ELSEWEDY
UNIVERSITY
OF TECHNOLOGY
- POLYTECHNIC OF EGYPT -

History of Engineering and Technology

Lecture 5: Engineering in the Renascent Era.

ELSEWEDY UNIVERSITY OF TECHNOLOGY
- POLYTECHNIC OF EGYPT -

Renascent Engineering

(~1400 AD→~1800 AD)

Renascent Engineering (~1400 AD→~1800 AD)

- Renaissance and Engineering.
- Florence Dome.
- Engineering and Art.
- Movable-Type Printing.
- Oceanic Exploration.
- Intellectual stimulation.
- Engineering Systematics.
- Regional Influences.
- Power of Steam.
- Industrial Revolution.
- Summary.

Renaissance and Engineering

Renaissance and Engineering.

- An artistic and intellectual renewal movement which began about the late 1300s in the southern parts of Europe

- Its main idea:

  To put aside many of the unenlightened Medieval practices and seek a revival an a REBIRTH of the more uplifting facets of classical cultures of the *Ancient World*, especially that of Greece

The Renaissance ENGINEERING proved to be consequent of 3 reasons:

- (a) Wide Spread Crafting Proficiency
- (b) Accumulation Private Wealth
- (c) Interest in Novelty

ELSEWEDY UNIVERSITY OF TECHNOLOGY
- POLYTECHNIC OF EGYPT -

Florence Dome

Florence Dome.

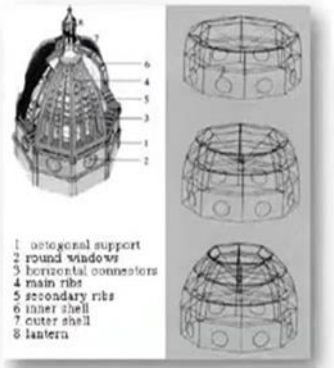
- The principal designer and construction: Italian craftsman Filipo Brunelleschi (in the 1430s)

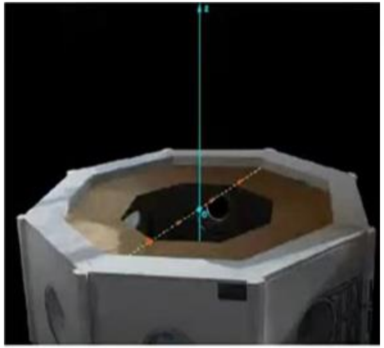
- unlike the dome of Hagia Sophia which was impressive when viewed from its interior, the Florence dome was to be also impressive from afar.

Florence Dome

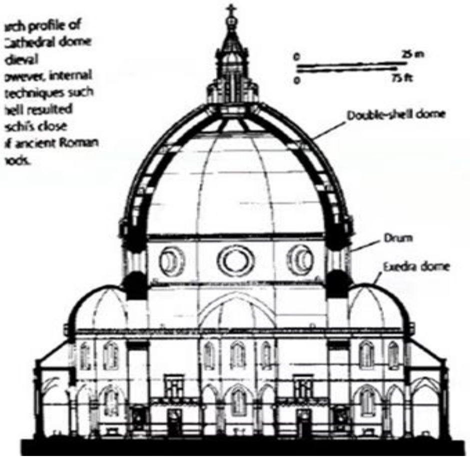
This project succeeded most obviously for 2 main reasons:

1. appealing geometric proportions





2. distant visibility



$$\cdots \to E(t)\left\{\begin{array}{l} \textit{project design and planning} \\ \textit{financial and labor force} \\ \quad \textit{management} \\ \textit{activity and material supply} \\ \quad \textit{scheduling} \\ \textit{development of case specific} \\ \quad \textit{tools and techniques} \\ \textit{establishment of an advisory} \\ \quad \textit{oversight committee} \end{array}\right\} \to D(t)\{dome\} \to \cdots$$

ELSEWEDY UNIVERSITY OF TECHNOLOGY
- POLYTECHNIC OF EGYPT -

Engineering and Art

Engineering and Art

Brunelleschi contributed to a unique technique in art.

the use of geometrical perspective

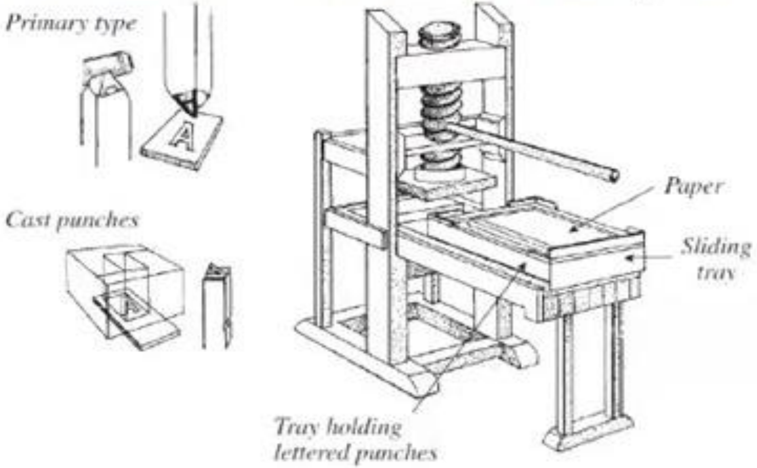
that is the technique of drawing building dimensions in inverse proportions to the distance from the point of view, and with lines of perspective converging to a vanishing point.

Movable-Type Printing

Movable-Type Printing

Gutenberg (1400–1468) developed a means of precision casting the mirror images of alphabetic letters at the end of punches made of an alloy of tin, lead, and antimony.

These could then be accurately and adjacently mounted—and subsequently reused—on transportable and movable printing plates for placement between the faces of an adapted wine press



Movable-Type Printing

By 1454, Gutenberg had organized the first commercial printing operation which was very important for the following reasons:

1. About 10,000 printing presses were operational throughout Europe producing 25 million books
2. The print-media innovations of newspapers appeared.
3. Literacy increased from less than 5% before Gutenberg to some 50% about two generations later.

$$
\begin{tikzcd}
N(t)\begin{Bmatrix} metals \\ fibers \\ wood \end{Bmatrix} \arrow[r] & E(t)\begin{Bmatrix} design \\ type\ casting \\ typesetting \end{Bmatrix} \arrow[r] & D(t)\begin{Bmatrix} movable\text{-}type \\ printing\ press \end{Bmatrix} \arrow[r] & S(t)\begin{Bmatrix} societal \\ fascination \end{Bmatrix} \arrow[ll, bend left, "positivefeedback"]
\end{tikzcd}
$$

Movable-Type Printing

the Gutenberg invention required the development and integration of new techniques and devices that were not known before:

(a) Working with soft metals (Lead, Tin, Antimony)
(b) Precision casting of interchangeable alphabetic characters
(c) Development of non-smudging and fast-drying ink

the experience of Gutenberg and his movable type printing press device changed **TECHNICAL PRACTICE**, for now a range of skills and knowledge all associated with a device had to converge:

$$\cdots \to E(t)\left\{\begin{array}{l} \textit{fundraising} \\ \textit{alloy casting} \\ \textit{precision machining} \\ \textit{adaptations} \\ \textit{process definition} \\ \textit{employee training} \\ \textit{marketing} \\ \textit{paper/ink assessment} \\ \vdots \end{array}\right\} \to D(t)\{\textit{printing press}\} \to \cdots$$

Oceanic Exploration

Oceanic Exploration

With the exception of Phoenician mariners who learned how to navigate on the Mediterranean at night by the moon and stars, most shipping was still limited to coastal sailing.

Towards the end of the Medieval period, European had adopted:

the magnetic compass
the sandglass for short time measurements

They also developed 2 additional devices to aid in sailing far from coastal visual reference points:

coastal maps and the knotted rope

this rope, with knots tied at agreed upon intervals, had an end-weighted imbalanced attached wooden slab to be laid overboard with knots counted during a specified time interval determined by the sandglass. Ship speed was thus measured in units of knots

Oceanic Exploration

- Stimulating some merchants to establish protected trade routes to the Middle East and from there connect to the Silk Road.
- This commerce became prompting other Europeans to seek their own alternate routes.
- In the early 1400s, Portugal's Prince Henry promoted a national interest in shipbuilding and navigation.
- Soon the Portuguese CARAVEL, a highly maneuverable ship design with triangular sails, began island hopping to the Azores and Madeira Islands, and collecting navigational data to be incorporated on maps and tables.

Based on this experience:

1. the Portuguese mariners acquired sufficient skill to explore the west coast of Africa, eventually learning to navigate on the southern hemisphere and discover the Cape of Good Hope.
2. the establishment of a marine trading corridor along the western seaboard of Africa as an alternative to camel transport across the forbidding Sahara Desert.

Oceanic Exploration

A significant change to the basic Carrack design occurred in the early 1500s and was called GALLEONS, when side-mounted cannons amoung other changes were introduced.

Galleons served well as both warships and traders and were soon also used on numerous colonization routes by Europeans.

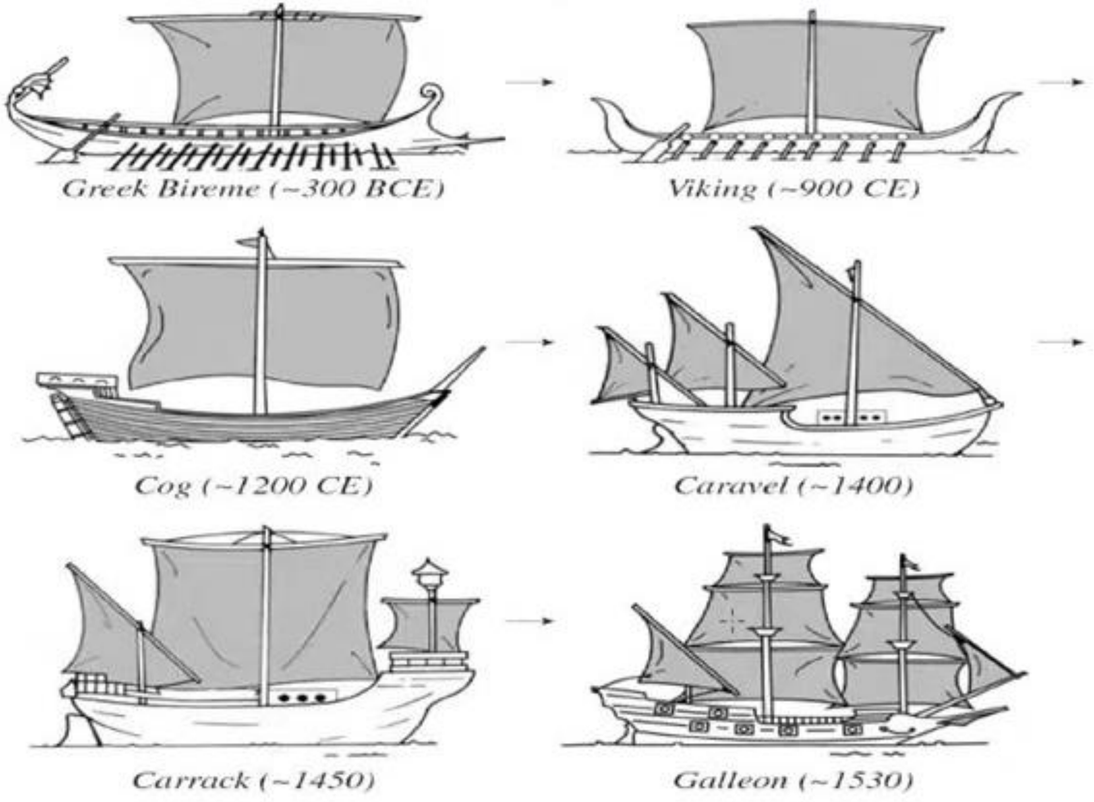
This exceptional ship design influenced:

1. **Trade in African slaves**
2. **the transport of Spanish gold and silver from Central and South America**
3. **large-scale sea battles**
4. **The emergence of the seafaring pirate industry**

$$N(t)\begin{Bmatrix}\textit{wood}\\ \textit{wind}\\ \textit{water}\end{Bmatrix}\rightarrow E(t)\begin{Bmatrix}\textit{navigation}\\ \textit{ship design}\\ \textit{construction}\end{Bmatrix}\rightarrow D(t)\begin{Bmatrix}\textit{sturdy}\\ \textit{ships,}\\ \textit{instruments}\end{Bmatrix}\rightarrow S(t)\begin{Bmatrix}\textit{adventure}\\ \textit{exploration}\\ \textit{profit}\end{Bmatrix}$$

positive feedback

Oceanic Exploration



Intellectual stimulation

Intellectual stimulation

Engineering became influenced by the idea of theory, analysis, and experiment to be used specifically in support of practice.

A number of individuals with a mechanistic and analytical viewpoint influenced engineering during the Renaissance:

LEONARDO DA VINCI (1452–1519)

1. was a self-taught Italian scientist and artist
2. excelled at painting, sculpture, architecture, and engineering.
3. possessed a particular capacity for the visualization of ingenious mechanical devices
4. produced imaginative sketches of bridges, tanks, gear systems, defensive embankments, aeroplanes, and even parachutes and helicopters.
5. promoted the use of experimentation as a substitute for guesswork
6. encouraged a methodological process in the design and production of devices.

Intellectual stimulation

NICOLAUS COPERNICUS (1474–1543) Poland

1. Had an education in medicine, law, and astronomy
2. Developed an interest in computational methods of predicting the position of planets which at that time were based on the geocentric model with the earth taken to be positioned at the center of the universe.
3. Dissatisfied with the existing inaccurate methods, he reintroduced an ancient Greek sun-centered hypotheses and found that calculations using the latest astronomical data yielded much greater accuracy
4. His theory met with opposition from the ecclesiastical establishment because it seemed to decrease the significance of humankind in the cosmos.
5. The idea that rational thought and free intellectual inquiry —rather than tradition—should decide on matters of physical reality became a critical stimulus to the ensuing Scientific Revolution.

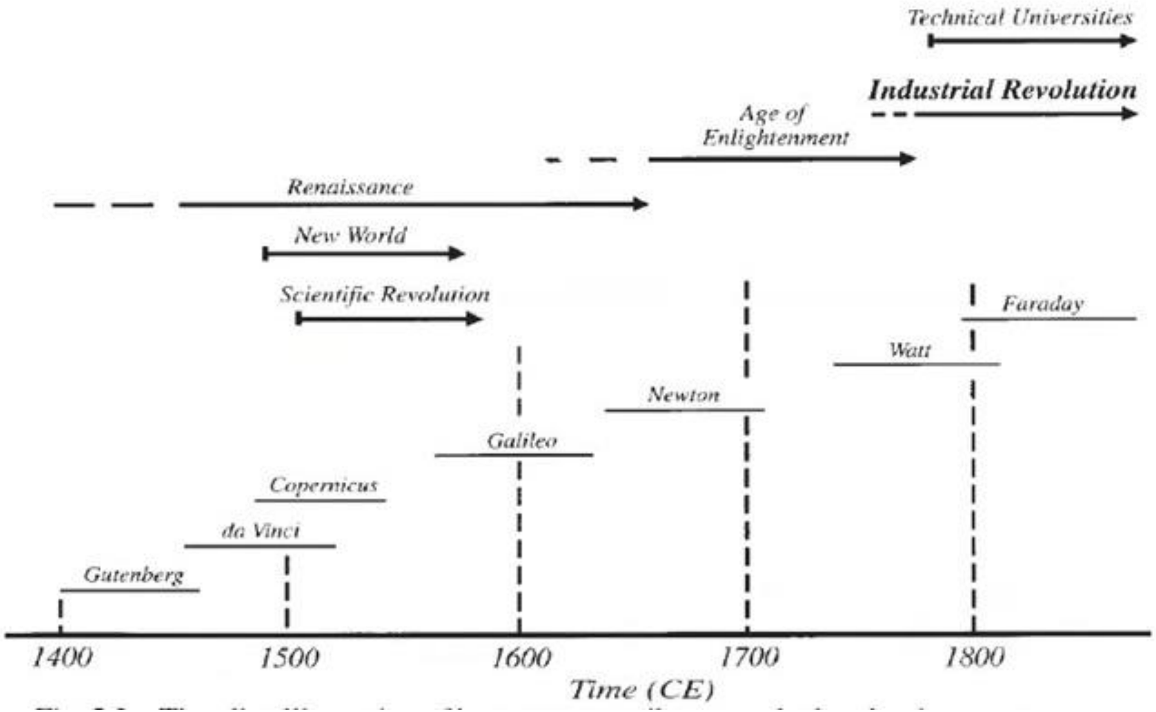
Intellectual stimulation

The Italian GALILEI GALILEO (1564–1642)

1. Combined theory and experiment.
2. Developed aspects of pendulum mechanics, thermometry, gravitational acceleration, structural strength, and both design and manufacture of telescopes together with techniques of observational astronomy.
3. Defended the work of Copernicus and was condemned for heresy by the Church of Rome — a judgment not lifted until the 1990s.

The works of da Vinci, Copernicus, and Galileo, together with an creative minds of the Renaissance— Kepler, Descartes, Boyle, Huygens, Hooke, Leeuwenhoek, Newton, Leibnitz, . . .—contributed profoundly to scientific thinking and device development of the Renaissance

Intellectual stimulation



Engineering Systematics.

Engineering Systematics

- Trial and error (experiment) characterized much of engineering at the end of the Medieval times.
- On the other side engineering has been systematized and associated with theory during the renascent period.
- This is due to the effort of six famous engineers of that period namely, Brunelleschi, Gutenberg, Prince Henry, da Vinci, Copernicus, and Galileo.

Engineering Systematics

- The aforementioned six individuals have discovered the cyclical process for solving engineering problems:

$$N(t)\to E(t)\left\{\begin{pmatrix}\textit{thoughts}\\ \textit{actions}\end{pmatrix}: \textit{propose}\to \overset{\textit{modify}}{\textit{critique}}\to \textit{adopt}\right\}\to D(t)\to S(t)$$

- Hence we suggest an informing and recursive loop

$$\begin{tikzcd} N(t) \arrow[r] \arrow[r, bend right] & E(t) \arrow[r] \arrow[loop above] & D(t) \arrow[r] & S(t) \arrow[ll, bend left] \end{tikzcd}.$$

Regional Influences

Regional Influences

- In the early part of the Renaissance, the evolution of engineering was associated with regional pockets of distinct innovations.
- For example, Italian architecture and engineering developed an early focus on building construction characterized by elaborate facades.
- In the Netherlands, engineers developed the systematics of harbor development, canal construction; additionally, the horizontal axis swivel windmill was improved and became most effective for pumping water between canals.

Regional Influences

- Moreover, accessible deposits of copper, gold, iron, lead, silver, and various minerals were discovered in southern Germany. Mining, together with an increasing interest in ore processing and smelting became an important engineering focus.
- Engineering in France developed an early interest in hydraulics with water supply projects for cities and palaces, and also canal construction.

ELSEWEDY UNIVERSITY OF TECHNOLOGY
- POLYTECHNIC OF EGYPT -

Power of Steam

Power of Steam

- One of the pivotal innovations in the historical evolution of engineering is the development of devices which relate to the use of steam as motive power.
- By the mid 1600s, the state of knowledge about water, steam, and the atmosphere could be summarized as follows:
  (a) Steam is evaporated water, with a volume increase by a factor of ~1700
  (b) When steam cools in a fixed volume, its intrinsic pressure decreases
  (c) The atmosphere exerts a constant pressure on all objects
  (d) Condensation of steam acts — due to atmospheric pressure — towards volume reduction

Power of Steam

- Denis Papin, France-England, inventor of the pressure cooker and pressure safety valve, demonstrated in 1679 that a suitably fitted piston could be made to move inside a cylinder by the process of steam condensation.
- By 1712 Thomas Newcomen of England, produced the first working steam engine and this engine was as impressive as it was simple:
  - (a) Steam from a boiler is admitted into a vertical cylinder equipped with a piston
  - (b) The steam in the cylinder is then condensed by a jet of cold water
  - (c) Atmospheric pressure forces the piston downward towards volume reduction of the steam chamber, thereby providing for a power stroke
  - (d) The cycle is repeated

Power of Steam

- Beginning in 1765, about 50 years after the invention of the Newcomen steam engine, James Watt, a Scottish instrument maker and machinist—but most of all an inspired inventor—introduced over the following decades numerous steam engine changes of which three were particularly significant improvements:

(a) Separate Condenser

Steam was transferred by force of flywheel action into a separate condensing chamber thereby allowing the cylinder to operate at a higher temperature.

(b) Double Action

A double-acting cylinder with steam entering alternately on both sides of the piston doubled the power-stroke frequency.

(c) Speed Control

A fly-ball governor provided for reliable autonomous mechanical feedback speed control.

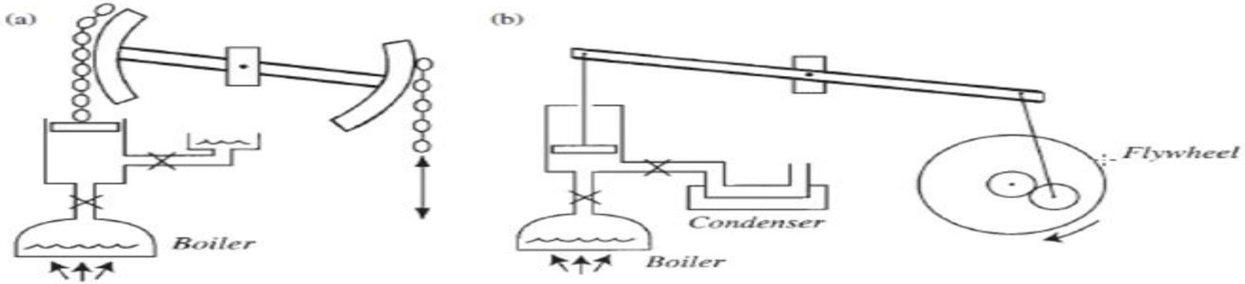
Power of Steam

- In a practical sense, it is the works of Papin → Newcomen →Watt which established the primal

$$N(t)\begin{Bmatrix}\text{water, fire,}\\ \text{metals}\end{Bmatrix} \to E(t)\begin{Bmatrix}\text{design, machining,}\\ \text{assembly}\end{Bmatrix} \to D(t)\begin{Bmatrix}\text{steam}\\ \text{engine}\end{Bmatrix}$$

And changes in theory were made suggesting four basic and connected processes:

$$\begin{pmatrix}\text{autonomous}\\ \text{energy release}\\ \text{during fuel}\\ \text{burning}\end{pmatrix} \to \begin{pmatrix}\text{burning fuel}\\ \text{converts}\\ \text{water into}\\ \text{steam}\end{pmatrix} \to \begin{pmatrix}\text{steam is}\\ \text{converted}\\ \text{into piston}\\ \text{motion}\end{pmatrix} \to \begin{pmatrix}\text{piston motion}\\ \text{is converted}\\ \text{into rotary}\\ \text{motion}\end{pmatrix}$$



ELSEWEDY UNIVERSITY OF TECHNOLOGY
- POLYTECHNIC OF EGYPT -

Industrial Revolution

Industrial Revolution

- The emergence of the reliable steam engine caused:

(a) Delivery of steady power over extended periods of time
(b) Power availability with a range of ratings

- These factors provided the power source for the large-scale centralization of the production of consumer and industrial goods, introducing thereby the concept of a factory. Indeed, from ~1750 to ~1800, the number of operating steam engines powering water pumps and crafting shops increased from

  500 to ~2500 in England alone. And in this expansion,

  engineers did not only build and operate steam engines but they designed, built, and operated machinery which would be powered by these engines:

$$N(t) \rightarrow E(t) \rightarrow D(t) \begin{Bmatrix} \textit{steam engine} \\ \textit{factory machinery} \end{Bmatrix}$$

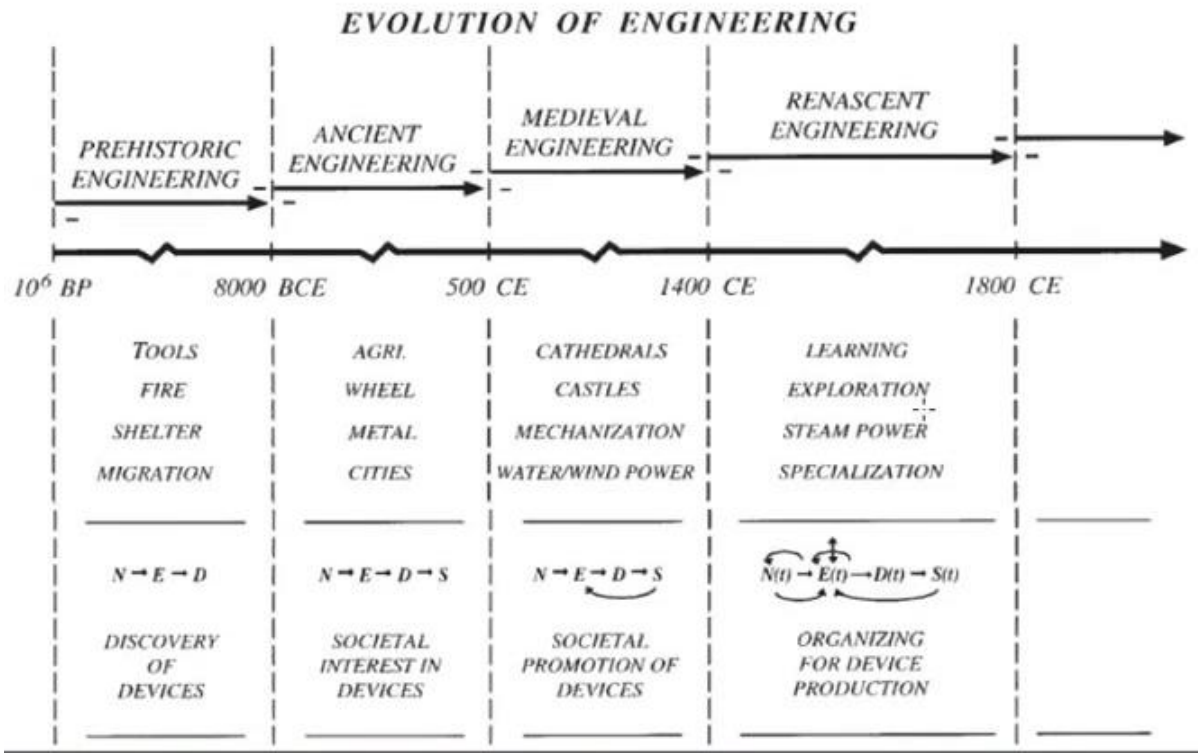
Industrial Revolution

- Moreover specializations appeared

1. *Machine Engineering (<1650)*
2. *Mining Engineering (~1700)*
3. *Textile Engineering (~1730)*
4. *Structural Engineering (~1770)*
5. *Railroad Engineering (~1800)*
6. *Marine Engineering (~1830)*

Summary

Summary



EVOLUTION OF ENGINEERING
PREHISTORIC ENGINEERING
ANCIENT ENGINEERING
MEDIEVAL ENGINEERING
RENASCENT ENGINEERING
10^6 BP
8000 BCE
500 CE
1400 CE
1800 CE
TOOLS
FIRE
SHELTER
MIGRATION
AGRI.
WHEEL
METAL
CITIES
CATHEDRALS
CASTLES
MECHANIZATION
WATER/WIND POWER
LEARNING
EXPLORATION
STEAM POWER
SPECIALIZATION
N → E → D
N → E → D → S
N → E → D → S
N(t) → E(t) → D(t) → S(t)
DISCOVERY OF DEVICES
SOCIETAL INTEREST IN DEVICES
SOCIETAL PROMOTION OF DEVICES
ORGANIZING FOR DEVICE PRODUCTION

Thank you !