Lecture 1: Historical Dimension

a) What is Engineering?

b) History of Engineering

c) Why Study History of Engineering?

d) Technology and Society

e) Grand Challenges for Engineering

What is Engineering?

Word engineering comes from "ingenuity" Creation

It has been pretty well agreed that the words 'ingenuity' and 'engineering' in English and 'ingéniosité' and 'ingénierie' in French are linked to the same Latin word-root and that the verb 'to engineer' means 'to be ingenious.' So the kinds of things engineers have done have been generally ingenious. And the word 'engine' means 'an ingenious and useful device.'

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Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

What is Engineering?

Definition #1

Engineering is the field or discipline, practice, profession and art that relates to the development, acquisition and application of technical, scientific and mathematical knowledge about the understanding, design, development, invention, innovation and use of materials, machines, structures, systems and processes for specific purposes.

Source: UNESCO Report, Engineering: Issues Challenges and Opportunities for Development, 2010

What is Engineering?

Definition #2

Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is **applied** with judgment to develop ways to utilize, economically, the materials and forces of nature for the **benefit of mankind**.

Engineers Council for Professional Development (1961/1979)

Engineering the World: The Impact of Engineering on Today's Society

https://www.youtube.com/watch?v=RwfSf8rBX-I&t=214s , 3:13

Engineers Can Solve World Problems

https://www.youtube.com/watch?v=9xHZfOz0shQ&t=16s

Engineers have a curiosity trait, needing to know why and how things work. Isaac Aviles suggests those talents be used answering a calling to solve world problems. How can we improve society? How can we move in a better direction?


ENGINEERS CAN
SOLVE WORLD
PROBLEMS

Engineer vs. Scientist

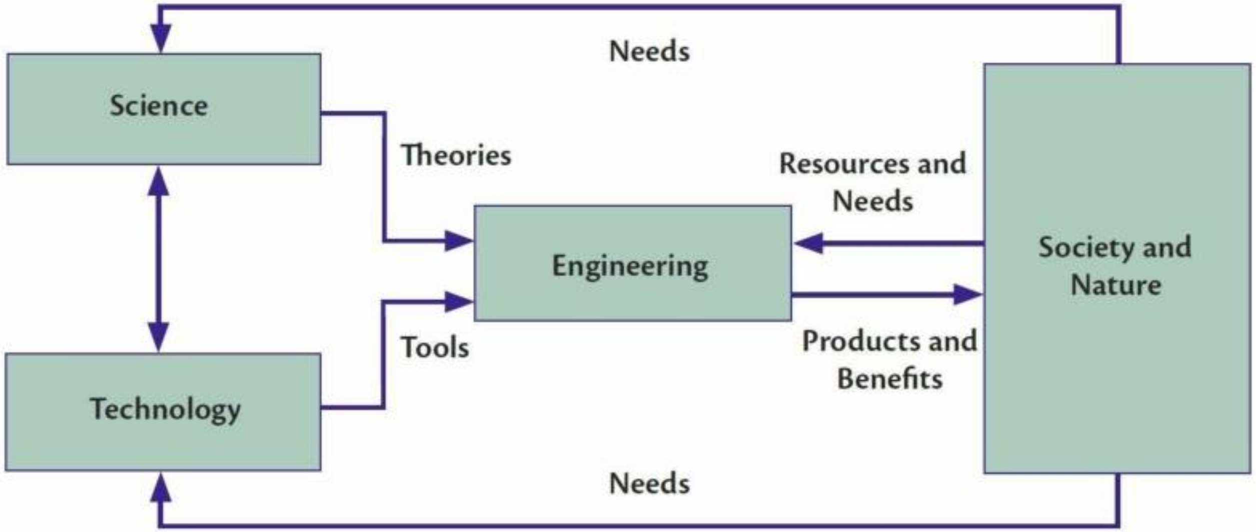
***Engineer*: The engineer applies knowledge of the mathematical and natural sciences gained by study, experience, and practice to develop ways to economically utilize the materials and forces of nature for the benefit of humankind**

***Scientist*: The scientist discovers and systematically investigates the fundamental laws of nature and defines the principles which govern them**

What do Engineers do?

The Relationship among Science, Technology and Engineering

Engineers use both scientific knowledge and mathematics on the one hand to create technologies and infrastructure to address human, social and economic issues, and challenges on the other. Engineers connect social needs with innovation and commercial applications.



Source: UNESCO Report, Engineering: Issues Challenges and Opportunities for Development, 2010

What do Engineers do?

Discussion Question:

What’s your experience from the realworld?

- Internships?
-Friends?
- Family?

History of Engineering

A Short History Of Engineering

https://www.youtube.com/watch?v=SXIuMLZqi0Y&t=2s

History of Engineering

The history of engineering is very much the history and pre-history of humanity itself. Human beings are partly defined as tool designers and users, and it is this innovation and the design and use of tools that accounts for so much of the direction and pace of change of history.

Most of the broader history of civilization, of economic and social relations, is the history of engineering, engineering applications and innovation. The Stone Age, Bronze Age, Iron Age, Steam Age and Information Age all relate to engineering and innovation shaping our interaction with the world.

Source: UNESCO Report, Engineering: Issues Challenges and Opportunities for Development, 2010

Introduction – 1000s of years B.C.

Creative

In prehistoric times, men and women had to be ingenious in order to survive hunger, enemies, climate and, later, the tyranny of distance. So there have always been 'engineers' around, many of whom were involved in activities we would not associate with engineering today. They were rather involved in hunting, farming, fishing, fighting, implement- and tool-making, transportation and many other things.

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Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Antiquity (~2500 B.C. – 500 A.D.)

- Geographically, these and many other developments took place in and around the Mediterranean, in the Middle East and in Asia Minor. Pyramids were erected in the Nile Valley
- The Greeks - the inventors - made significant contributions in the 1000 years that straddled the BC-AD divide. They produced the screw, the ratchet, the water wheel and the aeolipile, better known as Hero's turbine
- The Romans - the improvers and adapters - did likewise, building fortifications, roads, aqueducts, water distribution systems and public buildings across the territories and cities they controlled
- At the other end of the world, the Chinese have been credited with the development of the wheelbarrow, the rotary fan, the sternpost rudder that guided their bamboo rafts and, later, their junks. They also began making paper from vegetable fibres - and gunpowder

for steering boats

cart with a single wheel

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Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Dark Ages and Renaissance (~500 to 1700 A.D.)

- The so-called 'Dark Ages' that followed still produced some things that were ingenious. For example, there was the development of the mechanical clock and the art of printing. There was the technique of heavy iron casting that could be applied to products for war, religion and industry - for guns, church bells and machinery.

- These 'Dark Ages' were followed by the Renaissance of the 16th century, which the engineer/inventor/artist Leonardo Da Vinci dominated. But this whole period came under the influence of the architect/engineer, who built cathedrals and other large buildings, and the military engineer who built castles and other fortifications.

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

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Industrial revolution (1750-1850A.D.)

- During the century between 1750 to 1850, the Industrial Revolution in Western Europe dominated the evolution of engineering.
- It was significantly influenced by Savery, Newcomen, Watt and Trevithick and their steam engines;
- Whitworth and the development of screw-cutting and other machine tools, machinery for the mass production of industrial goods;
- New system of transportation - the railways - by Stephenson, Brunel and others.
- It also saw the beginnings of formal engineering education - notably in France - and the development of a new profession, that of civil engineering, in which 'civil' essentially means 'non-military.' The following 50-60 years saw the beginnings of travel by air and the experiments that led, much later, to nuclear power.

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Industrial revolution (1750-1850A.D.)

The economic developments of the 1800s saw the development of agrarian and handicraft economies in Europe and America transform into industrial urbanized ones. The term to describe this phenomenon would be known as the 'Industrial Revolution' and was first used by French writers, but made popular by English economic historian Arnold Toynbee.

https://www.youtube.com/watch?v=xLhNP0qp38Q

Comments about the American Experience

- The development of engineering in North America followed similar steps to Western Europe. The problems of survival and food production in sometimes a hostile climate and with the requirement of transportation in this large continent.
- During the latter part of that century, the influence of British military engineers increased significantly, and this continued into the early 19th century. The advent of the civil engineer - and of the mechanical engineering tradesman - was a mid-to-late 19th century phenomenon.
- This was also the period during which the most significant engineering activities in America were canal and railway construction. And it gave rise to the beginnings of engineering education and to the organization - in 1887 - of the first professional engineering societies.
- Later on America has been a major participant in the development of many other fields of engineering - for example, aviation, hydro and nuclear power, electronics and long distance communications, mining and forestry.

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Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Engineering in the Industrial Revolution

- The first phase of modern engineering emerged in the Scientific Revolution. Galileo's *Two New Sciences,* which seeks systematic explanations and adopts a scientific approach to practical problems, is a landmark regarded by many engineer historians as the beginning of structural analysis, the mathematical representation and design of building structures. This phase of engineering lasted through the First Industrial Revolution, when machines, increasingly powered by steam engines, started to replace muscles in most production.

scientific principles

- While pulling off the revolution, traditional artisans transformed themselves to modern professionals. The French, more rationalistic oriented, emphasized the civil engineering with strong roots in mathematics and developed university engineering education under the sponsorship of their government.
- The British, more empirically oriented, pioneered mechanical engineering and autonomous professional societies.
- Gradually, practical thinking became scientific in addition to intuition, as engineers developed mathematical analysis and controlled experiments.
- Technical training shifted from apprenticeship to university education. Information flowed more quickly in organized meetings and journal publications as professional societies emerged.

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Engineering in the Second Industrial Revolution

- The second industrial revolution, symbolized by the advent of electricity and mass production, was driven by many branches of engineering
- Chemical and electrical engineering developed in close collaboration with chemistry and physics and played vital roles in the rise of chemical, electrical, and telecommunication industries. Marine engineers tamed the peril of ocean exploration. Aeronautic engineers turned the ancient dream of flight into a travel convenience for ordinary people. Control engineers accelerated the pace of automation. Industrial engineers designed and managed mass production and distribution systems.
- College engineering curricula were well established and graduate schools appeared. Workshops turned into laboratories, artisanal manufacturing became industrial research, and individual inventions were organized into systematic innovations.

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Engineering in the Information Age

- Research and development boomed in all fields of science and technology after World War II, partly because of the Cold War and the Sputnik effect. The explosion of engineering research, which used to lagged behind natural science, was especially impressive, as can be seen from the relative expansion of graduate education
- Engineering developed extensive theories of its own and firmly established itself as a science of creating, explaining, and utilizing manmade systems
- To lead the progress of these sophisticated technologies, engineers have remade themselves by reforming educational programs and expanding research efforts. Intensive engineering research produced not only new technologies but also bodies of powerful systematic knowledge: the engineering sciences and systems theories in information, computer, control, and communications.

Internet, software engineering

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Engineering the information age

- Engineering was also stimulated by new technologies, notably aerospace, microelectronics, computers, novel means of telecommunications from the Internet to cell phones. Turbojet and rocket engines propelled aeronautic engineering into unprecedented height and spawned astronautic engineering. Utilization of atomic and nuclear power brought nuclear engineering
- Advanced materials with performance hitherto undreamed of poured out from the laboratories of materials science and engineering
- Above all, microelectronics, telecommunications, and computer engineering joined force to precipitate the information revolution in which intellectual chores are increasingly alleviated by machines
- This period also saw the maturation of graduate engineering education and the rise of large-scale research and development organized on the national level.

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

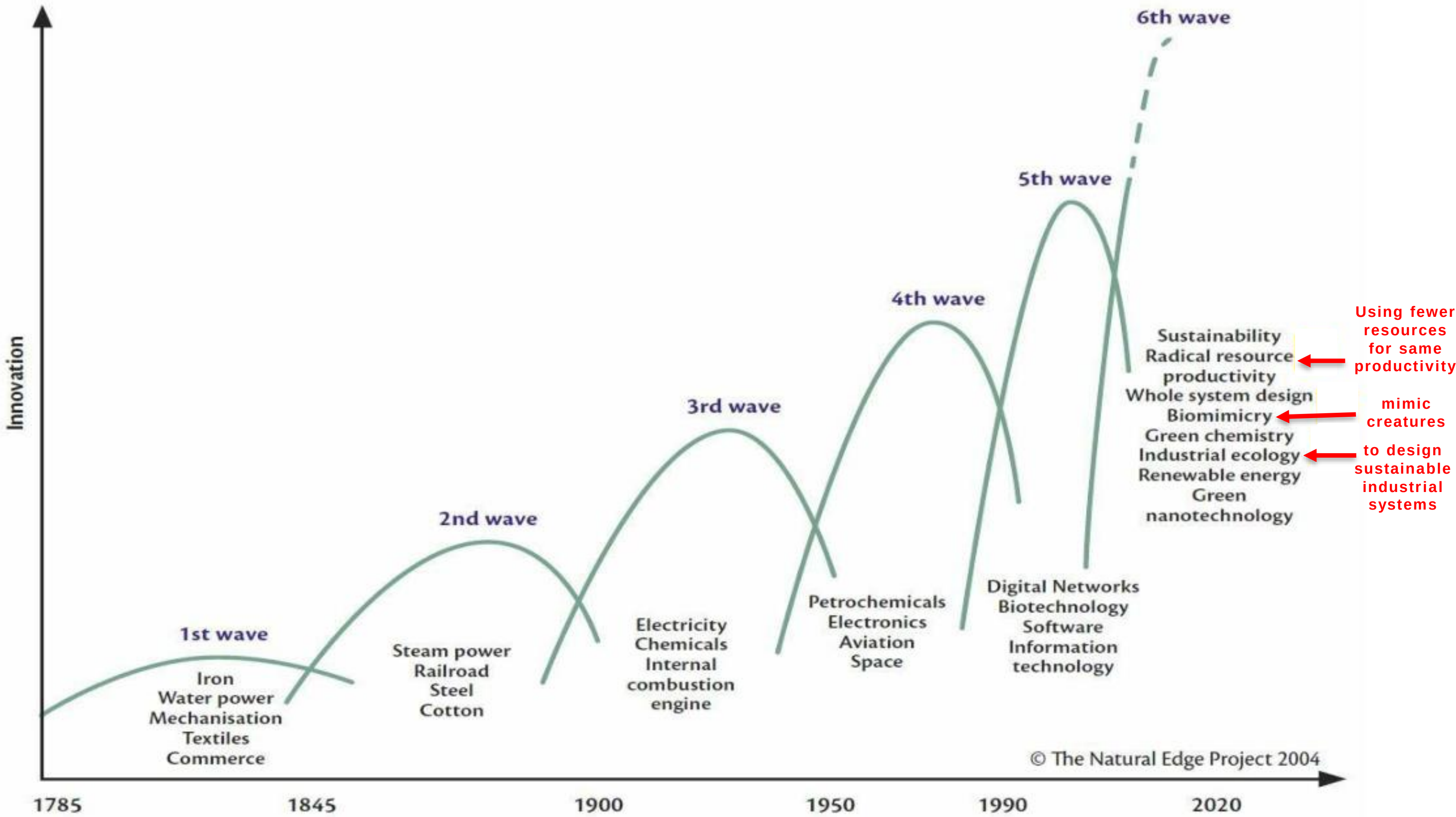
Engineering in the Future

- So far the physical sciences – physics and chemistry – have contributed most to technology
- They will continue to contribute, for instance in the emerging nanotechnology that will take over the torch of the microelectronics revolution. Increasingly, they are joined by biology, which has been transformed by the spectacular success of molecular and genetic biology. Biotechnology is a multidisciplinary field, drawing knowledge from biology, biochemistry, physics, information processing and various engineering expertise. The cooperation and convergence of traditional intellectual disciplines in the development of new technology has become the trend of the future.

Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Waves of Innovation

Waves of Innovation



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Source: UNESCO Report, Engineering: Issues Challenges and Opportunities for Development, 2010

"Revolutions and Waves" in Modern Era

Engineering powered the so-called Industrial Revolution that really took off in the United Kingdom in the eighteenth century spreading to Europe, North America and the world, replacing muscle by machine in a synergistic combination between knowledge and capital.

The first Industrial Revolution took place from 1750-1850 and focused on the textile industry. The second Industrial Revolution focused on steam and the railways from 1850-1900 and the third Industrial Revolution was based on steel, electricity and heavy engineering from 1875-1925. This was followed by the fourth Industrial Revolution based on oil, the automobile and mass production, taking place between 1900-1950 and onward, and the fifth phase was based on information and telecommunications and the post-war boom from 1950.

The sixth wave based on new knowledge production and application in such fields as IT, biotechnology and materials beginning around 1980, and the possible seventh wave based on sustainable 'green' engineering and technology seen to have begun around 2005.

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Source: UNESCO Report, Engineering: Issues Challenges and Opportunities for Development, 2010

Summary of history of engineering

The history of engineering can be roughly divided into four overlapping phases, each marked by a revolution:

- *Pre-scientific revolution*: The prehistory of modern engineering features ancient master builders and Renaissance engineers such as Leonardo da Vinci.
- *Industrial revolution*: From the eighteenth through early nineteenth century, civil and mechanical engineers changed from practical artists to scientific professionals. ← Steam engine
- *Second industrial revolution*: In the century before World War II, chemical, electrical, and other science-based engineering branches developed electricity, telecommunications, cars, airplanes, and mass production. ← integrated circuits
- *Information revolution*: As engineering science matured after the war, microelectronics, computers, and telecommunications jointly produced information technology. ← internet

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Source: 1. Engineering - An endless frontier, S. Y. Auyang, 2004, Harvard University Press,
2. http://www.creatingtechnology.org/engineering.htm

Q: Why do we study the History of Engineering?

Why Study the Historical Dimension?

- Engineers have ***responsibility*** for the things they create (… we will explore important aspects of this in the other dimensions, e.g. legal, professional, etc.)
  - **Active** responsibility
    - **Responsibility before something has happened** referring to a duty or task to care for certain state-of-affairs or persons. Example: safety issues in AI applications.
  - **Passive** responsibility
    - **Backward-looking responsibility**, relevant after something undesirable occurred; specific forms are accountability and liability.
- To **avoid mistakes** of the past, Engineers have a responsibility to know how and why things failed or succeeded.

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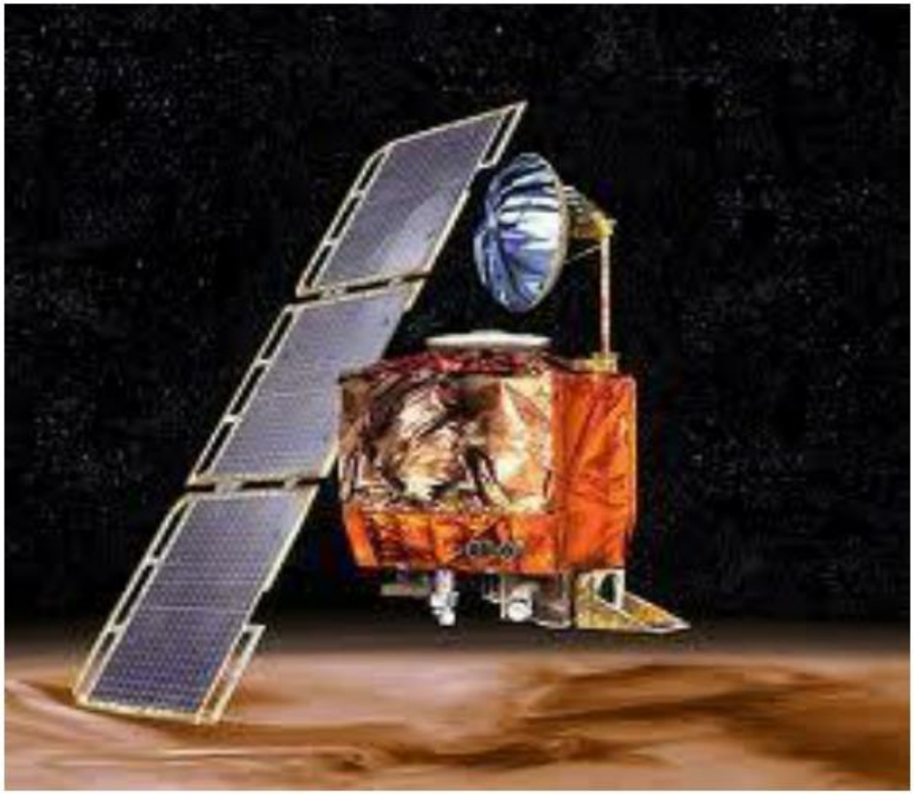
Engineering Disasters

A brief history of one of NASA's more embarrassing mistakes and the poor choices that led to it. This is what happens when everybody isn't using the same tools

https://www.youtube.com/watch?v=q2L5_swAT5A



What's the story behind these events?

Engineering Disasters

The blowout preventer that was intended to shut off the flow of high-pressure oil and gas from the Macondo well in the Gulf of Mexico during the disaster on the Deepwater Horizon drilling rig on April 20, 2010, failed to seal the well because drill pipe buckled for reasons the offshore drilling industry remains largely unaware of.

https://www.youtube.com/watch?v=gvuzuyEKLd8

What's the story behind these events?

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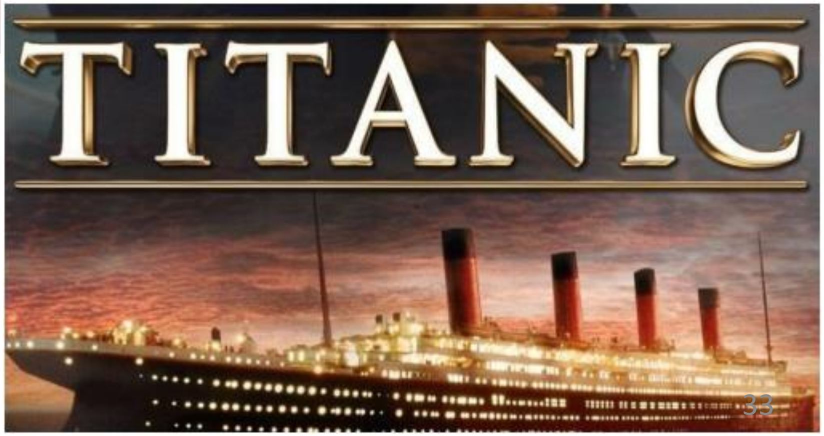
Engineering Disasters

https://www.youtube.com/watch?v=TpABdOzmxJY

What's the story behind these events?

From an iceberg to human error, a confluence of factors led to the sinking of the "unsinkable" RMS Titanic. Learn about the series of events leading up to the disaster, the laws that followed, and the discovery of the wreckage nearly 75 years later.



http://www.history.com/topics/titanic

Engineering Disasters

- The Titanic lacked a sufficient number of lifeboats decades after most of the passengers and crew on the steamship Arctic had perished because of the same problem.

Year 1854
350 people
dead

- In June 1966, a section of the Milford Haven bridge in Wales collapsed during the construction. In October the same year, a bridge of similar design was being erected by the same bridge-builder in Melbourne, Australia, when it too partially collapsed, killing 33 people and injuring 19.
- In June 1999, NASA's metric confusion caused Mars orbiter loss.

Builder use British unit
NASA use metric unit

- The BP Deepwater Horizon drilling rig collapsed in the Gulf of Mexico in April 22, 2010.
- Imperial Vs. Metric units (www.youtube.com/watch?v=9XwPn-Sb-Ro)

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The Primary Causes of Engineering Disasters

- Human factors (including both 'ethical' failure and accidents) ⟵ e.g. Crew run away instead of saving passengers
- Design flaws (many of which are also the result of unethical practices) ⟵ Not caring other…
- Materials failures ⟵ e.g. fracture in aircraft
- Extreme conditions or environments, and, most commonly and importantly
- Combinations of these reasons

e.g. Nuclear power plant failure in Japan:
earthquake>>tsunami>>
nuclear reactor melt down>> leakage of radioactive materials

The Primary Causes of Engineering Disasters

Insufficient knowledge	36%
Underestimation of influence	16%
Ignorance, carelessness, negligence	14%
Forgetfulness, error	13%
Relying upon others without sufficient control	9%
Objectively unknown situation	7%
Imprecise definition of responsibilities	1%
Choice of bad quality	1%
Other	3%

Technology and Society

Technology and Society

Questions to ask yourself:

1712 Steam engine

- When did engineering really begin?
- What is the connection between engineering and society?
- How do these activities affect other members of society?
- How do these activities affect you as an engineer?

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Five Major Characteristics of Technology

- A form of human cultural activity ← e.g. communication through internet
- It is essentially for practical and purposes ← solving problems
- It involves exercising human freedom and responsibility, particularly in choosing problems and in design approaches; that is, it involves making choices in response to normative values, such as those derived from a belief in God ← regulated by law and ethical standards, e.g. no cam in toilet
- It ultimately involves forming and transforming the material world and not primarily the sphere of ideas, thoughts, or symbols ← change and create our environment, e.g. buildings, air-con…
- It is typically done with the aid of tools and procedure

System approach in planning

Sustaining vs. Distruptive

Sustaining vs. Disruptive Technologies

Sustaining Technology

same market

- Incremental innovations
- Sustaining technologies foster improved product performance.
- Sustaining technologies can be discontinuous or radical in character, but they serve to improve the performance of established products along the dimensions of performance that mainstream customers have historically valued.

fundamental change

in long term

- **EXAMPLES?**

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Sustaining vs. Disruptive Technologies

<u>Disruptive Technology</u>

Creating new market
e.g. online publishing, smart phone

- Disruptive technologies usually result in worse performance, at least in the near term, according to the metrics of value that are used in the mainstream market.
- Disruptive technologies bring a different value proposition to the market than what had been available previously.
- Disruptive technologies are generally cheaper, simpler, smaller, low performing and more convenient to use.

low cost

e.g. emails to replace paper mails

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Sustaining vs. Disruptive Technologies

Disruptive Technology

- Promise low margins, not higher margins ← profit margins
- Disruptive technologies may be commercialized in emerging or insignificant markets
- Established firms' leading customers generally don't want, or can't use, a disruptive technology at first
- **EXAMPLES?** ← e.g. Sustaining technology: early automobile - because too expensive (no change to horse-drawn vehicle market)
  Disruptive tech.: Yr. 1908 mass produced automobile because it change the transportation market

Sustaining vs. Disruptive Technologies

Why Do Big Companies Fail? The Tale of Disruptive Innovation

Why Do Big Companies Fail? - "Companies are misguided when they continuously listen to their current customers." Disruptive innovations are the new innovations whose applications can significantly affect a market or industry functions. They create a new market and value systems which eventually disrupts the existing market, displacing market-leading firms, products, etc.

https://www.youtube.com/watch?v=42det8_W5Es

Why Do Big Companies Fail?

Basic Questions for Technology

- How and why was this technology developed? ← profit margins
- How has it been transferred? ← Technology transfer
- What are the “technology drivers” in this area?
- How have the goals of technological development in this area changed over time and how might they best be achieved?
- What are the roles and responsibilities of professional engineers with respect to this technology?
- What have been its broad social, political, economic, and environmental impacts?

Technology and Engineering in the Future

Q: How far will technology and engineering take society in your lifetime?

Grand Challenges for Engineering

The National Academy of Engineering (NAE) in the USA has identified 14 Grand Challenges, which engineers need to address in the 21st century, in order for humankind to flourish and progress into the next century. These Grand Challenges cover the areas of SUSTAINABILITY, HEALTH, SECURITY, and JOY OF LIVING.

Please refer to the *Grand Challenges Report*,
http://www.engineeringchallenges.org/File.aspx?id=11574&v=34765dff

http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

https://www.youtube.com/watch?v=wmHD8yzA63I

1. *ADVANCE PERSONALIZED LEARNING*
2. *MAKE SOLAR ENERGY ECONOMICAL*
3. *ENHANCE VIRTUAL REALITY*
4. *REVERSE-ENGINEER THE BRAIN*
5. *ENGINEER BETTER MEDICINES*
6. *ADVANCE HEALTH INFORMATICS*
7. *RESTORE AND IMPROVE URBAN INFRASTRUCTURE*
8. *SECURE CYBERSPACE*
9. *PROVIDE ACCESS TO CLEAN WATER*
10. *PROVIDE ENERGY FROM FUSION*
11. *PREVENT NUCLEAR TERROR*
12. *MANAGE THE NITROGEN CYCLE*
13. *DEVELOP CARBON SEQUESTRATION METHODS*
14. *ENGINEER THE TOOLS OF SCIENTIFIC DISCOVERY*

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http://www.engineeringchallenges.org/challenges.aspx

https://www.youtube.com/watch?v=wmHD8yzA63I

Grand Challenges for Engineering

1. Advance Personalized Learning

A growing appreciation of individual preferences and aptitudes has led toward more "personalized learning," in which instruction is tailored to a student's individual needs. Given the diversity of individual preferences, and the complexity of each human brain, developing teaching methods that optimize learning will require engineering solutions of the future.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

2. Make Solar Energy Economical

Currently, solar energy provides less than 1 percent of the world's total energy, but it has the potential to provide much, much more.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

3. Enhance Virtual Reality

Within many specialized fields, from psychiatry to education, virtual reality is becoming a powerful new tool for training practitioners and treating patients, in addition to its growing use in various forms of entertainment.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

4. Reverse-Engineer the Brain

A lot of research has been focused on creating thinking machines—computers capable of emulating human intelligence— however, reverse-engineering the brain could have multiple impacts that go far beyond artificial intelligence and will promise great advances in health care, manufacturing, and communication.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

5. Engineer Better Medicines

Engineering can enable the development of new systems to use genetic information, sense small changes in the body, assess new drugs, and deliver vaccines to provide health care directly tailored to each person.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

6. Advance Health Informatics

As computers have become available for all aspects of human endeavors, there is now a consensus that a systematic approach to health informatics - the acquisition, management, and use of information in health - can greatly enhance the quality and efficiency of medical care and the response to widespread public health emergencies.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

7. Restore and Improve Urban Infrastructure

Infrastructure is the combination of fundamental systems that support a community, region, or country. Society faces the formidable challenge of modernizing the fundamental structures that will support our civilization in centuries ahead.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

8. Secure Cyberspace

Computer systems are involved in the management of almost all areas of our lives; from electronic communications, and data systems, to controlling traffic lights to routing airplanes. It is clear that engineering needs to develop innovations for addressing a long list of cybersecurity priorities

http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

9. Provide Access to Clean Water

The world's water supplies are facing new threats; affordable, advanced technologies could make a difference for millions of people around the world.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

10. Provide Energy from Fusion

Nuclear fusion instead of nuclear fission.

Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way.

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http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

11. Prevent Nuclear Terror

The need for technologies to prevent and respond to a nuclear attack is growing.

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http://www.engineeringchallenges.org/challenges.aspx

12. Manage the Nitrogen Cycle

Engineers can help restore balance to the nitrogen cycle with better fertilization technologies and by capturing and recycling waste.

When plants lack nitrogen, they become yellowed, with stunted growth, and produce smaller fruits and flowers. Farmers may add fertilizers containing nitrogen to their crops, to increase crop growth. But we need to know how much nitrogen is necessary for plant growth, because too much can pollute waterways, hurting aquatic life.

http://www.engineeringchallenges.org/challenges.aspx

13. Develop Carbon Sequestration Methods

Engineers are working on ways to capture and store excess carbon dioxide to prevent global warming.

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change.

http://www.engineeringchallenges.org/challenges.aspx

Grand Challenges for Engineering

14. Engineer the Tools of Scientific Discovery

In the century ahead, engineers will continue to be partners with scientists in the great quest for understanding many unanswered questions of nature.

How to apply new scientific discovery? Example: building quantum computer.

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http://www.engineeringchallenges.org/challenges.aspx