Introduction to Computer Science

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Outline

- Computer Science
- Computer Systems
- Python Programming Language
- Computational Thinking and Problem

What is a computer?

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- A computer is a machine that stores data (**numbers, words, pictures**), interacts with devices (**the monitor screen, the sound system, the printer**), and executes programs.
- A computer program is a sequence of instructions and decisions that the computer carries out to achieve a task.
- Programs describe specific actions.
- A computer executes very simple instructions.
- A computer executes instructions very rapidly.
- A computer is a general purpose machine.
  - Because it is flexible, the computer must be programmed to perform tasks.
  - Different tasks require different programs.

Hardware and Software

- Hardware
  - the physical, tangible parts of a computer
  - keyboard, monitor, disks, wires, chips, etc.
- Software
  - programs and data
  - a *program* is a sequence of instructions
- A computer requires both hardware and software
- Each is essentially **useless** without the other

Schematic Diagram of a Computer

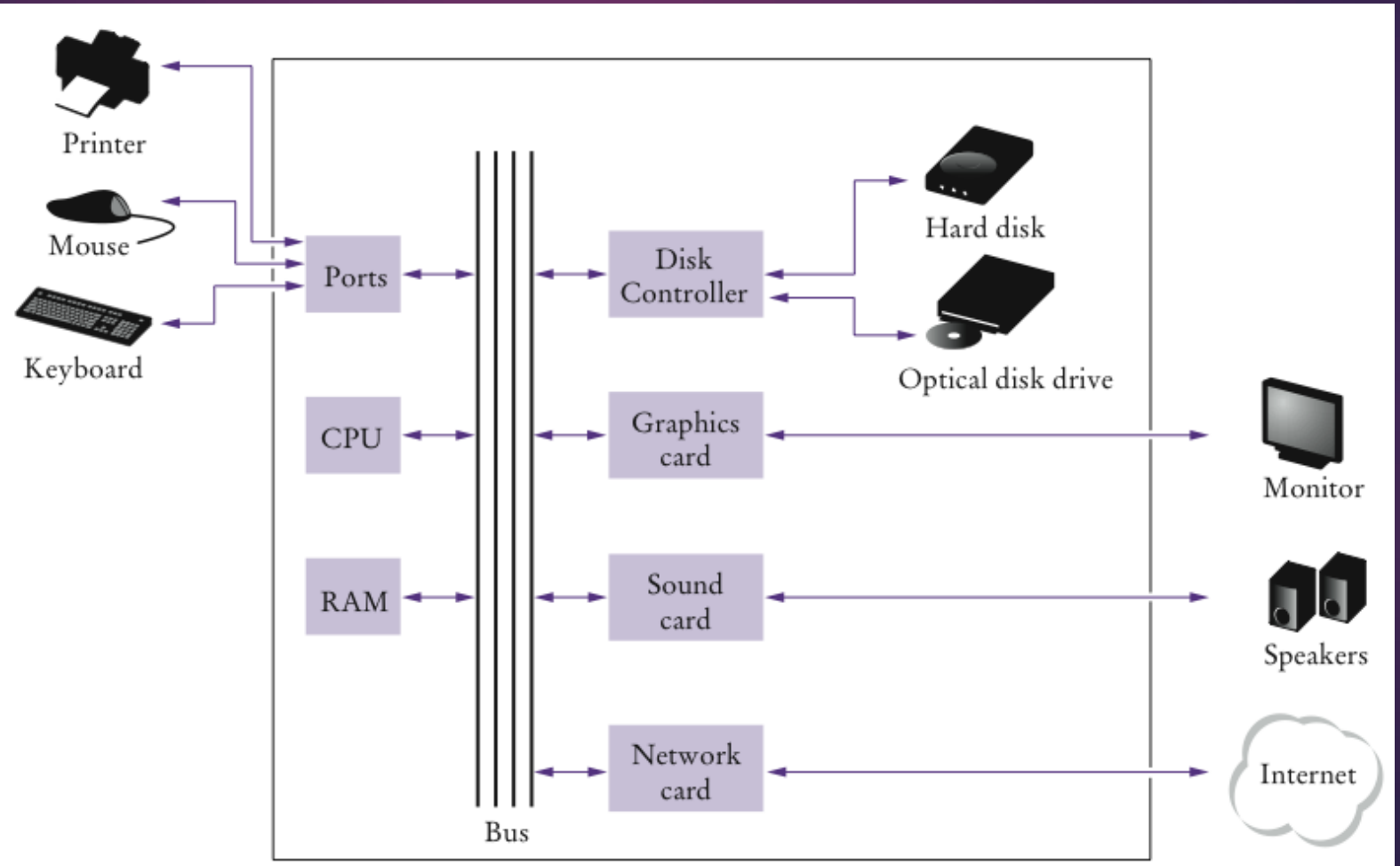


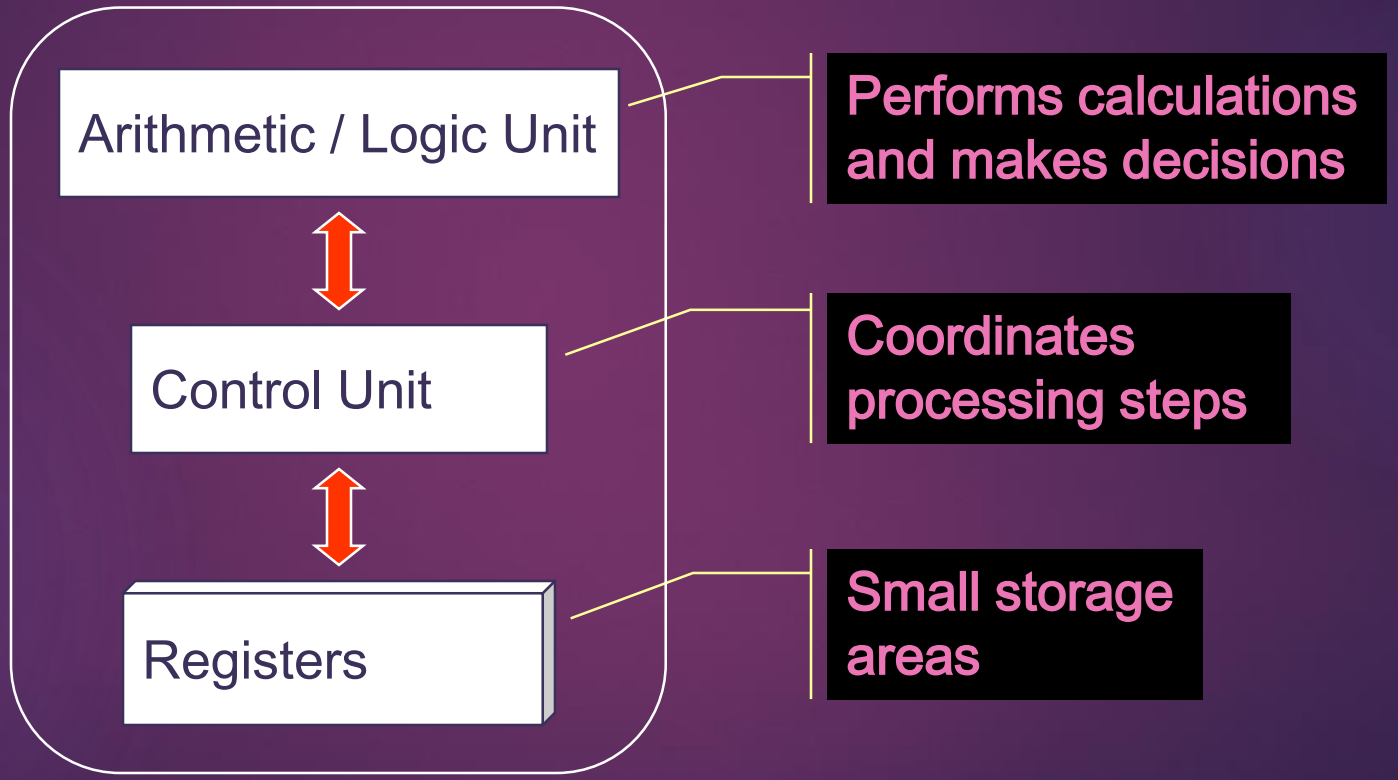
Figure 5 Schematic Diagram of a Computer

Anatomy of a computer

- At the heart of the computer lies the central processing unit (CPU).
- The CPU
  - locates and executes the program instructions;
  - carries out arithmetic operations
  - fetches data from external memory or devices or stores data back.

Anatomy of a computer

- The CPU contains:



Anatomy of a computer

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- The computer keeps data and programs in storage.
- Storage type:
  - primary storage, also called random-access memory (RAM) or simply memory.
  - secondary storage, usually a hard disk.
- Primary storage loses all its data when the power is turned off. Secondary storage persists without electricity.
- Most computers have removable storage devices: floppy disks, tapes, compact discs (CDs), flashdisks.

Anatomy of a computer

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- To interact with a human user, a computer requires peripheral devices.
  - input devices: keyboard, mouse.
  - output devices: display screen, printer.
- The CPU, the RAM, and the electronics controlling the hard disk and other devices are interconnected through a set of electrical lines called a *bus*.

Computer System

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- Five logical units of a computer system
  - Input unit: Mouse, keyboard
  - Output unit: Printer, monitor, audio speakers
  - Primary Storage unit (Memory unit): RAM
  - Central processing unit (CPU)
    - supervises operation of other devices
    - contains Arithmetic and Logic Unit (ALU)
    - ALU performs calculations
  - Secondary storage unit
    - Hard-disk drives, floppy-disk drives, CD drives

Central Processing Unit

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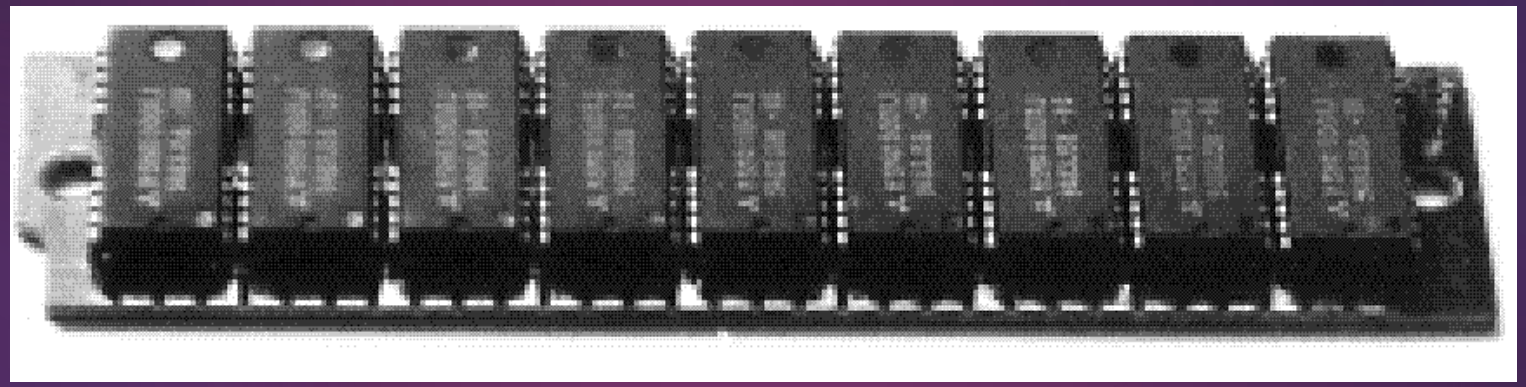
Figure 1
Central Processing Unit

RAM Chips



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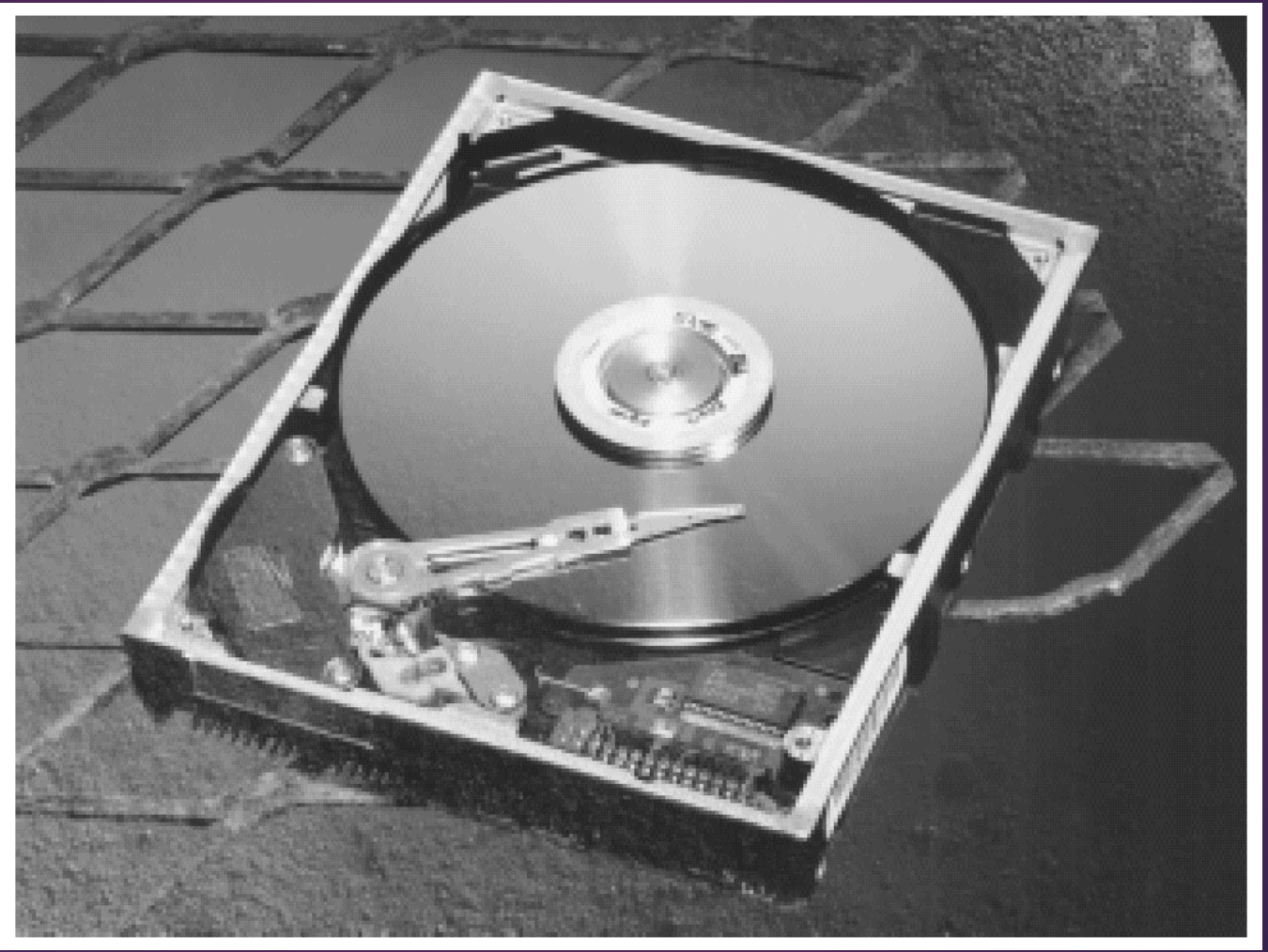
A Hard Disk



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What is computer software?

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- Computer software
  - set of program instructions, including related data and documentation, that can be executed by computer
- The syntax of a language
  - set of characters and the acceptable sequences of those characters.
- The semantics of a language
  - the meaning associated with each syntactically correct sequence of characters.

Syntax and Semantics

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- The *syntax rules*
  - define how we can put together symbols, reserved words, and identifiers to make a valid program
- The *semantics* of a program statement
  - define what that statement means (its purpose or role in a program)
- A program that is syntactically correct is not necessarily logically (semantically) correct
- A program will always do what we tell it to do, not what we meant to tell it to do

Program translation

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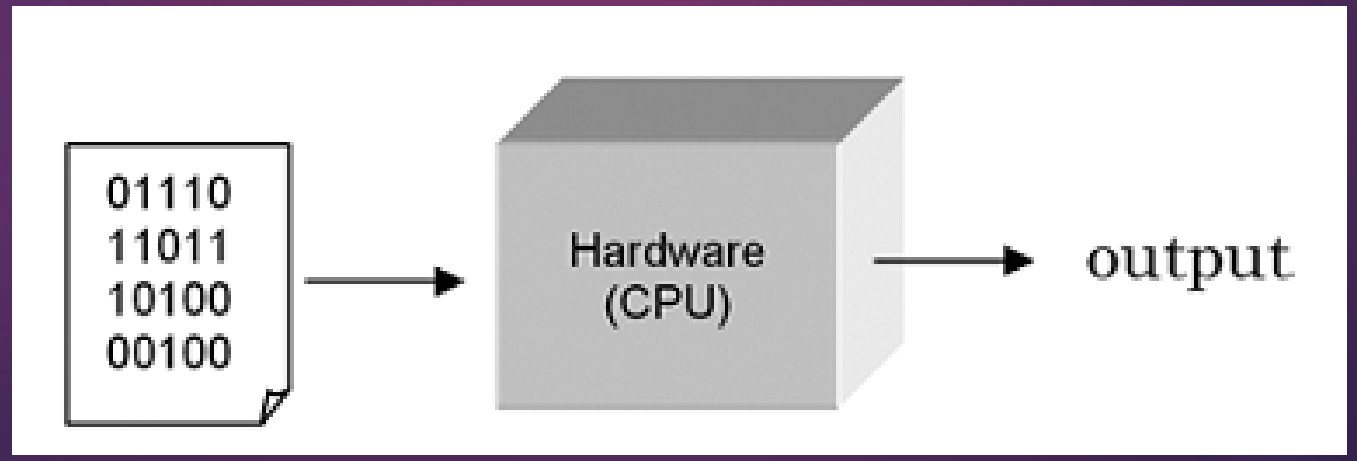
- A central processing unit (CPU)
  - designed to interpret and execute a specific set of instructions represented in binary form (i.e., 1s and 0s) called machine code.
- Only programs in machine code can be executed by a CPU



Program translation

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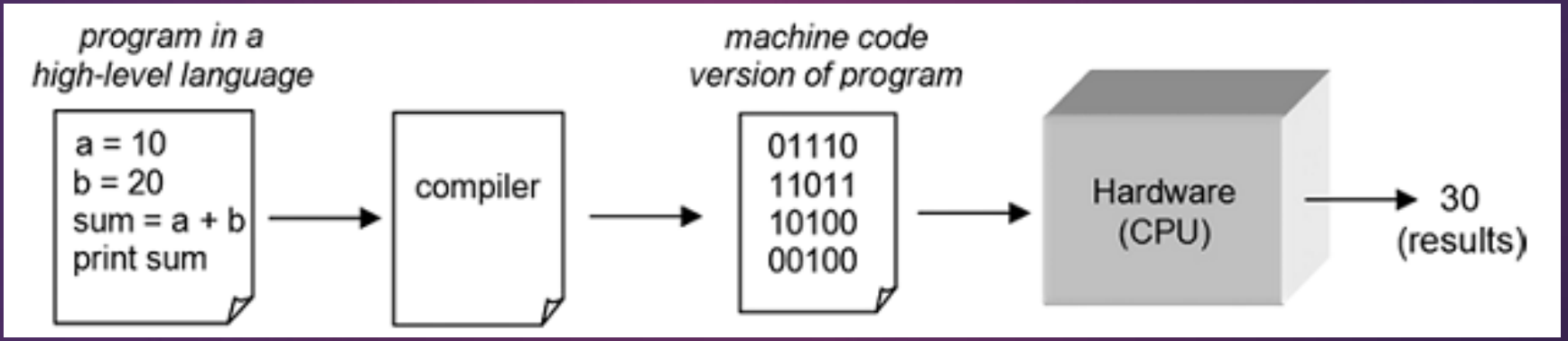
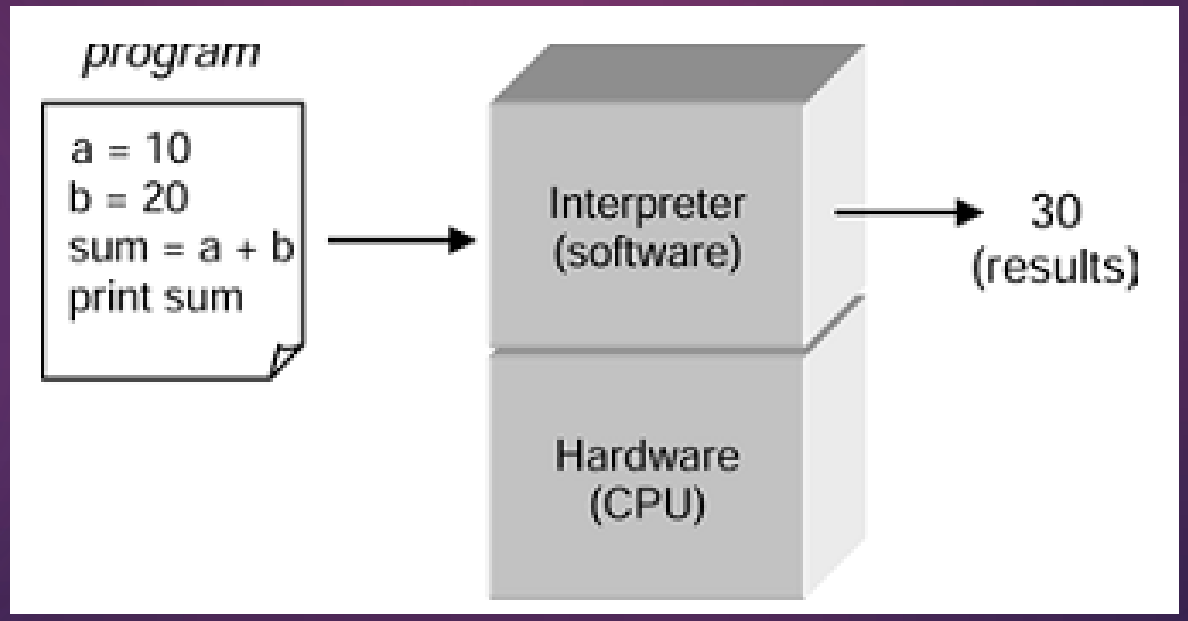
- A compiler is a translator program that translates programs directly into machine code to be executed by the CPU.



Program translation

- An interpreter executes program instructions in place of ("running on top of") the CPU.



What Is Computer Science?

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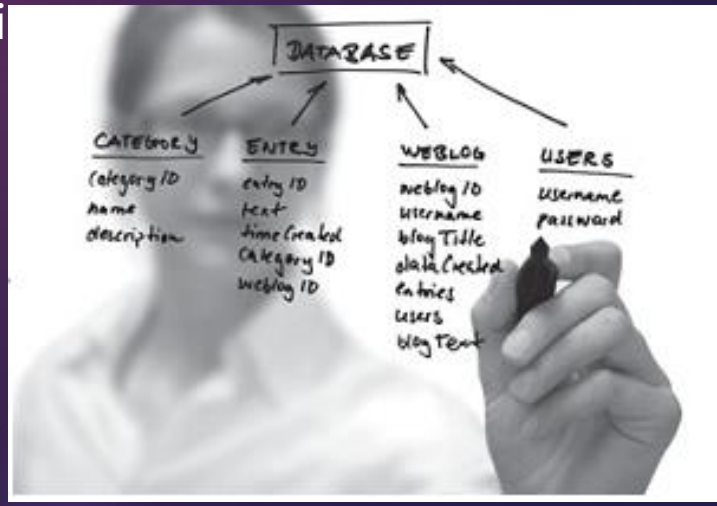
- What computer science is fundamentally is about **computational problem solving**—that is, solving problems by the use of computation
- There are various areas of study in computer science including :

  - software engineering (the design and implementation of large software systems),
  - database management,
  - computer networks,
  - computer graphics,
  - computer simulation,
  - data mining,
  - information security,
  - programming language design,
  - systems programming,
  - computer architecture,
  - human–computer interacti
  - robotics,
  - artificial intelligence,



The Essence of Computational Problem Solving

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- In order to solve a problem computationally, two things are needed:
  - a *representation* that captures all the relevant aspects of the problem, and
  - an *algorithm* that solves the problem by use of the representation.
- Man, Cabbage, Goat, Wolf problem

Algorithms

- Algorithm: A sequence of steps that is:
  - unambiguous
  - executable: the operations can be performed by computer
  - terminating
- Algorithm for deciding which car to buy, based on total costs:
  1. *For each car, compute the total cost as follows:*
  2. *annual fuel consumed = annual miles driven / fuel efficiency*
  3. *annual fuel cost = price per gallon x annual fuel consumed*
  4. *operating cost = 10 x annual fuel cost*
  5. *total cost = purchase price + operating cost*
  6. *If total cost1 < total cost2*
  7. *Choose car1*
  8. *Else*
  9. *Choose car2*

Pseudocode

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- Pseudocode: An informal description of an algorithm:
  - Describe how a value is set or changed:

    total cost = purchase price + operating cost
  - Describe decisions and repetitions:

    For each car

      operating cost = 10 x annual fuel cost

      total cost = purchase price + operating cost

    Use indentation to indicate which statements should be selected or repeated
  - Indicate results:

    Choose car1

Pseudocode

1. *display "what is the length"*
2. *get length*
3. *display "what is the width"*
4. *get length*
5. *calculate area = length x width*
6. *display area*
7. *stop*

Pseudocode

- display “What was your mark?”
- get *mark*
- is *mark* greater than or equal to 55?
  - yes
    - display “You Passed”
  - no
    - display “You Failed”
- stop

The Python Programming Language

- Guido van Rossum
  - the creator of the Python programming language,
  - first released in the early 1990s.
- Its name comes from a 1970s British comedy sketch television show called *Monty Python's Flying Circus*.
- Python is well supported and freely available at www.python.org.

Why Python?

- Python
  - simple syntax
    - Fewer alternatives, better alternatives
    - Focus on problem solving rather than on the language
  - clear and easy to read.
  - provides powerful programming features
    - Many of the best part of other language is included in python
    - "*Battery included*"
  - widely used
    - YouTube, Google, Yahoo, and NASA.

Why Python?

- Python
  - Open Source
    - Freely available
    - Large user based
    - New packages available to meet changing needs
  - Popular
    - In industry and academia due to concise, simple, intuitive syntax and extensive library

Python Downside?

- execution speed
  - May not always be as fast as that of fully compiled and lower level language such as C and C++

Python Development Version

- Developed
  - Two large teams of volunteers and available for free from Python Software Foundation
  - Python 2 and 3 version
    - Python 3 is newer version but it is not backward compatible
    - Python 2 will eventually be replaced by Python 3

The IDLE Python Development Environment

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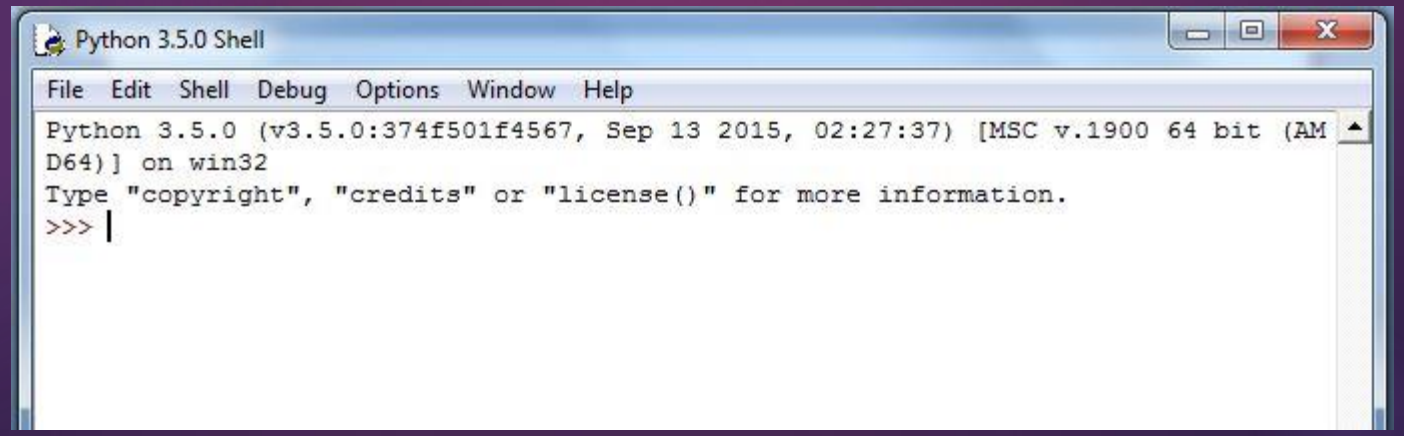
- IDLE is an integrated development environment (IDE). An IDE is a bundled set of software tools for program development. This typically includes an editor for creating and modifying programs, a translator for executing programs, and a program debugger.
- The window that provides this interaction is referred to as the Python shell



The Python Standard Library

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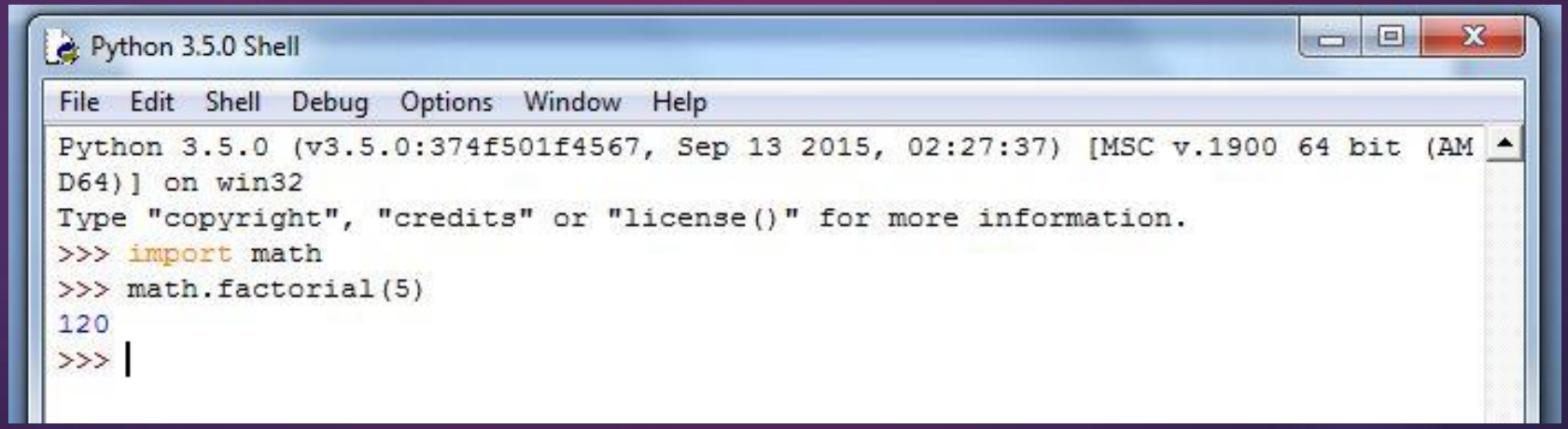
- The Python Standard Library
  - collection of *built-in modules*
  - each providing specific functionality beyond what is included in the "core" part of Python
  - Example : math module, random module, etc
- To use the module we have to import it



A Bit of Python

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- Variables : "a name that is assigned to a value'

```
n = 5          variable n is assigned the value 5
```

```
n + 20         (5 + 20)
```

```
n = 10
n + 20         (10 + 20)
```

A Bit of Python

- Some basic Arithmetic Operators

```
10 + 20        25 - 15        20 / 10

5 * 10  (5 times 10)        2 ** 4  (2 to the 4th power)

10 * (20 + 5)  CORRECT        10(20 + 5)  INCORRECT
```

Errors

- Three types of errors
  - Syntax Error
    - The compiler will find syntax errors and other basic problems
  - Run time error / Exceptions
    - A problem can occur during program execution, such as trying to divide by zero, which causes a program to terminate abnormally
  - Logic Error
    - A program may run, but produce incorrect results, perhaps using an incorrect formula

Syntax Errors

- a “grammatical” error
- caught by interpreter
- automatically found, usually the easiest to fix
- cannot run code until all syntax errors are fixed
- error message may be misleading

- Example:
  - Misspelling a command, for example “rturn” instead of “return”

Run-Time Errors

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- An execution error (during run-time)
- Not always so easy to fix
- Error message may or may not be helpful

- Example:
  - Division by zero - if your program attempts to divide an integer by zero it automatically terminates and prints an error message.

Logic Errors

- An error in the design (the algorithm) or its implementation
  - code runs without errors
  - no run-time error messages
  - but incorrect action or data occurs during execution
- Generally the most difficult to find and fix
- Need to be alert and test thoroughly
  - think about test cases and predict results before executing the code
- Formal Method: use mathematics to develop software and prove its correctness

Acknowledgement

- Charles Dierbach. Introduction to Computer Science Using Python: A Computational Problem-Solving Focus. John Wiley & Sons, 2012.
- Ljubomir Perkovic. Introduction to Computing using Python. 2nd Edition. Wiley, 2015