

# Unit 1. Basic Notions

- 1.1 Computer Science and Engineering
- 1.2 Basic Concepts
- 1.3 Information representation
- 1.4 Programming Languages

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# Objectives

- Understand which the basic components of a computer are,
- Understand how the data is stored,
- Understand what a programming language is

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# Computer Science and Engineering

## Definitions:

- Computer science, or computing science, is:
  - the study of the theoretical foundations of information and computation, and
  - their implementation and application in computer systems.

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# Basic concepts: Computer Architecture



Application Software



Operating Systems

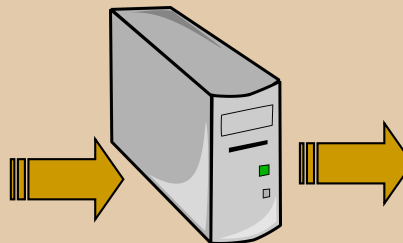


Hardware

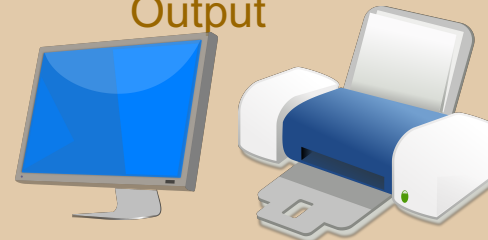
Input



Process



Output



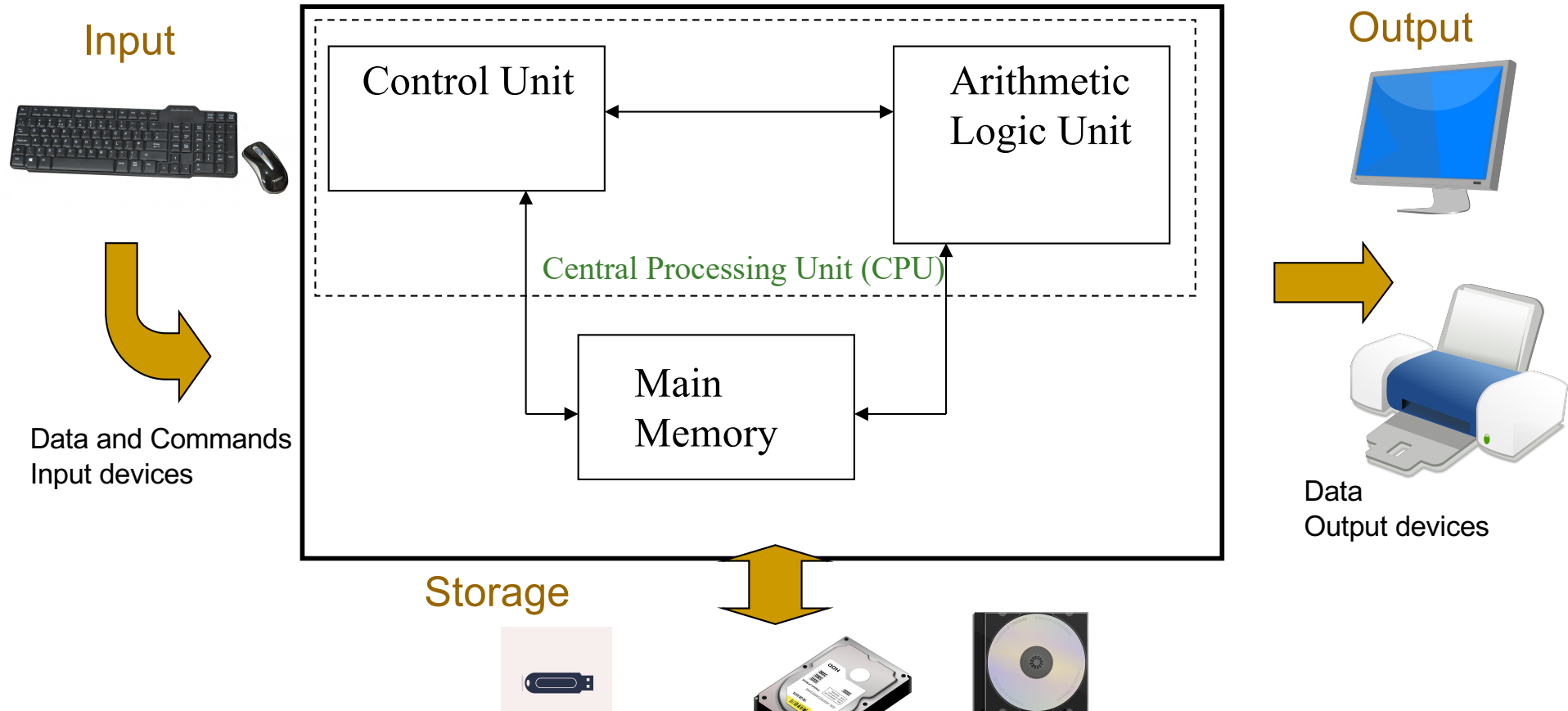
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# Basic Concepts: Computing



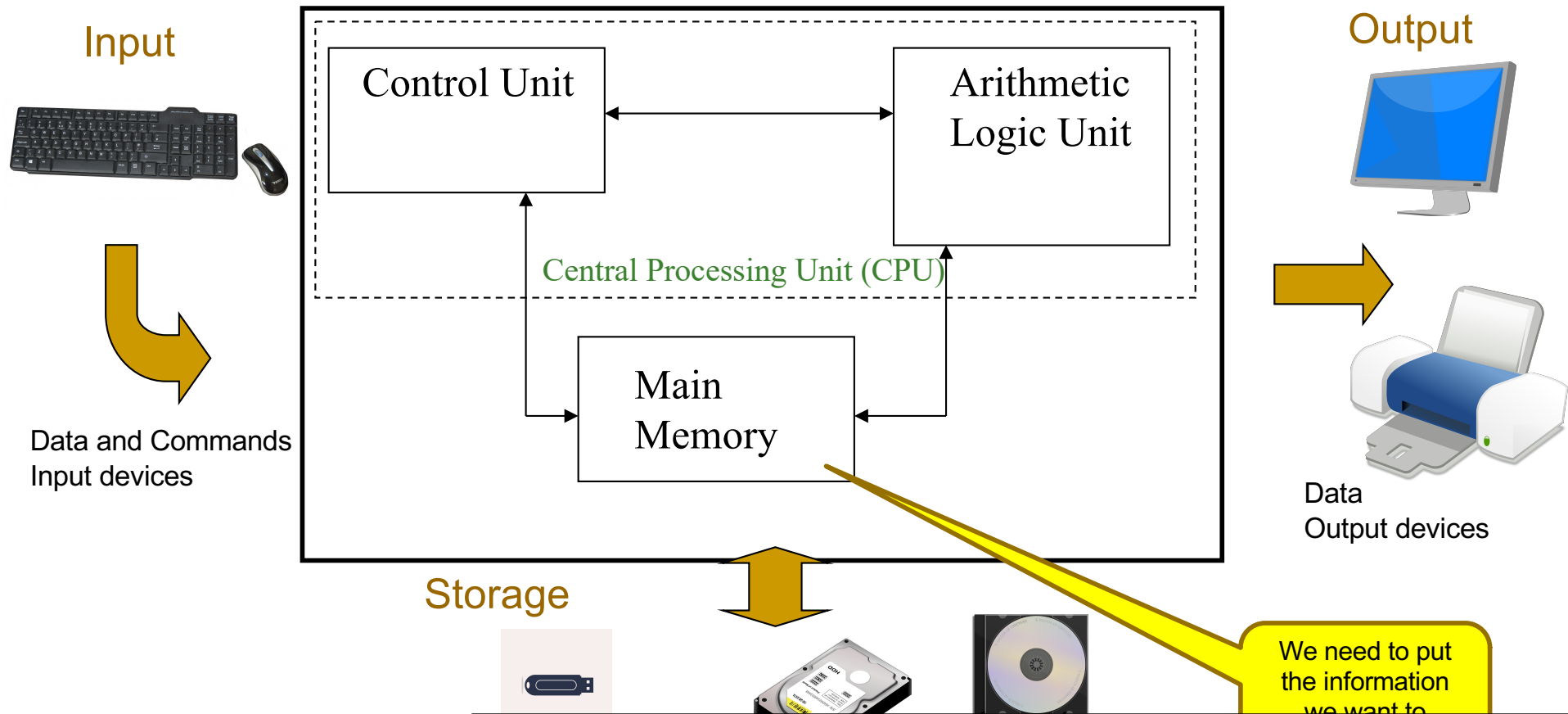
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# Basic Concepts: Computing



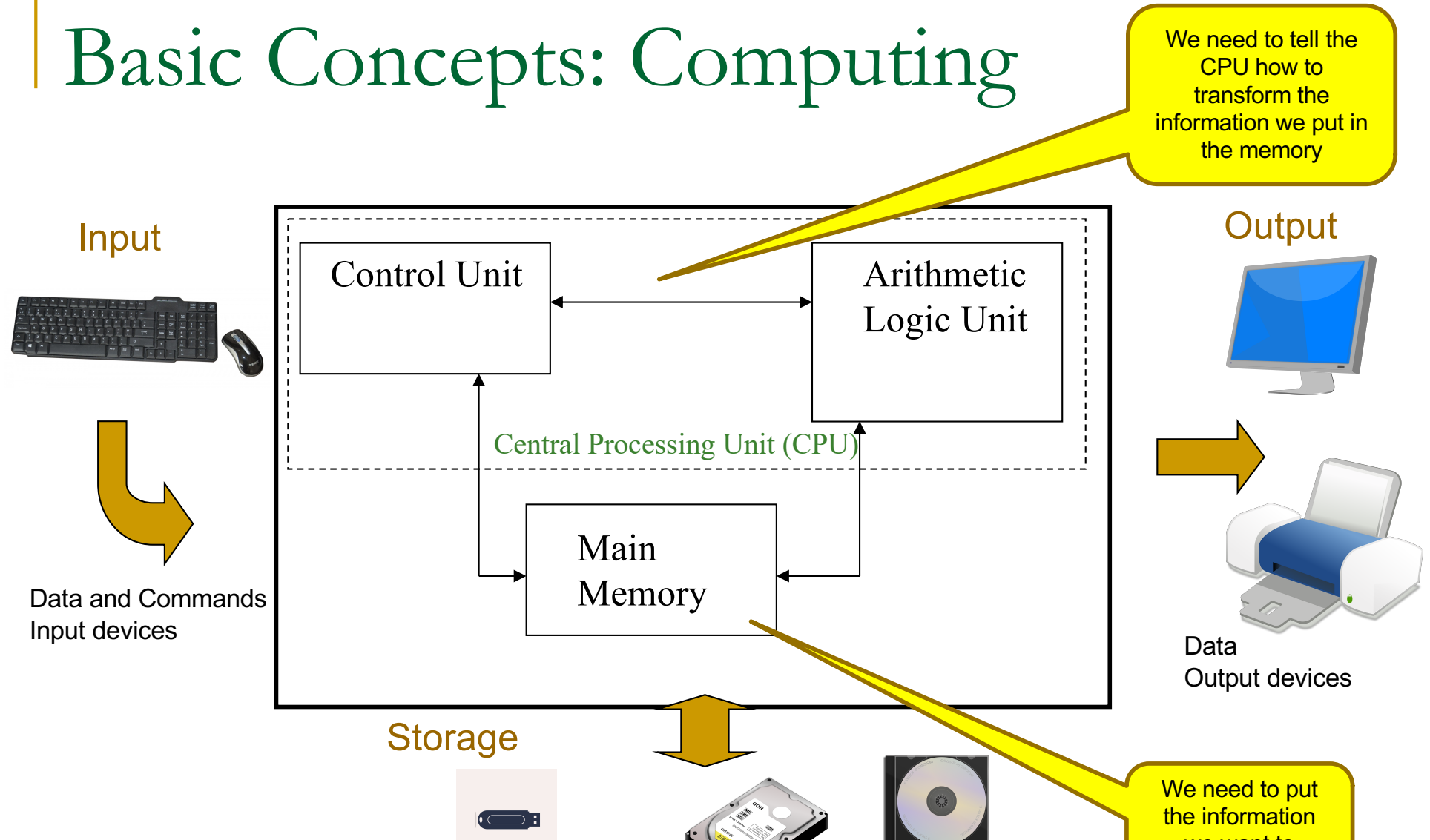
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# Basic Concepts: Computing



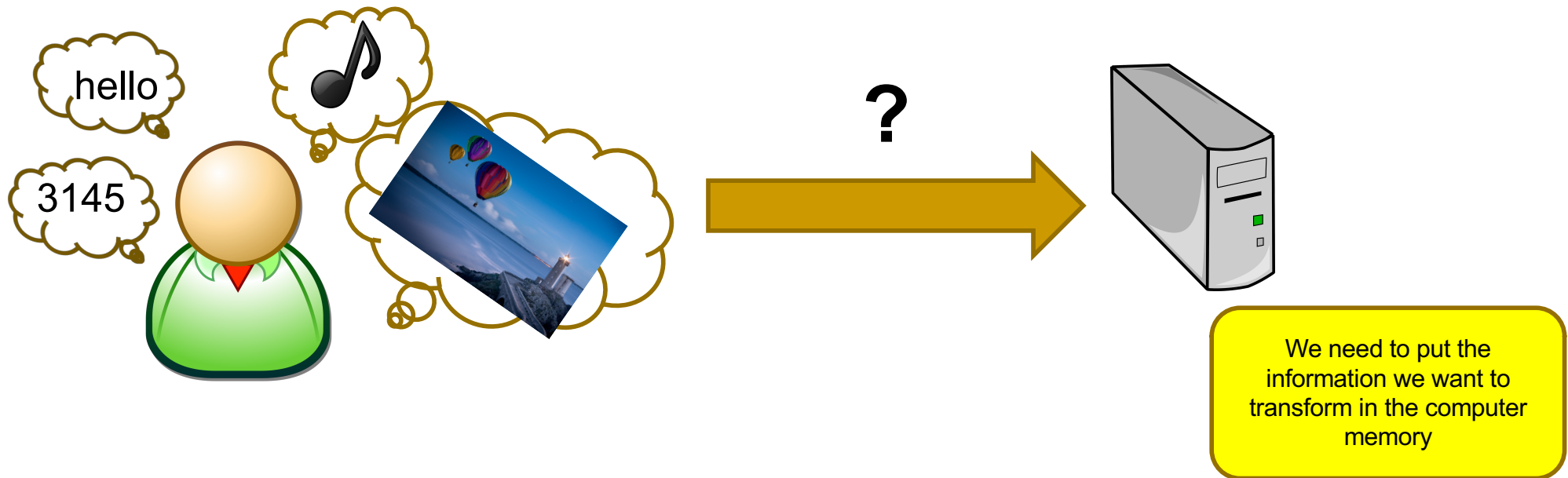
We need to tell the CPU how to transform the information we put in the memory

We need to put the information we want to

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# Basic Concepts: Information Representation



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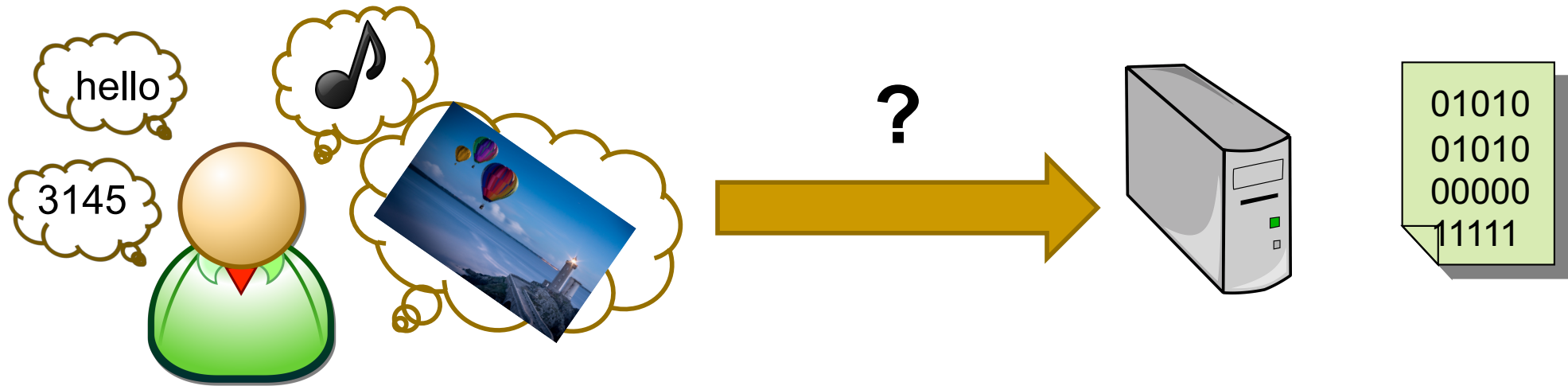
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# Basic Concepts: Information Representation



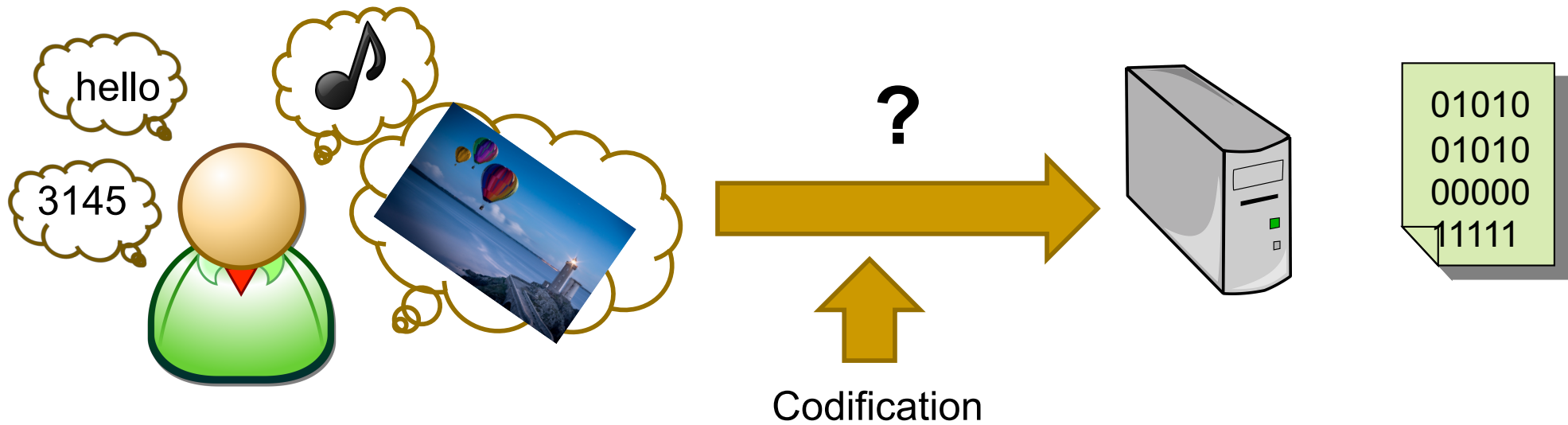
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# Basic Concepts: Information Representation



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# Information Representation

- Information and data managed by a computer are:
  - Elementary units: bit (Binary digIT)
  - Two possible states
  - Are represented by 0 and 1
- Bits can be used to represent characters, numbers, commands, code, colors, ...
- 8 bits = 1 byte (256 different values)
- Kilobyte (Kb): 1000 Bytes.
- Megabyte (Mb): 1000 Kb

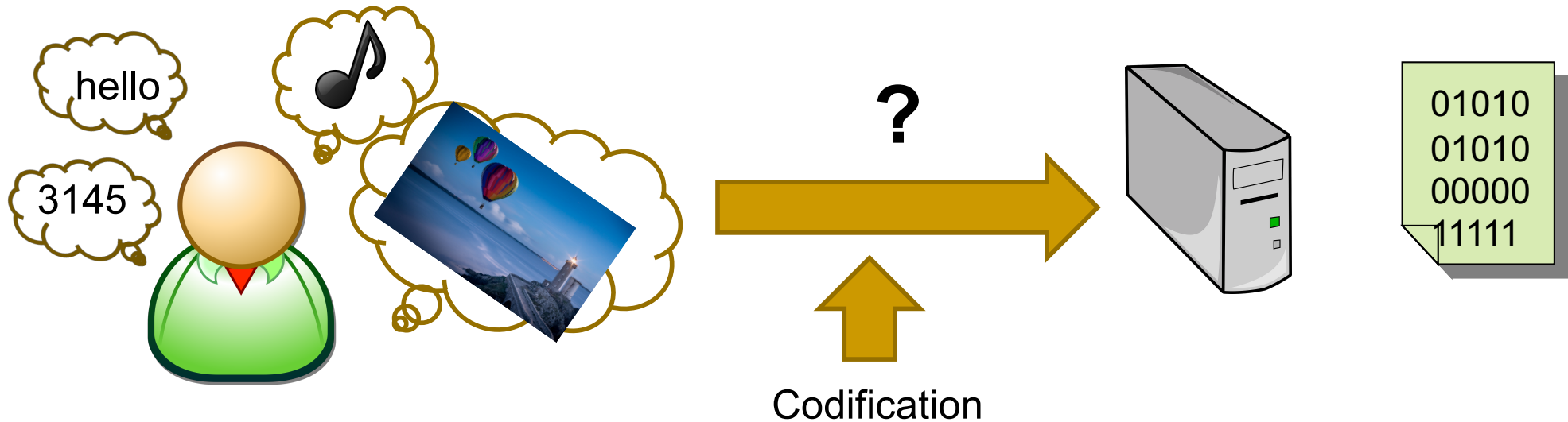
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# Basic Concepts: Information Representation



Numeric Data	Integer, Real
Text	ASCII, Unicode
Sound	Wav, MIDI, Mp3

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# Information Representation

## ■ Representing numbers:

- ❑ *Decimal numeral system*
  - ❑ 10 digits
- ❑ *Binary numeral system*
  - ❑ 2 digits
- ❑ *Hexadecimal numeral system*
  - ❑ 16 digits

There are methods and formulas to directly convert a decimal number into a binary one and viceversa.

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D

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# Information Representation

- Representing **numbers**:

- Positive and negative numbers

- Absolute value and sign

- $011 = 3$        $111 = -3$

*If the first digit is 0 it stands for +,  
if the first digit is 1 it stands for -*

- Real

- Floating

- $-324.8125_{(10)} = 101000100.1101_{(2)}$

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D

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# Information Representation

## ■ Representing characters

- Each character included in the keyboard is represented by binary numbers
  - ASCII
    - extended
    - Fixed coding (1 character = 1 byte)
  - Unicode
    - Unique template for 65.000 characters
    - Language independent
    - Variable coding (1 or 2 bytes)
    - Used on the web very often

ASCII		
Character	Decimal	Binary
A	65	0100 0001
B	66	0100 0010
...		
Z	90	0101 1010
a	97	0110 0001
z	122	0111 1010

Note that the relation between the character and



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# Programming Languages

We need to tell the CPU how to transform the information we put in the memory

- What is Programming?
  - A list of commands (sequence):
    - Executable by the CPU
    - Perform a certain task
  - Phases:
    1. Problem solving => creating an algorithm
    2. Adapting the algorithm to the computer => codify the algorithm by using a language understandable by the computer

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# Programming Languages

## ■ Algorithm Example:

Problem:

Compute the length of a vector.

Input data:

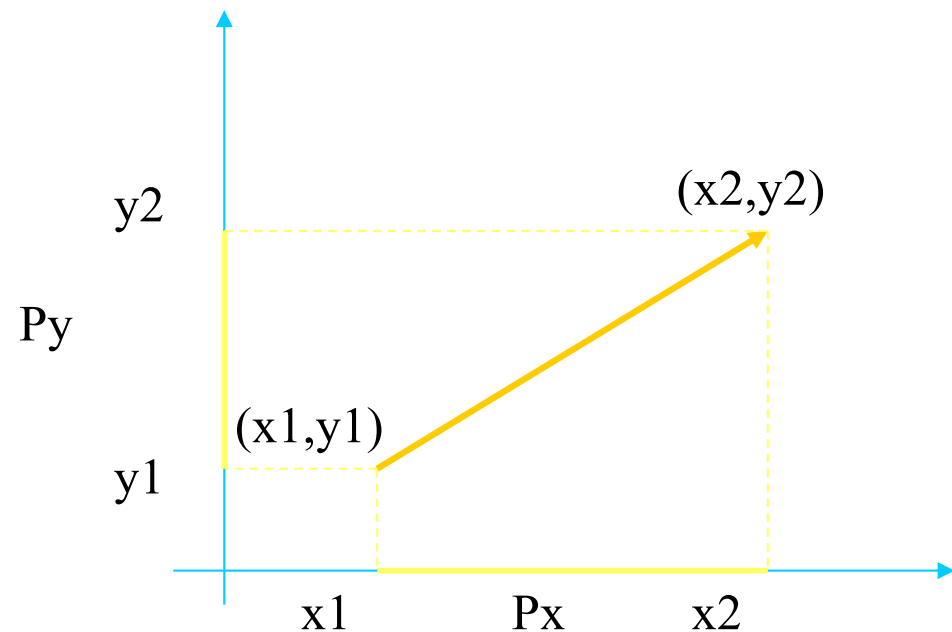
$(x1, y1), (x2, y2)$

Algorithm:

- Read  $x1, y1, x2, y2$
- Compute  $Px = x2 - x1$
- Compute  $Py = y2 - y1$
- Compute  $Px^2 = Px \cdot Px$
- Compute  $Py^2 = Py \cdot Py$
- Compute  $R = \text{sqrt2}(Px^2 + Py^2)$
- Print R

Output data:

R



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# Programming Languages

- **Language:**
  - a set of symbols (characters, number, ...) and rules allowing communication
- **Programming Language:**
  - a set of symbols (characters, number, ...) and rules allowing communication between the developer and the computer.
  - Includes alphabet, syntax and semantics.
- **Algorithm:**
  - an algorithm is a finite list of well-defined instructions for accomplishing some task that, given an initial state, will proceed through a well-defined series of successive states, possibly eventually **terminating** in an end-state; it is not codified in a specific programming language
- **Program:**
  - is a collection of instructions that describes a task, or set of tasks, to be carried out by a computer.

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# Programming Languages

## ■ Levels:

### □ Low level or machine language:

- Binary language interpreted by CU
- Hardware Specific
- Commands include a operation code and operands

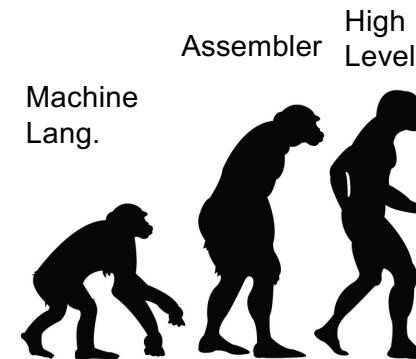
### □ Assembler:

- assembly instruction mnemonics into *operation codes*:

Machine Language	01000	001
Assembler	INC	CX

### □ High level.

- Commands are written in a language closer to the humans (*read, get, while, integer, ...*).
- Architecture independent.
- High level of abstraction. Easy to develop.
- Reduced program size.
- Allow data-types (integers, real, characters, ...)



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# Compiled Languages

- They need special programs (compilers) which translate source code (written in high-level language) and **produce a separated file containing machine code**
  - Compiler:
    - Translate a complete program (source code) into object code (binary)
    - Object code is stored into memory and can be executed directly
    - During the translation task errors can be detected

To execute the program you will need the executable code

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# Interpreted languages

- The source code is also compiled to produce the machine code that the processor can execute but the process to do that is different from compiled languages
- Source code is translated sequentially one statement at a time using a **command interpreter**
  - They do not produce a separate executable file when compiled by the command interpreter
  - To execute the program you will need the source code and the command interpreter
  - Interpreted languages are usually slower as programs need to be compiled each time we want to execute them
  - In other words: **the source code is compiled each time you execute the program**

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# Types of Programming Languages

- Classification based on the **type of compilation**:
  - Compiled Programs: C, C++, Java, Basic
  - Interpreted Programs: MATLAB, Javascript
- Classification based on the **purpose of the language**:
  - General purpose (Basic, Pascal, C)
  - Problem oriented (Fortran, Cobol, Lisp, SQL)
- Classification based on the **programming paradigm**:
  - Imperative programming: Pascal, C, MATLAB
  - Object Oriented Programming: Java, C++
  - Functional programming: Lisp
  - Logic programming: Prolog

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# Bibliography

- Handbook of theoretical computer science (vol. B): formal models and semantics, EA Emerson - 1991 - MIT Press, Cambridge, MA

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