Time

Aristotle, St Augustine, Newton, and Einstein all had something to say about time. Aristotle perceived time as “a number of change with respect to the before and after”. To Aristotle, change and time are intimately connected. St Augustine attempted to describe time and ultimately left it as undefined in the fourth century AD. His famous quotation was “What then is time? Provided that no one asks me, I know. If I want to explain it to an inquirer, I do not know”. Newton ascribed to an absolute time in order to formulate his equations of motion. Einstein made time variable in his Theory of Relativity. Many other philosophers have contemplated time with no clear resolution. It still remains an enigma. This essay is an engineers attempt to break time down into it’s components to understand it, as Socrates would have us do.

Celestial Time

I suppose that early humans, upon viewing the heavens, perceived the changing of seasons related to the motion of the planetary, solar, and lunar positions. The changing of seasons was paramount to survival to follow game, and later for agriculture. Consequently, the first measure of time was the calendar. It was a tool of human invention to describe celestial motion. The motion was natural. The calendar tool began to define a concept of past, present, and future, i.e. long periods of the change in the heavens that could relate to human activity.

These heavenly changes were also used by navigators on the seas to establish position. Here we have a relationship between changes somewhere else that could be observed and correlating those changes to position on the Earthly sphere. There was a ratio between changes.

The first measure of celestial changes was probably the gnomon, around 2300 BC in China. This was a stick that cast a shadow on the ground from the sun. The Egyptians referred to it as a

sundial. It was a measure of solar position, which became a measure of time for regulating human activity here on the ground.

Newton described an absolute time that exists in the universe and progresses at a steady rate independent of anything else. It was not available for humans to detect. It was a mathematical concept that was different from relative time. Relative time was capable of being used to describe perceivable motion. This absolute time was a property of the universe and not anything related to humans. This was necessary for Newton in formulating his equations of motion. This was the first physical definition of time. Along with this absolute time, he also defined absolute space to understand bodies at rest or in motion relative to this absolute space.

Biological Time

Does a fish swimming in the water perceive time? I do not know what it perceives, other than what it wants to eat or avoid being eaten, but it is certainly in motion while flapping it's fins. The fact that it is in motion means that it is in some kind of biological rhythm with it's environment. Respiration (breathing) and heartbeat are biological rhythms. In music, tempo is a rhythm. In dancing, people are moving together, and bonded, in a rhythm to the sound and their own bodies.

Biological systems are in motion, if they are alive, and therefore events happen one after the other. The elapse of one event followed by another can be described as a heartbeat away, or a previous flap and a present flap. The duration between events can be a definition of time. The durations will be variable depending on the creature and the motion, so there will be no consistency on what is a duration. What we are talking about here is the relative time duration between two events, or a relative time, as described by Sir Issac Newton. This leads to the standard measurement of time interval between two events.

Measurement

The calendar and the sundial were mentioned as devices for gauging celestial time. The calendar for long periods measured in days, months, and years. The sundial for dividing the day into hourly durations, or perhaps even minutes. Other devices for measuring time are sand hourglasses, water clocks, pendulums, and crystal vibrations. Modern time pieces are based on pendulums (the analog watch and clock tower), and crystal vibrations (electronic watches and atomic clocks). The science of measuring time is horology or chronology. The science assigns a number to time. We like numbers. The fundamental question is – Is it real? Is time, as a number, real or just a human construct to describe motion. Mathematics is considered a “pure” science and if we can measure something and quantify it, then it is considered real. We do not measure time. We measure frequency.

What is real is frequency. Things vibrate. They oscillate with a rhythm that is regular and repetitive. Physical objects have natural frequencies. Planets rotate and revolve with a regular “timing”. Bells ring. Hearts beat. Musical instruments are tonal. Crystals vibrate at specific frequencies depending on their physical geometry. Atoms vibrate. Natural vibrations are natural clocks based on frequency. If I take the reciprocal of frequency in hertz (cycles per second), that is, divide the number one by the frequency, then I get a unit of time in seconds. The results is the time period taken to complete one cycle of motion.

The international standard of time is the second, defined as 9,192,631,770 oscillations of the cesium -133 atom, or about 9 billion oscillations. Multiples of the second are minutes, hours, days, weeks, months, and years. Unfortunately, the latter units do not have a common mathematical base. The bases are 60, 24, 7, 30 or 31, and 12. This is why the international agreed upon unit for time in the SI (metric) system is the second. There are alternate measures of time, which have been alluded to. The bottom line is that time manages human relations. Having an agreed upon standard for that measurement means that we can all be on the same time – clock time.

Motion

If a system is unchanging, then it is timeless. That is the common understanding among the physics community concerning motion and time. I will not argue that. What I can speak to, as an engineer, is that some measure of time is required to talk about velocity, which is motion.

An object can change position. The difference between the starting position, point A, and the ending position, point B, is the displacement. The displacement is one way to describe motion. In fact, a vehicles' odometer tallies a number of miles or kilometers traversed during a trip. This is actually "excursion" and not precisely the displacement from point A to point B, unless the trip was a straight line. If I take the displacement and place it in the numerator and divide the displacement by the time taken to complete that motion, then I have defined velocity. In engineering terms, velocity = ds/dt. So this concept of time is a human invention that allows for another human invention – velocity. Without time, we cannot quantify velocity motion. We would be restricted to speak only of displacement or excursion.

These two measures of motion, displacement and velocity, are followed by another – acceleration. This is more abstract. Acceleration is displacement divide by the time squared. It now produces a definition of force (another abstract concept) as the product of mass and acceleration. The invention of time has been very productive in allowing for the numeration of motion and a clearer understanding of the physics of motion and engineering concepts of force, and ultimately energy.

According to Einsteins' Theory of Relativity, time is a dimension added to the three dimensions of space, resulting in Space-Time. In addition, time becomes variable. It does not proceed at a constant rate for all observers, as previously assumed. It depends on the relative velocity. Time is "soft". It can be stretched and compressed, depending on velocity. Strange concept. This suggests that time is not real. I will leave it there. Some places I do not want to go, just like I would command my dog to "leave it".

Philosophy

Now that we have placed a number on time, I suppose we can talk about positive time and negative time. If time was linear, that is, proceeding as if on a straight line in one direction and not diverting up or down, then we can talk about past, present, and future. My imagination can even indulge itself in time travel, since time is intimately connected to motion. The human psyche can produce all sorts of images that may not be real outside of the mind. So let's get real.

We are not born with time in our pocket. It is a resource that we can use, but we cannot save it, even though the phrase is commonly used to "save time". Time cannot be placed in bank vault. It can only be withdrawn and spent. In a sense, we are given a specific amount of time at birth, the amount is unknown. It is a resource to be used. Economists say that time is money. That is an oxymoron statement since they have different dimensions of value. Time cannot be controlled. Only effort can be controlled, and only ones' own effort with total success. So how does a child learn about time?

Is time even a learned concept, or is it innate? The young human learns how to read a clock and "tell" time, probably from the parents, teachers, or siblings. This is "clock time", or physical time. There are other concepts relating to time that have nothing to do with clocks. One is the subconscious. Our psyche is composed of biology and mind. Our bodies have a rhythm that we have little or no control over. Many parts are in motion that we are now fully aware of. There is some subliminal awareness of the passage of time because we dream motion. The perception of time also varies with age. Young people are very active, in vigorous motion, and can't wait with great anticipation for some expectation in the future. It slows down in later life. I remember my father telling me in his later years that he does not know where the last ten years went.

Time is a social construct that humans have created to manage living. All types of human activity proceed with greater efficiency when it is coordinated with timing, both good and bad. Trains move without colliding and armies march in step. Proper timing in war allows for more casualties and

more destruction. Timing is critical in military operations. In fact, tardiness is a crime in the Department of Defense, whereas in civilian life, it is only unprofessional. But coordinated movements in civilian life also allow for more efficient relations. In a sense, good timing can deliver happiness, and poor timing, frustration.

Finally, social information between generations is transmitted as rituals. This is cultural time. We can’t put a number on it, but it produces a cohesion among humans in a group. The rituals happen at specific calendar points and brings people together. This can be considered a biological timing, just as turtles return to spawn. It is embedded in the species as a rhythm.

Conclusion

Frequency is a real property of the natural world. Time is a mathematical construct derived from frequency and is a human invention. The concept of time allows for humans to manage living. In addition, motion is also real. Time turns out to be a convenient parameter to quantify motion with velocity and acceleration.