

EE-224:

Digital Design

Engineering + Mathematics

Virendra Singh

Professor

Computer Architecture and Dependable Systems Lab

Department of Electrical Engineering

Department of Computer Science & Engineering

Indian Institute of Technology Bombay

<http://www.ee.iitb.ac.in/~viren/>

E-mail: viren@{ee, cse}.iitb.ac.in



03 August 2023

CADSL

System Realization Process

Customer's need

Determine requirements

Write specifications

Design synthesis and Verification

Test development

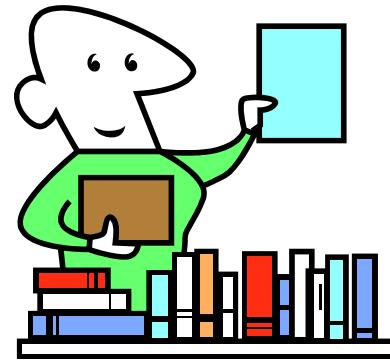
Fabrication

Manufacturing test

System to customer



Some Basic Definitions





What is Science, Technology, Engineering, and Mathematics???



CADSL

Science seeks to understand the natural world.

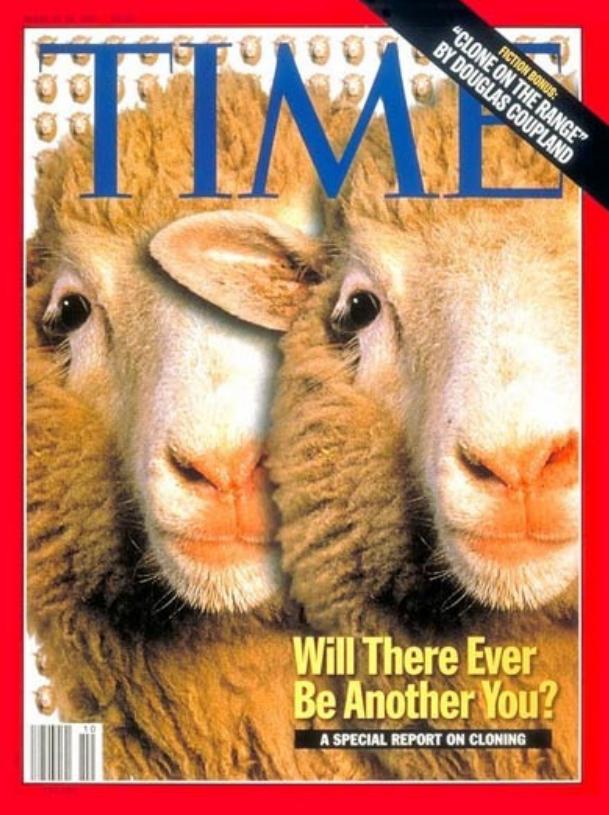
National Science Education Standards, National Research Council, 1996



What is Technology?



the world: to cut, shape, from one place to another voices, and senses. (*Benchmarks for Science*



- Technology is the process by which **humans modify nature to meet their needs and wants.** (*Technically Speaking: Why All Americans Need to Know More About Technology*, 2002)

What is Engineering



HIROSHIMA
&
NAGASAKI



By: Shelby
Canfield

experience, and practices are applied with judgments to develop ways to utilize economically the materials and forces of nature for the benefit of mankind.

(Accreditation Board for Engineering and Technology (ABET, 2002)



What is Mathematics

- ✓ The study of any patterns or relationships (AAAS, 1993)
- ✓ The science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations (Webster's Ninth New Collegiate Dictionary)



Science vs. Technology

- Deals with the **natural world**.
 - Is very concerned with **what is (exists)** in the natural world. (i.e.: Biology, Chemistry, Physics, Astronomy, Geology, etc.)
- Deals with **how humans modify**, change, alter, or control the natural world.
 - Is very concerned with **what can or should be** designed, made, or developed from natural world materials and substances to satisfy human needs and wants



Science vs. Technology

- Is concerned with processes that seek out the meaning of the natural world by “inquiry”, “discovering what is”, “exploring”, and using “the Scientific Method”.
- Is concerned with such processes that we use to alter/change the natural world such as “Invention”, Innovation”, Practical Problem Solving, and Design.

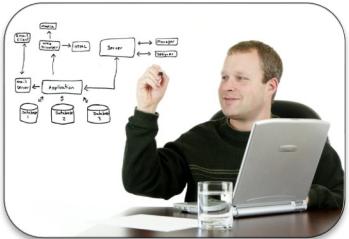


While technology and science have a common denominator being the natural world, they are similar yet very different.

Technology is not any more “applied science” than science is “applied technology”.



Engineers Apply Math and Science for the Betterment of Society



Design



Manufacturing



Research & Development



Management



Continual Improvement



Logistics

Above all, Engineers are **problem solvers** who make things work better, more efficiently, quicker and cheaper



Engineering Functions

The focus of an engineer's work typically falls into one or more of the following areas:

- **Research** - explore, discover and apply new principles
- **Development** - transform ideas or concepts into production processes
- **Design** - link the generation of ideas and the production



MOST EXOTIC NEED OF HUMANS

Mobile Power : Animal Driven Vehicles



Engineering Challenges: Mobility

- Solve problem for the betterment of society



Engineering Challenges: Mobility

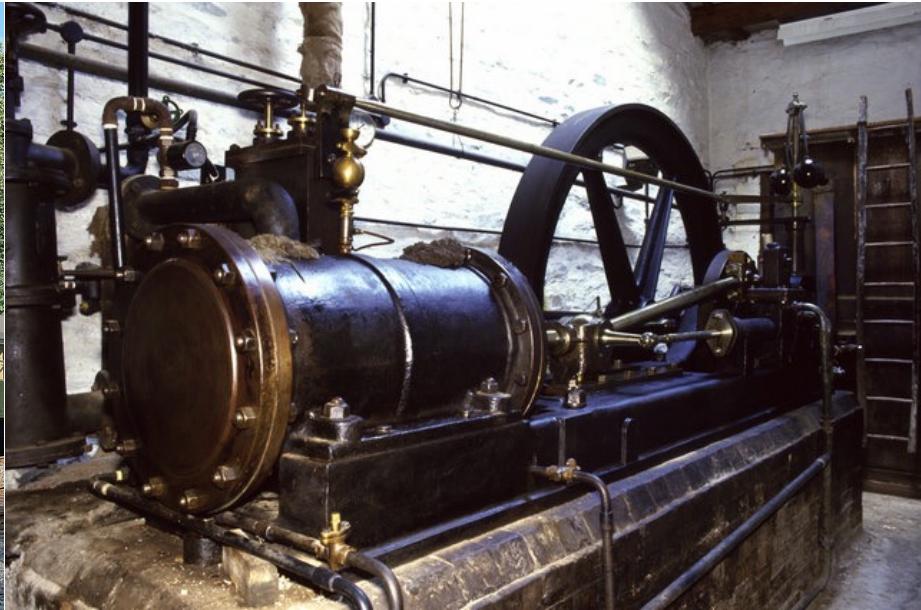
- Solve problem for the betterment of society



<http://www.poraschaudhary.com/>



Engineering Challenges: Mobility



Engineering Challenge - Shelter



At 5:30am on June 27, 2009, an unoccupied building still under construction in Shanghai city toppled over.



Engineering Challenge - Communication



a alamy stock photo

D2H1GK
www.alamy.com



03 Aug 2023

EE-224@IITB

20

CADSL

Engineering Challenge- Computing



What is Needed to Become an Engineer?

- Solid background of Science and Mathematics
- Analytical ability
- Engineering design principles
- Rigour



Engineering Challenges - Mobility

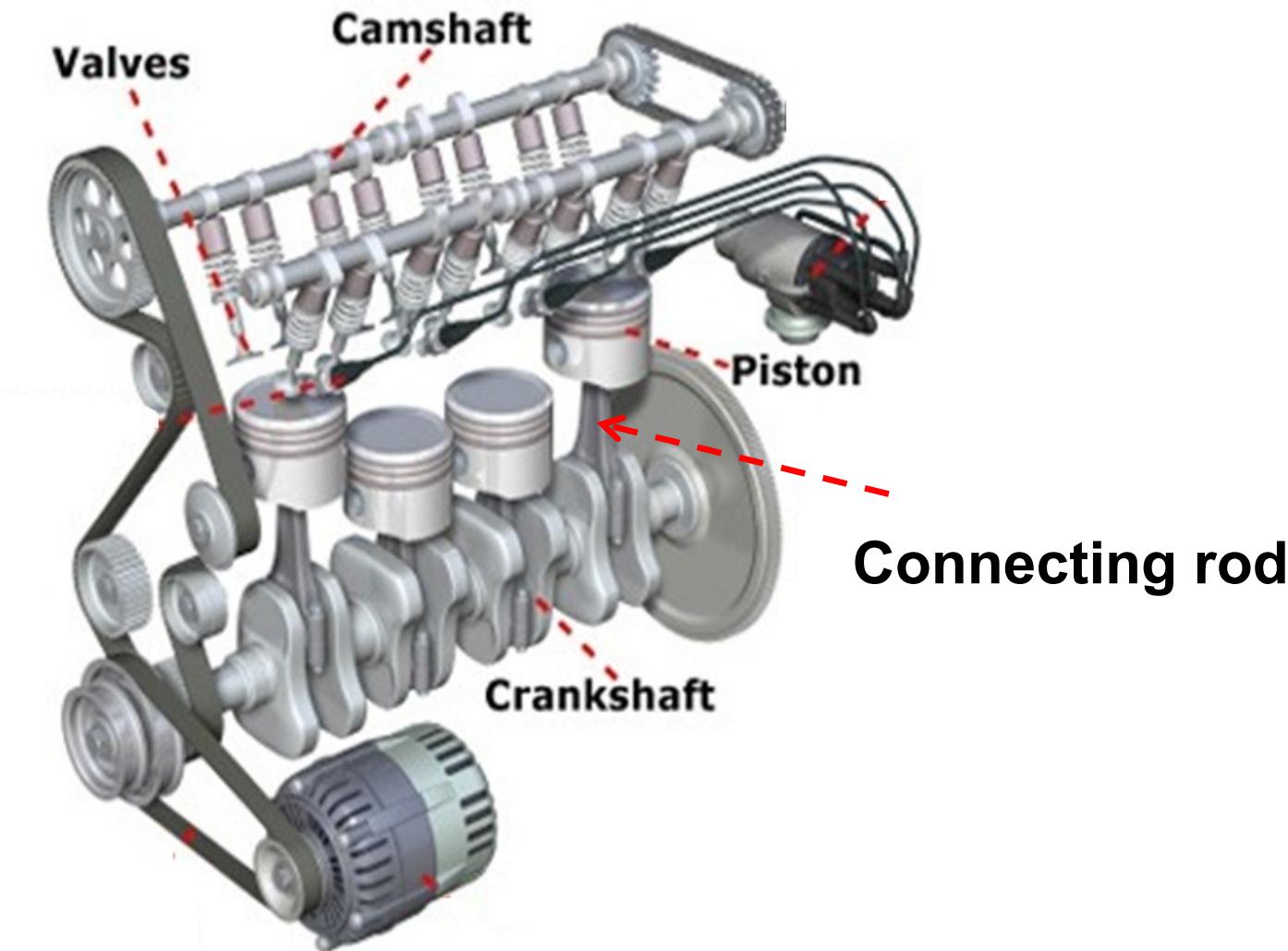


Designing Engine

- Requirements
 - Max Speed: 260 Kmph
 - Acceleration: 0-100 kmph in 8 seconds
 - Fuel Efficiency: 15 Kmpl (Desirable)
- Specification
 - Power: 275 BHP
 - Torque: 350 Nm

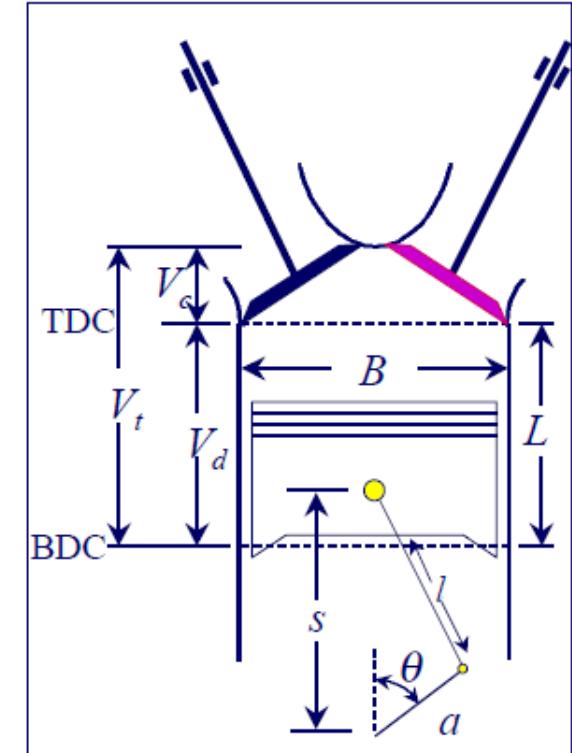
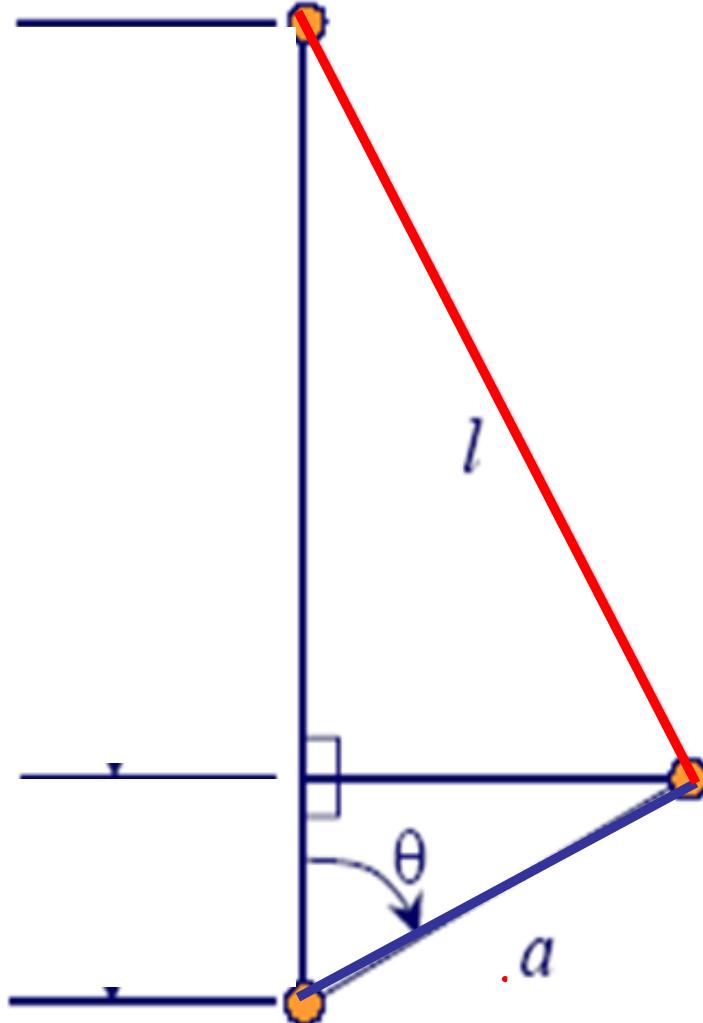


Major Components of A Multi Cylinder Engine



Piston Displacement & Speed

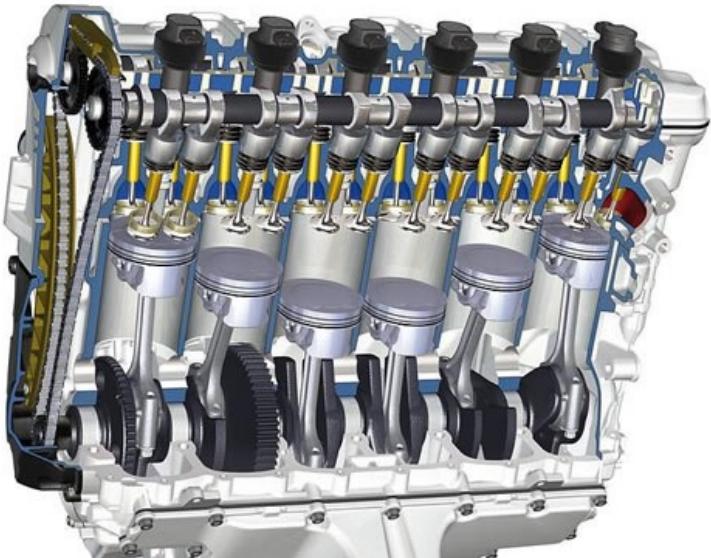
$$s(\theta) = a \cos \theta + \sqrt{l^2 - a^2 \sin^2 \theta}$$



Instantaneous Piston Displacement:

$$s(\theta) = \frac{L}{2} \cos \theta + \sqrt{l^2 - \frac{L^2}{4} \sin^2 \theta}$$

Engine

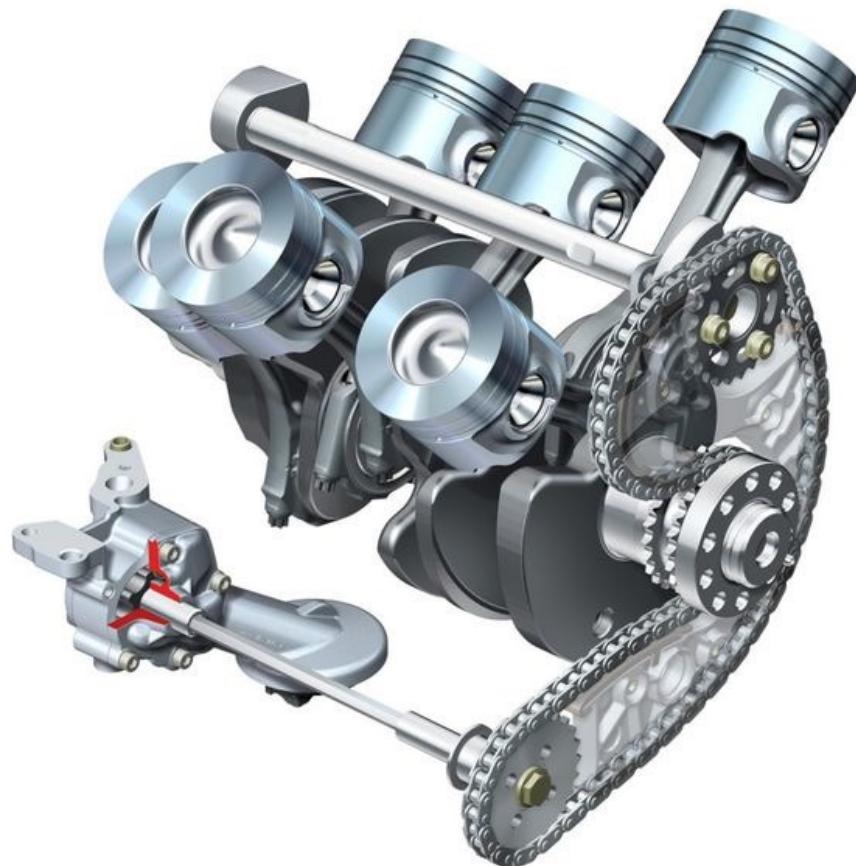
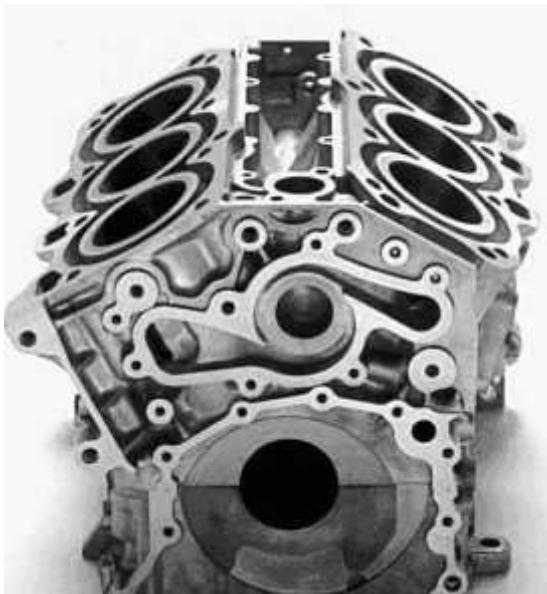


6 Cylinder Engine

3.5 litres

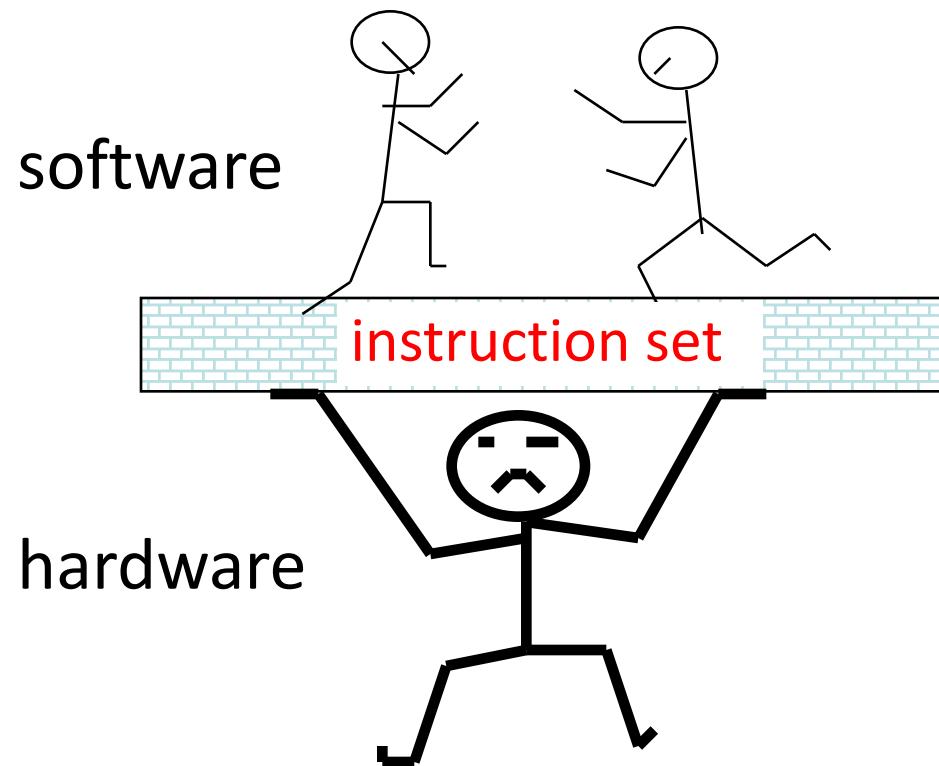
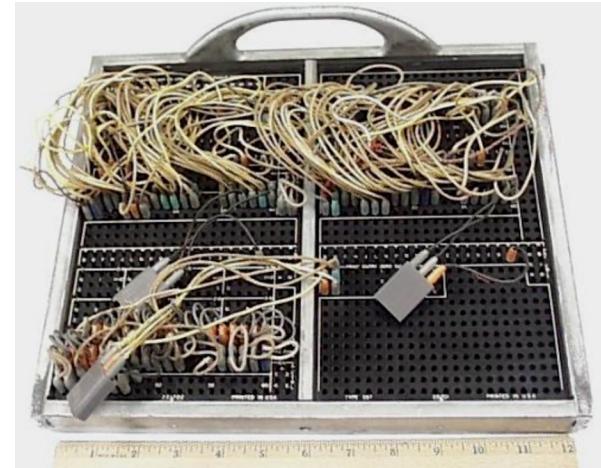
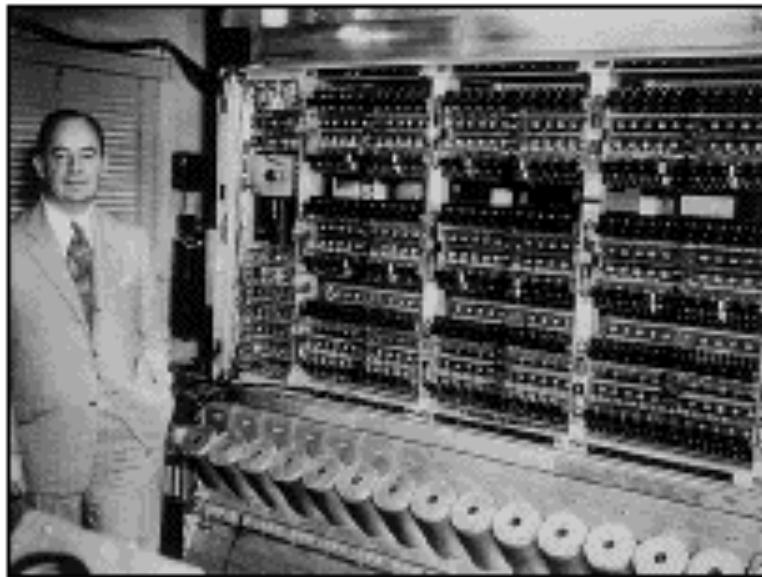


Engine



Fuel efficiency: **5 kmpl**

Computer System



Computer System



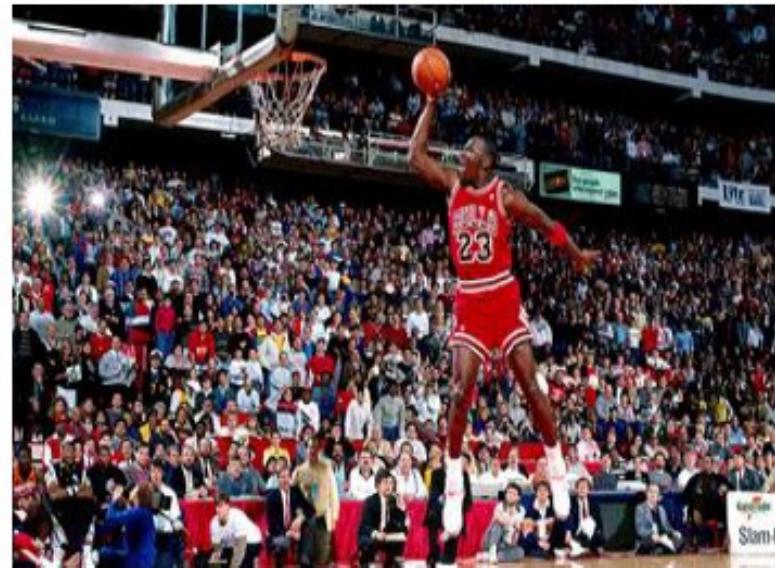
An Engineer to Star Engineer



Engineer to Star Engineer

Definition of Star

- 👉 Better problem solver and **creative**
- 👉 Driven and ambitious
- 👉 Smarter
- 👉 Will to succeed
- 👉 Born or Made?



Next Generation Vehicles



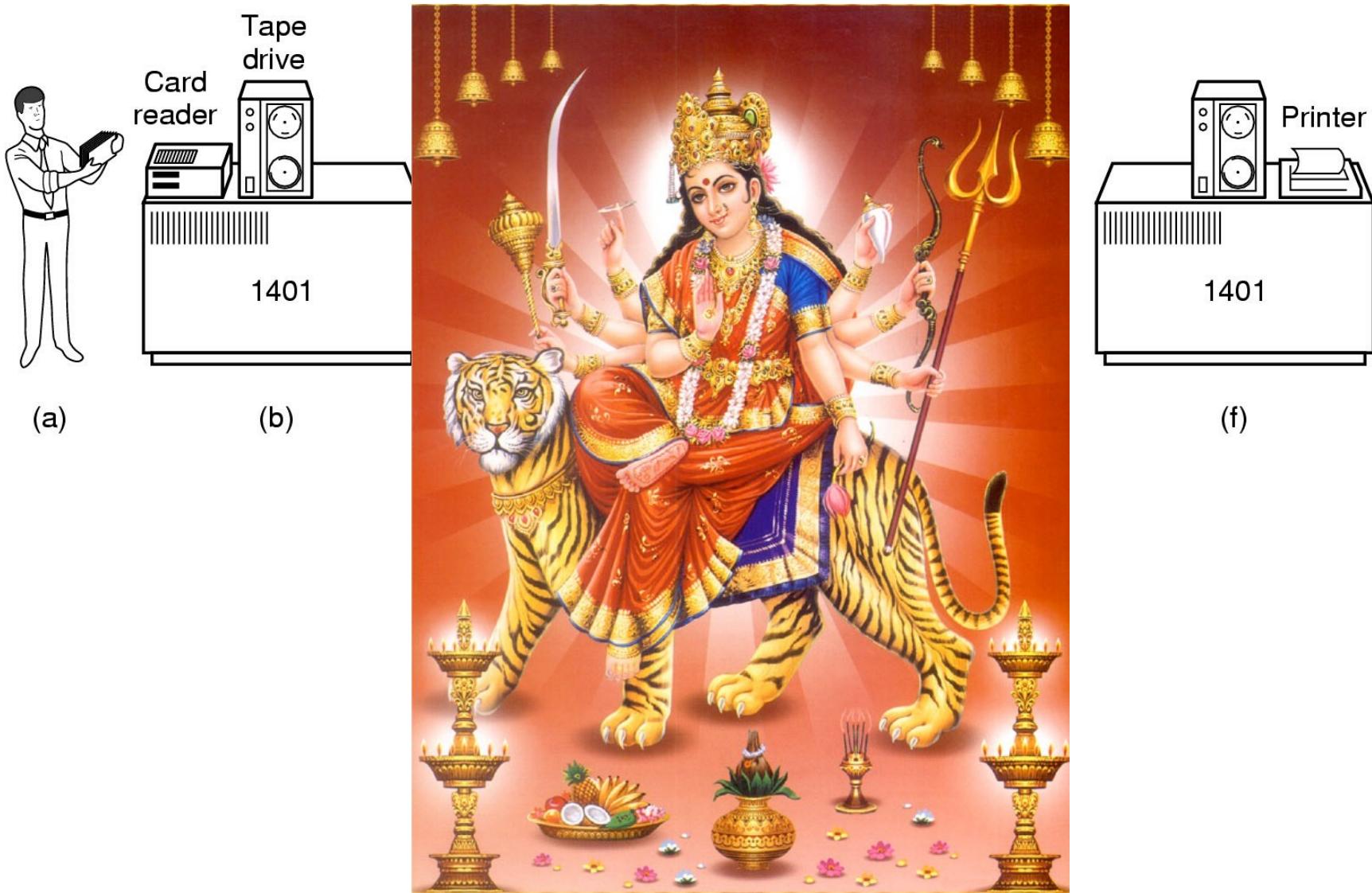
03 Aug 2023

EE-224@IITB

33

CADSL

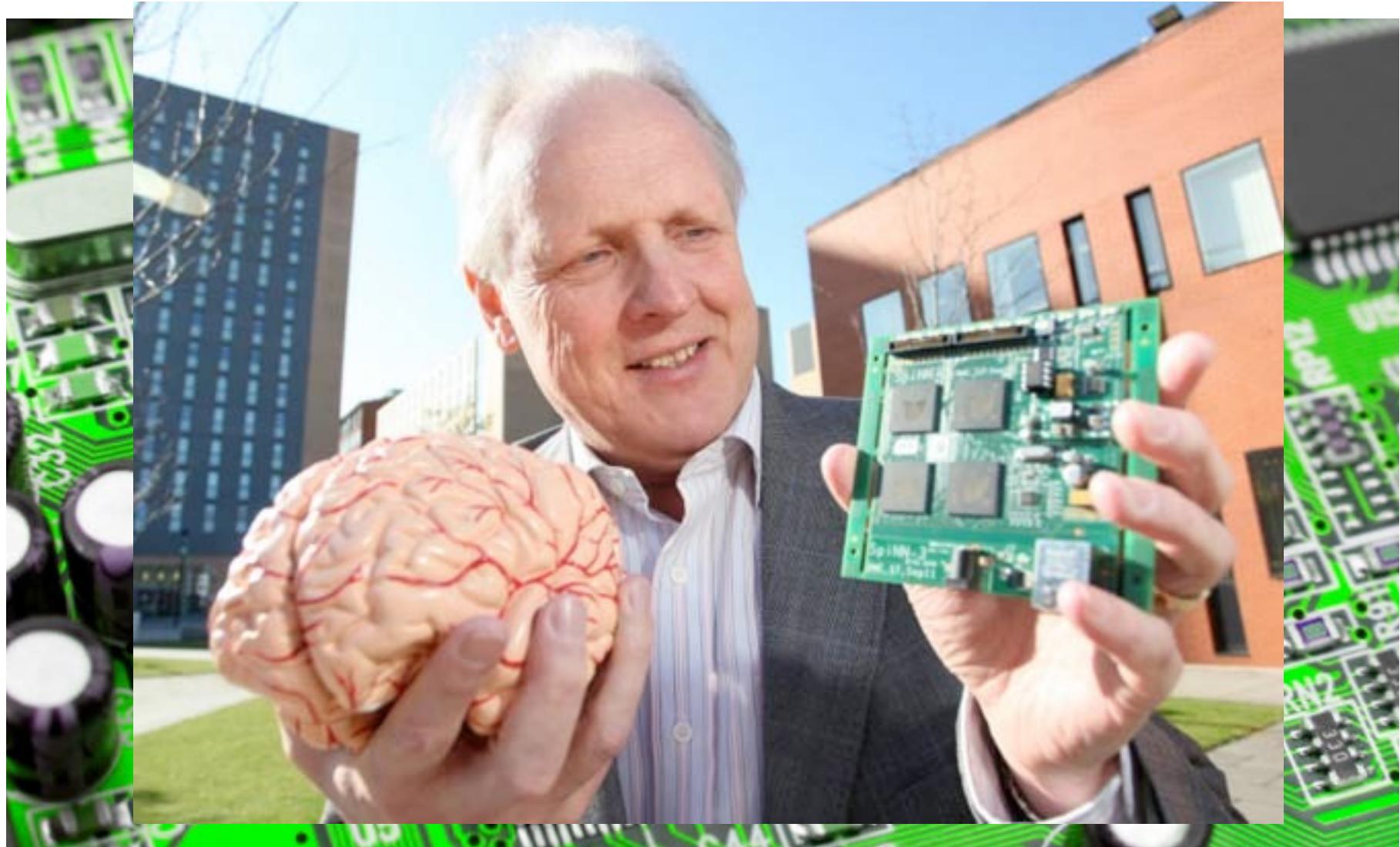
Computer System



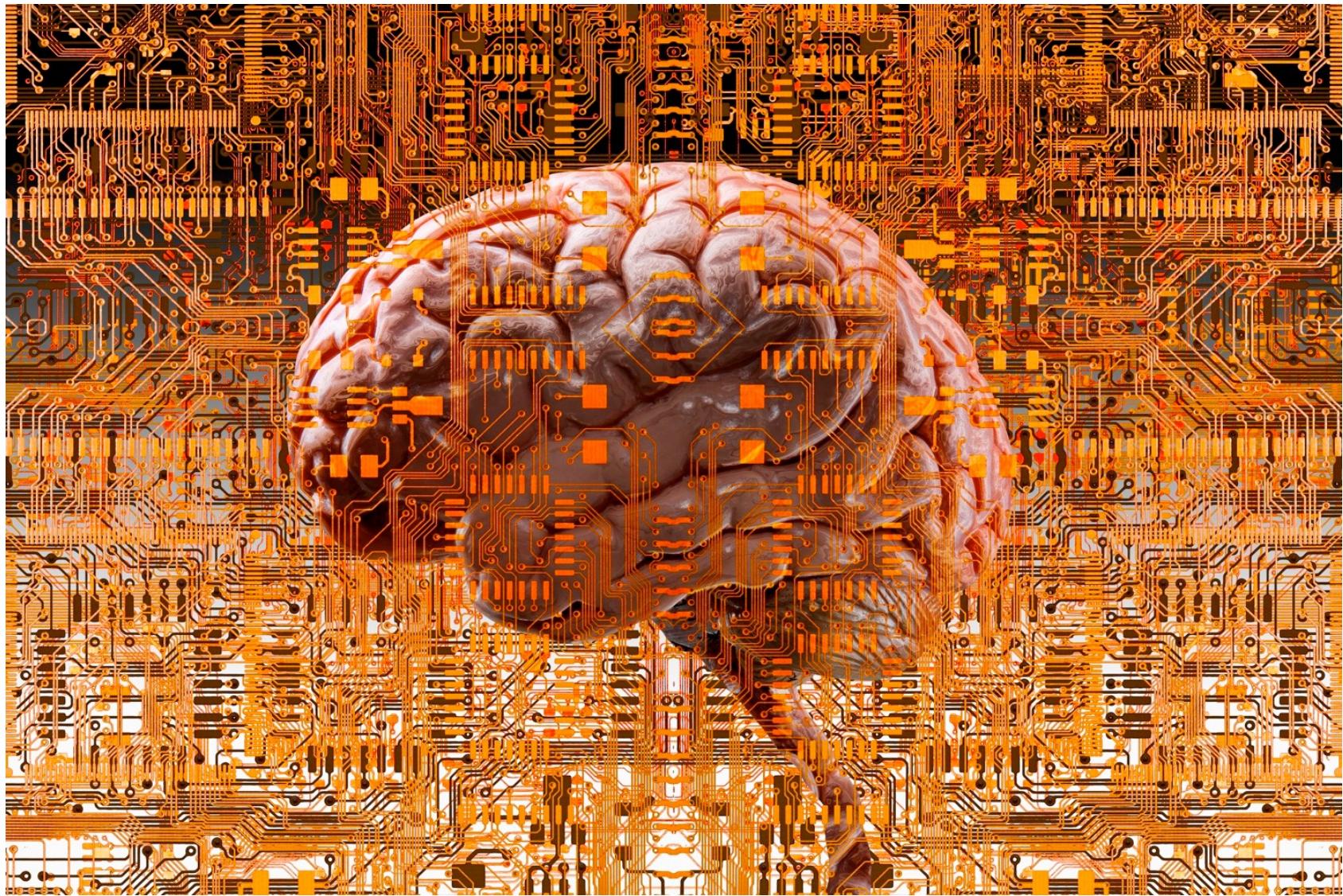
Computer System- Multitasking



What Next??



Next . . .



Passion

- Passion generates enthusiasm and builds great attitude
- Seek out responsibility above and beyond expected
- Be proactive
- Action oriented
- Ownership and responsibility

“I have no special talent. I am only passionately curious” – Albert Einstein



Diligence

- Attention to details
- Carpenter rule
 - ☞ “Measure twice, cut once”
- Laser focus on task at hand
- If you believe too much, you'll not notice faults
- If you doubt too much, you will never make progress



Do not pursue glory, pursue excellence –
Jack Welch

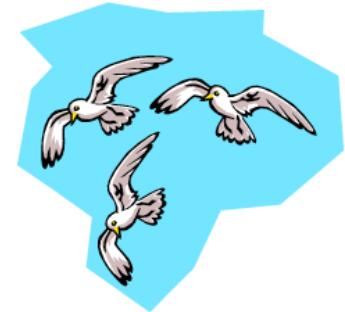


Soft Skills - Communication

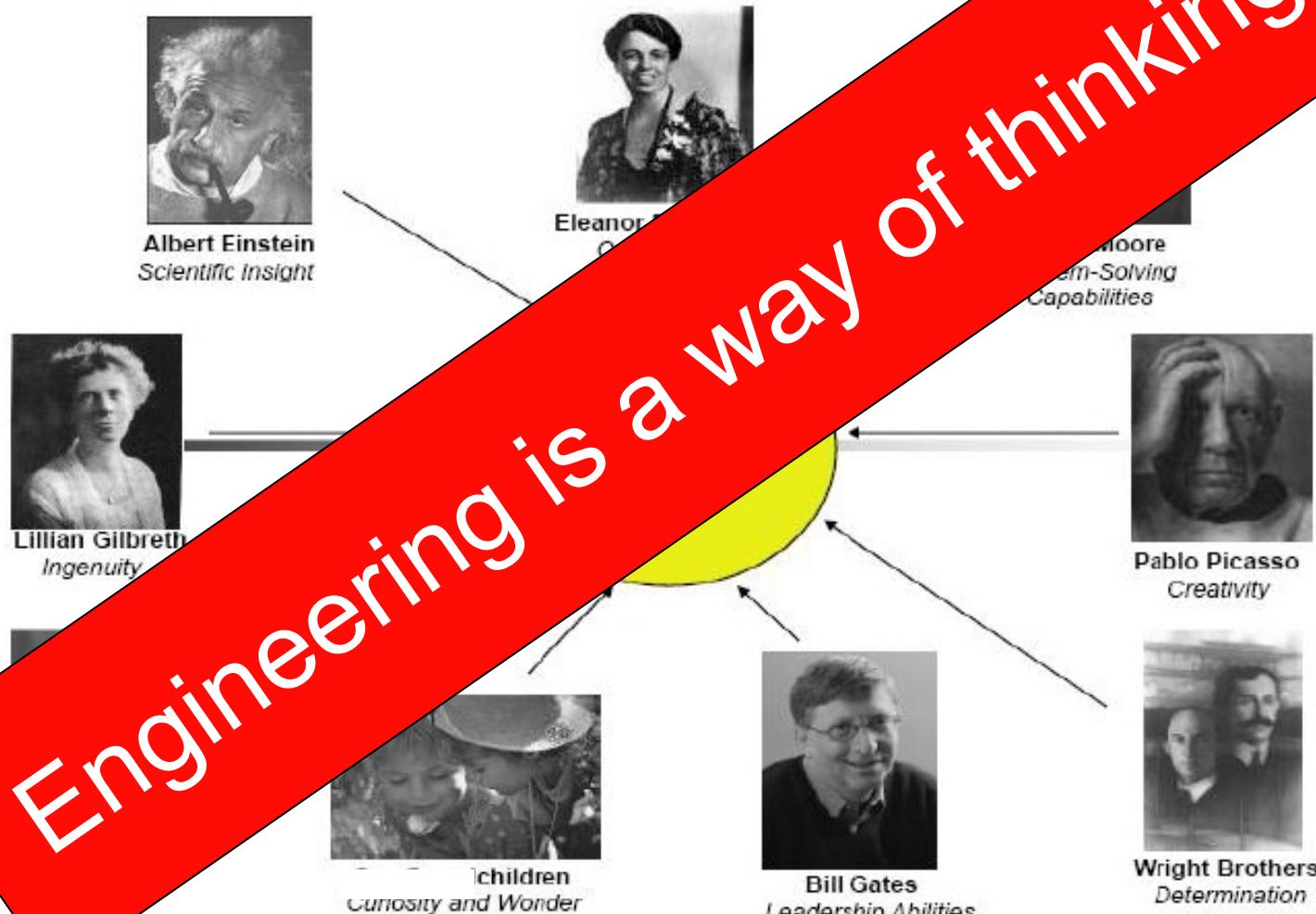
- Communication skills (oral and written)
- Succinct articulation
- Important to hear what is being said (active listener)
- Interpersonal skills (team work)



“Coming together is a beginning, keeping together is progress, and working together is success”
- Ford



Attributes of the Engineer 2020



21st Century World

“We have moved from a world where the big eat the small to a world where the fast eat the slow” (IBM, Compaq, Dell, next?)

(Klaus Schwab, Davos World Economic Forum)



The 21st Century at Work

Forces Shaping the Future Workforce and Workplace in the United States



“Rapid technological change and increased international competition place the spotlight on the skills and preparation of the workforce, particularly the ability to adapt to changing technologies and shifting product demand ... education becomes a continuous process.”

(Karoly et al, The 21st Workplace at Work)



System Realization Process

Customer's need

Determine requirements

Write specifications

Design synthesis and Verification

Test development

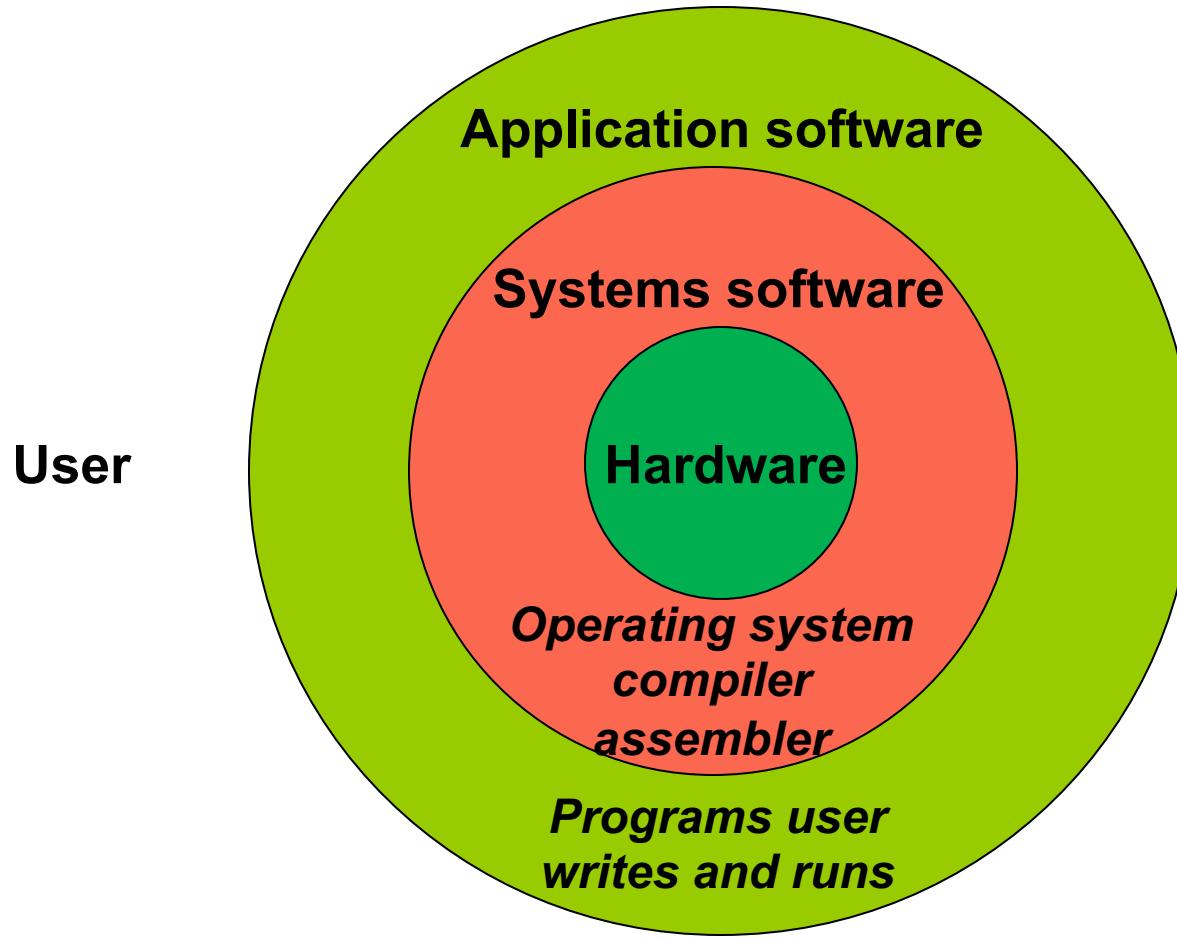
Fabrication

Manufacturing test

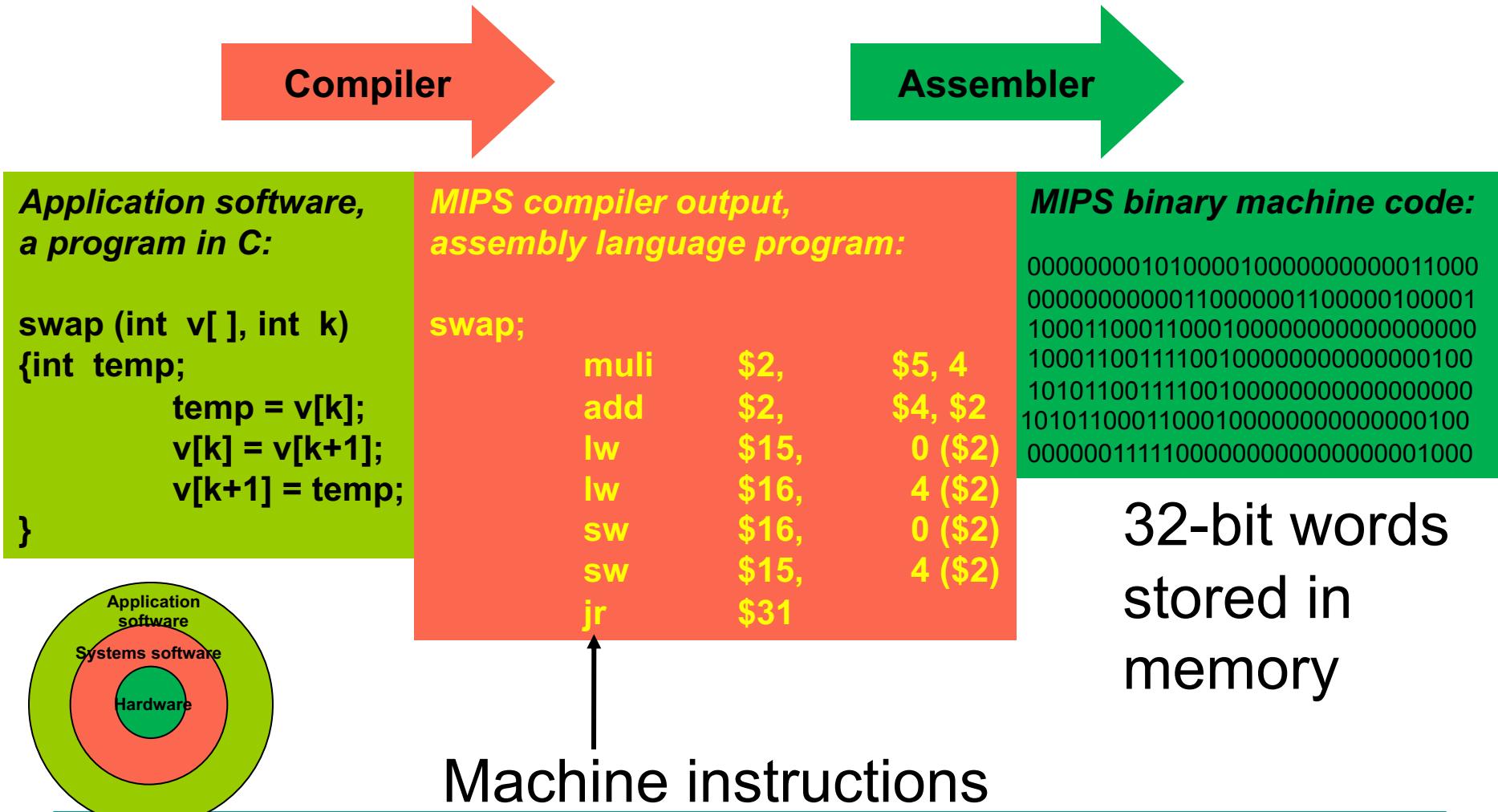
System to customer



The Concept of a Computer



Software



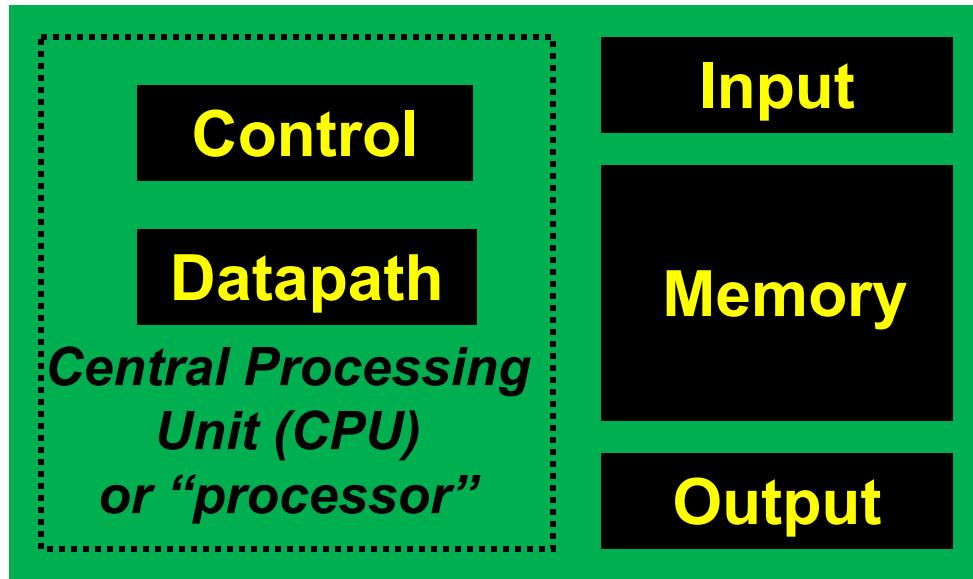
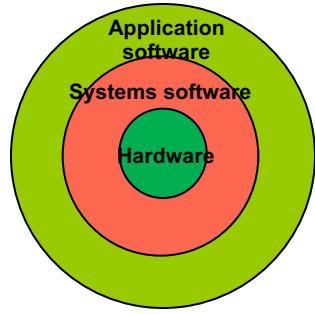
Binary Machine Code

Instruction
code
(opcode)

Encoded data



The Hardware of a Computer



FIVE PIECES



Digital Design

- Discipline of Engineering
- Based on mathematical logic
- Optimizations
 - Area
 - Performance
 - Power
 - Testability
 - Security
 - Intelligence



What is logic?

- Logic is the study of valid reasoning.
- That is, logic tries to establish criteria to decide whether some piece of reasoning is valid or invalid.

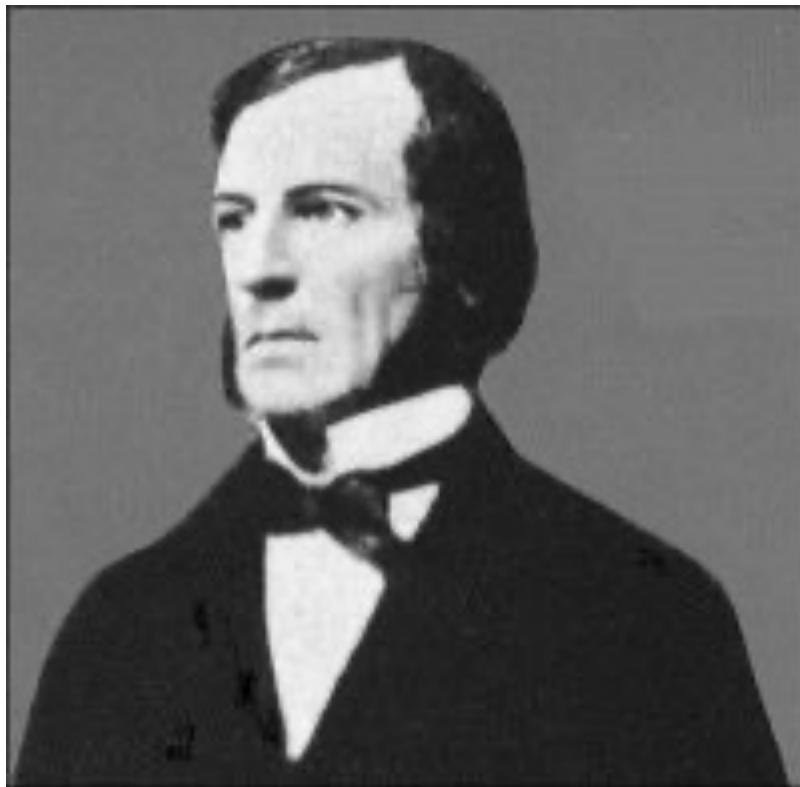


Logic

- Crucial for mathematical reasoning
- Used for designing electronic circuitry
- Logic is a system based on **propositions**.
- A proposition is a statement that is either **true** or **false** (not both).
- We say that the **truth value** of a proposition is either true (T) or false (F).
- Corresponds to **1** and **0** in digital circuits

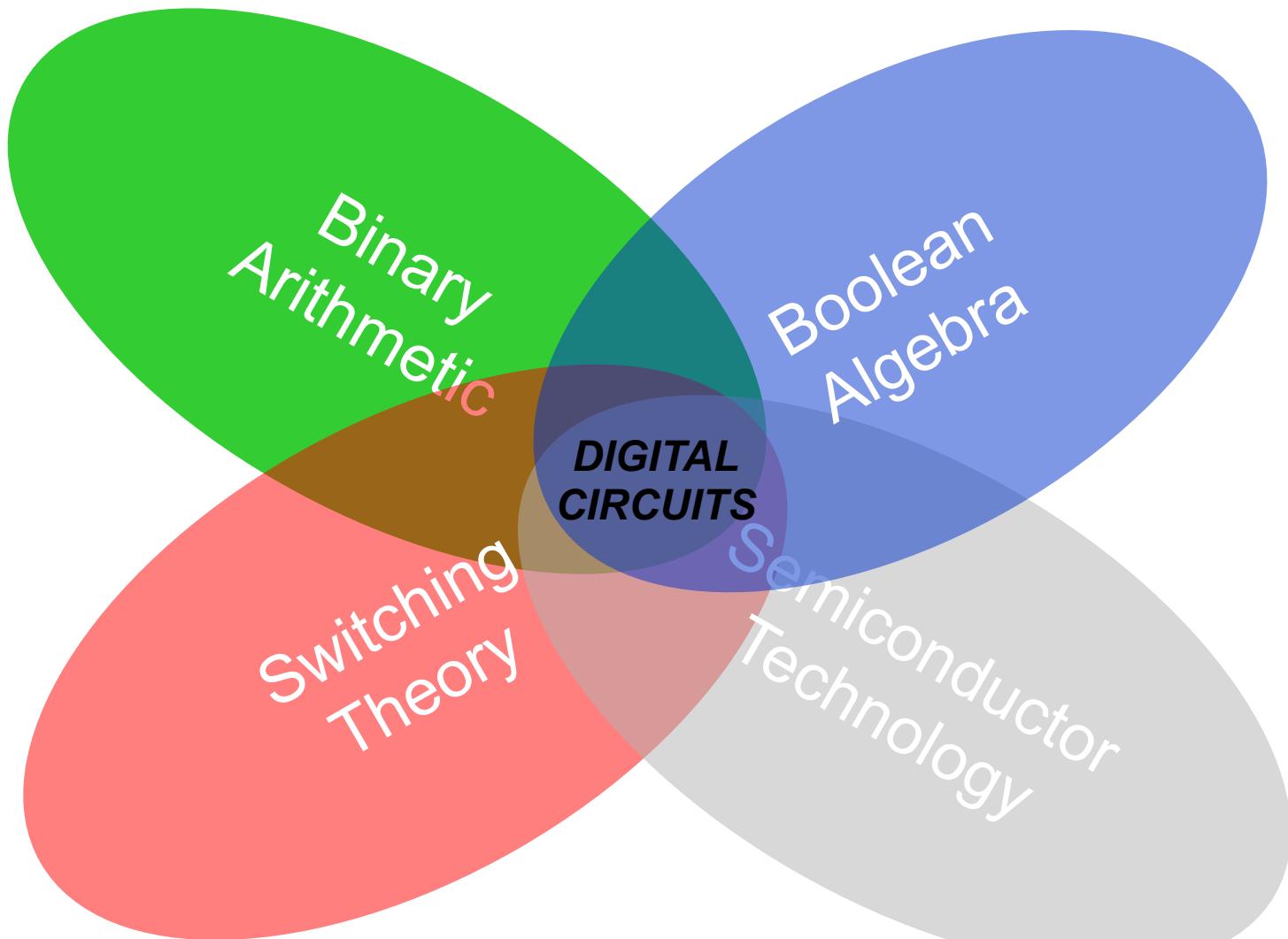


George Boole, 1815-1864



- Born, Lincoln, England
- Professor of Math., Queen's College, Cork, Ireland
- Book, *The Laws of Thought*, 1853

Digital Systems



Thank You

