DOWNLOAD PDF HISTORY OF TIME MEASUREMENT

Chapter 1 : HISTORY OF MEASUREMENT

As the sun moves across the sky, shadows change in direction and length, so a simple sundial can measure the length of a day. It was quickly noticed that the length of the day varies at different times of the year.

The sun rising over Stonehenge on the June solstice Many ancient civilizations observed astronomical bodies , often the Sun and Moon , to determine times, dates, and seasons. History of timekeeping devices in Egypt Ancient Egyptian sundial c. Daytime divided into 12 parts. It was positioned eastward in the morning, and was turned west at noon. Obelisks functioned in much the same manner: The obelisk also indicated whether it was morning or afternoon, as well as the summer and winter solstices. It measured the passage of time by the shadow cast by its crossbar on a non-linear rule. The T was oriented eastward in the mornings, and turned around at noon , so that it could cast its shadow in the opposite direction. One type consisted of a bowl with small holes in its bottom, which was floated on water and allowed to fill at a near-constant rate; markings on the side of the bowl indicated elapsed time, as the surface of the water reached them. The time was accurately measured by observing certain stars as they crossed the line created with the merkhets. Clepsydra, literally water thief, is the Greek word for water clock. The vat held a steadily increasing amount of water, supplied by a cistern. By morning, the vessel would have floated high enough to tip over, causing the lead balls to cascade onto a copper platter. Water emptied until it reached the siphon, which transported the water to the other jar. There, the rising water would force air through a whistle, sounding an alarm. The Tower of the Winds in Athens , Greece, a 1st-century-BC clocktower from the period of Roman Greece In Greek tradition, clepsydrae were used in court ; later, the Romans adopted this practice, as well. There are several mentions of this in historical records and literature of the era; for example, in Theaetetus , Plato says that "Those men, on the other hand, always speak in haste, for the flowing water urges them on". Up stepped an old man, whom I did not know. He was invited to speak for as long as there was water in the clock; this was a hollow globe into which water was poured through a funnel in the neck, and from which it gradually escaped through fine perforations at the base". Another consisted of a bowl with a hole in its centre, which was floated on water. Time was kept by observing how long the bowl took to fill with water. One of the more common problems in most types of clepsydrae was caused by water pressure: Along with this improvement, clocks were constructed more elegantly in this period, with hours marked by gongs, doors opening to miniature figurines, bells, or moving mechanisms. Water flows more slowly when cold, or may even freeze. The added complexity was aimed at regulating the flow and at providing fancier displays of the passage of time. For example, some water clocks rang bells and gongs , while others opened doors and windows to show figurines of people, or moved pointers, and dials. Some even displayed astrological models of the universe. Although the Greeks and Romans did much to advance water clock technology, they still continued to use shadow clocks. The mathematician and astronomer Theodosius of Bithynia , for example, is said to have invented a universal sundial that was accurate anywhere on Earth, though little is known about it. Marcus Vitruvius Pollio , the Roman author of De Architectura , wrote on the mathematics of gnomons , or sundial blades. Its gnomon was an obelisk from Heliopolis.

Chapter 2 : A Brief History of Weights and Measures

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Time, Measurement of The history of time measurement is the story of the search for more consistent and accurate ways to measure time. Early human groups recorded the phases of the Moon some 30, years ago, but the first minutes were counted accurately only years ago. The atomic clocks that allowed mankind to track the approach of the third millennium in the year by a billionth of a second are less than 50 years old. The study and science of time measurement is called horology. Time is measured with instruments such as a clock or calendar. These instruments can be anything that exhibits two basic components: Imagine your daily lifeâ€”getting ready in the morning, driving your car, working at your job, going to school, buying groceries, and other events that make up your day. Now imagine all the people in your neighborhood, in your city, and in your country doing these same things. The social interaction that our existence involves would be practically impossible without a means to measure time. Time can even be considered a common language between people, and one that allows everybody to proceed in an orderly fashion in our complicated and fast-paced world. Because of this, the measurement of time is extremely important to our lives. As Earth rotates, the side facing the Sun changes, leading to its apparent movement from one side of Earth, rising across the sky, reaching a peak, falling across the rest of the sky, and eventually disappearing below Earth on the opposite side to where it earlier appeared. Then, after a period of darkness, the Sun reappears at its beginning point and makes its journey again. This cyclical phenomenon of a period of brightness followed by a period of darkness led to the intervals of time now known as a day. Little is known about the details of timekeeping in prehistoric eras, but wherever records and artifacts are discovered, it is found that these early people were preoccupied with measuring and recording the passage of time. A second cyclical observation was likely the repeated occurrence of these days, followed by the realization that it took about 30 of these days actually, a fraction over 27 days for the Moon to cycle through a complete set of its shape changes: European ice-age hunters over 20, years ago scratched lines and gouged holes in sticks and bones, possibly counting the days between phases of the Moon. This timespan was eventually given the name of "month. However, as societies became more complex, the need developed to more precisely divide the day. The modern convention is to divide it into 24 hours, an hour into 60 minutes, and a minute into 60 seconds. The division into 60 originated from the ancient Babylonians b. The Babylonians divided the portion that was lit by the Sun into 12 parts, and the dark interval into 12 more, yielding 24 divisions now called hours. Ancient Arabic navigators measured the height of the Sun and stars in the sky by holding their hand outstretched in front of their faces, marking off the number of spans. An outstretched hand subtends an angle of about 15 degrees at eye level. Babylonian mathematicians also divided a complete circle into divisions, and each of these divisions into 60 parts. Babylonian astronomers also chose the number 60 to subdivide each of the 24 divisions of a day to create minutes, and each of these minutes were divided into 60 smaller parts called seconds. Early Time-Measuring Instruments The first instrument to measure time could have been something as simple as a stick in the sand, a pine tree, or a mountain peak. The steady shortening of its shadow would lead to the noon point when the Sun is at its highest position in the sky, and would then be followed by shadows that lengthen as darkness approaches. This stick eventually evolved into an obelisk, or shadow clock, which dates as far back as b. The Egyptians were able to divide their day into parts comparable to hours with these slender, four-sided monuments which look similar to the Washington Monument. The moving shadows formed a type of sundial, enabling citizens to divide the day into two parts. Sundials evolved from flat horizontal or vertical plates to more elaborate forms. One version from around the third century b. Apparently 5, to 6, years ago, civilizations in the Middle East and North Africa initiated clock-making techniques to organize time more efficiently. Ancient methods of measuring hours in the absence of sunlight included fire clocks, such as the notched candle and the Chinese practice of burning a knotted rope. All fire clocks were of a measured size to approximate the passage of time, noting the length of time required for fire to travel from one knot to the next. Devices almost as old as the sundial include the hourglass, in which the flow of sand is used to measure time intervals, and the water clock or "clepsydra" , in which the water flow indicates the passage of time. The Mechanization of Clocks By about b. Eventually, a weight falling under the force of gravity was substituted for the flow of water in time devices, a precursor to the mechanical clock. The first recorded examples of such mechanical clocks are found in the fourteenth century. A device, called an "escapement," slowed down the speed of the falling weight so that a cogwheel would move at the rate of one tooth per second. He was the first to confirm the constant period of the swing of a pendulum, and later adapted the pendulum to control a clock. The use of the pendulum clock became popular in the s when Dutch astronomer Christiaan Huygens applied the pendulum and balance wheel to regulate the movement of clocks. By virtue of the natural period of oscillation from the pendulum, clocks became accurate enough to record minutes as well as hours. Although British physicist Sir Isaac Newton continued the scientific study of time in the seventeenth century, a comprehensive explanation of time did not exist until the early twentieth century, when Albert Einstein proposed his theories of relativity. Einstein defined time as the fourth dimension of a four-dimensional world consisting of space length, height, depth and time. Quartz-crystal clocks were invented in the s, improving timekeeping performance far beyond that of pendulums. When a quartz crystal is placed in a suitable electronic circuit, the interaction between mechanical stress and electric field causes the crystal to vibrate and generate a constant frequency that can be used to operate an electronic clock display. But the timekeeping performance of quartz clocks has been substantially surpassed by atomic clocks. An atomic clock measures the frequency of electromagnetic radiation emitted by an atom or molecule. Because the atom or molecule can only emit or absorb a specific amount of energy, the radiation emitted or absorbed has a regular frequency. This allowed the National Institute of Standards and Technology to establish the second as the amount of time radiation would take to go through 9,,, cycles at the frequency emitted by cesium atoms making the transition from one state to another. Cesium clocks are so accurate that they will be off by only one second after running for million years. Time Zones In the s, the Greenwich time standard was established with the center of the first time zone set at the Royal Greenwich Observatory in England , located on the 0-degree longitude meridian. Today, when the time is But military time is measured differently. The military clock begins its day with midnight, known as either or hours "zero hundred hours" or hours "twenty-four hundred hours". An early-morning hour such as 1: In military time, An afternoon or evening hour is derived by adding 12; hence, 1: Greek and Roman Sundials. New Haven , CT: Yale University Press, Clocks and the Making of the Modern World. Tannenbaum, Beulah, and Myra Stillman. The Science of Clocks and Calendars. Medicine Wheelsâ€”stone circles found in North America dating from over 1, years agoâ€”also may have been used to follow heavenly bodies as they moved across the sky during the year. Cite this article Pick a style below, and copy the text for your bibliography.

Chapter 3 : History of Measuring Time

Temporal measurement and history. Generally speaking, methods of temporal measurement, or chronometry, take two distinct forms: the calendar, a mathematical tool for organising intervals of time, and the clock, a physical mechanism that counts the passage of time.

See Article History Clock, mechanical or electrical device other than a watch for displaying time. A clock is a machine in which a device that performs regular movements in equal intervals of time is linked to a counting mechanism that records the number of movements. All clocks, of whatever form, are made on this principle. See also atomic clock ; nuclear clock. The first mechanical clocks to which clear references exist were large, weight-driven machines fitted into towers and known today as turret clocks. These early devices struck only the hours and did not have hands or a dial. Components of a simple weight-driven clock. The oldest surviving clock in England is that at Salisbury Cathedral , which dates from The Salisbury clock strikes the hours, and those of Rouen and Wells also have mechanisms for chiming at the quarter hour. These clocks are large, iron-framed structures driven by falling weights attached to a cord wrapped around a drum and regulated by a mechanism known as a verge or crown wheel escapement. Their errors probably were as large as a half hour per day. The first domestic clocks were smaller wall-mounted versions of these large public clocks. They appeared late in the 14th century, and few examples have survived; most of them, extremely austere in design, had no cases or means of protection from dust. Paul Almasy About , clockmakers working probably in southern Germany or northern Italy began to make small clocks driven by a spring. These were the first portable timepieces, representing an important landmark in horology. The time-telling dials of these clocks usually had an hour hand only minute hands did not generally appear until the s and were exposed to the air; there was normally no form of cover such as a glass until the 17th century, though the mechanism was enclosed, and the cases were made of brass. Typical components in a watch powered by a mainspring. About Galileo noticed the characteristic timekeeping property of the pendulum. The Dutch astronomer and physicist Christiaan Huygens was responsible for the practical application of the pendulum as a time controller in clocks from onward. Clocks, weight-driven and with short pendulums, were encased in wood and made to hang on the wall, but these new eight-day wall clocks had very heavy weights, and many fell off weak plaster walls and were destroyed. The next step was to extend the case to the floor, and the grandfather clock was born. In the long, or seconds, pendulum was introduced by English clock makers with the anchor escapement. The anchor escapement, which was invented in the 17th century, allowed pendulum clocks to be regulated. Mechanical clocks The pendulum The pendulum is a reliable time measurer because, for small arcs, the time required for a complete swing period depends only on the length of the pendulum and is almost independent of the extent of the arc. The length of a pendulum with a period of one second is about 39 inches mm , and an increase in length of 0. Altering the length of a pendulum is therefore a sensitive means of regulation. The alteration is usually carried out by allowing the bob to rest upon a nut that can be screwed up or down the pendulum rod. Any expansion or contraction of the rod caused by changes of temperature will affect the timekeeping of a pendulum; e. For accurate timekeeping, the length of the pendulum must be kept as nearly constant as possible. This may be done in several ways, some of which use the differing coefficients of expansion the amount of expansion per degree change in temperature of different metals to obtain a cancelling-out effect. In one popular compensation method, the bob consists of a glass or metal jar containing a suitable amount of mercury. The gridiron pendulum employs rods of different metal, usually brass and steel, while in the zinc-iron tube the pendulum rod is made of concentric tubes of zinc and iron. An improved method, however, is to make the pendulum rod from a special alloy called Invar. This material has such a small coefficient of expansion that small changes of temperature have a negligible effect and can easily be compensated for if required. In a pendulum clock an escape wheel is allowed to rotate through the pitch of one tooth for each double swing of the pendulum and to transmit an impulse to the pendulum to keep it swinging. An ideal escapement would transmit the impulse without interfering with the free swing, and the impulse should be as uniform as possible. The double three-legged gravity escapement, which achieves the second of these but not the first, was invented by Edmund Beckett, afterward Lord Grimthorpe , and used by him for the great clock at Westminster, now generally known as Big Ben , which was installed in It became the standard for all really accurate tower clocks. The most common escapement was the verge-and-foliot. The verge-and-foliot was the most common mechanism for controlling the descent of a weight in a weight-driven clock. In a typical verge-and-foliot escapement, the weighted rope unwinds from the barrel , turning the toothed escape wheel. Controlling the movement of the wheel is the verge, a vertical rod with pallets at each end. When the wheel turns, the top pallet stops it and causes the foliot, with its regulating weights, to oscillate. This oscillation turns the verge and releases the top pallet. The wheel advances until it is caught again by the bottom pallet, and the process repeats itself. The actions of the escapement stabilize the power of the gravitational force and are what produce the ticktock of weight-driven clocks. The wheelwork The wheelwork, or train, of a clock is the series of moving wheels gears that transmit motion from a weight or spring, via the escapement, to the minute and hour hands. It is most important that the wheels and pinions be made accurately and the tooth form designed so that the power is transferred as steadily as possible. In a clock driven by a weight or a spring, the power is first transmitted by the main, or great, wheel. This engages with a pinion a gear with a small number of teeth designed to mesh with a larger wheel , whose arbor a turning rod to which gears are attached is attached to the second wheel that, in its turn, engages with the next pinion, and so on, down through the train to the escapement. The gear ratios are such that one arbor, usually the second or third, rotates once an hour and can be used to carry the minute hand. A simple to-1 gearing, known as the motion work, gives the necessary step-down ratio to drive the hour hand. The spring or weight is fitted with a mechanism so it can be rewound when necessary, and the arbor carrying the minute hand is provided with a simple slipping clutch that allows the hands to be set to the correct time. The timekeeping part of all weight-driven clocks, including large tower clocks, is substantially the same. The figure shows the mechanism of a simple weight-driven timepiece with a pendulum. The frame is made up of two plates that carry the pivots of the various wheels and other moving parts and that are united and spaced by four pillars. The driving weight hangs from a line coiled around a barrel or sprocket, which is raised by turning the winding square or, in some cases, by pulling on the line. The main wheel engages with the centre pinion, on the arbor axle of which is also mounted the centre wheel. The front pivot of this wheel and pinion is lengthened to the right of the illustration; it carries the minute hand and part of the gearing necessary to drive the hour hand. Main components of a weight-driven clock with a pendulum. The centre wheel is also coupled through a suitable gear train to the escape wheel, which engages with the pallets that are fixed to the arbor between the front plate and the pendulum suspension cock. Also fixed to the pallet arbor is the crutch, which terminates at its lower end in a fork that embraces the pendulum rod. The motion work used for driving the hands is mounted between the dial and the front plate of the frame. The cannon pinion, which drives the motion work, rotates once an hour; it is coupled to the centre arbor by a flat spring that acts as a clutch and permits the hands to be set. Electric clocks Electric currents can be used to replace the weight or spring as a source of power and as a means of signaling time indications from a central master clock to a wide range of distant indicating dials. Invented in , the first battery electric clock was driven by a spring and pendulum and employed an electrical impulse to operate a number of dials. Considerable experimental work followed, and it was not until that the first self-contained battery-driven clock was invented. In various modern master clocks the pendulum operates a light count wheel that turns through the pitch of one tooth every double swing and is arranged to release a lever every half minute. This lever gives an impulse to the pendulum and is then restored to its original position by an electromagnet. The pulse of current that operates the electromagnet can also be transmitted to a series of distant dials, or slave clocks, advancing the hands of each through the space of a half minute. Thus, a master clock can control scores of dials in a large group of buildings, as well as such other apparatus as time recorders and sirens. Electric master clocks of this type are good timekeepers, since the impulse can be given symmetrically as the pendulum passes through its middle position and the interference with its motion is small. With the application of the synchronous electric motor to clocks in , domestic electric clocks became popular. A synchronous electric motor runs in step with the frequency of the electric power source, which in most countries alternates at 60 hertz cycles per second. The electric motor is coupled to a reduction gearing that drives the clock hands at the correct rate. The synchronous electric clock has no timekeeping properties in itself and is wholly dependent upon the frequency stability of the alternating current supplied. If this frequency changes, the electric clock will not keep correct time. The most accurate mechanical timekeeper is the Shortt pendulum clock; it makes use of the movement described above for electric master clock systems. The Shortt pendulum clock consists of two separate clocks, one of which synchronizes the other. The timekeeping element is a pendulum that swings freely, except that once every half minute it receives an impulse from a gently falling lever. This lever is released by an electrical signal transmitted from its slave clock. After the impulse has been sent, a synchronizing signal is transmitted back to the slave clock that ensures that the impulse to the free pendulum will be released exactly a half minute later than the previous impulse. The pendulum swings in a sealed box in which the air is kept at a constant, low pressure. Shortt clocks in observatories are kept in a room, usually a basement, where the temperature remains nearly constant, and under these conditions they can maintain the correct time to within a few thousandths of a second per day. In the quartz crystal was first applied to timekeeping; this invention was probably the single greatest contribution to precision time measurement. Quartz crystals oscillating at frequencies of , hertz can be compared and frequency differences determined to an accuracy of one part in The timekeeping element of a quartz clock consists of a ring of quartz about 2. Electrodes are attached to the surfaces of the ring and connected to an electrical circuit in such a manner as to sustain oscillations. Since the frequency of vibration, ,hertz, is too high for convenient time measurement, it is reduced by a process known as frequency division or demultiplication and applied to a synchronous motor connected to a clock dial through mechanical gearing. If a , hertz frequency, for example, is subjected to a combined electrical and mechanical gearing reduction of 6,, to 1, then the second hand of the synchronous clock will make exactly one rotation in 60 seconds. The vibrations are so regular that the maximum error of an observatory quartz-crystal clock is only a few ten-thousandths of a second per day, equivalent to an error of one second every 10 years. Typical quartz clock mechanisms.

Chapter 4 : Time - Wikipedia

The history of time measurement is the story of the search for more consistent and accurate ways to measure time. Early human groups recorded the phases of the Moon some 30, years ago, but the first minutes were counted accurately only years ago.

Pounds Ounces The system of weights and measures is the collection of units and how they relate to each other. Example of System of Weights and Measures: Most of the world uses the "system international" that we call the metric system. The United States uses the "customary system" and is the only major industrialized country that does not require the metric system. This is done by making sure each weights and measures standard is compared to a weights and measures standard that is even more accurate. The weights and measures officials in California use standards that are checked against the national standards in Washington, This is the international prototype kilogram which is kept in a building near Paris, France. All standards in the world must match to this kilogram including the United States standards in Washington, D. History of Weights and Measures in the United States When the colonists came to North America, they brought with them the weights and measures they were used to. This meant there were many different systems of weights and measures. This caused a lot of confusion. To add to the confusion, a measurement unit in one colony may not mean the same thing in another colony. This meant that a bushel of oats for your horse in the colony of Connecticut weighed 28 pounds, but in the colony of New Jersey it weighed 32 pounds. Connecticut Bushel 28 lbs. Eventually the states developed uniform weights and measures laws and standards. History of Weights and Measures in California Early California weights and measures were influenced by measures brought from Mexico and Spain. The measurement most often used for length was the vara. It was a wood stick that measured between 32 and 35 inches. Because the vara and other measurements were not the same everywhere in California, this caused problems. The California gold rush made this problem even worse. Each mining camp had its own weights and measures laws. There was a need for standard units in measuring land and grain in agriculture and an accurate way in measuring and trading gold. When California became a state in , one of the first laws was to establish weights and measures standards. That shows how important weights and measures are. Today, all 58 counties in California have weights and measures officials whose job is to make sure that when you buy an item you are charged the correct price, the quantity is correct, and for some products, the quality is what you expect. The counties work with the Division of Measurement Standards to enforce weights and measures laws and regulations to protect consumers. The Division of Measurement Standards is responsible for weights and measures in the State of California. If you have questions you would like to ask about weights and measures, you can contact the Division of Measurement Standards at their e-mail address:

Chapter 5 : History of timekeeping devices - Wikipedia

The better measurement of time has been a human fascination for centuries but in the 18th century the clock emerged as a scientific instrument in its own right, notwithstanding its conventional.

Clock A large variety of devices have been invented to measure time. The study of these devices is called horology [22]. An Egyptian device that dates to c. The T was oriented eastward in the mornings. At noon, the device was turned around so that it could cast its shadow in the evening direction. The position of the shadow marks the hour in local time. The idea to separate the day into smaller parts is credited to Egyptians because of their sundials, which operated on a duodecimal system. The importance of the number 12 is due the number of lunar cycles in a year and the number of stars used to count the passage of night. They could be used to measure the hours even at night, but required manual upkeep to replenish the flow of water. The Ancient Greeks and the people from Chaldea southeastern Mesopotamia regularly maintained timekeeping records as an essential part of their astronomical observations. Arab inventors and engineers in particular made improvements on the use of water clocks up to the Middle Ages. A contemporary quartz watch , The hourglass uses the flow of sand to measure the flow of time. They were used in navigation. Ferdinand Magellan used 18 glasses on each ship for his circumnavigation of the globe Waterclocks, and later, mechanical clocks, were used to mark the events of the abbeys and monasteries of the Middle Ages. Richard of Wallingford â€” , abbot of St. The hours were marked by bells in abbeys as well as at sea. Chip-scale atomic clocks , such as this one unveiled in , are expected to greatly improve GPS location. They can be driven by a variety of means, including gravity, springs, and various forms of electrical power, and regulated by a variety of means such as a pendulum. Alarm clocks first appeared in ancient Greece around BC with a water clock that would set off a whistle. This idea was later mechanized by Levi Hutchins and Seth E. Initially, the term was used to refer to the marine chronometer , a timepiece used to determine longitude by means of celestial navigation , a precision firstly achieved by John Harrison. More recently, the term has also been applied to the chronometer watch , a watch that meets precision standards set by the Swiss agency COSC. The most accurate timekeeping devices are atomic clocks , which are accurate to seconds in many millions of years, [31] and are used to calibrate other clocks and timekeeping instruments. Atomic clocks use the frequency of electronic transitions in certain atoms to measure the second. One of the most common atoms used is caesium , most modern atomic clocks probe caesium with microwaves to determine the frequency of these electron vibrations. SI defines the second as 9,,, cycles of the radiation that corresponds to the transition between two electron spin energy levels of the ground state of the Cs atom. Today, the Global Positioning System in coordination with the Network Time Protocol can be used to synchronize timekeeping systems across the globe. In medieval philosophical writings, the atom was a unit of time referred to as the smallest possible division of time. It was used in the computus , the process of calculating the date of Easter. As of May [update] , the smallest time interval uncertainty in direct measurements is on the order of 12 attoseconds 1. A minute min is 60 seconds in length, and an hour is 60 minutes in length. A day is 24 hours or 86, seconds in length. The solar day is the time interval between two successive solar noons, i. The local meridian is an imaginary line that runs from celestial north pole to celestial south pole passing directly over the head of the observer. At the local meridian the Sun reaches its highest point on its daily arc across the sky. The SI base unit for time is the SI second. The International System of Quantities , which incorporates the SI, also defines larger units of time equal to fixed integer multiples of one second 1 s , such as the minute, hour and day. These are not part of the SI, but may be used alongside the SI. Other units of time such as the month and the year are not equal to fixed multiples of 1 s, and instead exhibit significant variations in duration. At its meeting, the CIPM affirmed that this definition refers to a caesium atom in its ground state at a temperature of 0 K. The definition of the second in mean solar time, however, is unchanged. World time While in theory, the concept of a single worldwide universal time-scale may have been conceived of many centuries ago, in practicality the technical ability to create and maintain such a time-scale did not become possible until the midth century. The timescale adopted was Greenwich Mean Time, created in History of the development of UTC With the advent of the industrial revolution , a greater understanding and agreement on the nature of time itself became increasingly necessary and helpful. As international commerce continued to increase throughout Europe, in order to achieve a more efficiently functioning modern society, an agreed upon, and highly accurate international standard of time measurement became necessary. In order to find or determine such a time-standard, three steps had to be followed: An internationally agreed upon time-standard had to be defined. This new time-standard then had to be consistently and accurately measured. The new time-standard then had to be freely shared and distributed around the world. The development of what is now known as UTC time came about historically as an effort which first began as a collaboration between 41 nations, officially agreed to and signed at the International Meridian Conference , in Washington D. At this conference, the local mean solar time at the Royal Observatory, Greenwich in England was chosen to define the "universal day", counted from 0 hours at Greenwich mean midnight. In contrast astronomical GMT began at mean noon, i. The civil system was adopted as of 0 hours civil 1 January Nautical GMT began 24 hours before astronomical GMT, at least until in the Royal Navy , but persisted much later elsewhere because it was mentioned at the conference. In , the Greenwich meridian was used for two-thirds of all charts and maps as their Prime Meridian. This was to avoid confusion with the previous system where the day had begun at noon. As the general public had always begun the day at midnight the timescale continued to be presented to them as Greenwich Mean Time. By , universal time had been split into various versions â€” UT2, which smoothed for polar motion and seasonal effects, was presented to the public as Greenwich Mean Time. Later, UT1 which smooths only for polar motion became the default form of UT used by astronomers and hence the form used in navigation, sunrise and sunset and moonrise and moonset tables where the name Greenwich Mean Time continues to be employed. Greenwich Mean Time is also the preferred method of describing the timescale used by legislators. Even to the present day, UT is still based on an international telescopic system. Observations at the Greenwich Observatory itself ceased in , though the location is still used as the basis for the coordinate system. For the better part of the first century following the "International Meridian Conference," until , the methods and definitions of time-keeping that had been laid out at the conference proved to be adequate to meet time tracking needs of science. Still, with the advent of the "electronic revolution" in the latter half of the 20th century, the technologies that had been available at the time of the Convention of the Metre proved to be in need of further refinement in order to meet the needs of the ever-increasing precision that the "electronic revolution" had begun to require. The ephemeris second An invariable second the "ephemeris second" had been defined, use of which removed the errors in ephemerides resulting from the use of the variable mean solar second as the time argument. In this ephemeris second was made the basis of the "coordinated universal time" which was being derived from atomic clocks. It is a specified fraction of the mean tropical year as at and, being based on historical telescope observations, corresponds roughly to the mean solar second of the early nineteenth century. It is the basis of all atomic timescales, e. Atomic clocks do not measure nuclear decay rates, which is a common misconception, but rather measure a certain natural vibrational frequency of caesium As it has been adopted as the civil timescale by some countries most countries have opted to retain mean solar time it is not permitted to deviate from GMT by more than 0. This is achieved by the occasional insertion of a leap second. Current application of UTC Most countries use mean solar time. However, UTC is widely used by the scientific community in countries where mean solar time is official. UTC time is based on the SI second, which was first defined in , and is based on the use of atomic clocks. Between and , UTC was periodically adjusted by fractional amounts of a second in order to adjust and refine for variations in mean solar time, with which it is aligned. After 1 January , UTC time has been defined as being offset from atomic time by a whole number of seconds, changing only when a leap second is added to keep radio-controlled clocks synchronized with the rotation of the Earth. Earth is split up into a number of time zones. Most time zones are exactly one hour apart, and by convention compute their local time as an offset from GMT. For example, time zones at sea are based on GMT. In many locations but not at sea these offsets vary twice yearly due to daylight saving time transitions.

Chapter 6 : A brief history of telling time

In Dublin, the official measurement of time became a local custom, and by a public clock stood on top of the Tholsel (the city court and council chamber). It was the first of its kind to be clearly recorded in Ireland, and would only have had an hour hand. [].

When you finish this page, try the History of Measuring Time Quiz. Prehistoric man, by simple observation of the stars, changes in the seasons, day and night began to come up with very primitive methods of measuring time. This was necessary for planning nomadic activity, farming, sacred feasts, etc.. The earliest time measurement devices before clocks and watches were the sundial, hourglass and water clock. The forerunners to the sundial were poles and sticks as well as larger objects such as pyramids and other tall structures. Later the more formal sundial was invented. It is generally a round disk marked with the hours like a clock. It has an upright structure that casts a shadow on the disk - this is how time is measured with the sundial. The hourglass was also used in ancient times. It was made up of two rounded glass bulbs connected by a narrow neck of glass between them. When the hourglass is turned upside down, a measured amount of sand particles stream through from the top to bottom bulb of glass. Another ancient time measurer was the water clock or clepsydra. It was a evenly marked container with a spout in which water dripped out. As the water dripped out of the container one could note by the water level against the markings what time it was. One of the earliest clocks was invented by Pope Sylvester II in the s. Later on chimes or bells were added as well as dials to the clocks. Early clocks were powered by falling weights and springs. Later clocks with pendulums came into existence in Electric clocks came into being after , but were not popular until the twentieth century. An electric motor with alternating current powers these clocks. Later digital clocks with LCD liquid crystal displays rivaled the electric clocks. Quartz clocks use the vibrations of a quartz crystal to power the clock. Watches are different than clocks in that they are carried about or worn. The first watches appeared by the s and were made by hand. They were very fancy and their faces were covered by fine metal strips to protect the markings. Watches were manufactured by machine in the mid s. At first watches had knobs on the outside that the wearer wound to keep the mainspring powered inside. Later on, self-winding watches derived power from the movement of the wearer. With the advent of quartz crystal watches with digital displays, the need for motors for watches has decreased.

Chapter 7 : The History of Measurements | 14th Century to 21st Century | MTI Instruments

Noticing the regular movement of the Sun and the stars has led to a desire to measure time. This article for teachers and learners looks at the history of man's need to measure things.

This was necessary for planning nomadic activity, farming, sacred feasts, etc.. The earliest time measurement devices before clocks and watches were the sundial, hourglass and water clock. Find out more about these types of clock here The forerunners to the sundial were poles and sticks as well as larger objects such as pyramids and other tall structures. Later the more formal sundial was invented. It is generally a round disk marked with the hours like a clock. It has an upright structure that casts a shadow on the disk - this is how time is measured with the sundial. The hourglass was also used in ancient times. It was made up of two rounded glass bulbs connected by a narrow n eck of glass between them. When the hourglass is turned upside down, a measured amount of sand particles stream through from the top to bottom bulb of glass. Another ancient time measurer was the water clock or clepsydra. It was a evenly marked container with a spout in which water dripped out. As the water dripped out of the container one could note by the water level against the markings what time it was. At first, they had no faces, and no hour or minute hands; rather, they struck a bell every hour. Later, clocks with hour, and then minute hands began to appear. These early mechanical clocks worked by using an escapement, a lever that pivoted and meshed with a toothed wheel at certain intervals. This controlled the movement, or "escape" of either the weights or the springs that were powering the clock, in order to regulate the speed at which the gears and wheels which measured the time turned. This discovery made smaller clocks, and later watches, possible. Then, in , Christiaan Huygens invented the pendulum clock, which used weights and a swinging pendulum. These clocks were much more accurate than previous clocks, off by less than a minute a day, compared to the 15 minutes a day of earlier clocks. The bigger the pendulum, the more accurate the clock was. In , the British Parliament offered a cash reward to anyone who could invent a clock accurate enough for use in navigation at sea. Thousands of sailors died because they were unable to find their exact position, because the exact time was needed to find longitude, and pendulum clocks would not work at sea. For every minute lost by a clock, it meant that there would be a navigational error of 15 miles, and sailors died because they were lost or smashed against rocks because they were unable to figure out their exact position. Then, in , after 4 attempts, John Harrison finally succeeded at inventing a small clock accurate enough to use for navigation at sea. Eli Terry developed machines, patterns, and techniques that produced clock parts that were exactly alike, so they could be mass-produced and interchanged from one clock to another. This drove the price of clocks way down, and allowed common people to own at least one, if not many, timekeeping devices. At the dawn of the 20th century, only women wore wristwatches. No self-respecting "real man" would wear one. However, in the first World War, soldiers wore wristwatches because taking out a pocket watch to check the time was difficult or impossible in battle. After the war was over, it was considered "socially acceptable" to wear wrist watches, and they became popular. Half a century later, digital watches, which used electrical currents running through quartz crystals to cause vibration and tell the time very accurately, began to appear. The next great advancement in timekeeping was in , when the atomic clock, which used the oscillations of cesium atoms to tell time, was invented. This clock had an error ratio of 1 second for every 1. Recently, in , scientists developed the cesium fountain atomic clock, which is off by only one second every 20 million years. This clock is the most accurate in the world.

Chapter 8 : History of measurement - Wikipedia

History Of Measuring Time. When you finish this page, try the History of Measuring Time Quiz.. Prehistoric man, by simple observation of the stars, changes in the seasons, day and night began to come up with very primitive methods of measuring time.

The inch is a thumb. The foot speaks for itself. The yard relates closely to a human pace, but also derives from two cubits the measure of the forearm. With measurements such as these, it is easy to explain how far away the next village is and to work out whether an object will get through a doorway. For the complex measuring problems of civilization - surveying land to register property rights, or selling a commodity by length - a more precise unit is required. The solution is a rod or bar, of an exact length, kept in a central public place. In Egypt and Mesopotamia these standards are kept in temples. The basic unit of length in both civilizations is the cubit, based on a forearm measured from elbow to tip of middle finger. Weight For measurements of weight, the human body provides no such easy approximations as for length. But nature steps in. Grains of wheat are reasonably standard in size. Weight can be expressed with some degree of accuracy in terms of a number of grains - a measure still used by jewellers. As with measurements of length, a lump of metal can be kept in the temples as an official standard for a given number of grains. Copies of this can be cast and weighed in the balance for perfect accuracy. But it is easier to deceive a customer about weight, and metal can all too easily be removed to distort the scales. An inspectorate of weights and measures is from the start a practical necessity, and has remained so. Volume Among the requirements of traders or tax collectors, a reliable standard of volume is the hardest to achieve. Nature provides some very rough averages, such as goatskins. Baskets, sacks or pottery jars can be made to approximately consistent sizes, sufficient perhaps for many everyday transactions. But where the exact amount of any commodity needs to be known, weight is the measure more likely to be relied upon than volume. Time Time, a central theme in modern life, has for most of human history been thought of in very imprecise terms. The day and the week are easily recognized and recorded - though an accurate calendar for the year is hard to achieve. The forenoon is easily distinguishable from the afternoon, provided the sun is shining, and the position of the sun in the landscape can reveal roughly how much of the day has passed. By contrast the smaller parcels of time - hours, minutes and seconds - have until recent centuries been both unmeasurable and unneeded. Sundial and water clock: It also makes possible more elaborate calculations, as in the attempt of Erathosthenes to measure the world - see Erathosthenes and the camels. The result is the sundial. An Egyptian example survives from about BC, but the principle is certainly familiar to astronomers very much earlier. Early attempts at precision in time-keeping rely on a different principle. The water clock, known from a Greek word as the clepsydra, attempts to measure time by the amount of water which drips from a tank. This would be a reliable form of clock if the flow of water could be perfectly controlled. In practice it cannot. The clepsydra has an honourable history from perhaps BC in Egypt, through Greece and Rome and the Arab civlizations and China, and even up to the 16th century in Europe. But it is more of a toy than a timepiece. The hourglass, using sand on the same principle, has an even longer career. It is a standard feature on 18th-century pulpits in Britain, ensuring a sermon of sufficient length. In a reduced form it can still be found timing an egg. Plotting the relative position of features in a landscape, essential for any accurate map, is a more complex task than simply measuring distances. It is necessary to discover accurate angles in both the horizontal and vertical planes. To make this possible a surveying instrument must somehow maintain both planes consistently in different places, so as to take readings of the deviation in each plane between one location and another. Hero adapts, for this new and dificult task, an instrument long used by Greek astronomers such as Hipparchus for measuring the angle of stars in the sky. It is evident from his description that the dioptra differs from the modern theodolite in only two important respects. It lacks the added convenience of two inventions not available to Hero - the compass and the telescope. It is a practical division of the day into 12 segments 12 being the most convenient number for dividing into fractions, since it is divisible by 2, 3 and 4. For the same reason 60, divisble by 2, 3, 4 and 5, has been a larger framework of measurement ever since Babylonian times. The traditional concept of the hour, as one twelfth of the time between dawn and dusk, is useful in terms of everyday timekeeping. Approximate appointments are easily made, at times which are easily sensed. Noon is always the sixth hour. Half way through the afternoon is the ninth hour - famous to Christians as the time of the death of Jesus on the Cross. The trouble with the traditional hour is that it differs in length from day to day. And a daytime hour is different from one in the night also divided into twelve equal hours. A clock cannot reflect this variation, but it can offer something more useful. It can provide every day something which occurs naturally only twice a year, at the spring and autumn equinox, when the 12 hours of day and the 12 hours of night are the same length. In the 14th century, coinciding with the first practical clocks , the meaning of an hour gradually changes. It becomes a specific amount of time, one twenty-fourth of a full solar cycle from dawn to dawn. And the day is now thought of as 24 hours, though it still features on clock faces as two twelves. With the arrival of dials for the faces of clocks, in the 14th century, something like a minute is required. The Middle Ages, by a tortuous route from Babylon, inherit a scale of scientific measurement based on Thus, on a principle years old, minutes and seconds find their way into time. Minutes are mentioned from the 14th century, but clocks are not precise enough for anyone to bother about seconds until two centuries later. Barometer and atmospheric pressure: Evangelista Torricelli, assistant to Galileo at the end of his life, is interested in why it is more difficult to pump water from a well in which the water lies far below ground level. He suspects that the reason may be the weight of the extra column of air above the water, and he devises a way of testing this theory. He fills a glass tube with mercury. Submerging it in a bath of mercury, and raising the sealed end to a vertical position, he finds that the mercury slips a little way down the tube. He reasons that the weight of air on the mercury in the bath is supporting the weight of the column of mercury in the tube. If this is true, then the space in the glass tube above the mercury column must be a vacuum. But it also encourages von Guericke , in the next decade, to develop the vacuum pump. The concept of variable atmospheric pressure occurs to Torricelli when he notices, in , that the height of his column of mercury sometimes varies slightly from its normal level, which is mm above the mercury level in the bath. Observation suggests that these variations relate closely to changes in the weather. The barometer is born. With the concept thus established that air has weight, Torricelli is able to predict that there must be less atmospheric pressure at higher altitudes. It is not hard to imagine an experiment which would test this, but the fame for proving the point in attaches to Blaise Pascal - though it is not even he who carries out the research. The brother-in-law descends from the mountain with the welcome news that the readings were indeed different. Atmospheric pressure varies with altitude. Alcohol expands rapidly with a rise in temperature, but not at an entirely regular speed of expansion. This makes accurate readings difficult, as also does the sheer technical problem of blowing glass tubes with very narrow and entirely consistent bores. By Fahrenheit has made great progress on the technical front, creating two separate alcohol thermometers which agree precisely in their reading of temperature. In that year he hears of the researches of a French physicist, Guillaume Amontons, into the thermal properties of mercury. Mercury expands less than alcohol about seven times less for the same rise in temperature , but it does so in a more regular manner. Fahrenheit sees the advantage of this regularity, and he has the glass-making skills to accomodate the smaller rate of expansion. He constructs the first mercury thermometer, of a kind which subsequently becomes standard. There remains the problem of how to calibrate the thermometer to show degrees of temperature. The only practical method is to choose two temperatures which can be independently established, mark them on the thermometer and divide the intervening length of tube into a number of equal degrees. In Newton has proposed the freezing point of water for the bottom of the scale and the temperature of the human body for the top end. He therefore accepts blood temperature for the top of his scale but adopts the freezing point of salt water for the lower extreme. Measurement is conventionally done in multiples of 2, 3 and 4, so Fahrenheit splits his scale into 12 sections, each of them divided into 8 equal parts. A more logical Swede, Anders Celsius, proposes in an early example of decimilization. In English-speaking countries this less complicated system takes more than two centuries to prevail. With the help of the simple and ancient astrolabe , the stars will reveal latitude. But on a revolving planet, longitude is harder. You need to know what time it is, before you can discover what place it is. The terms are demanding. To win the prize a chronometer a solemnly scientific term for a clock, first used in a document of this year must be sufficiently accurate to calculate longitude within thirty nautical miles at the end of a journey to the West Indies. This means that in rough seas, damp salty conditions and sudden changes of temperature the instrument must lose or gain not more than three seconds a day - a level of accuracy unmatched at this time by the best clocks in the calmest London drawing rooms. The challenge appeals to John Harrison, at the time of the announcement a year-old Lincolnshire carpenter with an interest in clocks. It is nearly sixty years before he wins the money. Luckily he lives long enough to collect it. By Harrison has built the first chronometer which he believes approaches the necessary standard.

Chapter 9 : Clock | measurement device | calendrierdelascience.com

A brief speech I gave at Target Headquarters on a topic of my choosing. I chose to discuss the history of time measurement in the world and how it preceded every major thought revolution in physics.

Messenger We live in a world where time is all important. In his bestseller, A brief history of time , physicist Stephen Hawking reminded us that: But the arrow of time does carry us forward, and humans have measured this time through the ages in different ways. Sundials and water clocks We will never know who was the first man or woman to try to give structure to the measurement of time, although in the Bible, the book of Genesis exemplified change on a day-to-day basis, and with evening and morning. The Ancient Egyptians used simple sundials and divided days into smaller parts, and it has been suggested that as early as 1,BC , they divided the interval between sunrise and sunset into 12 parts. An ancient Egyptian sundial. University of Basel Our familiar divisions of time are more recent and current terminology about time and time-keeping originated from the Babylonians and the Jews the seven-day week in Genesis. The Ancient Romans, during the republic, went with eight days â€" including a shopping day where people would buy and sell things. The sundial of course an effective instrument only when the sun shines was refined by the Greeks and taken further by the Romans a few centuries later. The Romans also used water clocks which they calibrated from a sundial and so they could measure time even when the sun was not shining, at night or on foggy days. Known as a clepsydra , it uses a flow of water to measure time. Typically a container is filled with water, and the water is drained slowly and evenly out of the container â€" markings are used to show the passage of time. But the changing length of the day with the seasons in the Roman world made time measurement much more fluid than today: The water clock made it possible to measure time in a simple and reasonably reliable way. Clocks come of age The better measurement of time has been a human fascination for centuries but in the 18th century the clock emerged as a scientific instrument in its own right, notwithstanding its conventional role to mark the passing of the hours. The pendulum clock owes is refinement to Galileo noticing the regularity of a suspended lamp swinging back and forth in the cathedral of Pisa, when he was still a student there. The high water mark of an instrument of measuring time that was both perfectly fit for purpose and elegant was the marine chronometer invented by John Harrison in England. It was a response to the need to measure time on board ship to a high level of precision, and so to be able to determine longitude the pendulum clock was unsuitable for marine use due to the motion of the ship. The Harrison clock on display at the Royal Observatory in Greenwich. His clock enabled the measurement of time, and so a position at sea, to high accuracy. It gave the Royal Navy an unprecedented tool for navigation. The work of 20th-century watch and clock makers continued that tradition â€" the skill of George Daniels in Britain in creating some of the best and most beautiful timepieces using traditional and hand-crafted methods can be seen in the permanent exhibition now at the Science Museum in London. Atoms and lasers Measuring time also changed in the 20th century changed through the development of the atomic clock in the s at the National Physical Laboratory. This allowed for new and better definition of time, and the second as its prime measure. The invention of the laser in changed time measurement for ever. Instead, it is through an atomic frequency: Time has moved away from terrestrial measurement to a measurement that could, in principle, be carried out on another planet or across the universe. The accuracy of this atomic time continues to be refined through research, and work at National Physical Laboratory in the UK is a world-leading presence. To quote Hawking again: The first episode of The Anthill , a podcast by The Conversation, looks at different aspects of time: