Computer Programming (NCSV101) [Winter 2025-26]

Slides 1.1

Introduction to Computing

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You know this device well…

What does it do?

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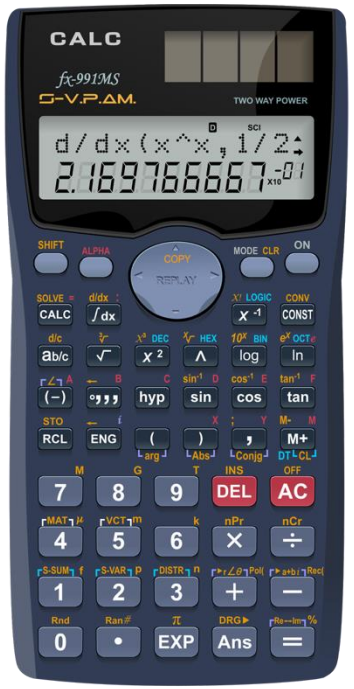
What does it do?

Computations – Addition, Subtraction, Multiplication, Division… and maybe a few more !!

You will use this one soon as well !!



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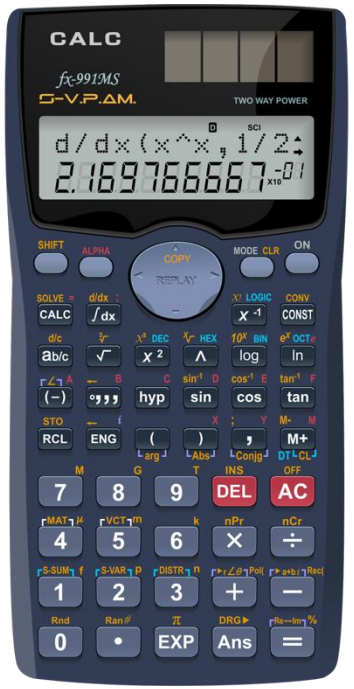

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Just that it can do way more than just basic arithmetic

… and what about these?

They can actually do far more than just simple computations

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They can actually do far more than just simple computations

You can use them for performing “higher level” tasks – which are closer to human lifestyle

How do these devices do what they do?

Calculator

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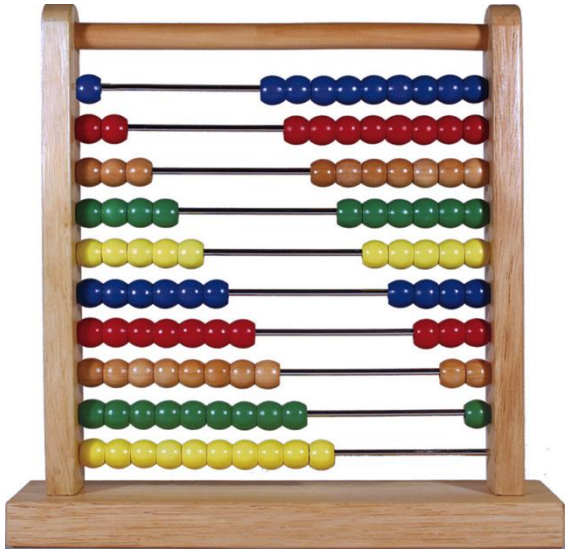

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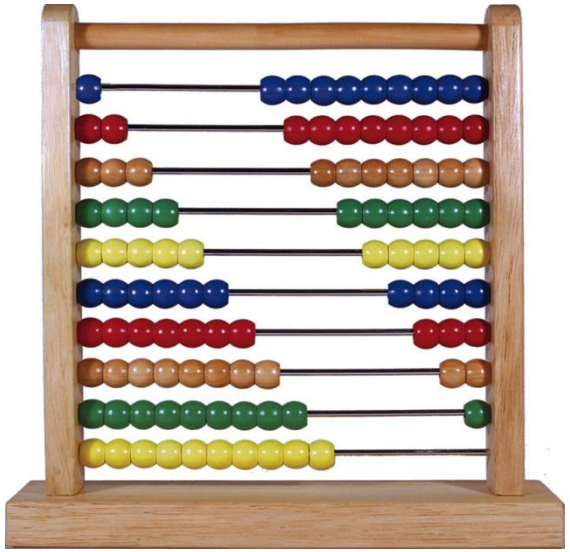

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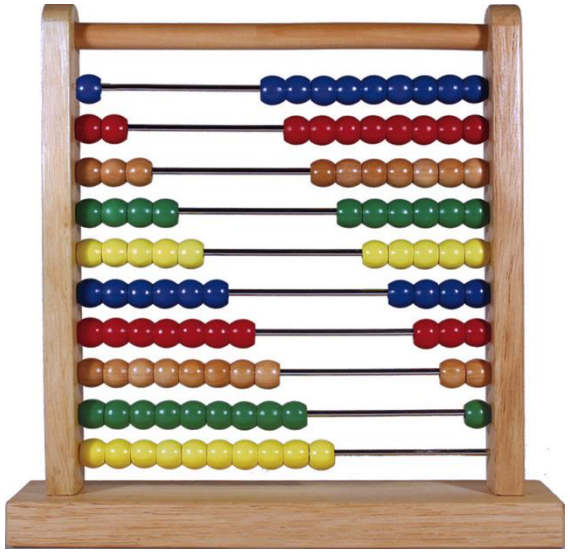

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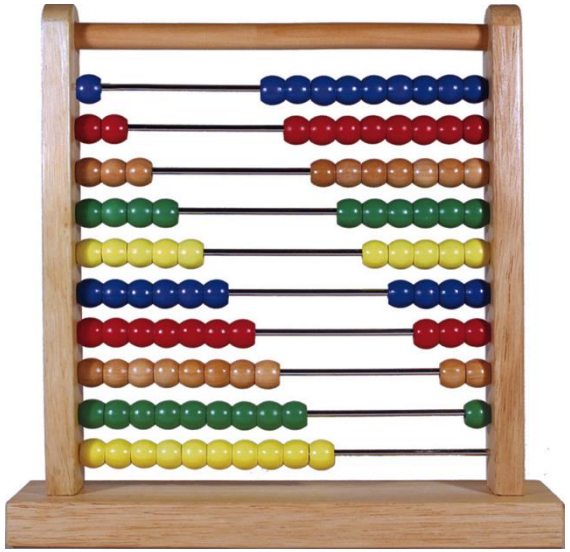

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We then started adding *digits in corresponding* positions, and learnt the concept of a *carry-over* to the next position

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But why base 2? Why can't they work with base 10?

- It is because electronic circuits are mostly made up of *transistors*
- A transistor can either be *on* or *off*; based on its state, we can do a number of tasks !!
- Since the Binary System only has two digits – *0* and *1* – it is natural to use that for all computing devices

Logical Operations

Using the transistors, we can perform arithmetic and “logical” operations

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  - The OR function has a value 0, if and only if, all variables have the value 0
  - Otherwise, the function has a value 1
- The *NOT* function is defined over one Boolean variable as
  - The NOT function has a value 1, if the variable has the value 0
  - Otherwise, the function has a value 0 (i.e., when the variable has the value 1)

The “Central Processing Unit”

At the heart of any sophisticated computing device, is an **Arithmetic-Logic Unit** or **ALU**

It performs the arithmetic and logical operations which are the basis of all complex computations

Computers also have another unit which can be considered as the *boss* of ALU :-P

- It controls the use of ALU, i.e., which Arithmetic and Logic operation is performed at what time
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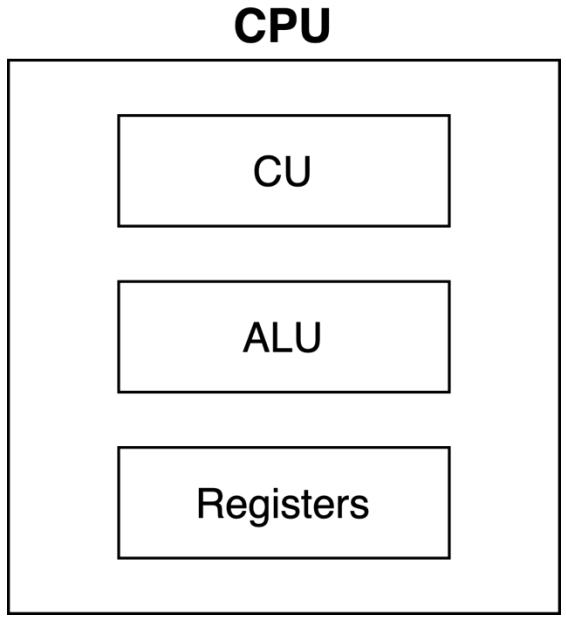
To store intermediate state of variables of a complex computation, some “memory” is also needed

- Known as **Registers**, these elements are capable of holding on to some 0s and 1s, till we keep them powered
- Each 0 or 1 is called a *bit* and a set of eight 0s or 1s is called a *byte*

The ALU, CU and the Registers, together constitute the brain of a computer

- We call this brain the **Central Processing Unit** or **CPU**

The block diagram of a CPU



Just what we discussed !!

von Neumann Architecture

We can now try to imagine the block diagram of a basic computer

It will certainly have a CPU

You will need a way to send some “inputs” to the CPU – telling it what computations to do

The CPU must “output” the results of the computation somewhere on completion

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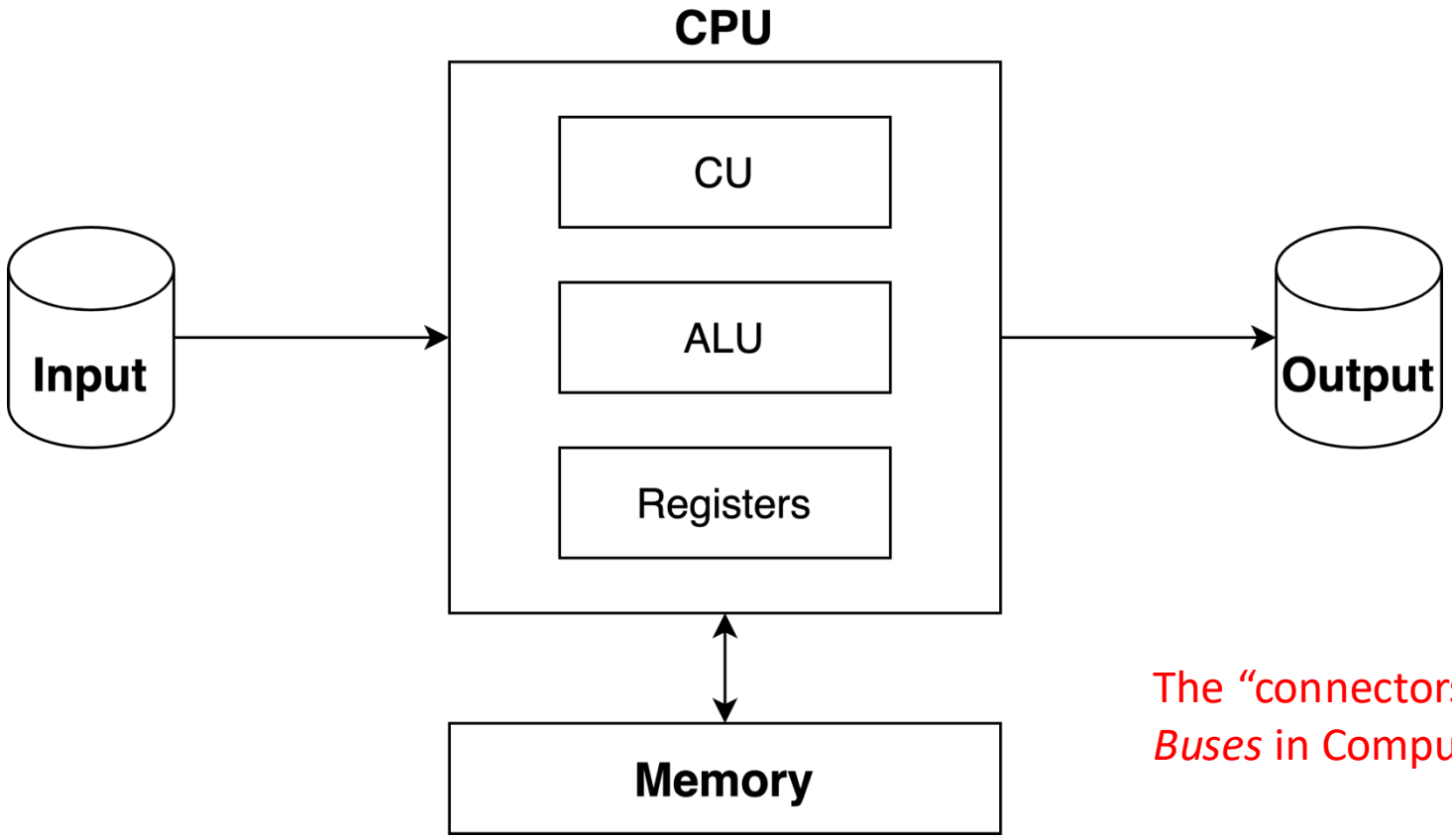

The “connectors” here are also called *Buses* in Computer Science terminology

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- It is named after the scientist who first proposed it in 1945 – John von Neumann
- While the modern computers are not based on this, it was very close to the initial computers

Stored-program Computer

Imagine a computer that is built over the von Neuman Architecture

What this computer does is something like this

- It uses the Memory unit to “store some instructions” – essentially a sequence of computations
- It uses the same Memory to “contain some data” – essentially the data or operands for computations
- The Control Unit interprets the instructions stored in the memory
- Based on the type of computation, it fetches the expected data from the memory as well
- It instructs the ALU to perform the computations, and stores the results back in the Memory

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- This type of a computer, is known as the *Stored-program Computer*

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While we have evolved to more complex computers, the core principles of computing are the same, i.e., there is a Memory where data and instructions reside, and the CPU executes them in a particular order

Homework !! (life is cruel, you know :-P)

Read about the criticism of von Neumann Architecture

- To be precise, read about von Neumann bottleneck
- Start here:
  https://en.wikipedia.org/wiki/Von_Neumann_architecture#Von_Neumann_bottleneck

The definition of Stored-program Computer is somewhat a grey area

- This is why we did not discuss a proper definition of the term
- The Wikipedia page for Stored-program Computer talks about some *Universal Turing Machine*
- You'll formally study about Turing Machines in a course on Theory of Computation
- However, it is not a bad idea to try and understand the concept (it is fine even if you don't get much)
  The relevant Wikipedia pages are:
  https://en.wikipedia.org/wiki/Stored-program_computer
  https://en.wikipedia.org/wiki/Universal_Turing_machine