

Time Revisited Summary

Our perception of time varies with culture, age, education and technology. Many observations can illustrate weird time facts which skew our sense of history. For example, Oxford University was formed before the Inca Empire and Cleopatra is closer in time to the invention of the cell phone than to the construction of the Giza Pyramids. So many times we do not really appreciate a true perspective of time. Our perspective on the art of time keeping is something few of us realize or think about, but it is important to understand how and why accurate time keeping has developed and how it affects our modern society and our fundamental understanding of the universe.

Let us examine a bit of time keeping history. The Earth made a wonderful time keeper until the late 1800's. An agrarian society didn't need super accurate time. For thousands of years sundials, water clocks, and one-handed mechanical clocks worked fine. With the advent of world sea travel, the industrial revolution, trains, and WWI, the tide started to shift. Each world event ushered in a demand for more and more accurate time keeping. Time zones had to be established. Ship navigation had to be improved. More and more accurate mechanical clocks had to be built to meet the need. Finally, WWII and the invention of radar demanded very high clock accuracy and led to the invention of the all electronic quartz clock. Electronic clocks improved the accuracy over mechanical clocks by a factor of 1000. After 1943 micro second accuracy was achieved.

Today computers, GPS, cell phones, and other modern devices are demanding more and more accurate timing. Today times are being used at the Femto and Atto second level to meet scientific and industrial accuracies. The standard clock today is the Cesium Atomic Fountain clock. The accuracy of the F2 clock is 1 second in 300 million years. To achieve more accuracy, atomic clocks have been moved into orbit and utilize relativistic properties.

In May of 2024 a nuclear clock time standard was introduced which improves time accuracy to about ((10-13) Femto seconds. Scientists estimate Femto second accuracy will ultimately become possible in a couple more years with the new nuclear clock. Lasers excite the protons in the thorium 229 nucleus into vibration much like the atomic clock excite electron in the Cesium atom to provide about a thousand times more accuracy. With this new clock scientists think they can measure the perturbations of the universe by noting time changes in constants such as the speed of light.

We can measure time faster than the clock accuracy, but we have to give up accuracy to obtain it. In 2023 the Nobel Prize for chemistry was given for taking a picture at the Atto second level, and the scientists think in the next couple of years they might be able to photograph at the Zepto second. Some of these photos can be seen on YouTube.

Scientists think the overall limit to the speed and accuracy about $5.391(10^{-44})$ seconds set by Planck's constant. You can see, at best, we are only a little less than half way there. The future may hold many more surprises for us

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Maybe minute and minute should be spelled differently.