THE IDEA OF TIME by G. J. W. Imperial College of Science and Technology

One of the peculiarities of modern civilization is the importance it attaches to the idea of time. Time is considered a kind of linear progression measured by the clock and the calendar. The tendency is to regard this idea as a necessity of thought, but acquaintance with the beliefs of other civilizations shows that this is not the case.

a) Evolution of the Idea of Time

Generally speaking, time was not a concept of primary importance in ancient thought. The Greeks tended to regard the cosmic process as a cyclic alternation of opposing forces rather than as a continual evolution. For example, A. stated that even the tendencies of heavy bodies to fall and light bodies to rise are all part of a cyclic process, so that these apparently straight-line motions are in fact circular like the perpetual circular motion of the heavenly bodies, which had neither beginning nor end.

A. also held that time and motion were independent, movement being measured by time and time by movement. He recognized that time cannot cease, whereas motion can[Image]except for the motion of the heavens [Image]and concluded that time must be associated closely with this motion, which he regarded as the perfect example of uniform motion.

Belief in the cyclic nature of time was widespread in antiquity, and it gave rise to the idea of the Great Year. There were two versions of this idea. In one, the Great Year was considered simply as the period required for the sun, moon, and planets to attain the same positions relative to one another as they had held at some previous given time. This was the sense in which Plato used the idea. On the other hand, the Great Year for H. signified the period of the world from its formation to its destruction and rebirth. These two versions were combined by the Stoic philosophers. The Stoics believed that when the heavenly bodies returned to the same relative positions they had at the beginning of the world, everything would be restored as it was before and the entire cycle would be renewed in every detail.

Early Christian leaders rigorously disputed the traditional cyclical view of time. Prominent among them was St. A. He laid great emphasis on the idea that the crucifixion of C. must be regarded as a unique event, not subject to repetition, implying that time is linear rather than cyclic. He was also the pioneer of the study of internal, or mental, time. Dissatisfied with A's close association of time with motion, St A. chose to regard time as an activity of the "soul," or mind, endowed with powers of memory, attention, and anticipation.

In the scientific revolution of the 17th century, I. N. took the view that time exists independently not only of human minds but also of all material objects, and that it "flows" uniformly of its own accord. On the other hand his contemporary L., the German philosopher and mathematician, regarded time simply as the order of succession of phenomena.

The problem of reconciling these different ideas of time was tackled by the German philosopher I. K. in the 18th century. K. was an enthusiastic believer in N's natural philosophy, but he rejected N's idea of time. Instead he argued that time is simply a feature of the way men's minds visualize the external world and is not a characteristic of external reality itself. He reasoned that if time were a characteristic of the world, equally good arguments could be advanced to show both that the world originated and did not originate in time. In view of this contradiction, K decided that time does not apply to the universe but only to the way in which men think about the universe.

b) Concept of Time in Relativity

In the 19th century, as a result of the arguments advanced by geological and biological evolutionists, the modern idea of time as linear advancement finally prevailed over the older, cyclic conceptions. [1] The tempo of everyday life was speeded up, and the temporal aspects of existence were increasingly regarded as of predominating importance. It therefore came as a shock when, in 1905, A. E. pointed out an unsuspected difficulty in the prevailing idea of time and concluded that time depends on the observer in a way not previously imagined, even by K.

It had been taken for granted[Image]both by those who followed K's ideas and those who did not[Image]that is a single worldwide time order and that each instant of this order corresponds to a definite contemporaneous state of the whole universe. This, as Einstein observed, was only an assumption. The order in which events are perceived is not always the order in which they are believed to occur. For a simple example, lightning is seen before thunder is heard, but both are manifestations of the same electric discharge in the atmosphere. Yet until E. raised the question, it was universally assumed as self-evident that when the rules are found that determine the time of each perception by the time of the event giving rise to it, all events thus perceived must necessarily fall into a definite time-sequence that is the same for all observers.

After much thought on the measurement of time and motion, Einstein came to realize that a person may have an immediate awareness of the simultaneity of two events in his personal experience but have no such awareness when one event is directly experienced and the other occurs at a distance. For example, suppose an explosion were to occur on Mars. An observer on earth records the instant at which he sees the flash. If light traveled instantaneously, the instant of observation on earth would coincide precisely with the instant the explosion was recorded by a hypothetical observer on Mars. However, there is definite experimental evidence that light takes time to travel, so the terrestrial observer must in fact "correct" the time recorded on his watch to make allowance for the time taken by the light to reach him.[2]

In principle, the velocity of light can be determined only if the way to measure time at all places that it traverses is known. But this is precisely what no longer can be known, once the traditional assumption of worldwide simultaneity for all observers is abandoned. To escape this vicious circle, Einstein decided to jettison the classical theory of the measurement of space and time and begin on a totally different basis.

The classical theory, E. realized, leads to absurdity when one tries to imagine what would happen when traveling through space at the same velocity as a beam of light. According to the idea of relative motion based on classical theory, the beam of light would then appear to the observer to be at rest. And a vibrating electromagnetic field at rest is a concept in conflict with electromagnetic theory, which E. saw no reason to reject. Instead he concluded that the laws of physics[Image]including those concerning the propagation of light must remain the same for all observers in uniform motion [3],, however fast they may be moving. In particular, the velocity of light in empty space must be the same for all such observers. Since this velocity is finite, it is the classical idea of relative motion that must be modified.

A curious result of E.'s theory is that, in general, observers in relative motion must assign different times to the same event [4]. Only observers at relative rest can assign the same time to the event. The discrepancy can be illustrated by saying that a clock in relative motion between two other clocks will measure a smaller time interval than will the two clocks at rest, as it passes from one clock to the other. For velocities encountered in everyday life the difference is negligible, but the nearer the relative velocity of the moving clock is to that of light, the greater the difference will be. The relativistic effect has been amply confirmed by experiments with elementary particles moving at nearly the speed of light.

c) Time, Space-Time, and Causality

The idea of the relativity of time that is, that time depends on the observer and that there is no absolute measure of duration[Image]entails the relativity of spatial measurement as well. Due to the universal character of the velocity of light, the distance between two places can be measured by the time it takes light to travel from one place to the other. This measurement in turn depends on the observer.

This similarity between space and time is part of the new universal concept introduced by the German mathematician Hermann M. in 1908. If an interval of time is regarded as a kind of "distance" in the time dimension, it can be converted into a distance by being multiplied by c, the velocity of light, thus obtaining the distance light would travel in that time. If the time difference between any two events is T, according to a particular observer, the associated spatial interval is cT. Then if R is the actual distance in space between these events, it can be shown that although both cT and R depend on the particular observer, the difference between cT2 and R2 has the same value for all observers in uniform relative motion. This difference is the square of what is called the space-time interval between the two events. Space-time is a four-dimensional analog of three-dimensional space, the fourth dimension being the dimension of time.

If the universe is pictured as a system of events in space-time, then the times and spaces of different observers are simply different "cross sections" or individual perspectives of this system. [5] Although the space-time interval between two events is the same according to all observers at rest or in uniform motion, it is split up by different observers into different space and time components.

The idea of space-time also leads to the new concept of forward and backward light-cones associated with a given event E. Each of these cones has the vertex E, and the cone surfaces are formed by the space-time paths of all conceivable electromagnetic rays passing through that vertex. The forward cone is directed toward the future; the backward cone converges toward E from the past. Only those events lying inside the forward or backward light-cone of a given event E are in the future or past of that event in any absolute sense. The temporal relationship of all other events to E depends on the observer. Thus for a given event F lying outside the light-cones of E, observers can be found who will regard F as later than E, simultaneous with E, or earlier than E. No such ambiguity arises in the classical theory of time, in which the temporal relationship of any two events is the same for all observers.

The concept of light-cones has had a profound influence on the concept of causality because those events that lie inside each other's light cones can be in absolute causal relationship with one another. Einstein later extended his ideas about space-time to include cases in which observers are in accelerated motion in gravitational fields.

d) Time and the Universe in Modern Cosmology

Although the classical concept of universal time has been undermined, modern cosmologists have reintroduced the idea of a worldwide time that is common to an important but restricted class of observers. According to most cosmological theories, there is a preferential time scale at each place in the universe. This scale is associated with the "local" cosmic standard of rest determined by the "local" bulk of distribution of matter for example, the center of mass of the stars in our galaxy. The time scales of the observers associated with these local standards of rest, throughout the universe, "fit together" to form one worldwide cosmic time.(note T.O.: compare this to the cakra tempometer-design at the designspage)

It is with reference to this cosmic time that objective meaning can be given to concepts such as the age of the earth, the sun, our galaxy, and even the universe itself. Thus despite the theory of relativity the concept of a cosmic time scale can be retained, even though it is not the time scale of every observer.

According to ideas based on the spectroscopic study of light from distant galaxies, the universe is believed to be expanding, which may imply further limitations on the human idea of time. If the rate of expansion is uniform, the age of the universe would be about 10 billion years, or about twice the age of the sun and the earth. If the rate of expansion is decreasing, the age would be somewhat less. However, if it is increasing, not only would the age be somewhat greater, but there also would be regions receding from our own galaxy at velocities greater than that of light. Hence no light or any other physical influence from such regions could ever reach our galaxy, and no events in the regions could find a place in our time scale. They would lie beyond our "time horizon." Therefore no time scale could comprise all events, and "worldwide" cosmic time would in fact be restricted to events within each observer's time horizon.

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Notes:

[1] modern psychology reintroduced the concept of cyclic time stressing the importance of conditioning in recurring patterns of time.

[2]: think of our timesystem with timezones that give the delusion of occurence at the same time while in fact the sun rises in Berlin much earlier than in Madrid.

[3} Therefore in uniform motion time and space are not independent of oneother and thus would the theorem of non-cyclic linear time be rejected. (practically: on the move in a train e.g. one needs standardtime and staying home true timing to the sun)

[4] with the event of the sun, therefore standardtime is at odds (makes a psychology or instability of the time-experiece) with the logics of physics in particular and science in genral. compare time as defined by The Order of Time

[5] Compare with true time measurement relative to standardtime measurement