CSC 103: How Computers Work

Spring 2016

Smith College

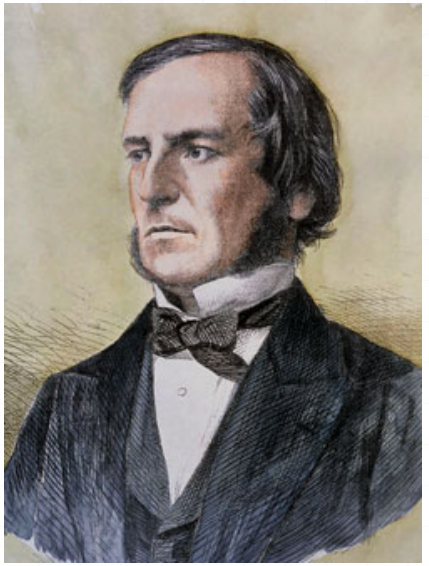
Prof. Sheehan

Class 3: March 28
Outline

- Review of terminology
- Begin: parts of a computer
- More practice with logic gates and truth tables

Boolean algebra

- Named after George Boole



George Boole (1815-1864)
Credit: wikipedia

Boolean algebra

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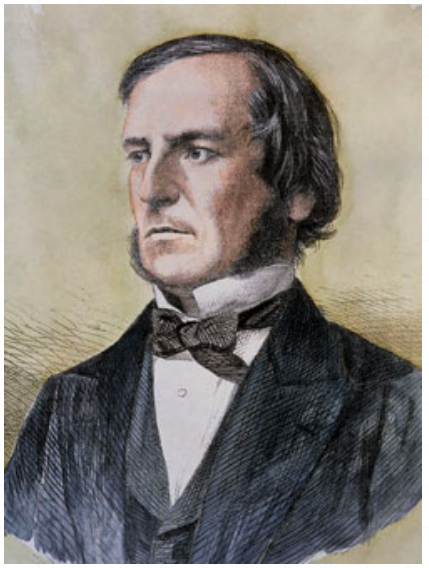
- A “boolean” variable is either **true** (1) or **false** (0)



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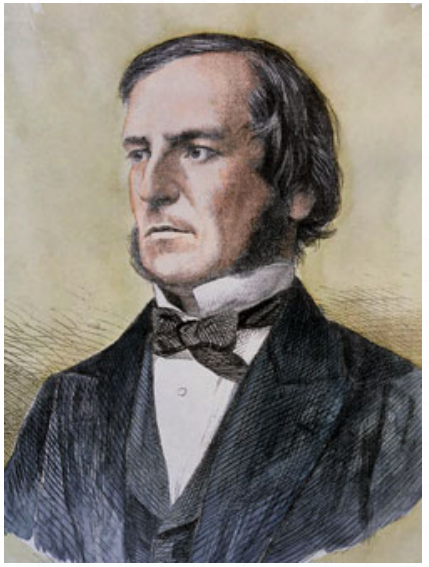

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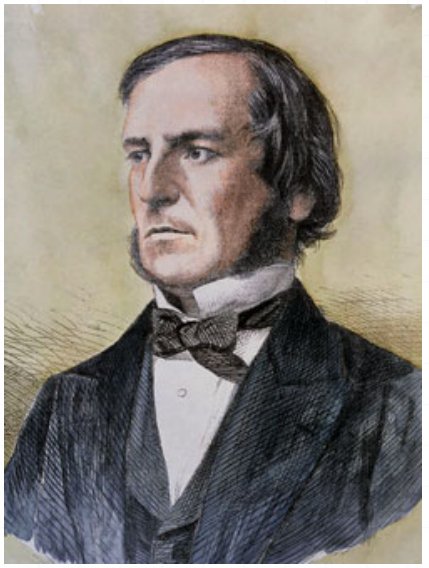
- Example:

  f(**a**,**b**,**c**,**d**) = (**a** and **b**) or (**c** and **d**)



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Binary numbers and bases

- Computer stores *everything* as binary numbers
  - Text data (Word documents, etc)
  - Pictures, video, audio
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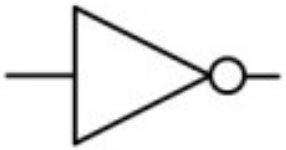
- "Special" bases:
  - **Binary**: base 2 — digits: **01**
  - **Octal**: base 8 — digits: **01234567**
  - **Decimal**: base 10 — digits: **0123456789**
  - **Hexadecimal**: base 16 — digits: **0123456789ABCDEF**

Logic gates



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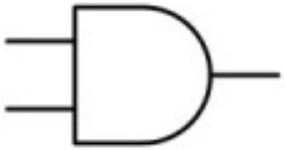

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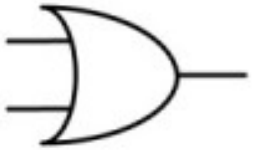
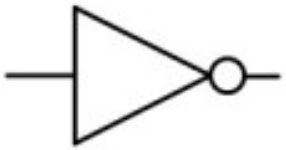


OR

Image Credit: http://www.sectorfej.net/

Logic gates



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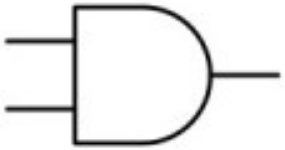
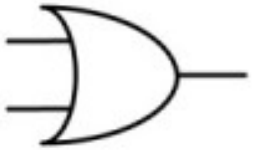
$\bar{A}$



AND

$A \cdot B$



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$A + B$

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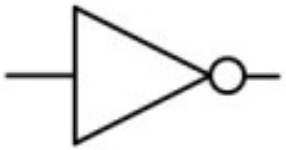
Logic gates



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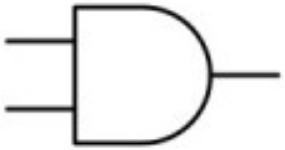

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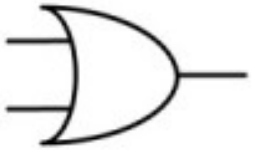

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- All operations can be built from these 3 gates

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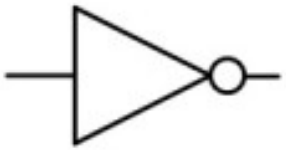
Logic gates



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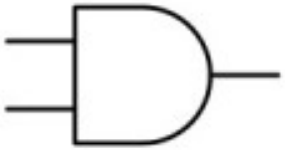

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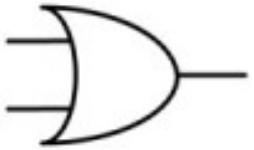

OR

$\overline{A}$ $A \cdot B$ $A+B$

- All operations can be built from these 3 gates
- **Boolean functions, logic gate circuits, and truth tables are all equivalent!**

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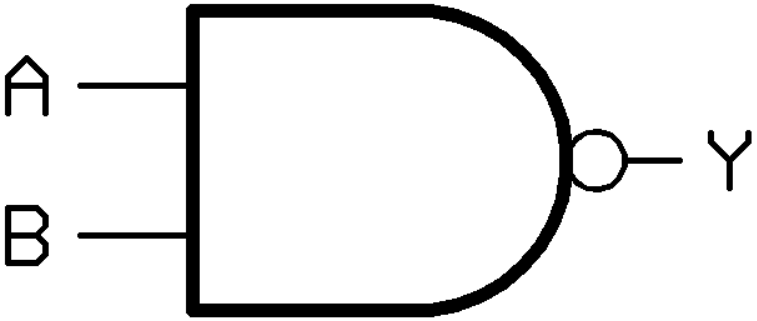
Other logic gates



NAND: not(A and B)

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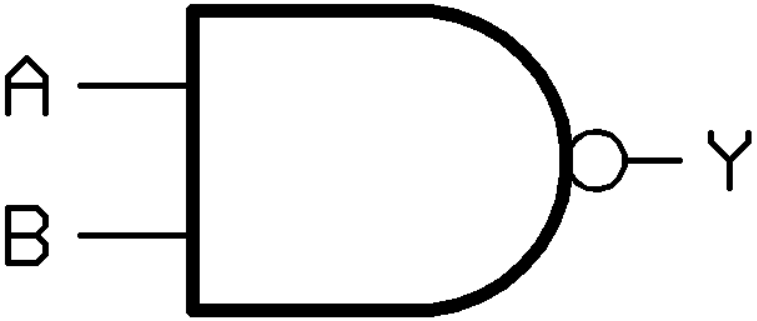

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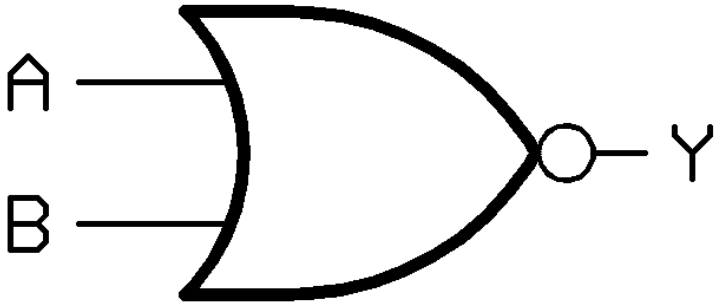

NOR: not(A or B)

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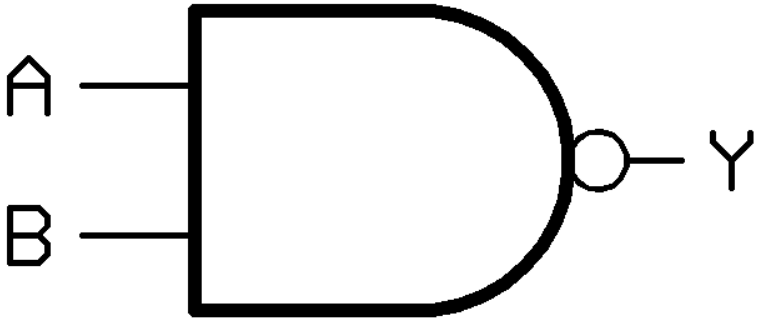

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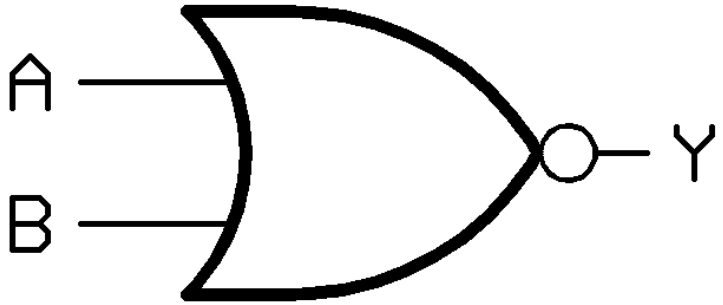

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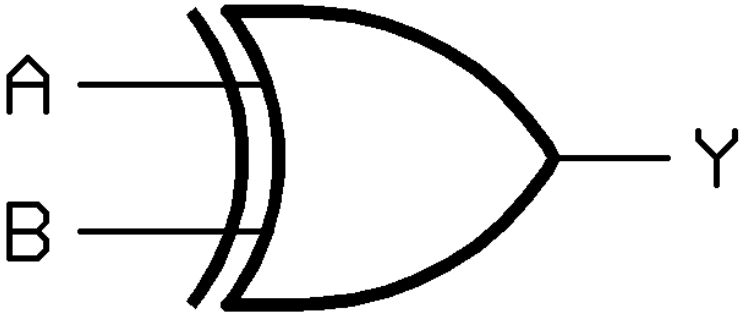

XOR: A xor B

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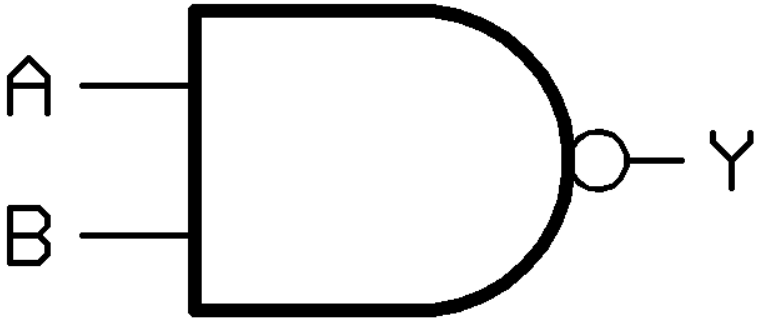

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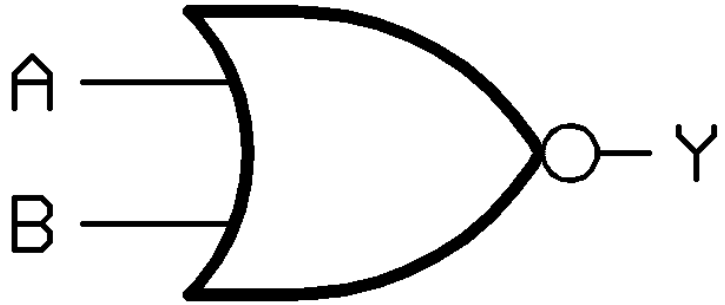

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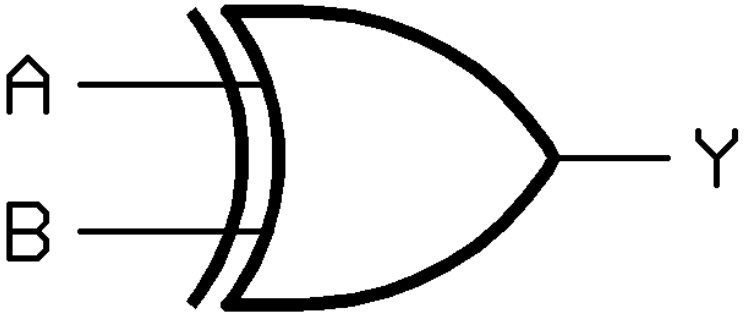

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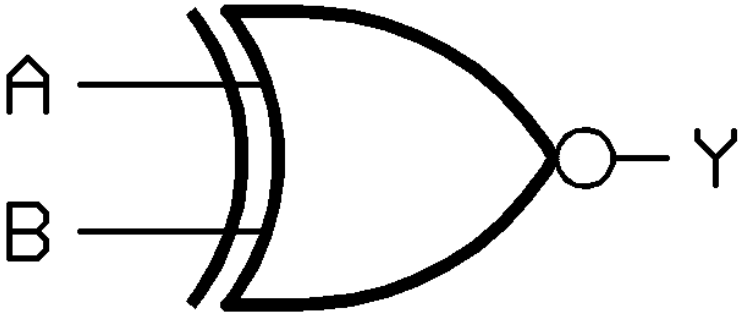

XNOR: not(A xor B)

Q: How do these gates work in a computer?

Enter: Claude Shannon

- Demonstrated that Boolean algebra could be encoded using **electrical switches**.
- Through this mechanism, any logical computations could be performed.

Claude Shannon (1916-2001)
Credit: wikipedia

How computers do logic gates

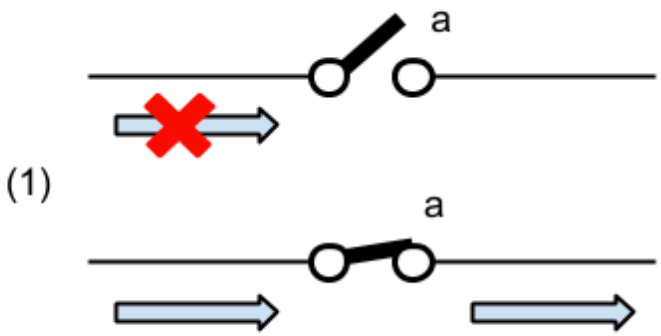

Image Credit: Dominique Thiebaut

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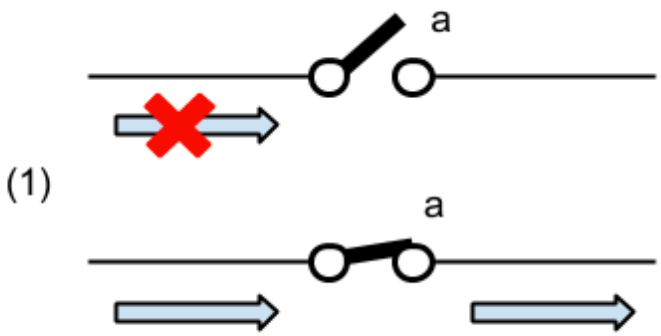

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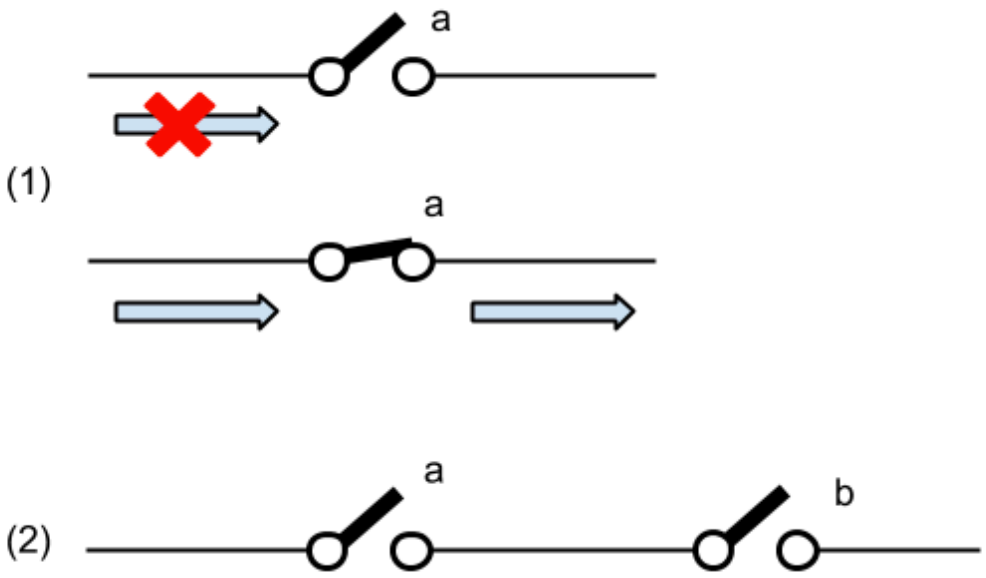

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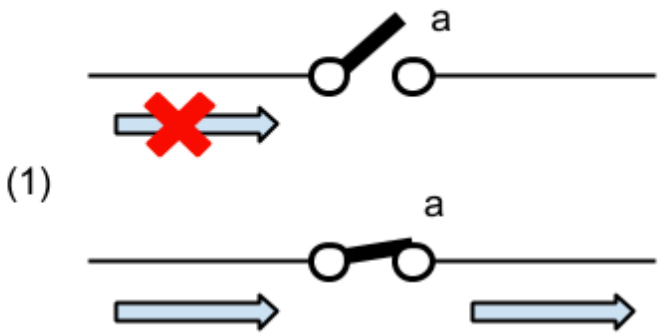

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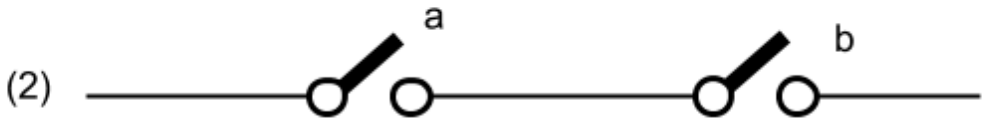

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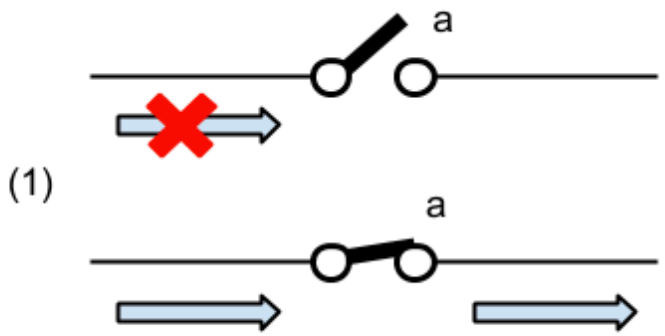

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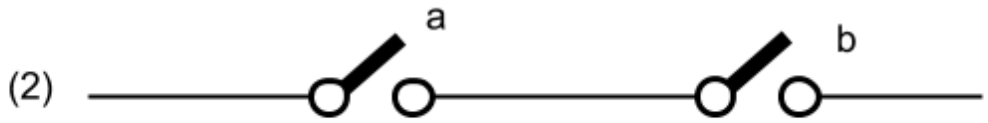

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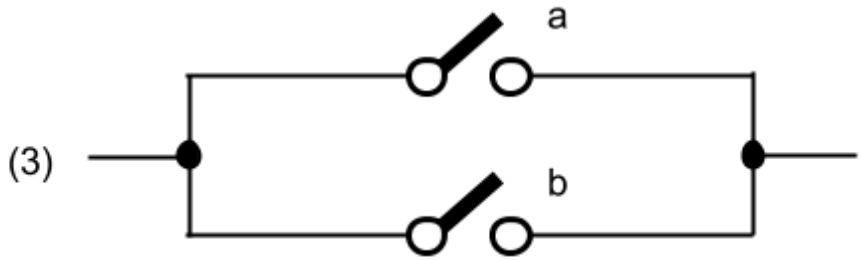

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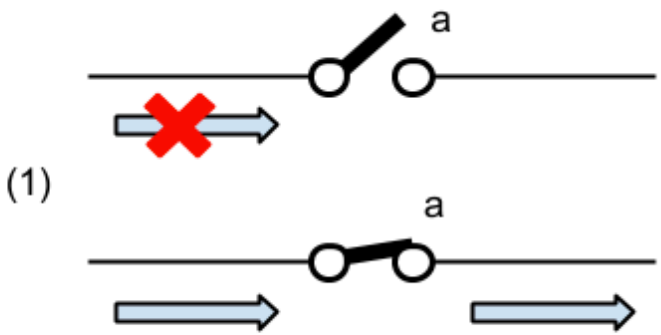

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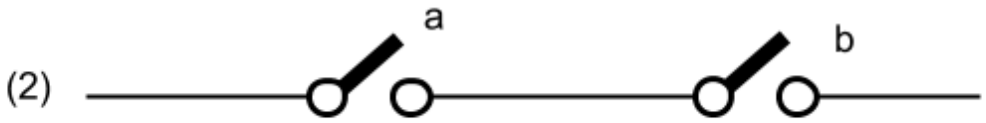

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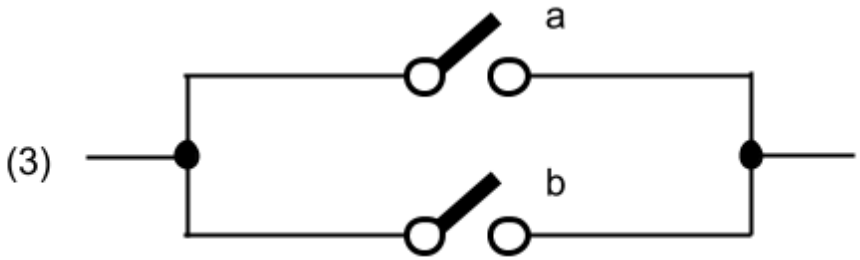


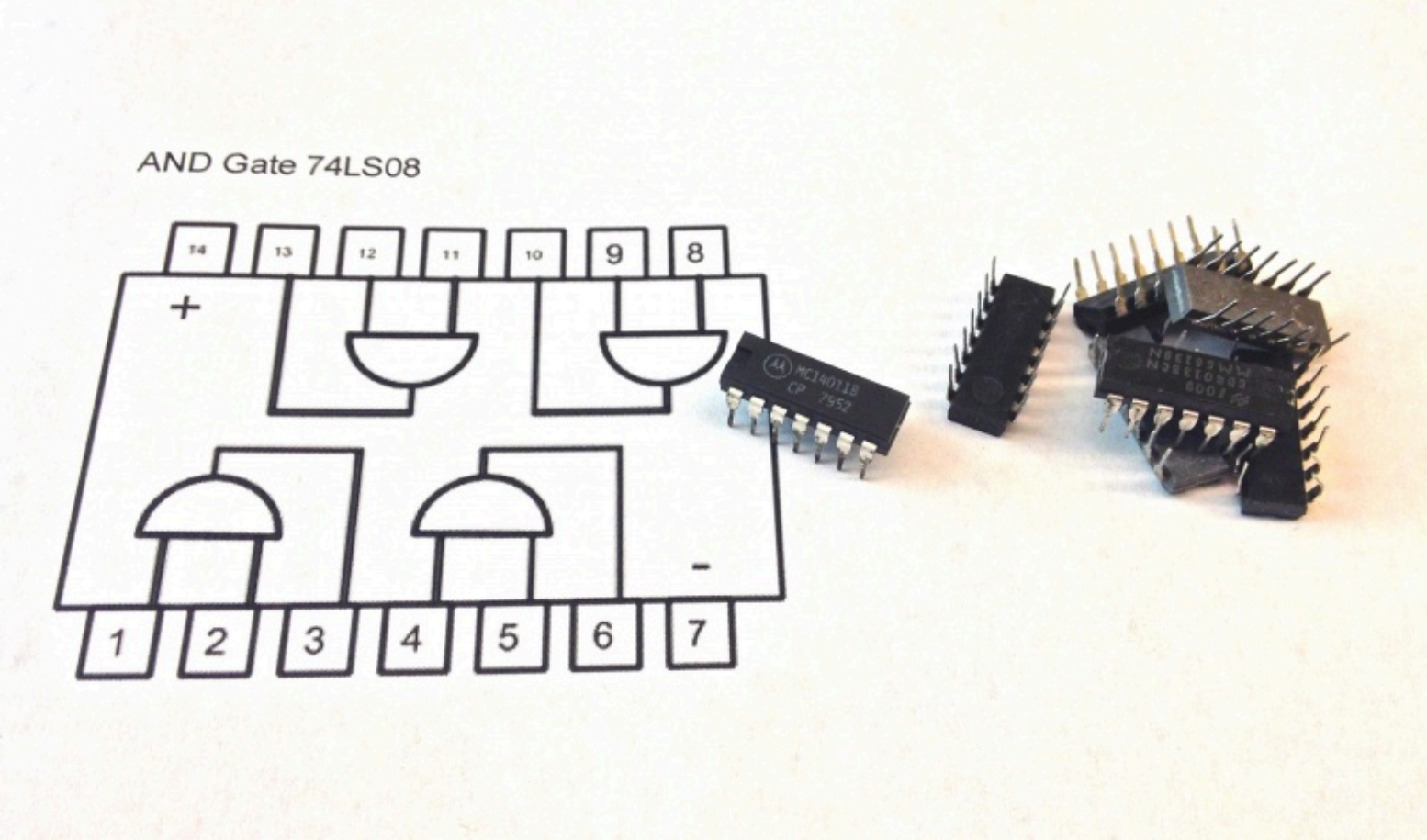
OR

Image Credit: Dominique Thiebaut

Transistors

- These switches form a model for **transistors**
- Transistors are the building blocks of **integrated circuits (ICs)**
- Integrated circuits can have billions of transistors in the size of a dime!
- Transistors can also have other functions, such as amplification
- Use **semiconductor** material

Integrated Circuit



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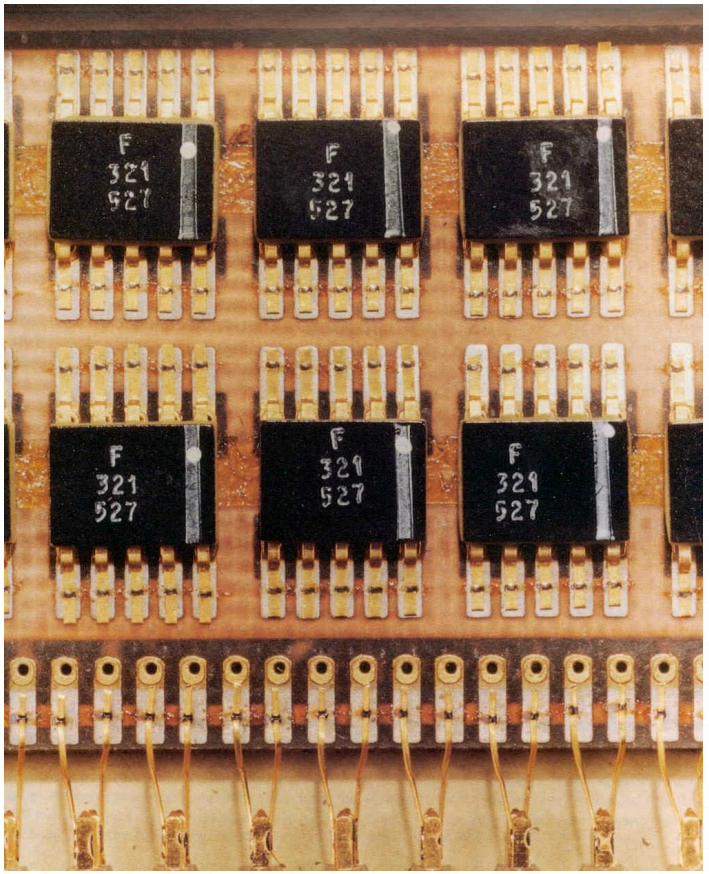
Apollo guidance computer

- Developed for the Apollo program in the 1960s
- First computer to use integrated circuits
- 4,100 ICs, each with a single NOR gate



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