# The Twin Paradox explained without math

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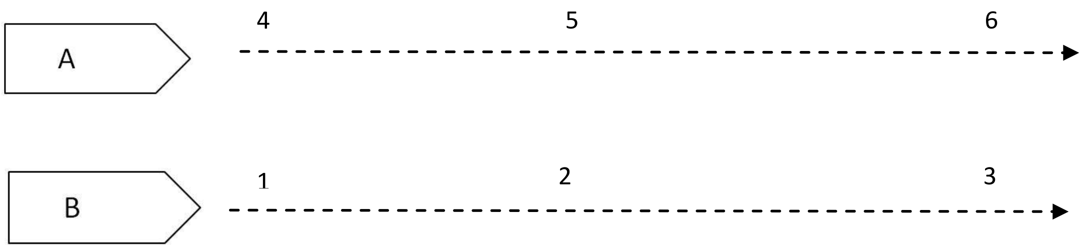
**Anyone who has studied special relativity, will have stumbled upon the famous puzzle of the twin paradox. In most books the author tries to solve the problem exclusively with special relativity. The solution given in this paper is based upon special and general relativity. Surprisingly, no complicated calculations turn out to be necessary to clarify the puzzle.**




**The symmetrical journey of the twins**

## A symmetrical situation

The journey of the twins, sketched in the diagram, is somewhat different from the usual way the journey is depicted. The rockets A and B are floating together somewhere in space, far from earth and other celestial bodies. Both ships have an accelerometer on board. In this initial period the meters show no reaction. Both ships have the same constant speed. They are navigated by the twin brothers A and B, having the same age.
If both would accelerate at the same time, making a long trip together with constant speed, then decelerate again, it is obvious that their clocks would show no different times.

But in our thought experiment one of the twins will leave first.
Twin B decides to go away from his brother. He starts his rocket engine and observes his accelerometer indicates the acceleration (1). Soon he reaches a speed that approximates the speed of light. He turns off the engine and travels with that constant speed in a straight line (2). After a trip of some light-years he decelerates and continues with constant speed (3).
When twin A gets nostalgic for his brother he starts his rocket engine, accelerates in the same way as his brother (4), travels with the same constant speed in the same direction and during an equal period (on his clock) (5), decelerates as his brother did and catches up with his twin brother (6).

**Which twin is now younger? Or are they the same age?**

In the above described situation one cannot indicate a difference between the journeys of the brothers. The second journey is only shifted in time. But this does not make a difference. There is symmetry in this case.

Consequently:

> **Clocks of the twins will give equal readings when they come together, there is no difference in age between the twins.**

Special relativity learns us that during the journey with constant speed each of the twins may say that the other one's clock is running more slowly. This sounds like a paradox but it is merely an application of special relativity. Let's consider the situation from the point of view of A. A may say that his brother is aging slower during phase 2, B's clock is running behind A's clock. After the complete journey this dilatation might be two or three years, whatever, we will define this period as the unit time $T$. In phase 5 A will see his brother coming towards him and again he may say that B's clock is running behind with $-T$. Now it summands to $-2T$.
If we consider the situation from B's point of view we get the same result.
**But the total time dilation** $-2T$ **is never applicable to both twins**.
For then we really would have a paradox. Both twins cannot be younger than the other.
There cannot be any difference of age. This means that the total time difference must be zero.
Both clocks must therefore experience a time advancement of exactly $+2T$. Special relativity does not provide this timeshift. We have to consider the theory of general relativity that deals with accelerations.
We know that when a clock is placed in a gravitational field it runs more slowly than a clock outside this field. This means that the clock far away will run faster than the clock in the gravitational field.
Clocks in A and B are submitted to accelerations. The equivalence principle learns us that we cannot make a distinction between clocks that are accelerated and clocks in a gravitational field.

When during phase 4 A accelerates and decelerates in phase 6, clock A runs slower and thus clock B will run fast, seen from A. The total advancement must be exactly $+2T$ in order to neutralize the results of the special theory.
From the point of view of B the clock of A will run fast in phase 1 and 3. The total amount must also be $+2T$.

## The 'classical' Twin Paradox

With these results we are now fully prepared to look at the 'classical' Twin Paradox. Now only B will use his rocket engine. He travels through the phases 1, 2 and 3. Then he turns around, accelerates and travels with constant speed back to A, decelerating on arrival. The return trip is a mirror image of the outward journey.

Only B will experience acceleration, this gives asymmetry. On the most remote point of his trip (3) when he returns to A, B experiences yet a second acceleration compared to the symmetrical trip and on arrival is an extra deceleration. The clock advancement that B will assign to A must be double the value found with the symmetrical journey. It must be $+4T$ instead of $+2T$.
This is why B sees $-2T+4T=+2T$ for A.
Since A does not accelerate, A sees only $-2T$. This resolves the paradox. Twin brother B is less old compared to A. A's clock runs ahead and B concludes that A is older.