Albert Einstein did not pick anything from thin air, but he concluded from facts of exerience (which of course include experimental results). One very import *conclusion* of his is that the *speed of light* be a *universal constant* that has identically the very same value for each and every observer, independent of any velocity of the light source and also totally independent of any mutual velocity of two observers.

It means that if you and I pass each other at a mutual velocity of say half or three quarters of the *speed of light*, we still measure exactly the same speed of one and the very same single ray of light. If you cannot conceive this, you should please take it for granted. It simply ***IS*** how light behaves.

Please recognise that the length of a rigid rod is not influenced by anything perpendicular to it. Now I am holding a rod with a lamp on one end and a detector on the other. A ray of light will need some time to travel along the rod from lamp to detector. Suppose I am passing you at half or three quarters of the *speed of light* and I am holding this rod perpendicular to my movement how you observe it. Then you see my rod moving sideways while the ray of light is travelling from lamp to detector. Then *you* see the light follow an oblique path, not perpendicular to the rod's motion. Basic geometry tells us that an oblique path is longer than a perpendicular one (cf. crossing a road).

But because of the constancy of the *speed of light*, you see the light travel this oblique longer path at ***THE*** *speed of light*, which to you is exactly precisely identically pleonastically the same as to everyone, no matter whomever's velocity. Since travelling a greater distance at the same velocity needs more time, *you* measure a **longer** *time span* than what *I* measure for the very same ray of light to travel from the very same lamp to the very same detector.

As a direct result of the fundamental constancy of the *speed of light*, we now obviously no longer have the same experience of *time*. This is called ***time dilation***. *Time dilation* is the most important aspect of Einstein's ~~theory~~ conclusion of relativity. *Time dilation* means we each have our own perception of *time*, each from our own perspective.

THAT is what Einstein's conclusion of relativity is all about:
we observe everything from our own perspective, including *time*.

You have *your* time and *I* have *mine*. *Time* is something **individual**, not universal. ***THE*** time does **not** exist, but *your* time and *my* time. *Time* is something **individual**, not universal. ***THE*** time does **not** exist, but *your* time and *my* time. *Time* is something **individual**, not universal. ***THE*** time does **not** exist, but *your* time and *my* time[1]. If you get this, the universal constancy of the *speed of light* will no longer be a mystery. We both measure it in our *own time* and any difference lives right there. What *does* exist is ***THE*** *speed of light*.

An now we're going abstract: we both have our own *time line*. To *me*, *my* time line is always completely normal and it goes straight ahead from *my* perspective. To *you*, *your* time line is always completely normal and it goes straight ahead from *your* perspective. But when we pass one another at an extremely great velocity, your *time line* becomes skewed to me and my *time line* becomes skewed to you. Since the *time lines* themselves are of course invisible, we cannot truly observe this skewness, but it is fully comparable to the obliquity of the path of the ray of light that you observe when watching the ray of light going from lamp to detector. The fact that you measure a longer *time span* for this traversal than what I measure is called *time stretching*. It is a perspective distortion due to the abstract skewness of our *time lines*, but just the other way round as for visible entities, where angled things appear shorter.

Important: *time stretching* applies to *time spans* between events that take place at the passerby (e.g. emission by the lamp and absorption by the detector). They last longer for a stationary observer than for this passerby himself. When we pass one another at great velocity, *you* see more time between *my* events than what *I* perceive myself, and *I* see longer time spans between *your* events than what *you* measure yourself.

Now suppose you see me (and my detector) go faster than light. From your perspective, the light from the lamp is travelling at ***THE*** *speed of light*, so it can of course not keep up with the detector, which goes faster,

[1] Repetitio est mater studiorum -- rehearsal is the mother of learning.

so you'll observe a complete miss. But to me, the detector has zero velocity, so I see the light hit the bull's eye. **I see a perfect hit and you see a miserable failure of the very same ray of light going from the very same lamp towards to very same detector.** My dear mother tought me (in Dutch): *Wat niet kan is nog nooit gebeurd*. It means: something impossible has not yet ever happened. Galileo Galilei wrote: *Due verità non posson mai contrariarsi*, two truths cannot ever contradict one another.

ANY premise that implies an impossiblity MUST be false (this is the essence of the proof by contradiction). The premise was: *suppose you see me (and my detector) go faster than light*. That must be false, so you cannot see me go faster than light, no matter how flashingly clever I may be. It would lead to a severe contradiction. The *speed* ***limit*** *of light* directly follows from the constancy of the *speed of light*.

It should be obvious that the light *does* have a speed component towards the detector, so its obliquity *MUST* be less than 90°. This means our *time lines* cannot ever have a skewness greater than or equal to 90°. That's another way to say the *speed of light* is unattainable and can certainly not be exceeded.

And please remember the term *time dilation*, as well as its meaning: *time* is something **individual**, not universal. ***THE*** time does **not** exist, but *your* time and *my* time. It should be obvious that the greater our mutual velocity, the larger the *time dilation* will be, since the skewness increases with the velocity. Would we approach the *speed of light*, time dilation will climb towards infinity.

We now have the path of the light along the perpendicular rod as observed by me, the oblique path of the light as observed by you, and the travelled sideward distance of the rod as seen from your perspective. Do you see these form a right-angled triangle? And did you ever learn some well-known theorem about right-angled triangles? We convert between *your* and *my* time using the Pythagorean theorem! But isn't that some nasty formula containing squares? And have you learned that a square cannot ever be negative? Would our mutual velocity exceed the *speed of light*, we would have to solve an equation containing a negative square, which is impossible. There we have the mathematical reason why the *speed of light* cannot be exceeded.

Now the two of us are together without any mutual velocity, thus being one single so called stationary observer. We witness a wise wingless witch with a wig and a widget which switched her bewitched wiper for a wicked broom, willingly waving with the wind at a weird *relativistic speed*. The latter means it is high enough for *time dilation* to become significant. Of course she won't go off course, but fly rectilinear. She holds her broom straight in the direction of motion and for some obscure reason we must know the length thereof. We must measure from our own perspective, with non-moving instruments, and she will definitely not stop to let us measure her broom. How can we achieve that?

By counting tiles we can use the pavement as a stationary ruler, and we both have identical perfect clocks. You measure how much time the witch needs to travel a given amount of tiles, thus determining her velocity. I measure how much time her broom needs to pass the tip of my nose. Then we multiply the duration of the broom passage by the witch's velocity and bingo! We have measured the length of the moving broom, using only stationary instruments.

But from the witch's point of view, *we* are passing *her*. *She* measures - in *her* time! - how long it takes for *us* to pass her broom, as seen from *her* perspective. She observes time dilation (i.e. stretching) of the time span *we* measure for her broom to pass *us*. It means *she* measures a longer time span than *we*. Therefore *we* measure a shorter time span than *she* does. This implies *we* measure a shorter broom than what *she* measures whilst sitting on it. For *her*, the broom is a non-moving object, hence completely normal, so *we* measure a shorter broom! Please reread this paragraph until you get it.

As a direct result of *time dilation*, moving objects appear shortened in the direction of motion, as seen by a stationary observer. This is called Fitzgerald-Lorentz contraction, named after the two persons who independently came up with this idea more than ten years before Einstein appeared. But both George Francis Fitzgerald and prof. Hendrik Antoon Lorentz picked it from thin air. Lorentz nearly litterally said: "I could excogitate just one thing". Einstein on the other hand drew *conclusions* from *facts of experience*. He later described this surmise by Fitzgerald & Lorentz as "an ad hoc assumption that only appeared as an artificial means to save the theory". Nevertheless, Einstein showed (i.e. concluded from facts without contriving any concoctions) that it was correct.

To a stationary observer, moving objects appear shorter. And we are going abstract once again: the fast moving broom (or whatever object) is skewed towards the direction of *time*. But the broom itself is a non-abstract physical object, so I'll call this *half abstract* skewness. Of course this contraction is a perspective distortion as before, but this time it is simple shortening just like any oblique physical object appears shorter. The obliquity itself is however invisible, since it is towards *time*.

As said, moving objects appear shorter to a stationary observer. And the faster the witch flies, the more her broom will become contracted as seen by the stationary observer. But can it become shorter than zero? Nope. That's why the witch can't fly faster than light.

Summarizing we can say that both the *time line* and the *spatial line* (physical length) in the direction of movement of a fast moving object become skewed, which is called *time dilation*. The greater the velocity, the greater this skewness, approaching 90° if the velocity nearly equals the *speed of light*. The skewness itself is abstract since it is not spatial but time-like. Its effect is that we observe *time stretching* and *length contraction*. Both are only observed by the stationary observer.

Until now, I have silently presumed that our mutual velocity never changes. But now suppose you see me pass by while I am accelerating, i.e. my velocity is increasing. Then the skewness of *my* time line as it is from *your* perspective increases with my velocity. And my velocity increases while time is progressing. But isn't the progress of time the same as "walking" the time line? So as I travel along my time line, it becomes more and more skewed to you. Doesn't that mean it becomes curved? When I am accelerating, my time line becomes curved to you!

Now look at an accelerating witch's broom. Its skewness will then also increase as it passes by with an ever greater velocity. Doesn't that imply the broom's spatial line in the direction of motion becomes curved as well? But this is skewness and curvature in the direction of time. Not directly visible.

When a passerby is accelerating, both his time line and his spatial line in the direction of motion become curved. *This* is the curvature of spacetime you may have heard about. But it is abstract curvature. You cannot truly see it, but its effects are of course increasing time stretching and length contraction as perceived by the stationary observer.

While accelerating, you gain extra velocity with respect to your initial state, i.e. when you were not yet accelerating. So during acceleration, you have built up a velocity with respect to when your acceleration was zero. When acceleration equals nought, we call it *inert motion*. Acceleration yields a velocity with respect to your own *inert motion* you would have had without accelerating.

In his Philosophiæ Naturalis Principia Mathematica, Sir Isaac Newton published his laws of motion. The 1st law says that velocity does not change unless a force is exerted and the 2nd law says the change in motion is proportional to this force. In mathematical notation it is: $F = m \times a$, where a is the acceleration, m is the mass of the body (amount of stuff it consists of), and F is the force. In essence, if a massive body accelerates, a force is exerted on it, and if a force is exerted on it, it accelerates. It means acceleration has everything to do with forces, i.e. spacetime becomes curved if a force is exerted. *Curvature of spacetime* is due to a *force*. Spatial curvature (towards the direction of *time*, as said) applies to spatial lines in the direction of this force. But since space is considered te remain continuous, this force implicitly distorts perpendicular lines as well. *Inert motion* now means that *no force* is exerted.

And then Einstein got the happiest thought of his life, which in ***my*** words is: it does not matter where a force comes from, be it an engine or gravitation. Have you ever felt a slight change of your own weight in a lift? Would you not have known you were in a lift, you might just as well have been on another planet where gravity slightly differs from how it is on Earth. It's indistinguishable.

Einstein's happiest thought has suddenly turned relativity into a theory of gravitation! And, presuming you are currently sitting on a chair, what do you *actually feel* (with your bottom) as far as gravity is concerned? Do you really *feel* Earth *pulling* you towards it? Or do you *feel* that the chair prevents your free fall by *pushing* you *up*wards? It's the latter! The chair seat pushes you *up*wards, just like the aforementioned lift floor as it accelerates upwards or decelerates when going down. Essentially, there is *NO* difference!

When you fall from a height of just one metre, you'll hit the (horizontal) floor at roughly 16 km/h. Would it feel essentially different when you rush against a vertical wall at that same speed? When hitting the target, you'll undergo a (large!) deceleration, which is negative acceleration. Actually, Einstein's happiest thought was that *acceleration* and *gravitation* are essentially indistinguishable and that a person in free fall does not feel his own weight.

Would the upward force by the chair (essentially the resilience of Earth's surface) not be there, you would fall freely (which doesn't hurt at all) until you hit something (which can be very harmful). Were Earth fully penetrable without any resistance, you would freely fall all the way down to its centre. Without *feeling* any force being exerted on you, you are in free fall. Didn't we call it *inert motion* if there is no force? *Free fall* is *inert motion*, i.e. without any force being exerted. Contrary to what you may have learned, free fall involves *NO* force! But the chair *does* exert a force. **Free fall means no force is exerted, being stationary in a gravitational field requires a force.** This force implies you are seemingly accelerating, so you have gained some velocity since you started this apparent acceleration. It may seem odd, but when you sit on a chair, you actually have a velocity with respect to your own fictional inert motion towards the centre of the earth. Let's call it *gravitational* (*pseudo-)velocity*. It is the velocity you would have if you were in a free fall all the way from infinity towards Earth's centre. And it causes time dilation, hence time stretching and length contraction!

What was explained before gravity entered this story is called *kinematic time dilation*, due to *mutual velocity* together with the constancy of the *speed of light*. This *pseudo-velocity* due to gravity causes what we call *gravitational time dilation*. Therefore we have both *kinematic* and *gravitational* time stretching as well as *kinematic* and *gravitational* length contraction.

The *time span* between for example two flashes of light occurring in a strong gravitational field appears stretched to a distant observer experiencing way less gravity. And vice versa: here on Earth we see shorter time spans between successive clock ticks of the atomic clocks in satellites, where Earth's gravitation is weaker. We see them tick faster then what the satellite itself sees. Furthermore, the satellite has an orbital velocity too, causing *kinematic time stretching* as well.

For GPS (Global Positioning System) this *kinematic time stretching* is roughly 7 microseconds per day, and the *gravitational time stretching* is about –45 µs/d (note the minus sign, we see it tick faster). Together, they yield –38 µs/d, which is to be multiplied by the *speed of light*. It renders a drift in the location determined by *YOUR* satnav of 475 metres per hour(!) whilst you just stay put. Of course this has been corrected by design (they simply adjusted the speed of the on-board clocks before launch). It means the accuracy of satnav (8 metres in so called open field) is confirming Einstein's *conclusion of relativity* each and every time when you lookup where you are hanging around.

Finally, this document is not about black holes. Well, one thing: you probably have heard they got some *event horizon*. Simply said, that is the distance to a massive object where the *escape velocity* equals the *speed of light*, so nothing - not even light - can escape from within it. Nothing comes out, but you can fall into it (only from your own perspective; due to gravitational time stretching, a distant observer will never see it happen). That's why it's called a black hole. One can also say it is where the gravitational curvature of spacetime asymptotically approaches a skewness of 90°, which is uncome-at-able and can definitely not be exceeded, as explained. Therefore we essentially know nothing about a black hole's interior.