

How a Few Simple Things Changed History

Class 7

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What We Will Cover Today

- Overlooked Technologies
 - Eyeglasses and their progeny
 - Telescope
 - Microscope
 - The Clock
 - Before the Clock
 - Prayer & the Invention of the Clock
 - Consequences of the Clock
 - The Wristwatch

Definition of Eyeglasses

- Eyeglasses = an optical frame or device with lenses that is worn in front of the eyes, normally for vision correction (to aid in the viewing of objects not readily seen) or eye protection

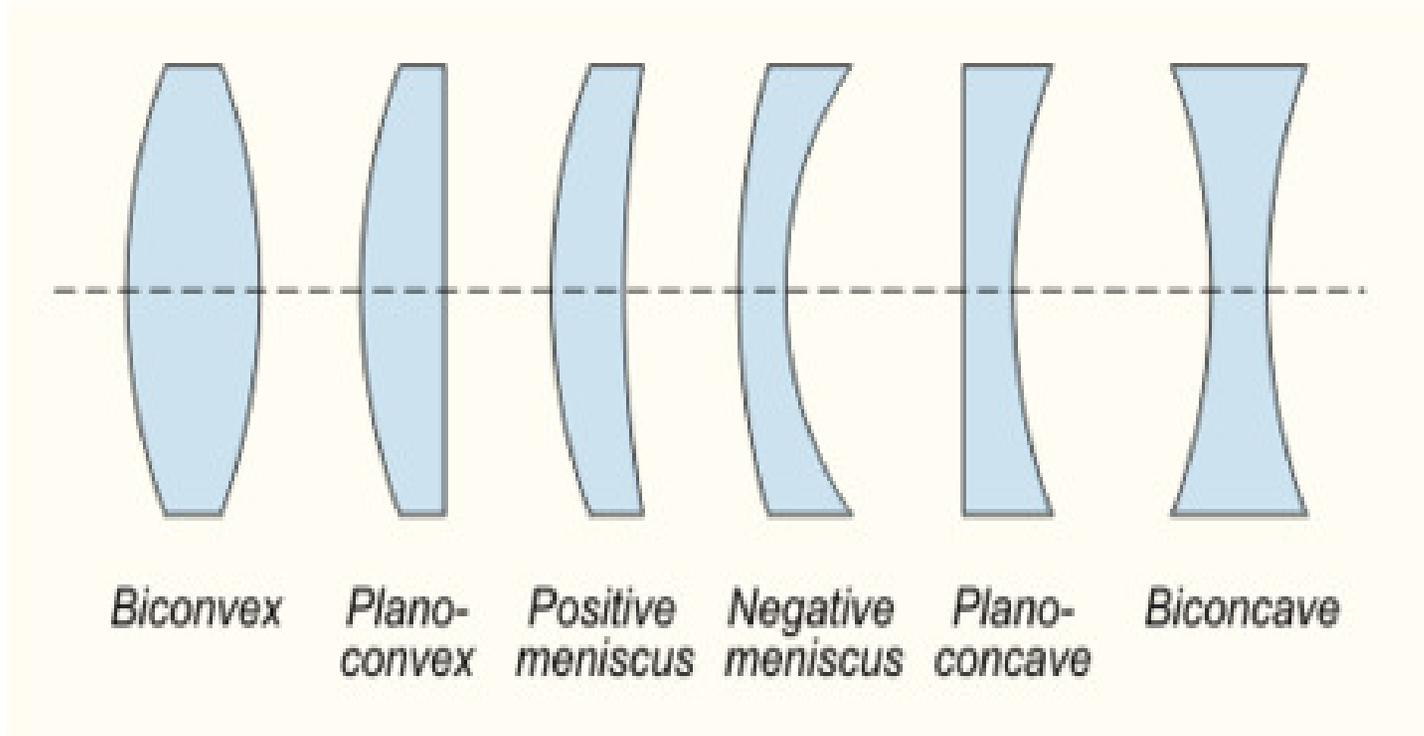
Definition of Lens

- Lens = a piece of transparent material (as glass) that has two opposite regular surfaces either both curved or one curved and the other plane and that is used either singly or combined in an optical instrument for forming an image by focusing rays of light

Notes on Lenses

- There are several types of lenses
 - Convex - curved or rounded outward like the exterior of a sphere or circle
 - Concave - hollowed or rounded inward like the inside of a bowl
 - Plano-concave – flat on one side and concave on the other
 - Plano-convex - flat on one side and convex on the other
 - Convexo-concave - having the convex side of greater curvature than the concave

Different Types of Lenses



The Invention of Eyeglasses - 1

- In the 1st century AD, Seneca the Younger made mention of the use of glass as a lens to magnify letters
- In 1235, Robert Grosseteste mentions use of optics to “read the smallest letters at incredible distances”
- In 1268, Roger Bacon made a reference to the magnifying property of lenses
- Marco Polo reported that glasses were being used in China by the rich and elderly

The Invention of Eyeglasses - 2

- A 1289 manuscript contains a mention by the author that he would be unable to read or write were it not for the recent invention of glasses.
- A 1305 sermon by Fra Giordano da Rivalto remarked that glasses had been invented less than 20 years earlier by a Pisan craftsman whom he knew
- A 1352 portrait of Cardinal Hugh de Provence shows the Cardinal with eyeglasses

Notes About Eyeglasses

- Every literate society has overlapping populations whose vision needs correction
 - Myopes (Nearsighted) – Can read, but distance vision is blurred
 - Hyperopes (Farsighted) – Can see at a distance, but near vision is blurred
 - Presbyopes — Unable to focus sharply for near vision due to loss of elasticity in the lens of the eye. Common among the middle-aged and elderly
 - Astigmatics – Suffer from blurred vision

Notes About Eyeglasses

- Early eyeglasses had convex lenses that could correct for both hyperopia and presbyopia
- In the 15th century, Nicholas of Cusa discovered that concave lenses could correct for myopia
- Benjamin Franklin who suffered from both myopia and presbyopia devised bifocals in 1784 to avoid having to continually switch from one pair of glasses to another

Notes About Eyeglasses

- In 1825, British astronomer George Airy devised the first lenses for correcting astigmatism
- Early glasses were either of the pince-nez or monocle variety. The modern style of glasses, with temple arms passing over the ears, was developed c1727 by the British optician Edward Scarlett

Notes About Eyeglasses

- The development of plastic lenses and eventually contact lenses was an outgrowth of military research in the 1940s
 - Sunglasses were an outgrowth of the attempt to enable aviators to cope with the glare from clouds

Impact of Eyeglasses - 1

- By correcting for farsightedness, eyeglasses made it possible for artisans and craftsman with presbyopia to do fine work and be productive in middle and old age
- Served as a basis for further optical advances
 - Glasses for nearsightedness (15th Century) and astigmatism (19th Century)
 - Telescope (c1600)
 - Microscope (c1600)

Impact of Eyeglasses - 2

- Facilitated the development of mass literacy
 - Mass literacy made vision aids necessary for millions of people
 - Thus, development of mass literacy and advances in optics mutually interacted and fostered each other

Impact of Eyeglasses - 3

- Advances in optometry led to different types of glasses and eventually to the development of contact lenses, sunglasses, and safety glasses
 - Advances also made glasses relatively cheaper and affordable to both the working classes and rural poor

Notes on Three Types of Eyeglasses

- Pince-nez = a style of glasses which are supported without earpieces, by pinching the bridge of the nose.
- Monacle = a type of corrective lens used to correct the vision in only one eye. It consists of a circular lens, generally with a wire ring around the circumference that can be attached to a string. The other end of the string is then connected to the wearer's clothing to avoid losing the monocle.

Notes on Three Types of Eyeglasses - 2

- Longnette = a pair of eyeglasses with a handle, used to hold them in place, rather than fitting over the ears

Notes on the Pince-Nez Glasses

- Originated in the 15th century in France, but were not popular until the 19th century
- Were popular from 1880 to 1900, but lost popularity thereafter
- Were worn by Theodore Roosevelt and Hercule Poirot (the fictional detective) among others

Teddy Roosevelt



Notes on the Monocle

- The monocle was invented in Rome in the 1720s in order to enable scholars and jewelers to closely examine engravings and engraved gems
- In the 1790s, it became popular as a fashion statement. By the 1890s, it was sort of costume accessory of both the high-ranking German officer and many public figures
 - German officers who actually wore a monocle included Erich Ludendorff, Werner von Fritsch, Walter Model , Hans Sperrle & Hans von Seeckt among others
 - Public figures who wore a monocle include Joseph Chamberlain, Mohammed Ali Jinnah, Alfred Lord Tennyson & Karl Marx

Notes on the Monocle - 2

- The monocle went out of style for two reasons:
 - Advances in optometry allowed for better measurement of refractive error, so that glasses and contact lenses could have different strengths in each eye
 - Reaction to the stereotypes associated with the monocle
- Many characters of music, movies, and novels wore monocles
 - 3 characters in Gilbert & Sullivan
 - Charlie McCarthy
 - The Count on Sesame Street
 - Colonel Klink (played by Werner Klemperer)
 - Amelia Bones (Harry Potter series)

GEN Hans Sperrle, Luftwaffe



Notes on Longnette Eyeglasses

- Were used more as a piece of jewelry rather than to enhance vision
- Were very popular in the 19th century with fashionable ladies at the opera and at masquerade parties
 - Were the model for today's opera glasses (which are fancy compact, low-power binoculars)

Notes on the Telescope - 1

- Telescope - a usually tubular optical instrument for viewing distant objects by means of the refraction of light rays through a lens or the reflection of light rays by a concave mirror
- Once eyeglasses had been invented, it did not take long for people to happen upon a combination of lenses inserted into tubes

Notes on the Telescope - 2

- The refracting telescope was invented in 1608 by Hans Lippershey, Zacharias Jansen, and Jacov Metius
- In 1609, Galileo devised a greatly improved version that he used to study the heavens. He discovered:
 - The moon has prominences, valleys, and chasms
 - There are a large number of stars invisible to the naked eye, but visible with a telescope
 - That Jupiter had four moons

Impact of the Telescope - 1

- The telescope shattered our Ptolemaic illusions about our world, the universe, and our place in the universe
 - It led Galileo and others to conclude that Copernicus' theory that the earth revolves around the sun was right
 - Galileo's outspoken support of Copernicus led to conflict with the Catholic Church and his eventual house imprisonment
 - The events surrounding Galileo and the Ptolemaic views embodied in the Bible led to the widespread perception that Science and the Bible are in conflict

Impact of the Telescope - 2

- Led to the discovery that light had a finite speed
- Established the Copernican Theory once and for all by showing that stars had a detectable parallax
 - In 1838, Friedrich Wilhelm Bessel showed that 61 Cygni was 10.9 light-years distant
- Led to the discovery of infrared and ultraviolet radiation
- Led to the discovery of spectroscopy

Impact of the Telescope - 3

- Led to the discovery of Cepheid variable “standard candles”
 - In 1919, Edwin Hubble used Cepheid variables in the Andromeda galaxy to show that Andromeda and other spiral nebulae were far distant galaxies
- Led to the discovery that the universe is expanding

Impact of the Telescope - 4

- Led to the realization that astronomical observations tended to produce a range of results
 - Karl Friedrich Gauss noted that when observations by different astronomers were plotted on a graph, they were found to follow a normal distribution or bell-shaped curve
 - L.A. J. Quetelet used the concept of the bell-shaped curve to produce the concept of the “average man.”

Notes About the Microscope

- Microscope = an optical instrument consisting of a lens or combination of lenses for making enlarged images of minute objects
- The microscope was invented around 1590 by Hans Lippershey and Zacharias Jansen, inventors of the telescope. Galileo devised an improved version in 1625

Notes About the Microscope - 2

- The first clear description of minute living organisms - “minute worms in decaying substances” - was published by Athanasius Kircher in 1646
- In the 1670s, Antony van Leeuwenhoek discovered protozoa and rotifers
 - In 1683, he discovered bacteria

Impact of the Microscope

- The discovery of bacteria and other living organisms not visible to the naked eye opened a whole new world for science and medicine to explore
- It paved the way for Louis Pasteur and Robert Koch in the 19th century to prove that certain bacteria and viruses could cause disease
- The desire for ever-greater levels of magnification led to both advances in optics and the eventual development of the electron microscope

The Impact of Clocks

Before the Clock - 1

- Peasants and country dwellers lived according to a diurnal schedule regulated by the rising and setting of the sun, the seasonal requirements of agriculture, and the weather
- In the towns and cities, the craftsman awoke with the dawn and worked as long as natural light and oil lamps permitted

Before the Clock - 2

- Prior to the invention of the clock, time was circadian, lunar, and seasonal – tied to the rotation of the planet and rhythms of nature
- Days had natural boundaries of darkness and light, but hours were subject to arbitrary definitions and varied in length with the seasons
- Before the invention of the clock, time was kept with a sundial or a clepsydra (water clock)

Before the Clock - 3

- The central unit of time was the whole day
 - People lived through it, accomplishing their tasks to the rhythm of light and dark
 - Hours were arbitrary divisions of daylight that varied with the length of the seasons
- Work was defined by the nature of the task, not by the number of hours it took to complete it

Prayer & Time

- Both Judaism and Islam had set times a day for prayer
 - Judaism – 3 times a day (after sunrise, before sunset, & after dark)
 - Islam – 5 times a day (at dawn just before sunrise, just after noon, before sunset, just after sunset, & after dark)
- Prayer times in both religions were bands rather than points in time
- Prayer in both religions was a personal act done without clerical or congregational mediation

Prayer & Time - 2

- In contrast, monastic Western Christianity developed set prayer times
 - Reflected Jewish prayer practices, the need to avoid attracting the attention of Roman persecutors, the idea of a vigil to await the parousia, and certain passages in scripture
- With the Benedictine Rule of St. Benedict came the concept of the Divine Office with its canonical hours of communal prayer

Prayer & Time - 3

- Since monastic canonical prayer services were congregational rather than individual, time discipline and punctuality were seen as important
 - This provided an incentive to invent the mechanical clock
 - The first mention of the mechanical clock dates from the 13th century
 - Reflected in the use of the term “clock” [from the Latin *clocca* (“bell”)] rather than the term “horologia” to designate a time-telling device

The Clock

- Clocks have four essential components
 - A source of power
 - A regulator of that power
 - Oscillator or a means of regulating flow
 - A way of transmitting the results of the oscillator or amount of flow to a face or dial or bell

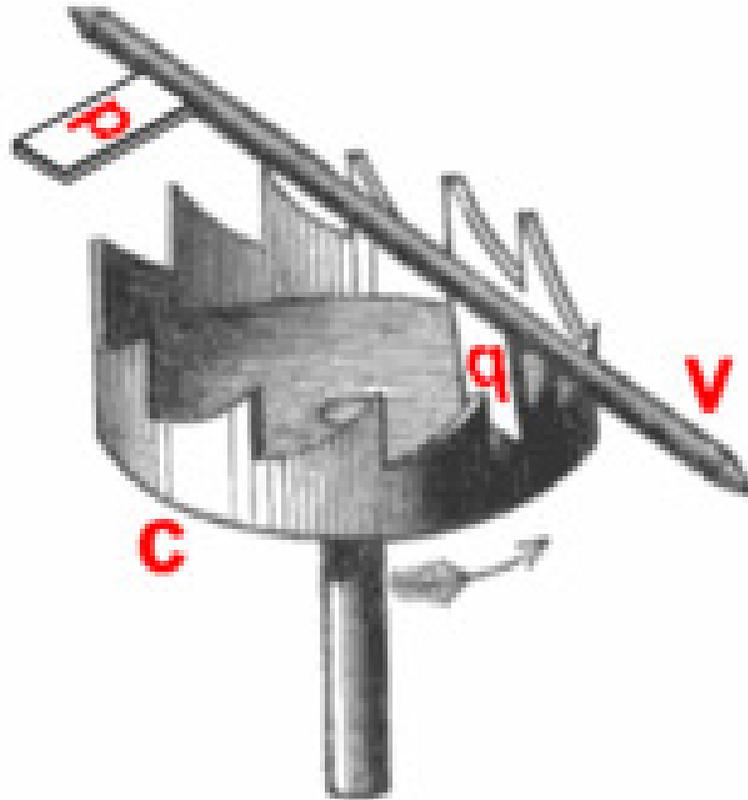
The Mechanical Clock

- The Mechanical Clock had four key elements
 - A slowly descending weight on a cord to drive the clockwork at a steady rate
 - A verge-and-foliot escapement that divided and transmitted the driving force
 - A balance (and later a spring) oscillator
 - A time indicator – either a bell or a dial with hands

The Mechanical Clock - 2

- The mechanical clock differed in two key ways from earlier clocks
 - It used gravity induced oscillation rather than something that flowed
 - It had a verge-and-foliot escapement by which the oscillation of the foliot caused a saw-toothed wheel to alternatively move, stop when a saw tooth engaged a protrusion on the verge, and move when the foliot oscillated and caused the verge to turn

Verge Escapement



The Mechanical Clock - 3

- The mechanical clock had a turning wheel controlled by a stop-and-go mechanism that curbed the motion of the turning wheel so that it turned once in 24 hours
- The stop-and-go mechanism divided time into discrete beats which could be counted and transmitted the count to a visual or auditory indicator (such as hands, dials, moving figures, or bells)
 - It was the action of the stop-and-go mechanism that created the tick-tock of the clock

Clock Innovations - 1

- Clock face or dial (1344)
- Spring-driven clock (15th century)
 - Made possible miniaturization and portability
- Watch (16th century)
- Pendulum clock (1657)
 - By the late-1600s, the pendulum clock increased accuracy from 15 minutes a day to 10 seconds a day

Clock Innovations - 2

- 20th Century innovations
 - Electric battery replaced weights and mainsprings as a source of power
 - Quartz crystals and later cesium atoms replaced the verge-and-foliot, balance wheel, and pendulum as a time divider
 - Integrated circuit counts the crystal's vibrations and transmits the count to the clock face

What the Mechanical Clock Did

- Clocks produced hours, minutes, and seconds
 - These time segments are always the same, winter and summer, day in and day out
 - These time segments are both uniform and arbitrary
- The clock lifted time out its relationship to the rhythms of nature and made it an abstraction independent of nature
 - Time was no longer a sequence of experiences but a collection of hours, minutes, and seconds

Consequences of the Clock

- Allowed the *hour* to replace the *day* as the basic unit of labor time in the medieval world's largest industry – textile manufacturing
 - Work became subject to the precision of timekeeping
- Disassociated time from human events and human events from nature
 - People now woke up when the alarm went off at 6:00 AM rather than when the sun rose
 - Work and even eating and sleeping came to accommodate themselves to the clock

Consequences of the Clock - 2

- Gave rise to the modern notion of productivity
 - Productivity is defined as “the ratio of the quantity and quality of units produced to the labor per unit of time”
 - The notion of productivity led to continual effort to increase productivity
 - This led to a dynamic of both technological innovation and the substitution of machines for human labor

Consequences of the Clock - 3

- Facilitated synchronization of daily activities and scheduling of events
 - Made it easy to schedule meetings and events
- Facilitated scientific observation & the development of science
 - Many natural phenomena consist of things or happenings taking place within a defined period of time and are recorded or measured in terms of speed, rate of change, number per unit of time, etc
 - Clocks made possible precise measurement of such phenomena

Consequences of the Clock - 4

- Gave rise to the concept that time was something that could be saved and used
- Gave rise to the notion of “being on time”
- Once railroads and steamships came on the scene, gave rise to timetables

Consequences of the Clock - 5

- The clock created the idea of a numerically quantified and mechanical universe
 - Gave rise in the 18th century to the Deist notion that the universe was analogous to a clock that God wound up at the beginning of time and allowed to unwind in accordance with Newtonian laws
 - Deism provided the first intellectual challenge to Christianity since the rise of Islam

Impact of Deism

- Led to the alienation of Western intellectuals from traditional Christianity
 - In America, this led to the First Amendment and the separation of church and state
 - In France, it eventually, in combination with other factors, led to the French Revolution
- Eventually led many intellectuals to agnosticism and atheism
 - Some Deists became Unitarians while others reverted back to traditional Christianity

Consequences of the Clock - 6

- Impacted upon Western theology and philosophy
 - Paley used the analogy of a watch implying the existence of a watchmaker to argue that the existence of the universe implied the existence of God

The Clock & Navigation

- The clock facilitated ocean-going navigation
 - One problem that led to many shipwrecks was not knowing where your ship was – latitude could be precisely determined but not longitude
 - But longitude could be understood as a function of time – every 24 hours the earth rotates through 360°
 - Each degree of longitude equals 4 minutes of time

The Clock & Navigation - 2

- In 1707, 4 Royal Navy ships capsized off the Scilly Isles because of a longitude miscalculation
 - In 1714, Queen Anne offered a £20,000 reward to anyone who found a way to calculate longitude to within half a degree
- What was needed was a clock that could keep precise time at sea
- In 1759, clockmaker John Harrison created a chronometer that could do just that.

The Clock & Mass Production

- The clock and the gun were the first precision-machined items to be mass-produced
 - In 1806, Eli Terry began mass production of clocks
 - In 1838, the brass clock was invented
- Starting in the late-18th century, the French-speaking Jura section of Switzerland became the world's center of watch manufacture

Watches

- The railroads created a major market for watches among railroad employees and passengers
- World War I led to the wrist watch replacing the pocket watch since the former was much more useful in a battlefield situation
 - When the doughboys came home, they continued and popularized the practice of wearing wristwatches

Impact of the Wristwatch

- It enabled individuals to order their life and work in a manner once reserved to the community – where the town clock was visible to all
 - Personalization of time was a major stimulus to individualism
- It made time pieces both a fashion statement and a status symbol
 - A fine watch became a mark of status