Chapter 1

Engineering and Society

Objectives

- To articulate a view of our environment as containing both naturally occurring and human-made or artificial things and to discuss the role of engineers in developing and producing these artificial things to meet human needs and desires;
- To describe what is meant by a system and to discuss examples of systems, including the engineering working environment;
- To discuss some of the opportunities and challenges facing engineers over the next decade;

Objectives

- To describe the focus of some of the major undergraduate engineering disciplines and to list some of the professional settings in which engineers with these degrees are employed; and

- To discuss the role of computing and information processing in engineering practice.

Introduction

- Typically things in our environment fall into two categories:
  - Natural
  - Man-made (artificial)

- Natural Scientists ask:
  - How does this thing work?
  - What is it made of?
  - How did it get to be that way?

Introduction

- However, things made on our planet, or elsewhere in our solar system – are all designed and built with a purpose.

- As such, the typical question asked by engineers is:
  - What form should we give to this thing so that it will effectively serve its purpose?

Natural vs. Man-Made

The Engineering Method

- The word “engineer” derives from the Latin ingenium, which refers to one’s native genius, one’s ability to design or create things.

- Most engineering problems are open-ended, in that they don’t have a single solution. Just because a problem has more than one possible solution, however, doesn’t necessarily make it easier to solve; in fact, having multiple acceptable solutions often makes solving the problem more difficult.

The Engineering Method

- Most new engineering students find open- ended problems incredibly frustrating:
  - One reason for this is that most mathematics and science training in high school typically stresses coming up with the "right" answer to a problem, and further, fosters an expectation that this "right" answer will also have a simple and elegant form.
  - Second, in open-ended problems, the problem statement frequently doesn't provide enough information to apply a familiar technique, such as solving an equation. To circumvent this difficulty, it's often necessary to make assumptions, and knowing what assumptions to make and determining if they're reasonable often comes only with experience.

Science, Math, and Engineering

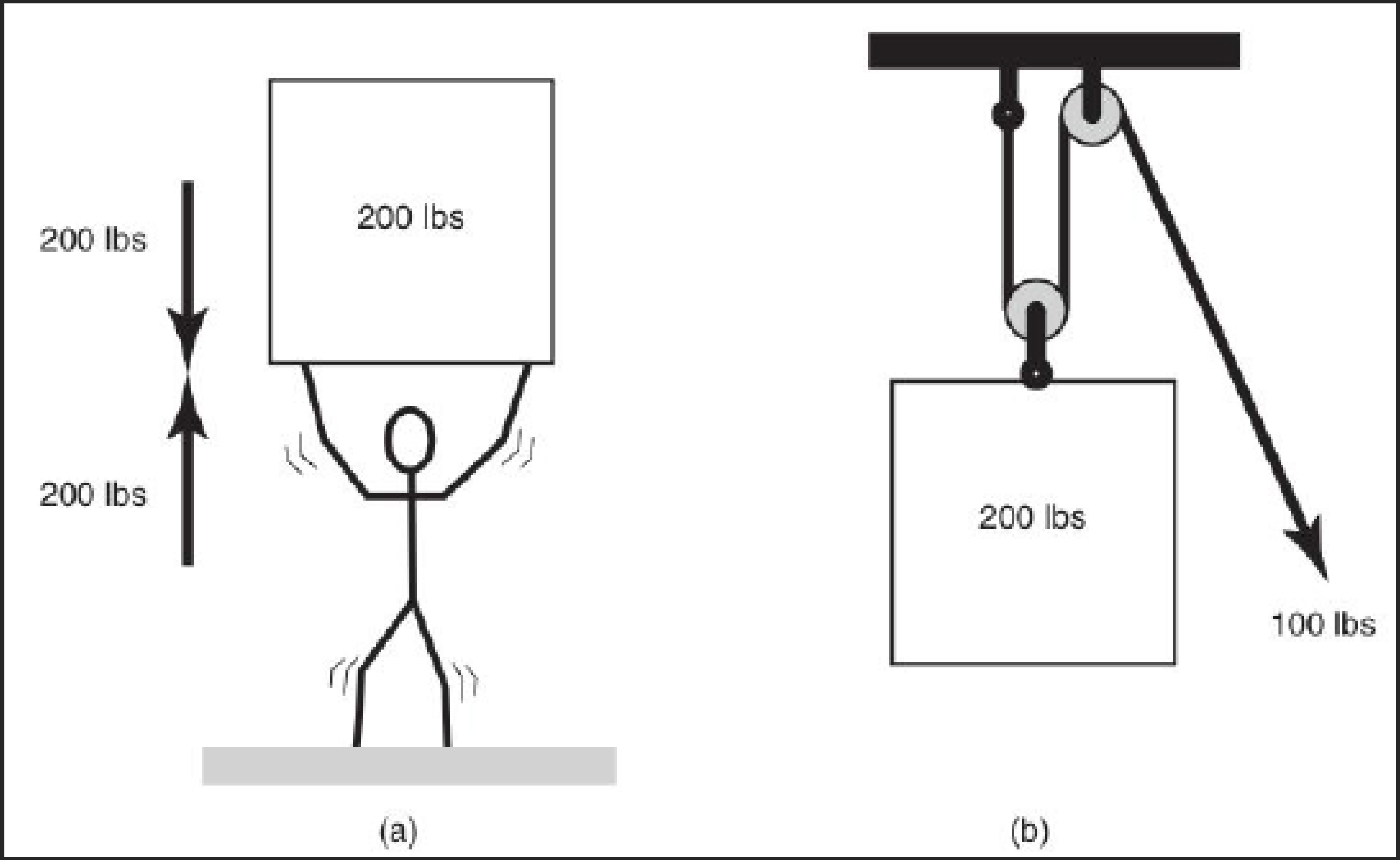
- These all work hand-in-hand.

- It is necessary to have a sound understanding of scientific principles and mathematics to be successful at engineering.

- Engineers have found extremely clever ways to skirt some of the laws of nature. They can't actually break or violate the laws, but through creative readings, engineers have managed to accomplish things that might seem impossible through stricter readings of "the law.

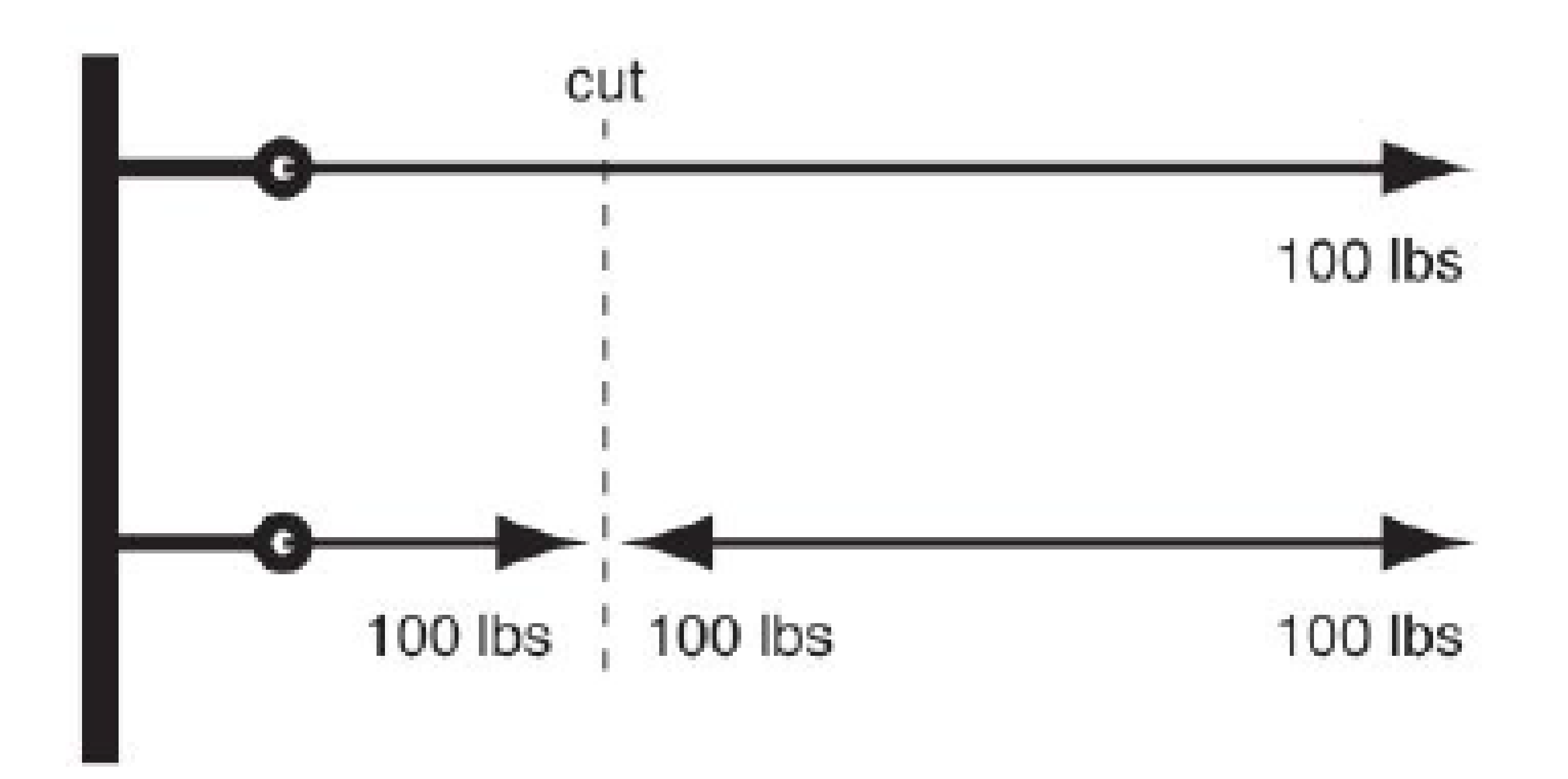
Block and Tackle

(Archimedes 200BC)



We can solve this problem using Newton's third law

Block and Tackle
(Archimedes 200BC)



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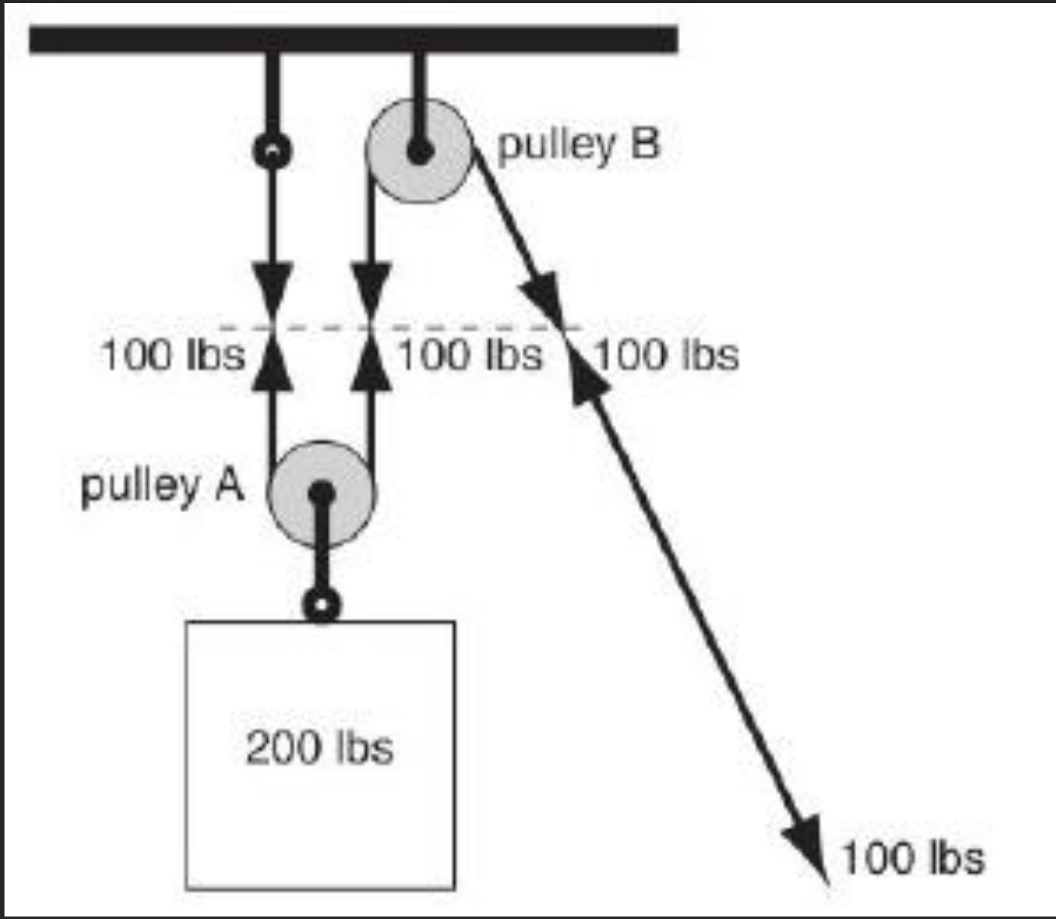
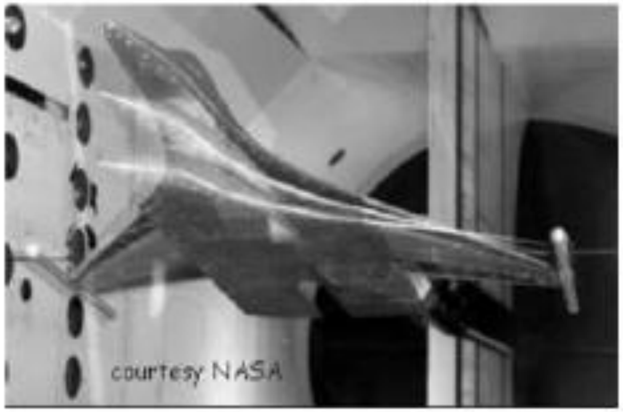


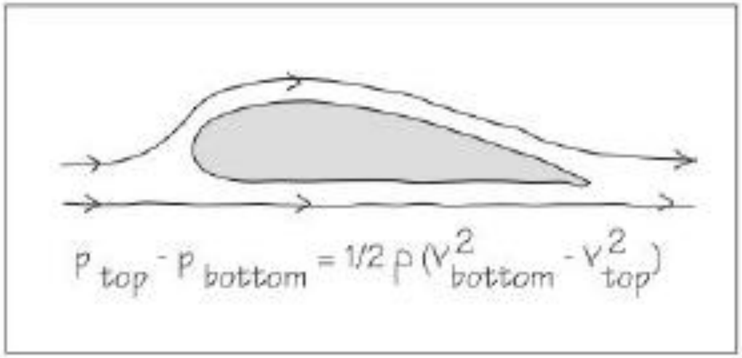
Because of the equal-and-opposite internal forces in the rope, each end of the segment around pulley A exerts an upward force of 100 lbs, for a total of 200 lbs.

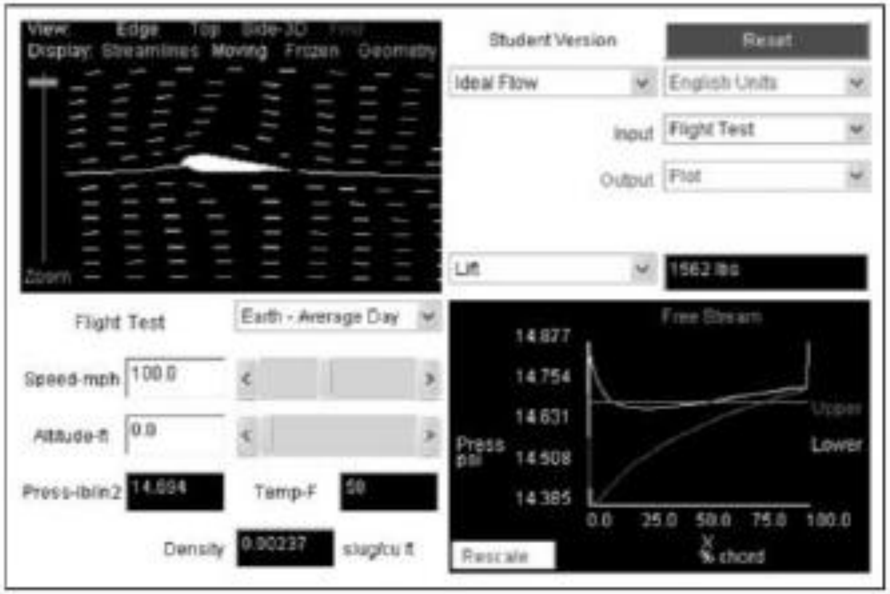
Engineering Models

- Engineers apply scientific theories by constructing models of their designs.
- A model, remember, is an approximation of a real system.
- When actions are performed on a model it will respond in a manner similar to the real system.
- The ability to use models to describe physical processes and phenomena is a core skill for all branches of engineering

Engineering Models





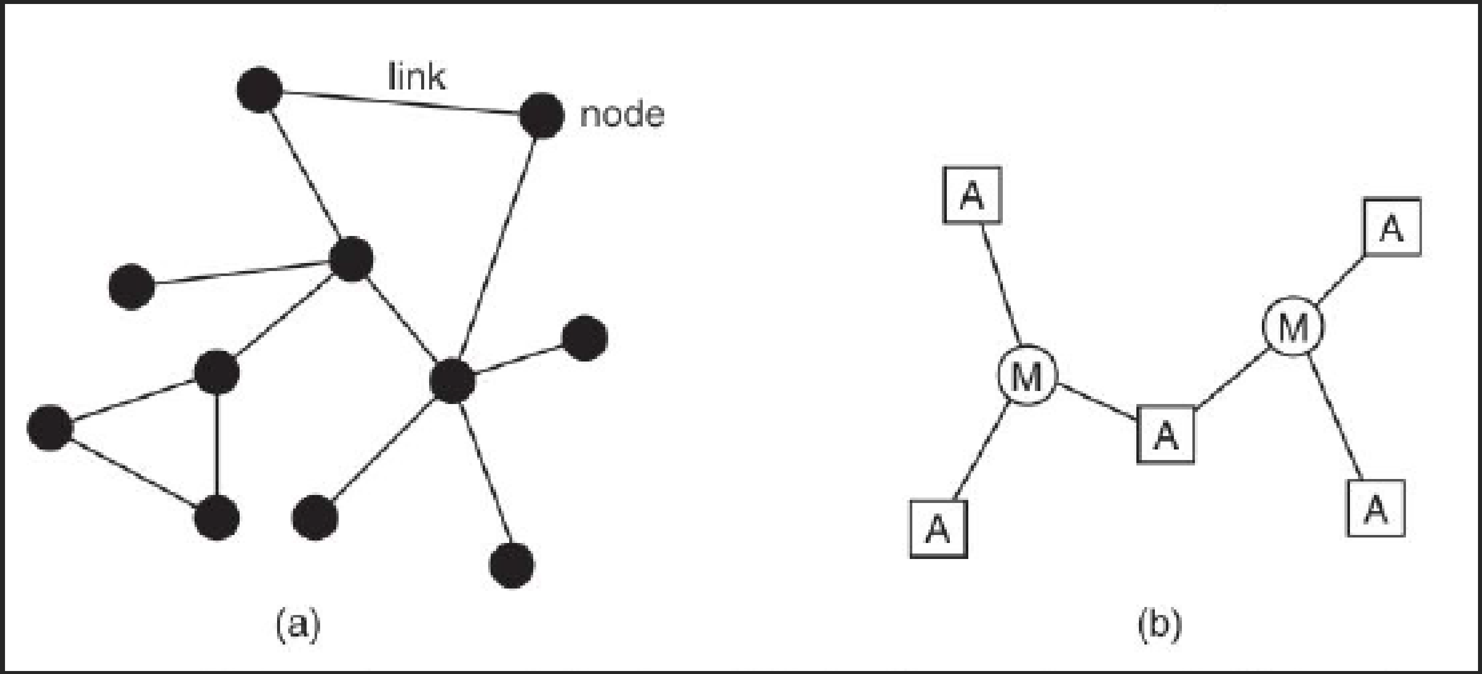


Networks and Systems

- Everything is connected to everything.
- This interconnectedness, that "everything depends on everything" characterizes the shape of engineering problems and solutions at all levels.

Networks and Systems

- Diagrams help us visualize complex situations, and we typically sketch networks using a type of diagram that mathematicians call a graph.

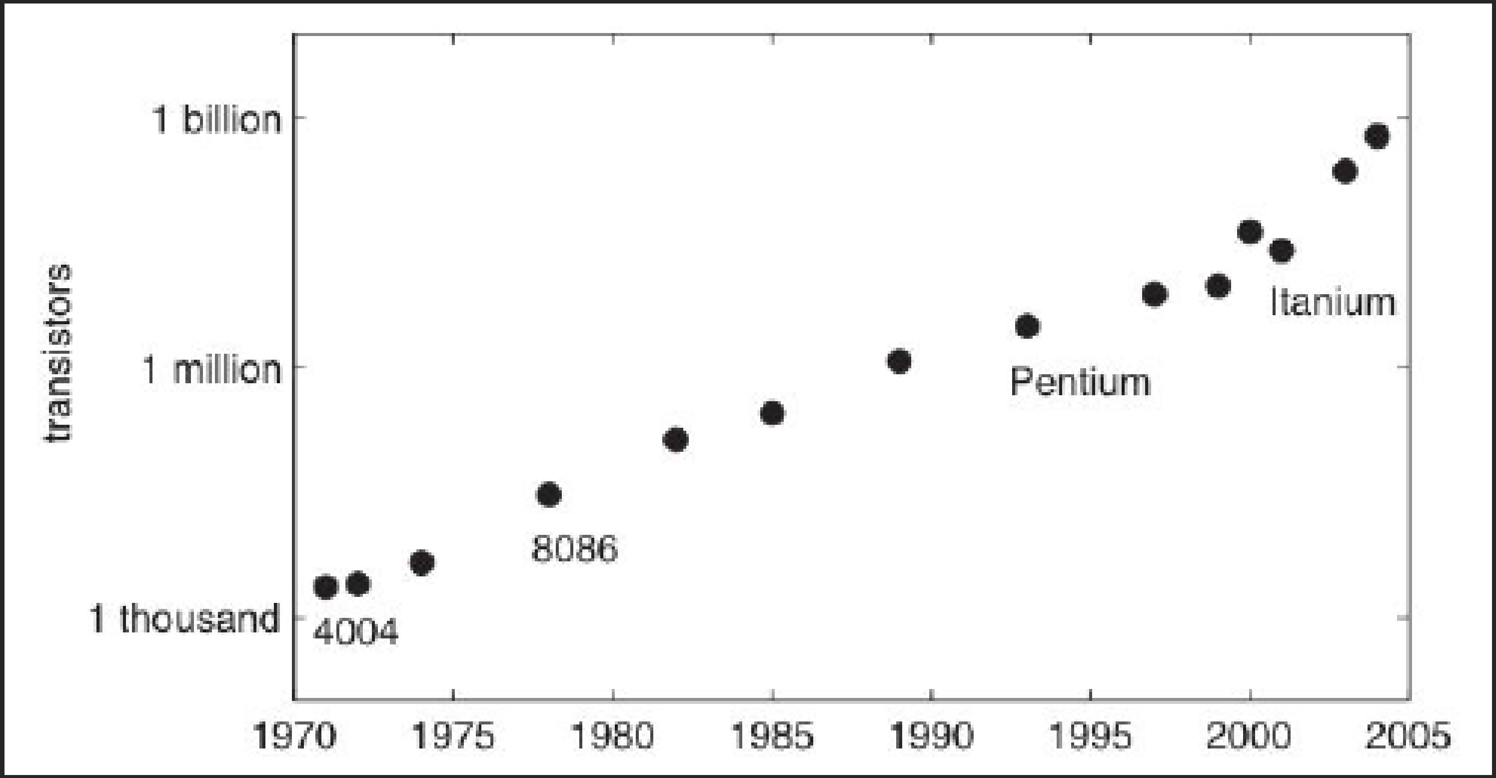


b) Links represent appearance of actors in movies

Moore's Law

(A Web of Innovation)

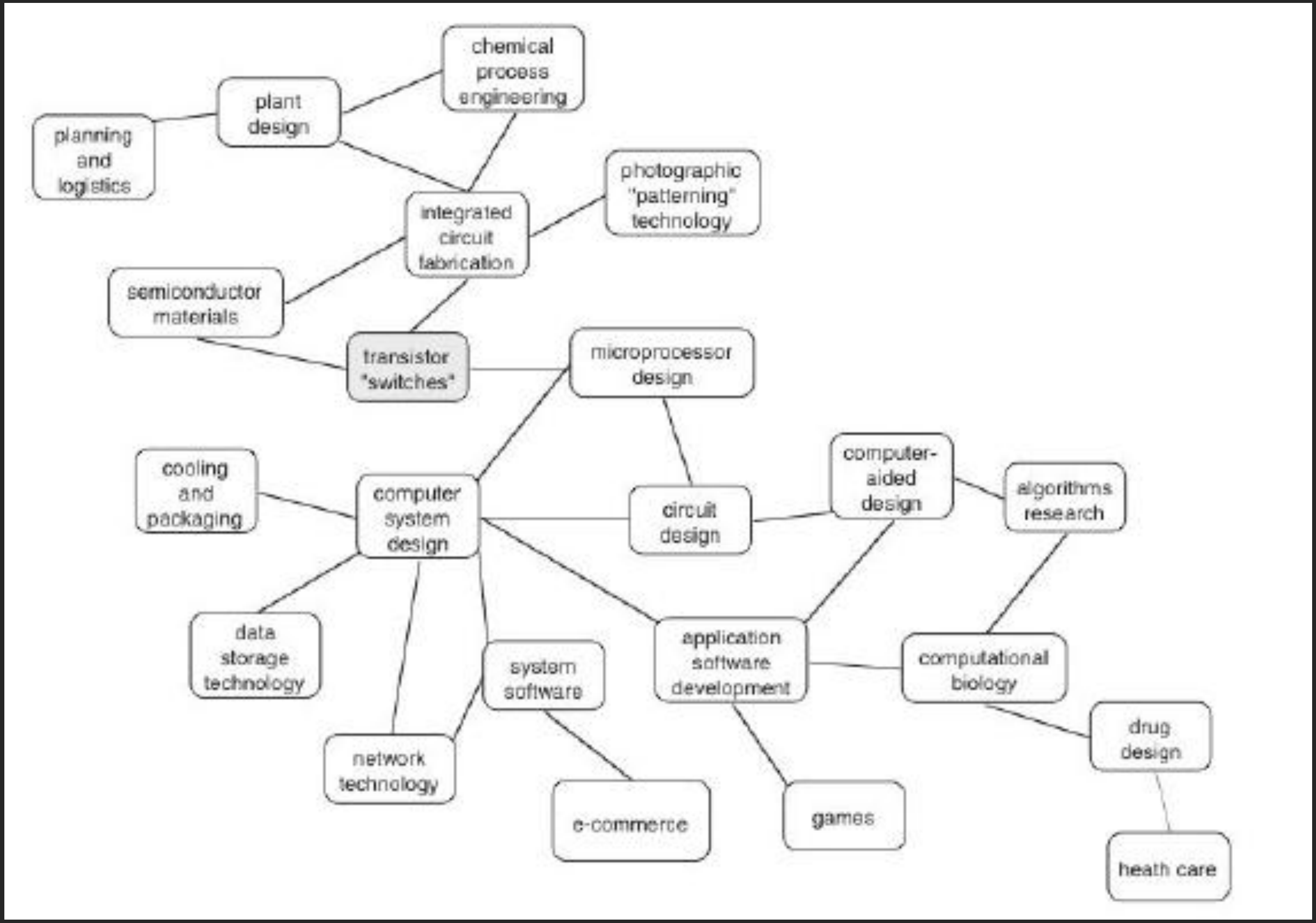
- In 1965, Gordon Moore, one of the founders of Intel, suggested that the number of transistors that could be integrated onto a single working chip would double every two years.



Moore's Law

(A Web of Innovation)

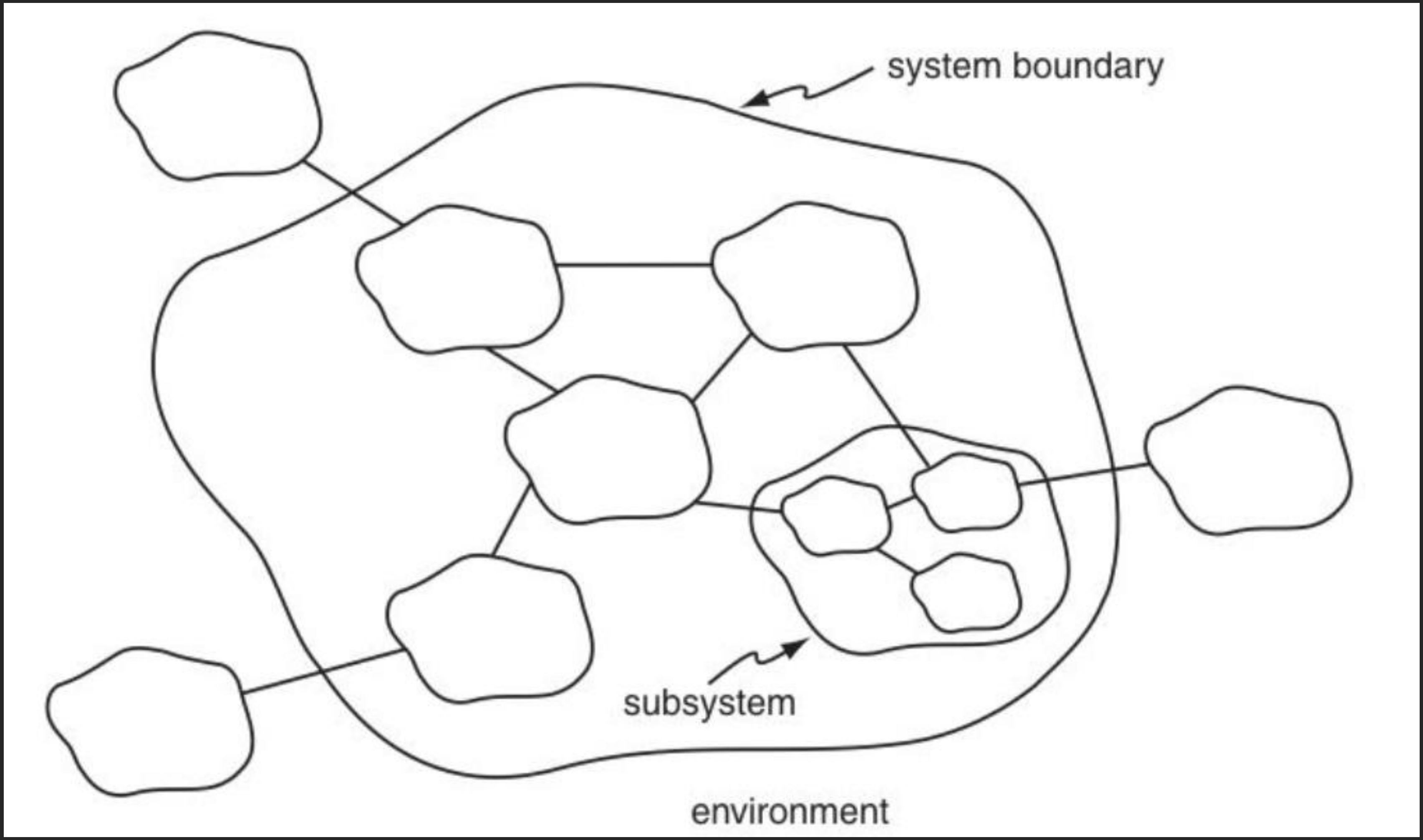
- A web of innovation in many technologies has keep Moore's Law on Track



Systems

- The span of the web attached to a given engineering problem can be truly overwhelming.
- The most powerful tool that they use to organize the vast network of information is the notion of a system.
- According to the Oxford English Dictionary, a system is "a set or assemblage of things connected, associated, or interdependent, so as to form a complex unity."

Systems



Systems

- We design systems as such in order to make them intellectually manageable, and we see the imprint of this feature of human problem solving in nearly every artifact produced.

- The physical justification for systems is that designs organized this way tend to be more robust.

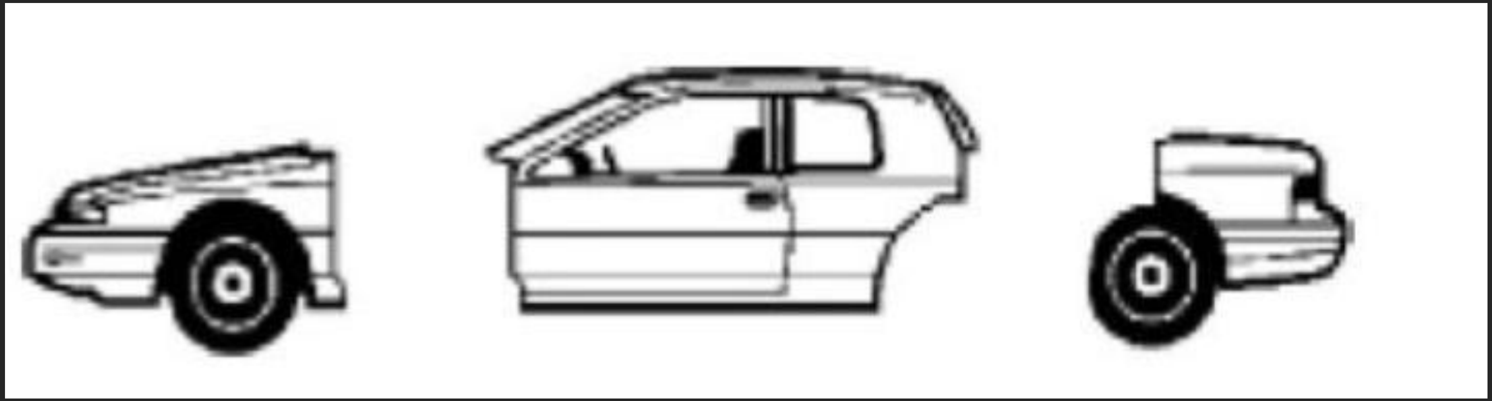
- More Than the Sum of the Parts The overall behavior of a system is typically more than just the sum of the behaviors of its parts. We sometimes say that the behavior of the system emerges when the components function together.

Systems: Boundaries and Interfaces

- A system interacts with its environment via the links that cross the boundary.
- Sometimes, it's straightforward to decide where to draw the boundary of a system, while other times it's less obvious.
- Biological Systems and computer systems are examples of this.

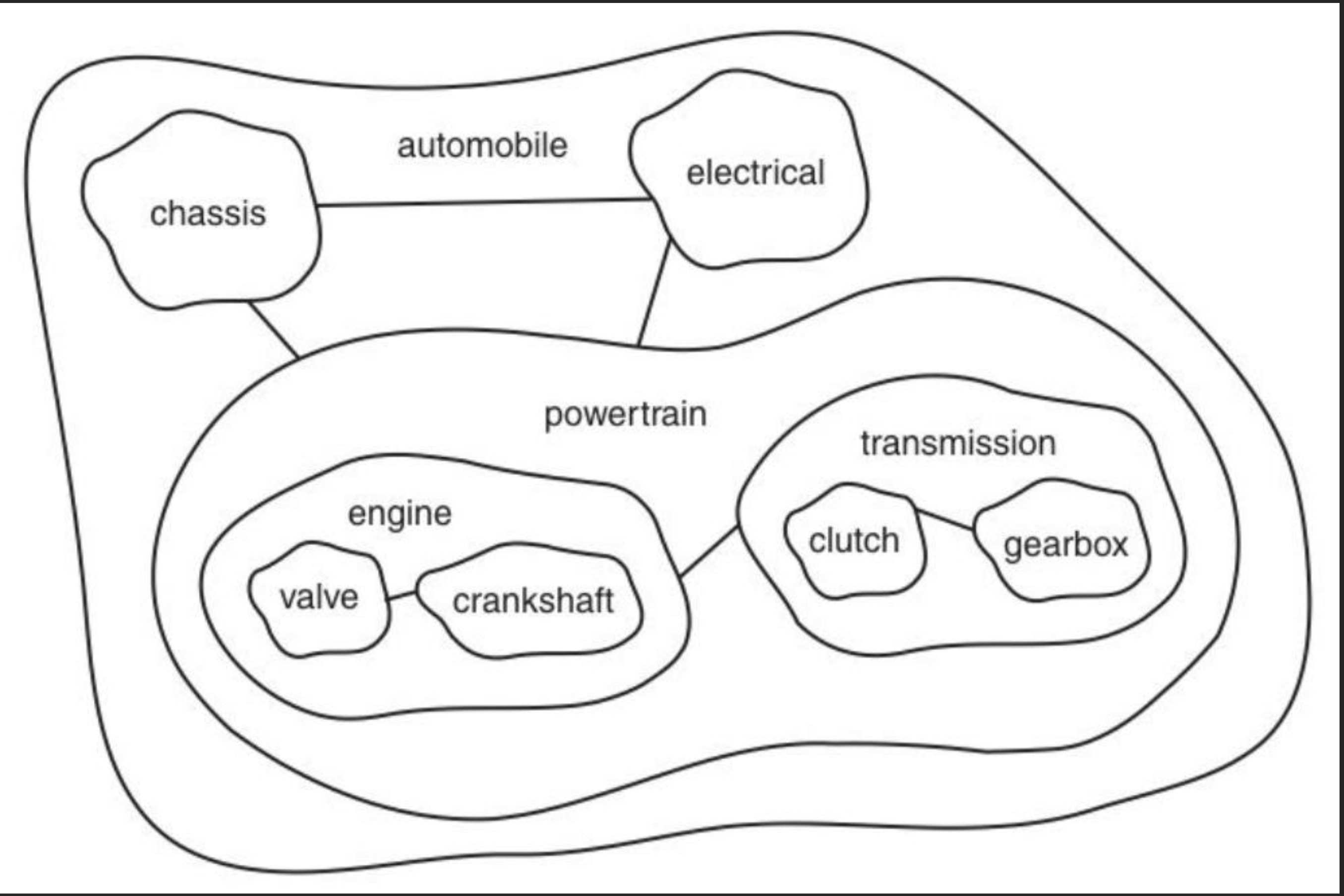
Systems: Boundaries and Interfaces

- Good System Boundaries:
  - Components designed independently (or as best as possible)



A breakdown of an automobile design problem that would be difficult to manage

Systems: Boundaries and Interfaces



Using sub-systems leads to a better breakdown of the automobile

Overview of Engineering Disciplines

- It is very important to realize that invariably, engineering is multi-disciplinary.
- Engineers work in teams from many different backgrounds.
- Engineers don't need to know the inner workings of every discipline, but MUST understand the interfaces between them

Overview of Engineering Disciplines

Online Resources:

- Sloan Career Corner- stone Center
  www.careercornerstone.org

- TryEngineering
  www.tryengineering.org

Engineering Disciplines

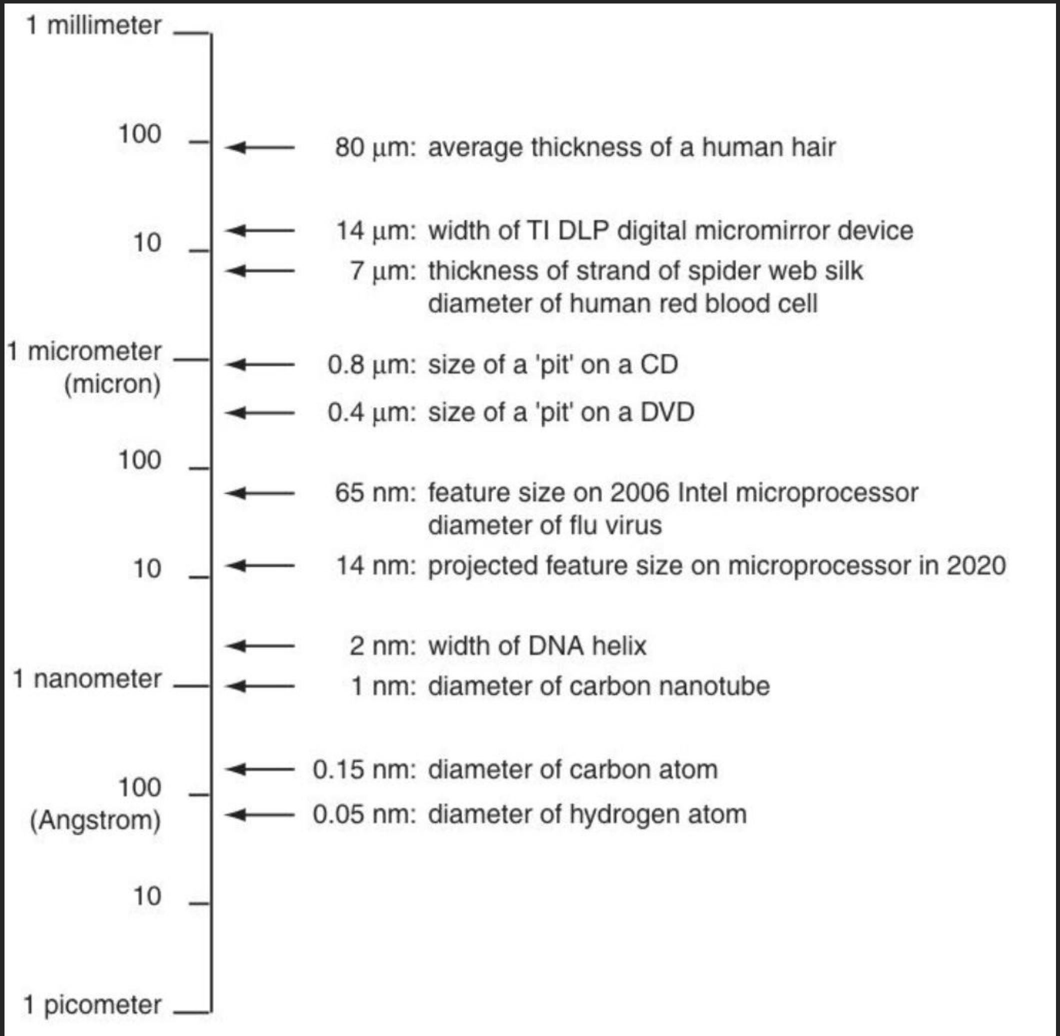
- Aerospace
- Agricultural
- Architectural
- Bio
- Chemical
- Civil
- Computer and Software
- Electrical
- Environmental
- Industrial
- Manufacturing
- Materials
- Mechanical
- Mining
- Nuclear
- Petroleum

Other Engineering Disciplines

- Ceramic Engineering
- Construction Engineering
- Drafting and Design
- Engineering (General)
- Engineering Management
- Engineering Mechanics
- Engineering Physics/Engineering Science
- Forest Engineering
- Geological Engineering
- Metallurgical Engineering
- Naval Architecture and Marine Engineering
- Ocean Engineering
- Plastics Engineering
- Surveying Engineering
- Welding Engineering

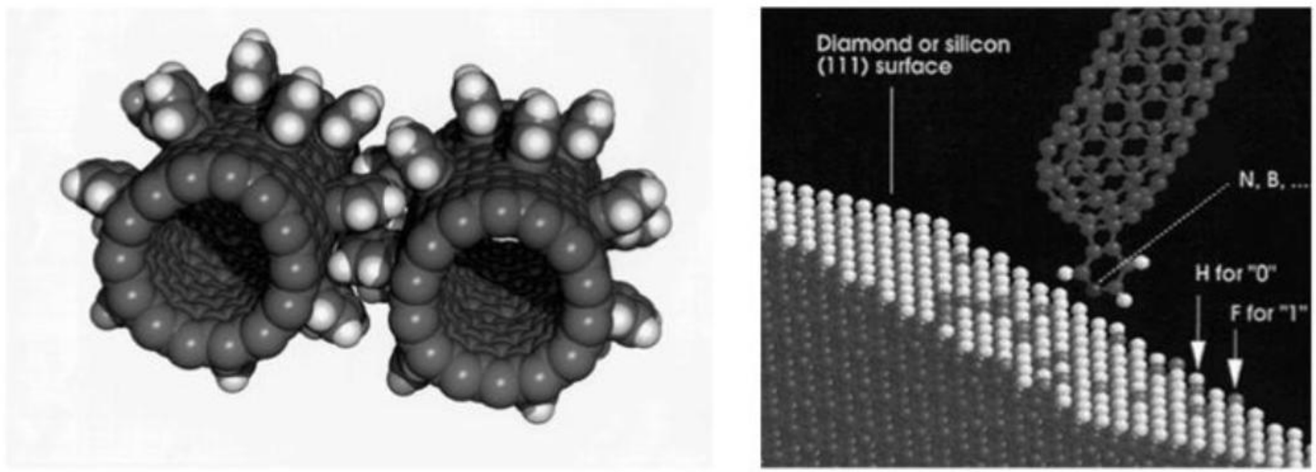
Innovations at the Interface Between Disciplines

- Nanotechnology and Molecular Engineering

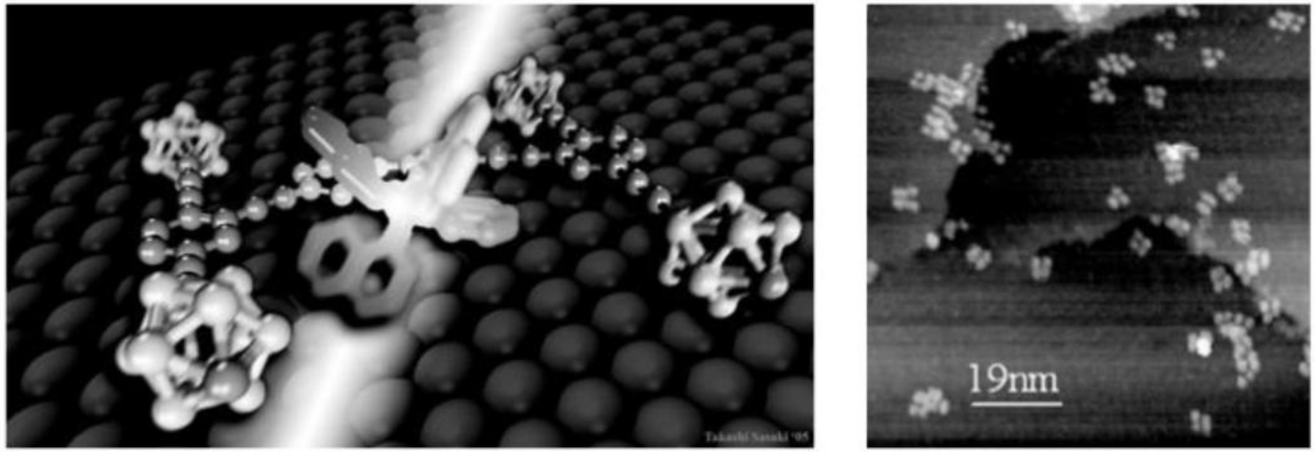


Innovations at the Interface Between Disciplines

- Bioengineering and biotechnology



Gears and probe-tips made from carbon nanaotubes



Computer model and actual fleet of nanocars on a gold surface

Engineering and Computing

- Like all professions today, engineers rely heavily on computers as tools for managing and processing information.
- This includes communication, searching for information, and producing documentation.
- It’s fair to say that on the whole, engineers have a more intimate relationship with computers than professionals in most other fields.

Engineering and Computing

(Programming and Logical Thinking)

- From creating a system for procuring and distributing clean drinking water, to developing a fabrication line for manufacturing integrated circuits, to formulating a test strategy for a new aircraft, engineers of all disciplines develop "programs" for solving problems.

- One of the most important communication skills an engineer must have is the ability to describe programs clearly and unambiguously.

Engineering and Computing

(Programming and Logical Thinking)

- The "stuff" that computational processes operate on is called data, from the Latin term for something "given" or "factual."

- The rules and procedures that govern the operation of computational processes are called computer programs, written in precise, specialized languages called programming languages.

Number Crunching

- The word “calculate” pays homage to one of the very first tools that humans devised for working with numbers: the pebble, or calculus in Latin.

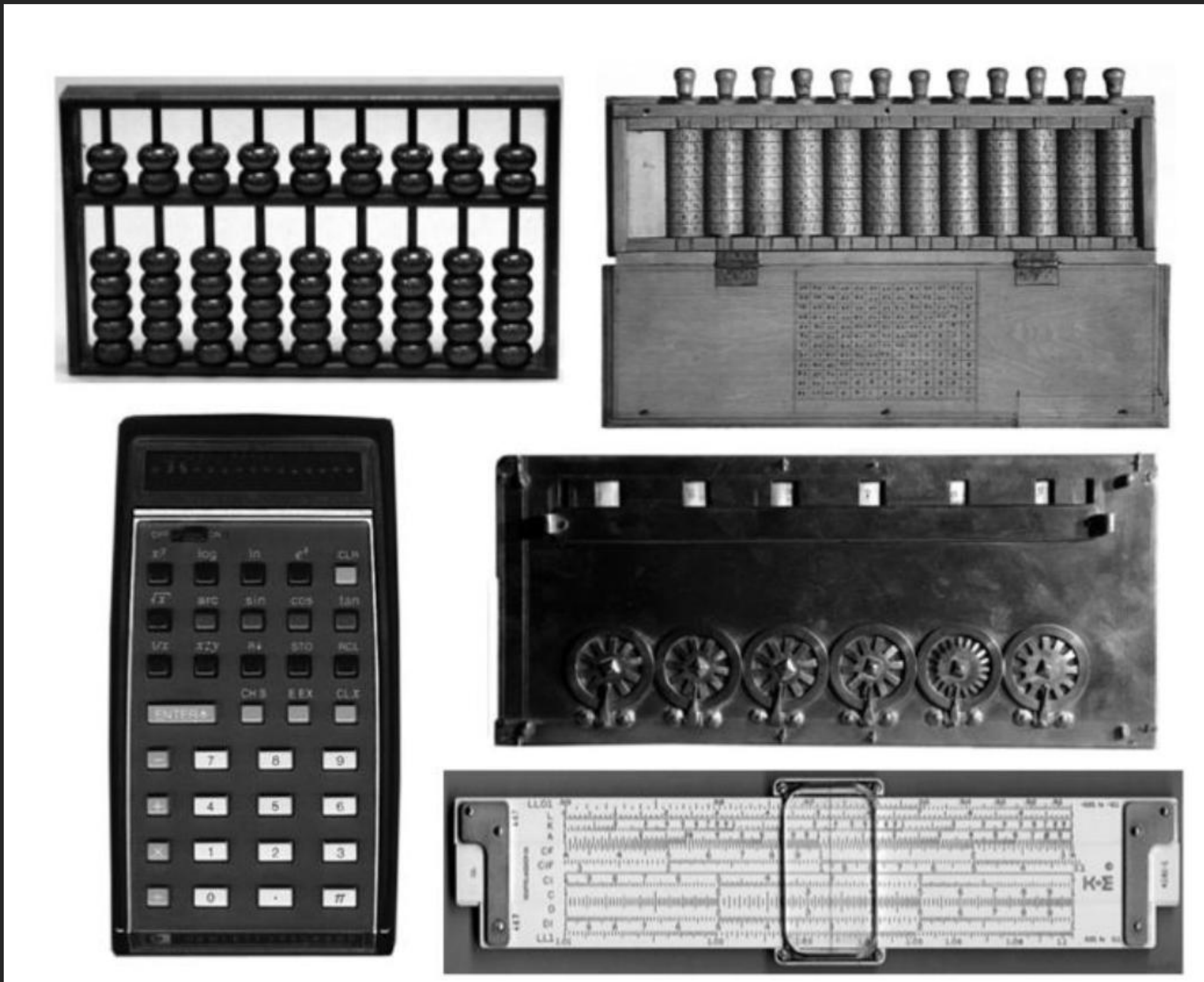
- Most of the calculations engineers perform, however, despite the stereotype, are actually quite simple. Even so, the computer still makes these tasks much more manageable.

Number Crunching

- The most common calculations an engineer—like everyone else— performs is simple arithmetic: the "big four" functions of:
  - addition,
  - subtraction,
  - multiplication, and
  - division.

- As well as the transcendental or "scientific functions" such as square roots, trigonometric functions, and exponentiation and logarithms.

Number Crunching



Abacus

Napier's Bones

Pascaline

Slide Rule

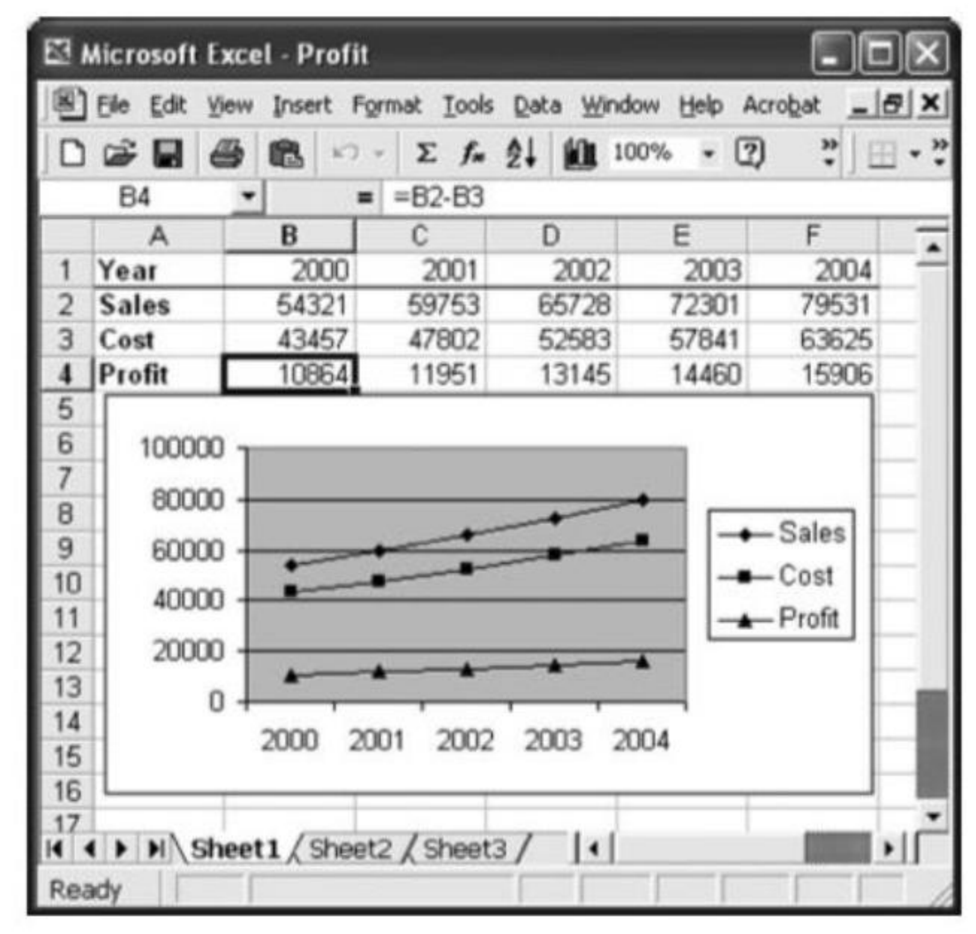
HP-35 Scientific Calculator ($395 in 1972)

Other Problems Solving Techniques

- Substituting numbers into formulas
- $F = ma$

Other Problems Solving Techniques

- Data analysis and plotting



Other Problems Solving Techniques

- Numerical Methods