How a Computer Works

What is it? What is it good for?

- Definition of "computer" prior to 1940s?
- *Mind tool*, *or intelligence amplifier*
- A *concept manipulator*

What does it do?

- Accepts inputs
- Manipulates them (transforms them)
- Produces outputs


DATA
IN
COMPUTER
Transformation
INFO
OUT

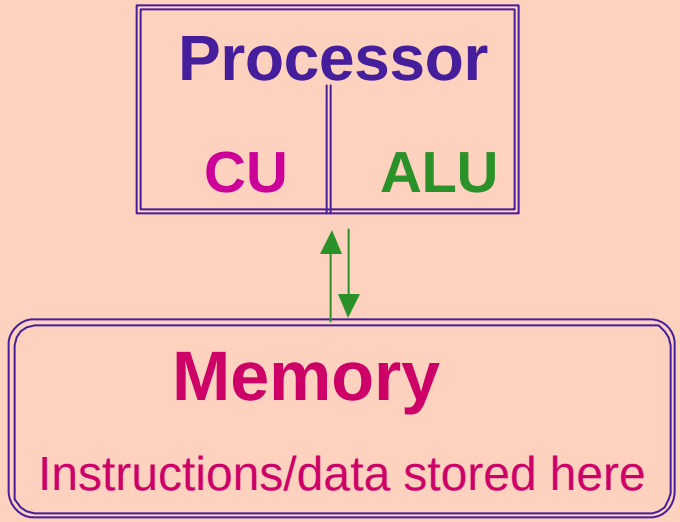
- So, what distinguishes the computer from other machines or tools?
- With computers, what *else* is needed to do the transformation, then?
  - How is that *different* from other machines/tools??
- In that case,what would be another good descriptor?
- Example of *special-purpose* computer?

How?

A computer system

- HARDWARE: physical components
  - Input (such as?)
  - Processing: CPU (microprocessor chip)
  - Storage (two kinds; physically, radically different)
  - Output (examples?)
- SOFTWARE:
  - *Program (code):*—step-by-step instructions that tell the computer *what to do* and *with what data*. Instructions are *imperative* and are carried out one after another.

- CPU
  - Control and manipulation of data occur here.
  - Simple minded!



Two parts:

1. Control unit
   - FETCHES INSTRUCTION
   - DECODES INSTRUCTION
   - Tells the Arithmetic & logic unit *what* to do.

2. Arithmetic & logic unit
   - Adds, subtracts, multiplies, divides, and tests things (compares).

- **MEMORY**: a place to hold data/information and instructions.

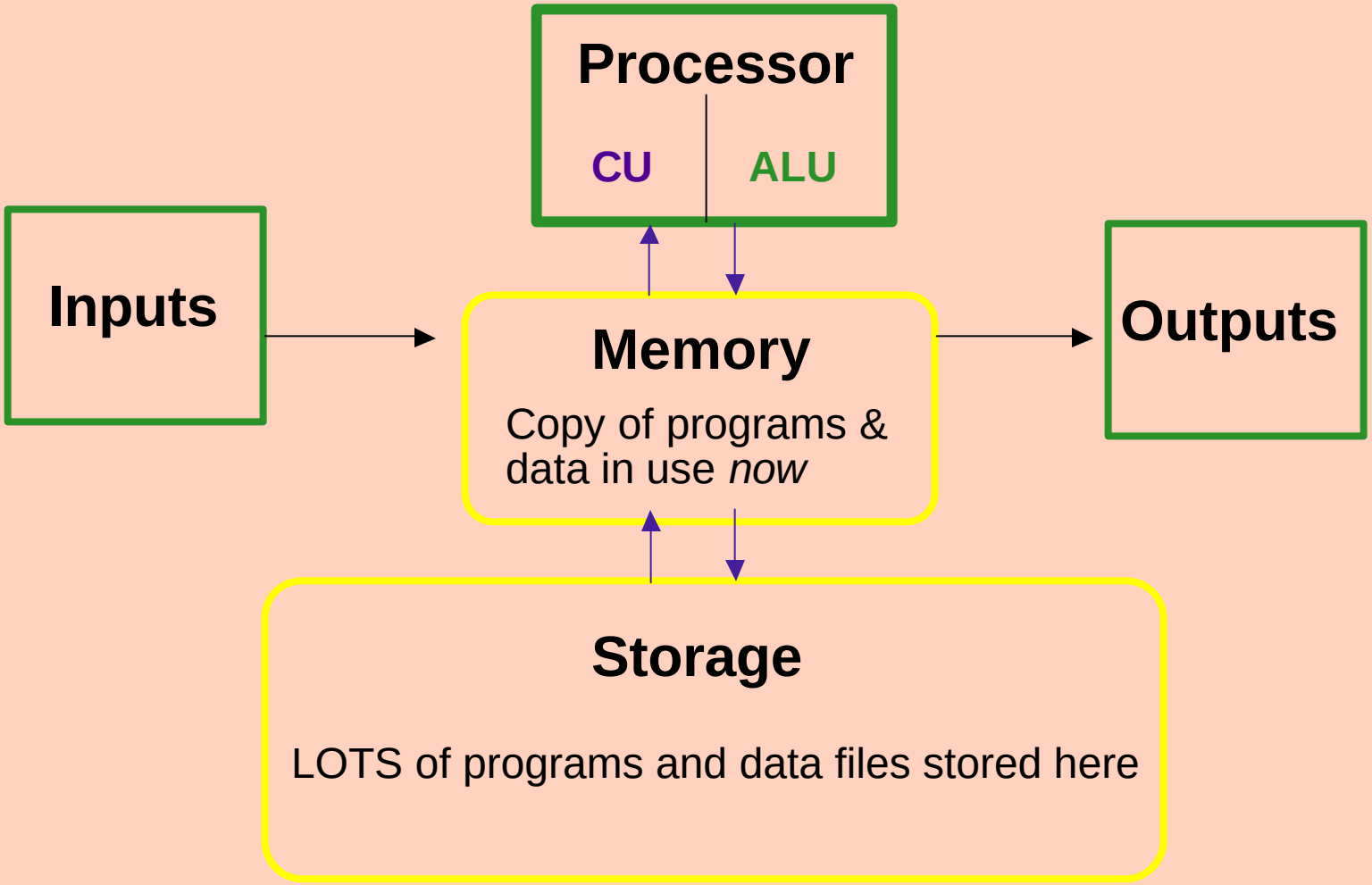
  "Two-level storage"

  – Primary memory
    - RAM: "User" memory. Temporary. Volatile.
    - Fully electronic (data stored as electrical charges—no moving parts). FAST!

  – Secondary memory (Auxiliary)
    - Permanent, long-term, plentiful, cheaper.
    - Examples?
    - Access: at least 10,000 times slower than primary memory. Why?

  – Why do we need secondary?

Logical organization



Data/information representation

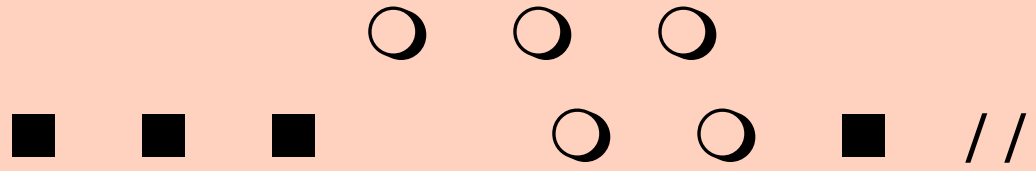
- How humans communicate with each other…
- What are the five kinds of "information"?
- We want to use a ***single*** way to represent *all* these forms of communication:
  - Because we want to use an ***electronic*** computer to manipulate them all.
  - The most basic component: the SWITCH ...
  - Therefore, to use switches to represent our many forms of communicating, we first need to *encode* those forms.

- *Data* & *instructions* can be encoded as **numbers**, which are associated with ***parts*** of an electronic machine (switches) and their *state* at a given moment.

- What kind of basic switch do we use every day?
  - how many states/conditions does it have?
  - Why use such a simple switch?
- First: representing *decimal numbers*

Something about numbering systems:

- Additive: / / / / / / / / / / / / (twelve)



- Positional: 12 (ten plus two)
  - "Face" value
  - "Place" value—depends upon the **base**
  - **Base** determines *number* of unique symbols used
- Decimal system (base ten): Arabic nos. 0–9

ten^5	ten^4	ten^3	ten^2	ten^1	ten^0
100,000	10,000	1,000	100	10	1 (place value)
		3	2	4	6

- All positional numbering systems work alike.

0 thru 9

  - **Decimal**: Decimal digits

Base 10

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0 and 1

  - **Binary**: **BI**nary digit**S** called "Bits"

Base 2

⇦ 2^6	2^5	2^4	2^3	2^2	2^1	2^0	
⇦ 64	32	16	8	4	2	1	(place value)
						0	
						1	
					1	0	
					1	1	
				1	0	0	
				1	0	1	
				1	1	0	
				1	1	1	
			1	0	0	0	
			1	0	0	1	
			1	0	1	0	

- Making sense?
  - How do you represent decimal value 37 in *binary* code?
  - What about decimal value 63?

- Just for culture; try these on your own...
  - What is the decimal number value of each of these?

```
   1111
  10111
1000110
```

- Recap: *Decimal* numbers can be represented & stored ***logically*** in *binary* form as bits, and ***physically*** with switches.
  - Numbers are associated w/machine parts and what *condition* each part is in at that moment:

    1 0 0 1

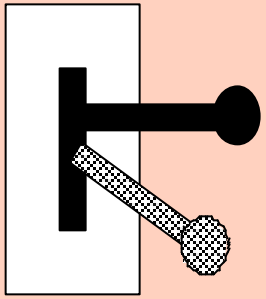
    On Off Off On
  - Binary system: Allows computer to represent *decimal* values as a collection of on/off signals.

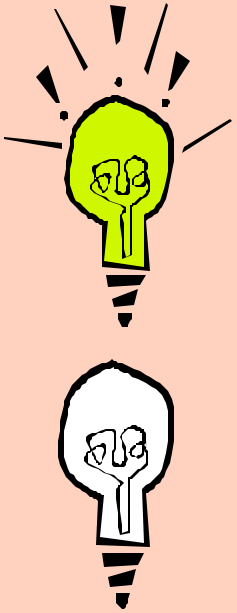
- Logical structure, then:
  - Binary **0**s and **1**s: **Bi**nary digi**ts**. **Bits.**
  - **Bit**: smallest, most basic *data unit* in a computer.
- So how do we represent a bit "in the box"?

1

0

=





8	4	2	1 (place values)	
0	0	0	0	=
0	0	0	1	=
0	0	1	0	=
0	0	1	1	=
0	1	0	0	=

Etc..

- What about representing numbers used only as ***text***; and ***letters*** and ***symbols***?
  - Binary **codes**: unique *bit patterns* of 1s and 0s
  - 2 switches (two-bit code) can represent four different things:

- **OFF OFF** **OFF ON** **ON OFF** **ON ON**

0 0 **0 1** **1 0** **1 1**

Just for Culture:

- 4 switches (four-bit code): enough *different* combinations to represent 16 things.
  - Four switches, two possible conditions each: 2^4
  - Enough to represent all decimal digits (used as **text**).

– Eight-bit code (8 switches): 256 unique things

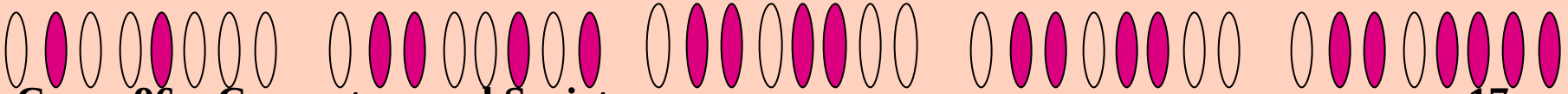
– Schemes: ASCII; EBCDIC; Unicode ...

8-bit ASCII sample

0	0101 0000
1	0101 0001
2	0101 0010
A	0100 0001
B	0100 0010
C	0100 0011

Hello

01001000 01100101 01101100 01101100 01101111



- Representing Pictures (RH-X) *(just for culture)*
- Representing Sounds (RH-X) *(just for culture)*
- Representing Instructions (RH-X) *(more shortly)*

"*Symbol-processing* machine"

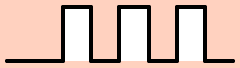
Units of storage:

Single binary digit	bit
7 or 8 bits:	byte (one character)
1 kilobyte (KB):	about 1000 bytes (2^{10})
1 megabyte (MB):	about a million bytes (2^{20})
1 gigabyte (GB):	about a billion bytes (2^{30})
1 terabyte (TB):	about a trillion bytes (2^{40})

Analog and digital

- Most everything around us: *continuously varying* intensities or values.
  - ANALOG: quality reduction w/reproduction.

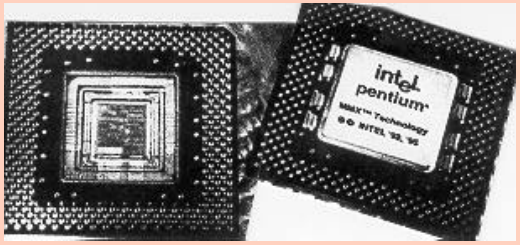
- Everything represented in the computer is stored as *discrete*, "countable" units. What are the units *called* (logical form)? Physical form?
  - DIGITAL: copy is exactly like original.



Word Game (RH-X)

- Who/what was the ***processor*** in this game?
- What was the ***basic instruction set*** used for?
- How did you know *what* to do in *what order*?

- How are *instructions* different from *data?*
- What was the output?
- What served as the input (raw data)?



Silicon-based unit

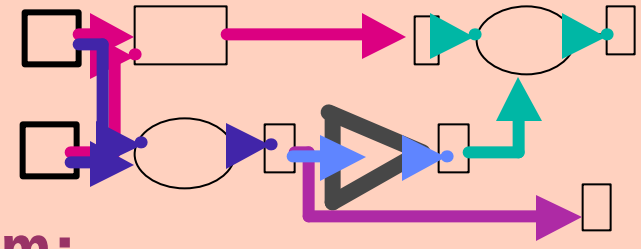
CPU (*obeys orders to transform raw data into meaningful info.*)

Basic instruction set:

Primitive commands (log'l) **it** *can* do with

STO; ADD; SUB; MUL; DIV; INC; CMP; JMP…

hardwired computer circuits (phy'l).



Program:

Tells CPU *which* to do in *what* order.

Carbon-based unit

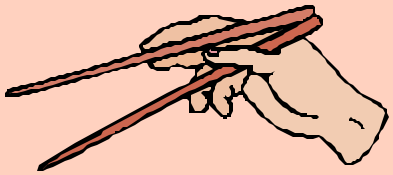
You (*obey orders to transform pages of words into meaningful message.)*

Basic instruction set:

Simple commands **you** *can* do with

GOTO #; SELECT LINE #, FORWARD #; BACKUP #; ;…

Hardwired skills; hands; eyes…



Program:

Tells you *which* to do in *what* order.