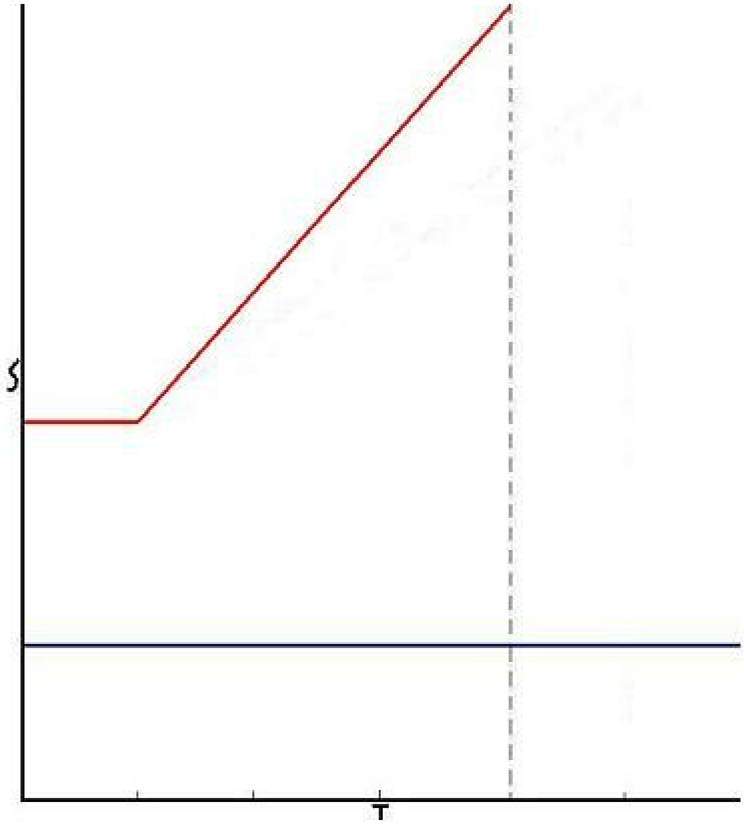
As there are only two dimensions we need to be concerned with when describing time dilation and length contraction and the dimensions are at right angels to each other, the relationship between two worldlines can easily be shown with a two dimensional diagram. Space is on the vertical axis and time is on the horizontal axis, the length of the worldlines is always the same so the combined velocity through spacetime of any object relative to all other objects is always the speed of light. The worldline of an object at rest relative to an observer in that frame is a horizontal parallel line, not moving at all through space and moving at the speed of light through time.



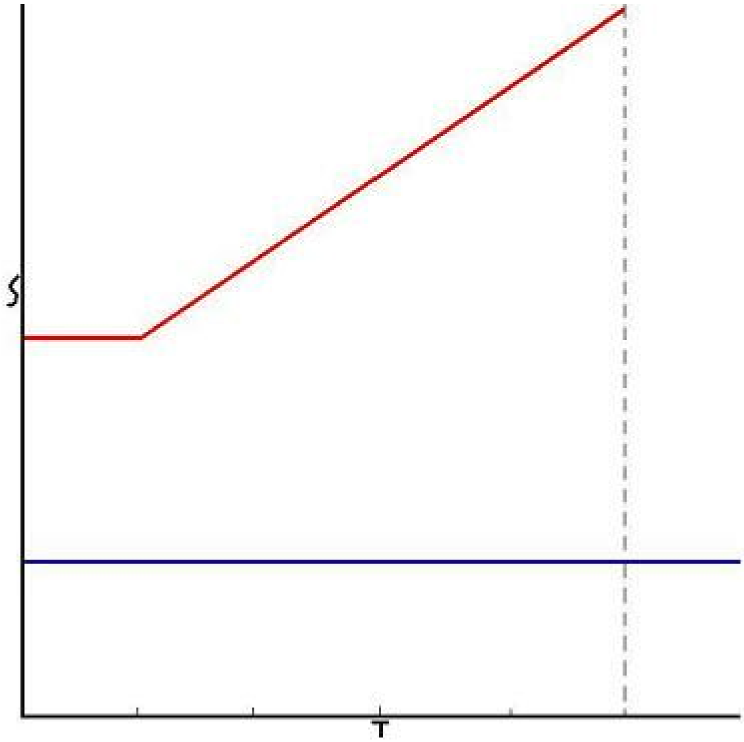
It takes a greater amount of acceleration to increase the angle by the same amount the closer the worldline is to vertical and so the closer the observer is moving to the speed of light, it would require infinite acceleration for the worldline to be vertical. An object approaching the speed of light relative to an object at rest in this frame would have a wordline approaching vertical.



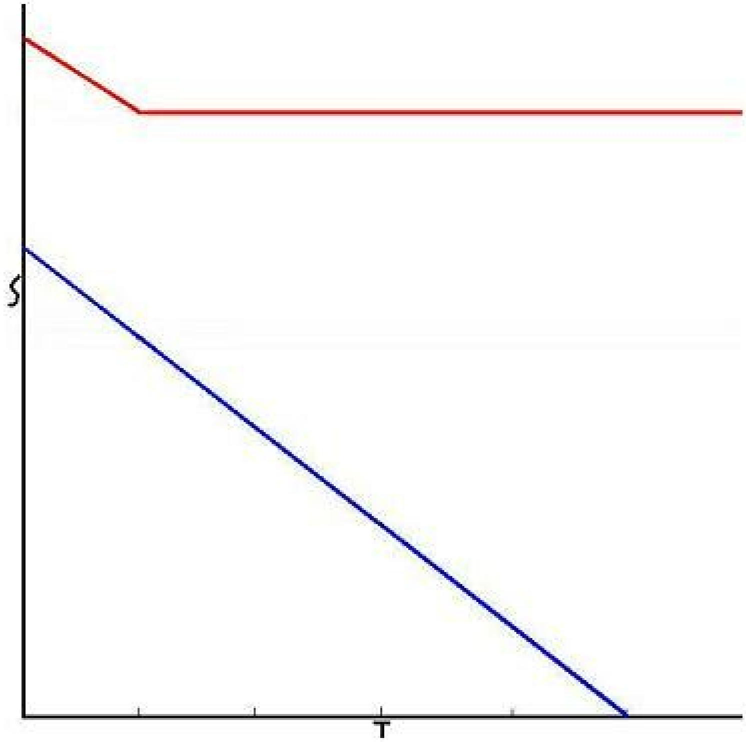
The red observer accelerates to .8c, with an angle of 72 (80% of 90) degrees each observer is time dilated and length contracted to 60% from the perspective of the other.



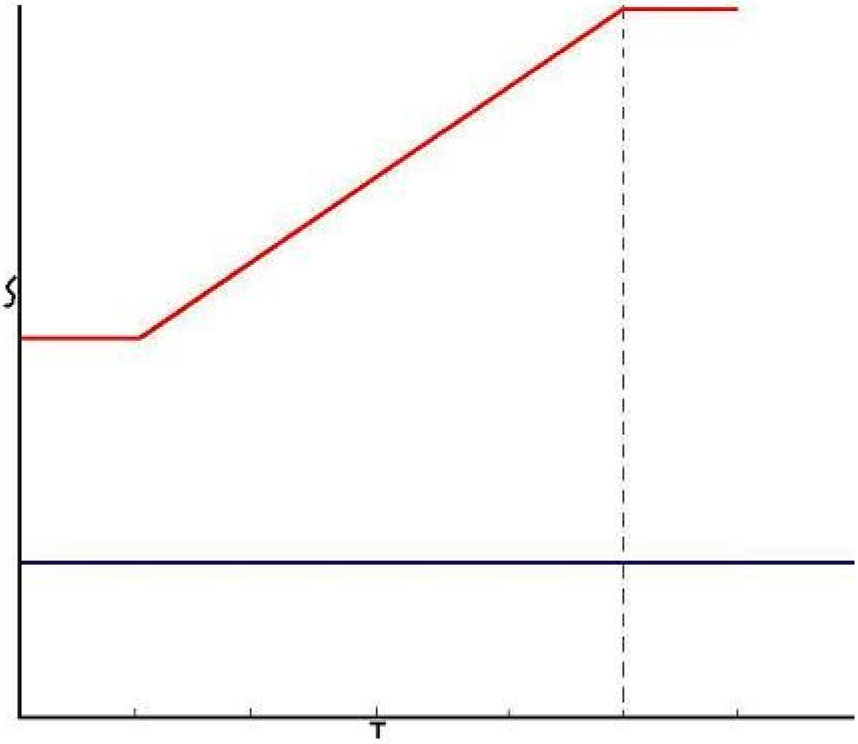
The red observer accelerates to .6c and with an angle of 54 (60% of 90) degrees the red observer is time dilated and length contracted to 80% from the blue observer's perspective...



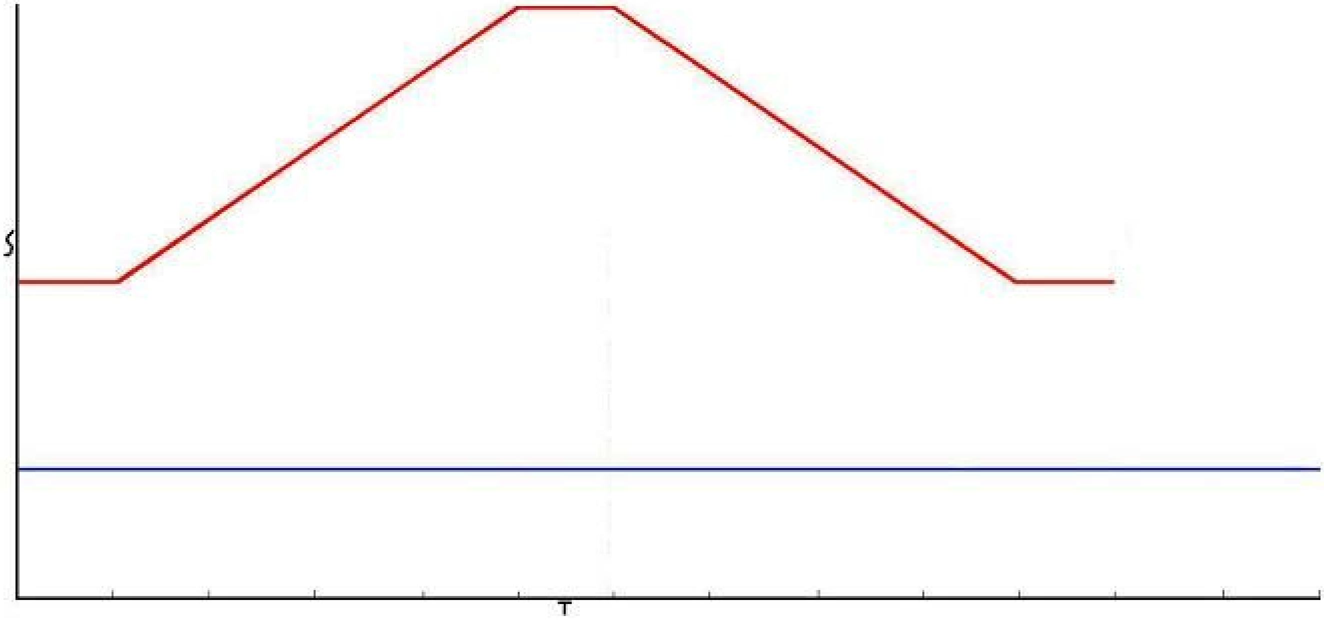
...and the blue observer is time dilated and length contracted to 80% from the red observer's perspective.



The red observer accelerates back to the original frame and their watch is behind the blue observer's watch due to the red observer's curved worldline compared to the blue observer's straight line.



And just to reset the scenario, the red observer accelerates towards the blue observer at .6c and then accelerates again so they are at rest relative to each other and the time difference on their watches is doubled.

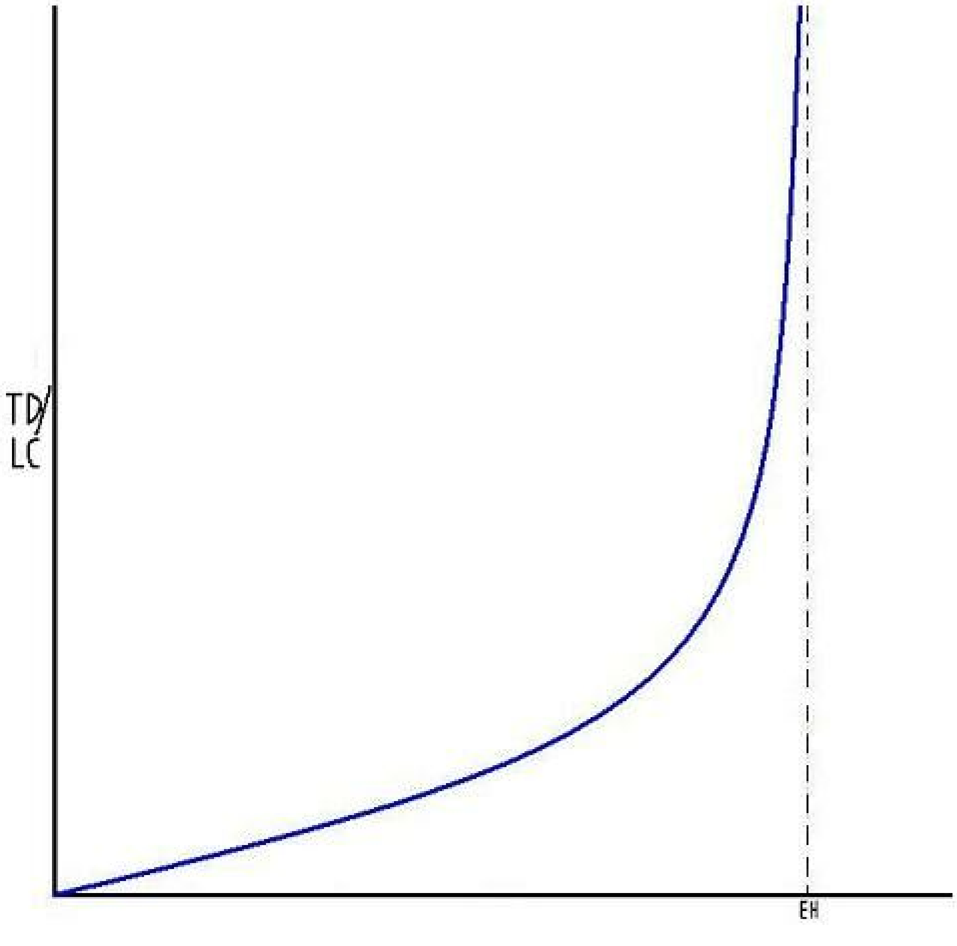


This applies equally to objects that follow a curved worldline due to acceleration caused by energy and objects that follow a curved worldline due to acceleration caused by mass. The only way to detect the curvature of spacetime is to detect the curvature of the worldlines of objects moving through it. Curved spacetime with a negative rather than a positive curvature can be applied to acceleration free from gravity to describe an object's worldline, just as gravitational acceleration can be viewed as the curvature of worldlines in flat spacetime. A straight path through curved spacetime leads to a curved worldline in the same way that a curved path through flat space time leads to a curved worldline.

Horizons

You can never switch to a valid coordinate system that shows a falling observer reaching the event horizon while the same observer never reaches the horizon (as shown by the Schwarzschild coordinates) from the perspective of a more distant observer because this would be the equivalent of showing that an accelerating object can reach the speed of light relative to another object from their own perspective by accelerating under their own power. It would require that the falling observer reach the speed of light relative to all more distant observers, which would require infinite gravitational acceleration as well as an infinite amount of time to pass on the watches of all more distant observers from the perspective of the falling observer.

This roughly shows the worldline of an object approaching an event horizon from the perspective of a more distant observer, and so also describes the worldline of an object accelerating towards the speed of light from the perspective of an inertial observer.



The observer's worldline never reaches the event horizon, as the Schwarzschild coordinate system shows and these coordinates extent to the accelerated frame of the falling object, the path of the worldline is not coordinate dependent. The observer's worldline becomes increasingly steeper but never completely vertical so the observer will always be closing on the horizon but will never reach it because the horizon is the point where the worldline would become vertical at infinite acceleration. The distance between the falling object and the horizon is divided by a progressively increasing amount over the same period of time from the perspective of a distant observer as the gravitational acceleration increases but is never divided by infinity.

A Rindler horizon is the point past which no signal travelling at the speed of light can ever reach an accelerating observer as long as they continue to accelerate at the same rate and is the opposite and equivalent to an event horizon or an observer free from gravity accelerating towards the speed of light. As an object is accelerated, in this case accelerated by gravity towards an event horizon, the Rindler horizon is always the same distance away from them in the opposite direction as the event horizon. It takes a greater increase in acceleration to close the gap by the same amount the greater their acceleration and the point where the two horizons would converge at the location of the accelerating observer is at infinite acceleration.

There is a time on the watch of the freefalling observer when they would reach and cross the event horizon but although time is progressing normally from their perspective time on more distant clocks is speeding up as they approach the horizon and the point in their proper time when they reach the horizon corresponds to an infinite amount of time passing on all more distant clocks. As there is never a point on any more distant clock that corresponds to any object reaching an event horizon, there is no possible lifespan of a black hole long enough to allow any object to reach its event horizon just as there's no amount of time that would allow a Rindler horizon to reach an observer constantly increasing their acceleration in the same way.

Singularities

Singularities are point-like in four dimensions, they exist for no amount of time because they are infinitely time dilated and have no spatial lengths because they're infinitely length contracted. Their apparent length in all four dimensions (and so their life span) increase at the same rate as each other as the distance of the observer increases making them four dimensional spheres at any distance, the event horizon is the edge of the singularity. An event horizon can never be reached because the size of the singularity approaches zero in all four dimensions as the horizon is approached, an observer accelerating towards an event horizon would see the horizon receding faster the closer they get to the horizon and approaching the speed of light as they approach the horizon.

This is already shown by the Schwarzschild coordinate system in which objects can never reach an event horizon from the perspective of a distant (any distance) observer. Instead the objects become increasingly time dilated and length contracted at a progressively increasing rate as they approach the horizon. Right up until the last moment of a black hole's life, there is never a point in time on a distant observer's watch when an object can reach an event horizon, so although an observer accelerating towards an event horizon would see distant watches ticking at a continually increasing rate as they themselves become increasing time dilated and length contracted, no amount of time passing on the watch of any distant observer will be enough for them to reach the horizon.

From the perspective of an observer freely falling towards an event horizon following behind another object freely falling towards the horizon, the object in front can never reach the horizon from the perspective of the more distant observer despite the fact that the distance between them is growing at a progressively increasing rate as they approach the horizon (due to the closer object always being under greater gravitational acceleration). If a closer object were able to reach the horizon from the perspective of a more distant observer then it would have to reemerge from inside the event horizon if the more distant observer were to accelerate away and this also holds regardless of whether the closer object and/or the more distant observer accelerate towards the horizon under their own power.

Conclusions

The physics of relativity is universal and can be described using a unified model that doesn't distinguish between flat and curved spacetime because the worldline of the accelerating object is what's relevant. Acceleration is a curved worldline, an object following a curved path through flat spacetime is indistinct from an object following a straight path through curved spacetime. Objects feel their own acceleration due to an uneven distribution of energy over different parts of the same extended object and in the case of gravitational acceleration this is referred to as tidal force.

The common misconception is that because there is a time on a faller's clock when they would reach the event horizon and time is moving normally from the perspective of the falling object, the falling object must be able to reach the event horizon but regardless of the black hole's four dimensional size there will never be a time on any distant clocks when the falling clock reaches the time in which it would reach the event horizon. If it were possible for an object to reach an event horizon then there would have to be a time on any distant watch when this event occurs.

An object's distance in spacetime from the singularity determines the black hole's dimensions, so an object would have to be closer in space to the singularity to experience the same amount of gravity at a later time in the same way that an object would have to be closer in time to the singularity to experience the same amount of gravity at a greater spatial distance, as an inverse square of the distance. The singularity doesn't exist over any extended distance in space or in time in its own frame so will be gone by the time any observer reaches its location.

Singularities are the same length (depending on the observer's distance) in all four dimensions so in this regard can't change over time because time is already part of their four dimensional shape. From the perspective of an observer perceiving a moving timeline a black hole starts out at full size as the information of the singularity's existence spreads out at the speed of light and so the black hole is at full size when that information reaches an observer and the event horizon recedes inwards faster the closer the observer is, approaching the speed of light at the horizon.