ESC201: Introduction to Electronics

Module 1: Circuit Analysis

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The Instructor

- Course Instructor :

  - Dr. Shubham Sahay

  - Email: ssahay@iitk.ac.in

  - Assistant Professor, EE

  - Research areas:

    Neuromorphic Computing

    Hardware Security

    Emerging Logic and Memory Devices

- Lab Coordinator:

  - Dr. Rik Dey

  - Email: rikdey@iitk.ac.in

  - Assistant Professor, EE

  - Research Areas:

    Solid-state Devices

    Spintronics

- ➢ **Ask questions** without thinking about your peers!
- ➢ **"Questions are never stupid",** What can be stupid is the answer to that question and that will come from my side!
- ➢ Get to **know your classmates**: Will be helpful in discussing course content and assignment solutions (and also forming groups for copying in the examination).
- ➢ In case of any problem, do not hesitate to mail me. Genuine problems would always be considered and attempts would be made to resolve them. The instructor is there for you!
- ➢ **In case of logistics/evaluation/regrading/non-technical requests/queries, please email: ad_esc@iitk.ac.in**
- ➢ Attending classes is strongly recommended!
- ➢ Missing more than 25 lectures → automatic drop/"F"

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- ➢ **Policy against copying in the exam**: **Copied answer sheets would be awarded 0 marks.** The guideline says immediately report such instances to SSAC and the penalty can be very harsh. Use the **"obliviate"** charm and forget "A friend in need is a friend indeed" in exam hall.
- ➢ If you miss an examination due to approved medical leave, following policy will be applied:

1. *Missed MQ/Quiz-1/Quiz-II/Mid-semester examination*: No make up examination.
2. Missed end-semester exam: Make-up examination. It is your responsibility to apply for it through DoAA office.
3. Missed Laboratory sessions: You will be allowed to complete the experiment in the designated make-up laboratory sessions. However, if you do not appear in the makeup sessions, you will be awarded zero marks for that experiment.

Grading Policy

Mode of evaluation*	Weightage/Marks*
Lab component	20% (20 marks)
Mini-Quiz (Tutorials best n-1 out of n)	14% (14 marks)
2 Major Quizzes (on 11th Feb & 8th Apr)	16% (16 marks)
Midsemester Examination	20% (20 marks)
End-semester Examination	30% (30 marks)

*May vary depending upon the extent of the use of unfair means!

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Acknowledgement

- Prof. Baquer Mazhari

- Prof. A. R. Harish

- Prof. S.S.K. Iyer

- Prof. Yogesh S. Chauhan

- Prof. Adrish Banerjee

- Prof. K. V. Srivastava

- Prof. Imon Mondal

- Prof. Pradeep Kumar

- Prof. Shilpi Gupta

- Prof. Ketan Rajawat

- Prof. Amit Verma

- Prof. Vipul Arora

- Prof. Abhishek Gupta

- Prof. Rik Dey

Why Electronics?

Modern world *has been* and *is being* rapidly transformed by Electronics

Electronics offers capabilities that can be exploited by almost all engineering branches

Almost all systems now include an electrical subsystem

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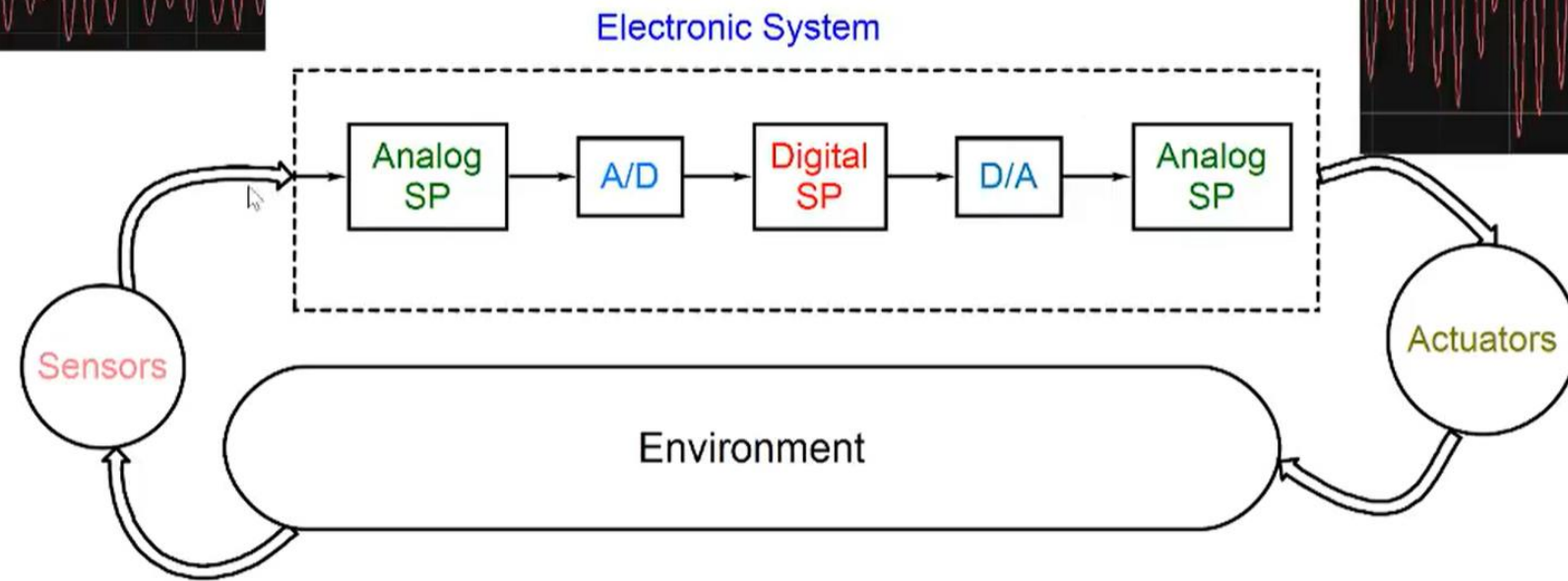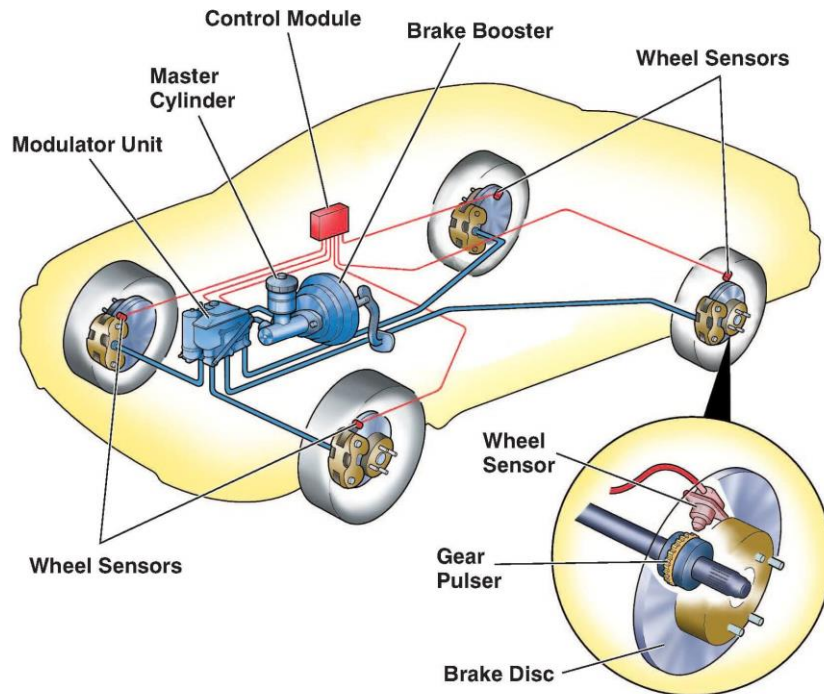
Why Electronics

- Every action requires energy
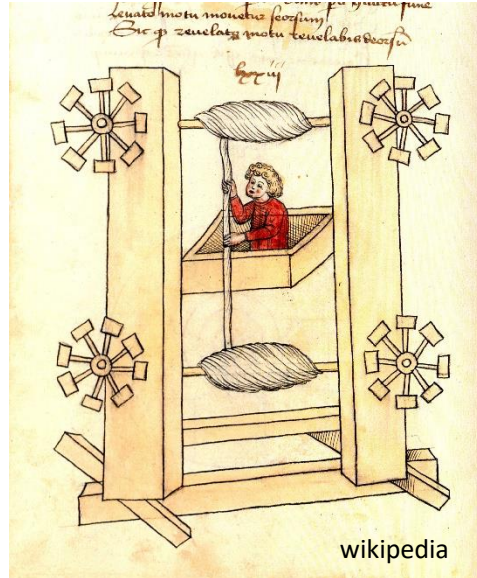
Pre-industrial era
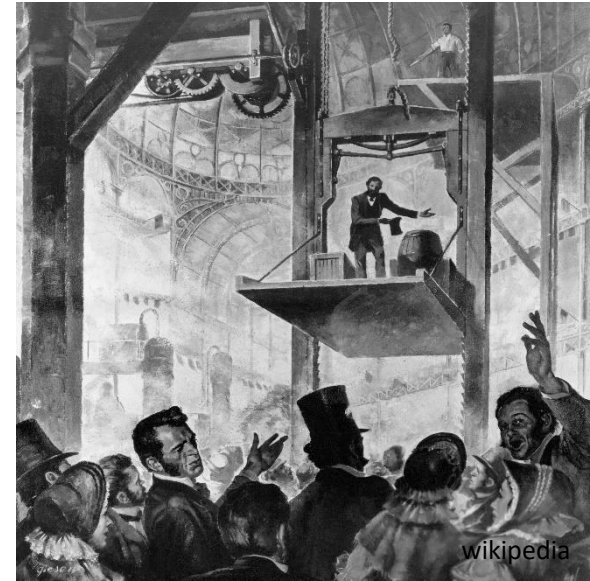
1853
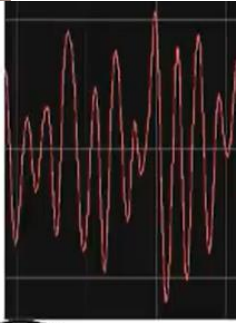

Now!

- Electricity is one of the most useful forms of energy

- It is easy to generate, easy to transport, can be easily converted into other forms of energy

- Can be Controlled precisely!

- Electronics helps to control the electrical signals precisely

Electronics provides Solutions!

- Audio system

- Anti-lock Braking System

Audio signal

Electronic System

Analog SP → A/D → Digital SP → D/A → Analog SP

Sensors

Actuators

Environment

1. Analog Signal Processing
2. Data Converter
3. Digital Signal Processing

Control Module
Brake Booster
Wheel Sensors
Master Cylinder
Modulator Unit
Wheel Sensors
Wheel Sensor
Gear Pulser
Brake Disc

Relationship of Electrical Engineering to Others

Math and Statistics
Networks, Graphs, Differential Equation, Integral Transform, Optimization

Aerospace
Control for devices and system dynamics, UAVs: Control and Communication

Biological Science
Biomedical, Bio-signal processing, Imaging, Neural Network, DNA coding/encryption

Civil, Earth Science
Transportation, Remote sensing and Monitoring, Optimization

Physics
Electro-Magnetic Theory

Chemical/Chemistry
Nano-machines, Molecular communications, System dynamics, Instrumentation

Material Science
Device Characterization, Semiconductors, Electrical properties of materials
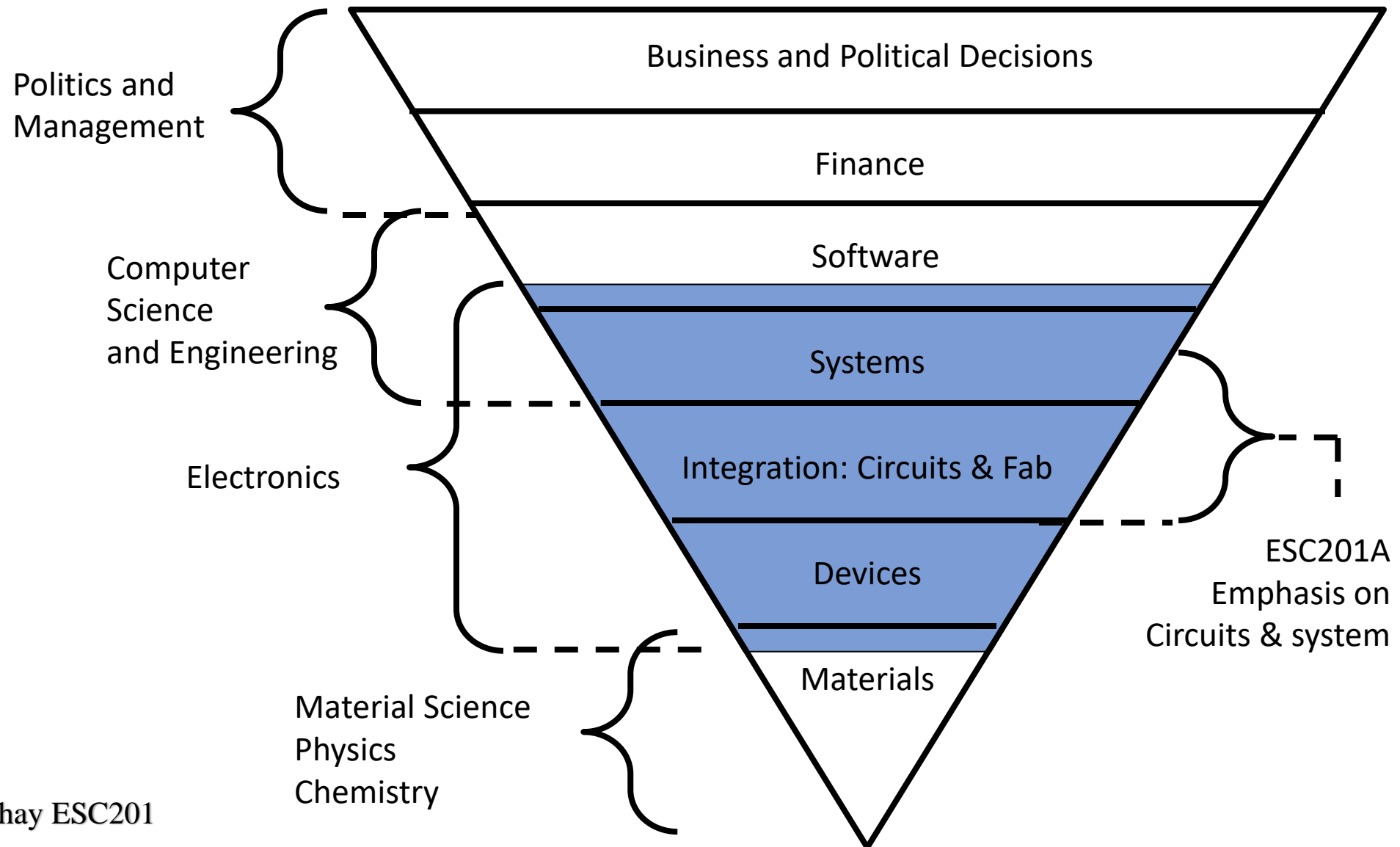
Mechanical
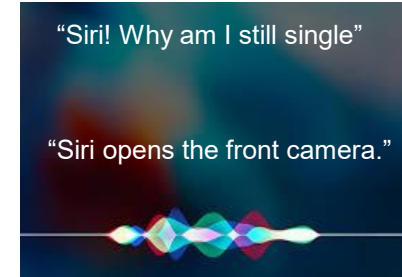Control for mechanical systems, Stability, Robotics, Optimization

Computer Sciences
Processor and Interface Circuits, Logic, Computer Architecture, Computer Organization

Where does this course fit?

Business and Political Decisions

Finance

Software

Systems

Integration: Circuits & Fab

Devices

Materials

Politics and Management

Computer Science and Engineering

Electronics

Material Science
Physics
Chemistry

ESC201A
Emphasis on
Circuits & system

SMART REVOLUTION

"Siri! Why am I still single"

"Siri opens the front camera."

➤ Smart revolution: advancement in transistor technology

    o Transistor-Human body analogy

    o Cell : Transistor :: Body : Smart devices

    o Billions of transistors enable your smartphone: small chunk of silicon dictates our lifestyle

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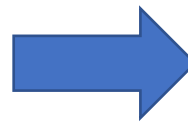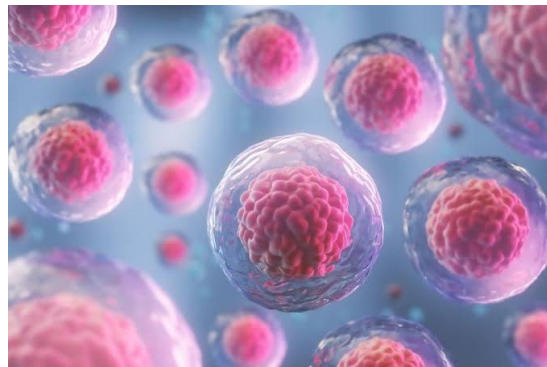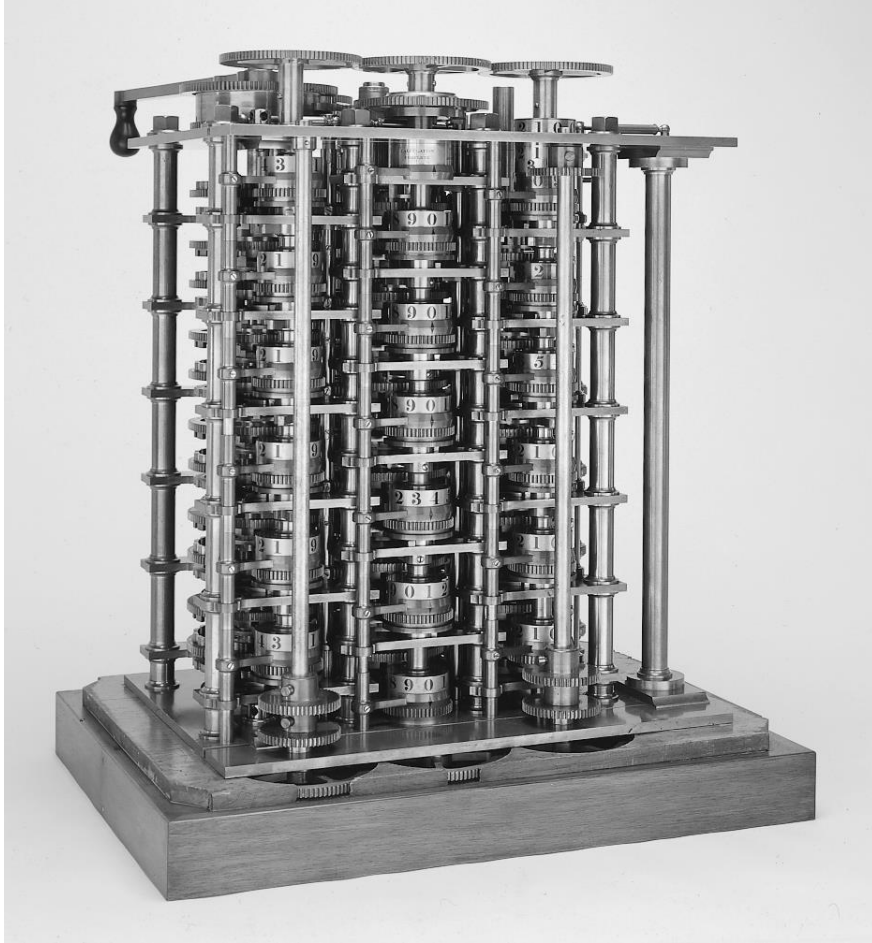
**The Babbage
Difference Engine
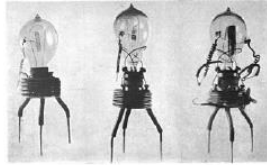(1832)**

25,000 parts
cost: £17,470

- Mechanical computing device, very close to modern CPUs
- Supports arithmetic operations in random order
- Pipelining was also introduced: parallel processing of several instructions.
- Complexity and cost too high
- Originally built in 1991
- Science Museum in London
- Size too large.
- Solution: go for electronic implementations.

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Electronics Revolution

- Diodes were discovered in 1904.

- Earlier electronics technology was vacuum tube-based.

- Scaling issue, reliability, huge power dissipation.

- ENIAC: first electronic computer (1946)

- 17,468 vacuum tubes, 7200 crystal diodes, 1500 relays, 70,000 resistors, 10,000 capacitors, Weight > 27 Ton, 1800 sq. ft., 150 kW of electricity

1904 Diodes

John Ambrose Fleming's diodes

1906 Triodes

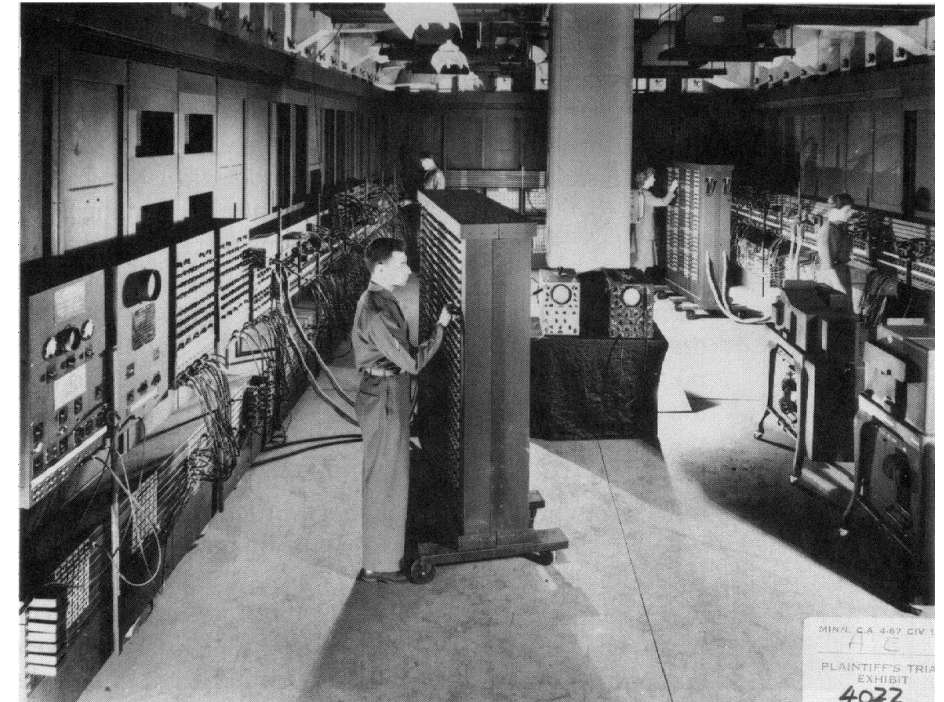Audion Triode invented by Lee De Forest

en.wikipedia.org

BM100 - IBM 603
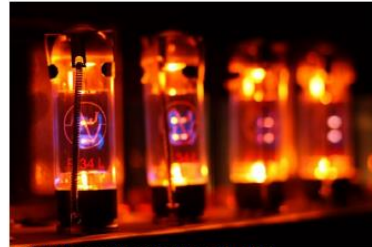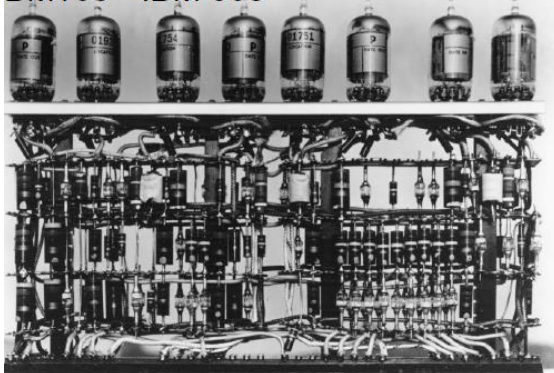
news.sciencemag.org

ENIAC Vacuum Tubes (1946)

CURIOUS CASE OF TRANSISTORS

- Bell labs: headed by William Shockley, set out to invent electronic switches

- Shockley came up with the theory in 1935 itself.

- Hired Physicists Brattain and Bardeen.

- Accidentally, Brattain and Bardeen fabricated Point contact transistor.

- Two years later, Shockley came up with the bipolar junction transistor.

- Shockley is credited and known as father of transistors.

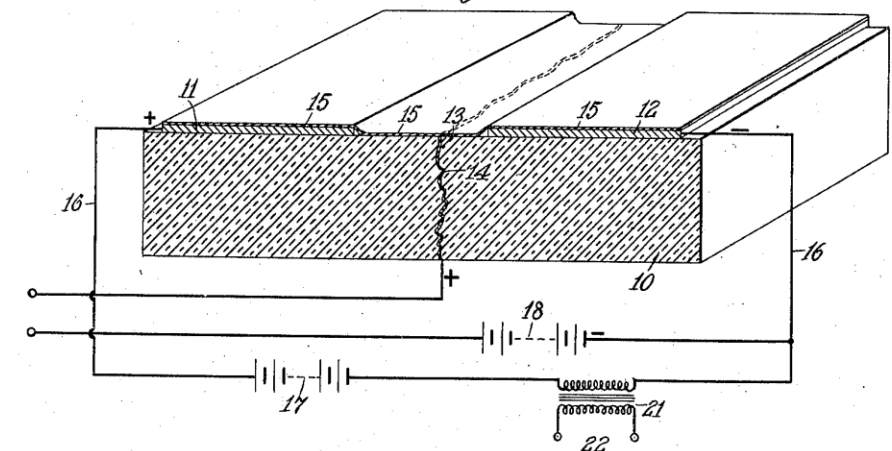- Julius Edgar Lilienfield: MOS transistor theory in 1930 itself.

Jan. 28, 1930.   J. E. LILIENFELD   1,745,175

METHOD AND APPARATUS FOR CONTROLLING ELECTRIC CURRENTS

Filed Oct. 8, 1926

Fig.1.

TRANSISTORS

- Transistor: Any device where current between two terminals may be controlled by voltage or current at another terminal.

- The term was coined as trans-resistance or transfer of resistance.

- When Bell labs discovered it, they welcomed lab mates to name it.

- Transistor basically acts like a resistor and it appears as if the voltage is being transferred across the device to control the resulting current.

- Transistors act like switches and combine to form circuits and logic gates.

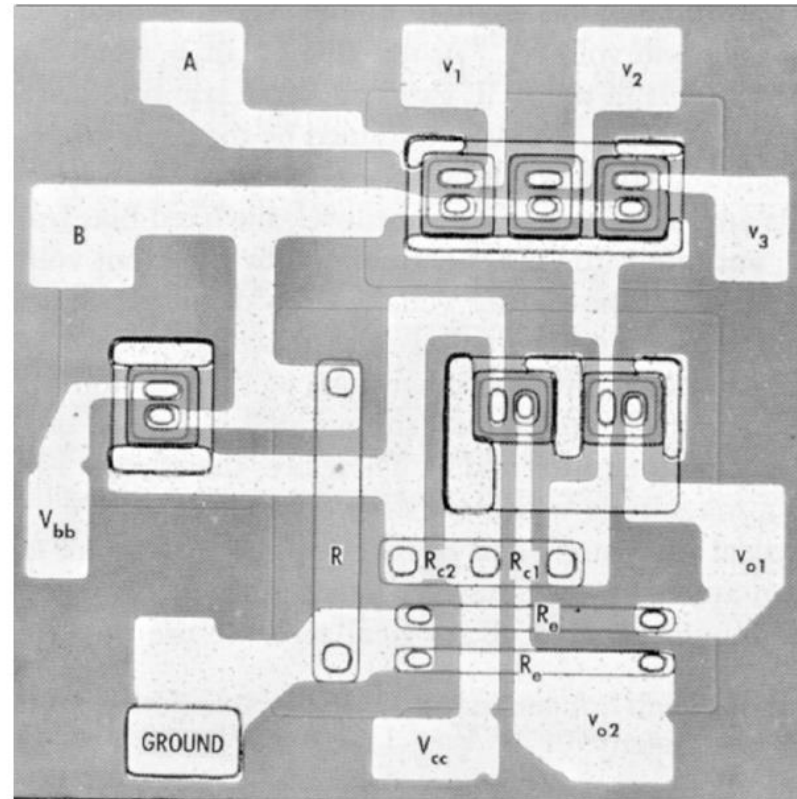- First discrete bipolar gate in 1956 by Harris.

INTEGRATED CIRCUITS

Inventors of ICs

Jack Kilby
at Texas Instruments
in 1958

Physics Nobel Prize
in 2000

Robert Noyce
At Fairchild Semiconductor
In 1957

ECL 3-input Gate
Motorola 1966

Bipolar logic
1960's

Rabaey et al.
© Digital Integrated Circuits[2nd]

- Monolithic integration.

- Realize all components: BJT, R, L, C on the same substrate or silicon wafer.

- TTL (transistor-transistor logic): First successful logic family.

- Discovered in 1962, dominated till 1980s.

- MOSFET fabrication process was challenging.

- Initially PMOS only logic.

- Shifted to NMOS only logic.

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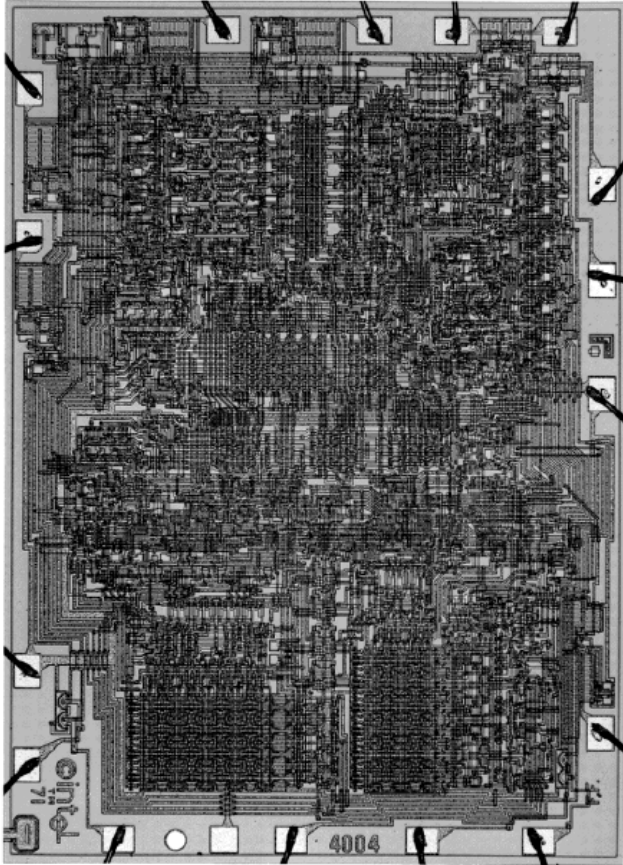
1971
2,300 transistors
108 kHz operation
10 micron technology

- Intel 4004: NMOS only logics.

- All transistors were handcrafted and placed manually.

- Late 1970s: NMOS only logic replaced by CMOS logic.

- Currently, BJTs are used only where high speed is needed.

- CMOS dominates the market.

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