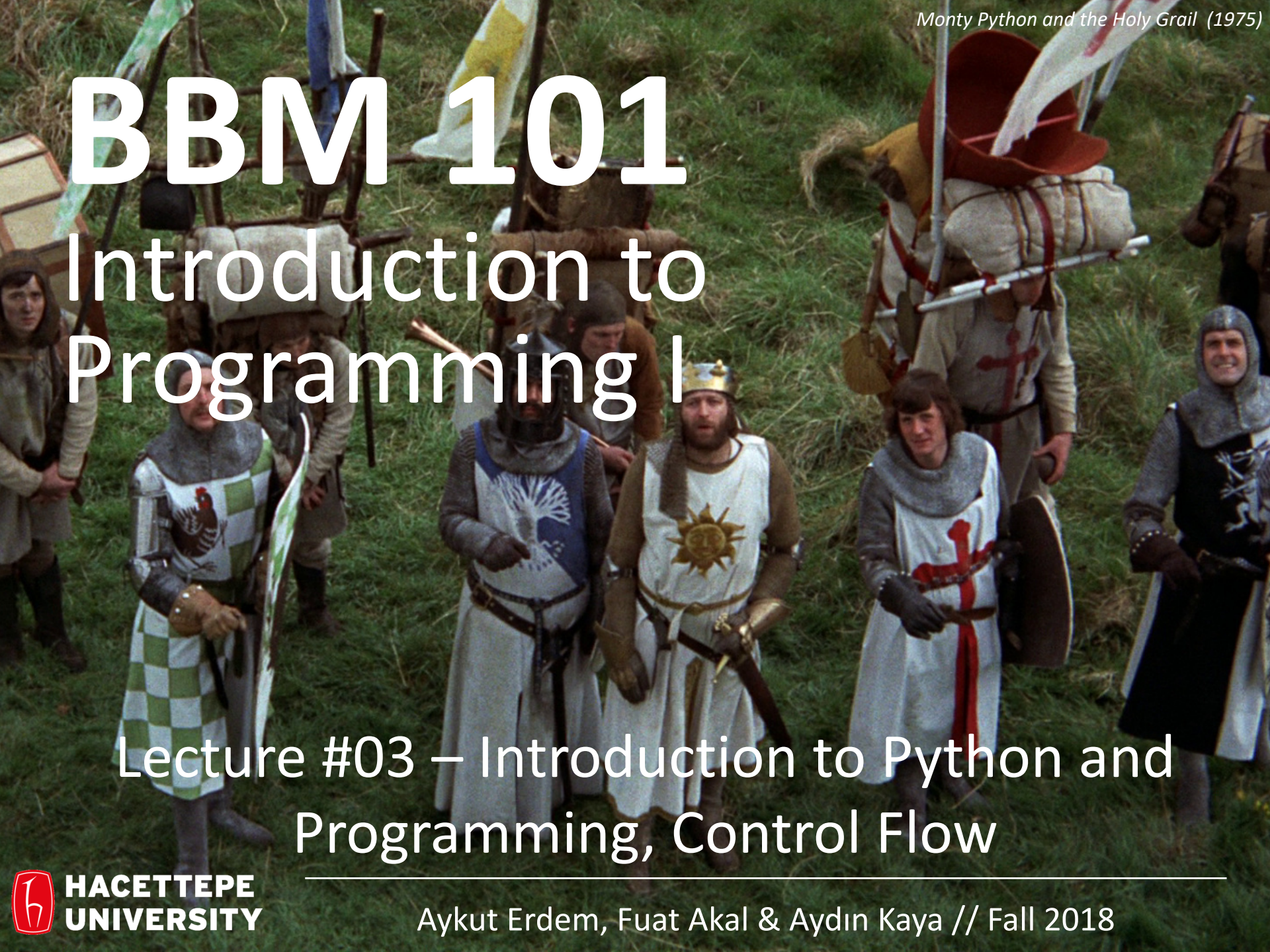


BBM 101

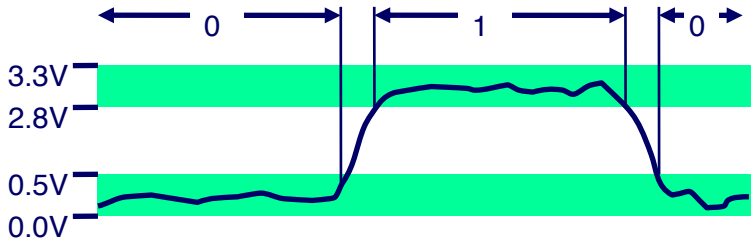
Introduction to Programming I

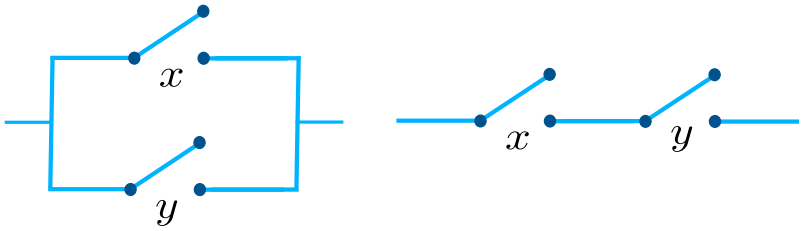
Lecture #03 – Introduction to Python and Programming, Control Flow

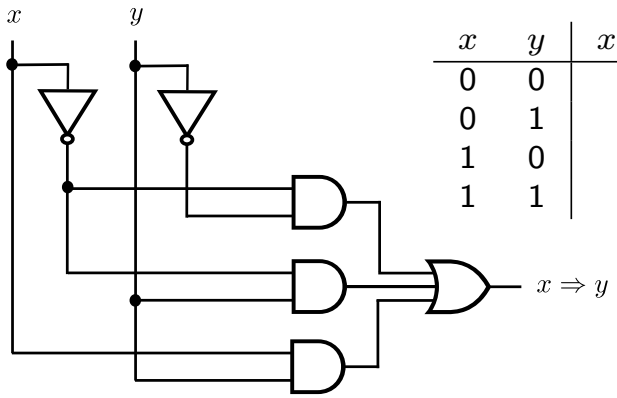
HACETTEPE UNIVERSITY

Aykut Erdem, Fuat Akal & Aydın Kaya // Fall 2018

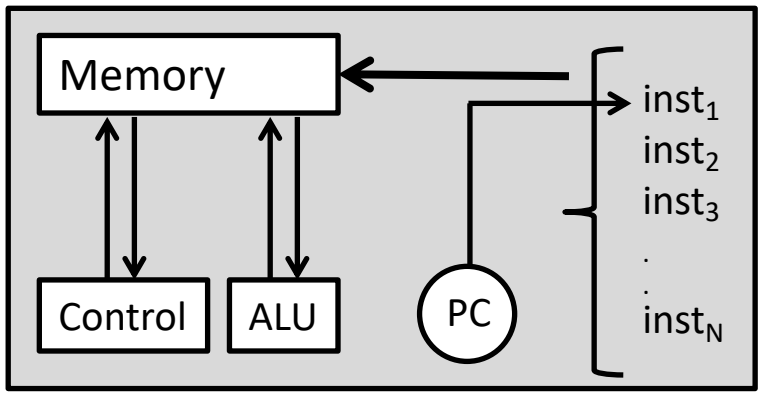
Last time… **How to build computers**







x	y	$x \implies y$
0	0	1
0	1	1
1	0	0
1	1	1



The Harvey Mudd Miniature Machine (HMMM)

triangle1.hmmm: Calculate the approximate area of a triangle.

```
0    read    r1       # Get base b
1    read    r2       # Get height h
2    mul     r1 r1 r2 # b times h into r1
3    setn    r2 2
4    div     r1 r1 r2 # Divide by 2
5    write   r1
6    halt
```

```
$ python hmmmAssembler.py -f triangle1.hmmm -o triangle1.b

----------------------
| ASSEMBLY SUCCESSFUL |
----------------------

0 : 0000 0001 0000 0001        0    read    r1       # Get base b
1 : 0000 0010 0000 0001        1    read    r2       # Get height h
2 : 1000 0001 0001 0010        2    mul     r1 r1 r2 # b times h into r1
3 : 0001 0010 0000 0010        3    setn    r2 2
4 : 1001 0001 0001 0010        4    div     r1 r1 r2 # Divide by 2
5 : 0000 0001 0000 0010        5    write   r1
6 : 0000 0000 0000 0000        6    halt
```

```
$ python hmmmSimulator.py -f triangle1.b -n
4
5
10
```

Lecture Overview

- Programming languages (PLs)

- Introduction to Python and Programming

Disclaimer: Much of the material and slides for this lecture were borrowed from
—E. Grimson, J. Guttag and C. Terman MIT 6.0001 class
—Ruth Anderson, Michael Ernst and Bill Howe's CSE 140 class
—Swami Iyer's Umass Boston CS110 class

Lecture Overview

- Programming languages (PLs)

- Introduction to Python and Programming

Programming Languages

- Syntax and semantics
- Dimensions of a PL
- Programming paradigms

Programming Languages

- An artificial language designed to express computations that can be performed by a machine, particularly a computer.

- Can be used to create programs that control the behavior of a machine, to express algorithms precisely, or as a mode of human communication.

- **e.g.**, C, C++, Java, Python, Prolog, Haskell, Scala, etc..

Creating Computer Programs

- Each programming language provides a set of primitive operations.
- Each programming language provides mechanisms for combining primitives to form more complex, but legal, expressions.
- Each programming language provides mechanisms for deducing meanings or values associated with computations or expressions.

Aspects of Languages

- Primitive constructs
  - Programming language – numbers, strings, simple operators
  - English – words

- Syntax – which strings of characters and symbols are well-formed
  - Programming language –we'll get to specifics shortly, but for example 3.2 + 3.2 is a valid C expression
  - English – "cat dog boy" is not syntactically valid, as not in form of acceptable sentence

Aspects of Languages

- Static semantics – which syntactically valid strings have a meaning
  - English – “I are big” has form <noun> <intransitive verb> <noun>, so syntactically valid, but is not valid English because “I” is singular, “are” is plural
  - Programming language – for example, <literal> <operator> <literal> is a valid syntactic form, but 2.3/’abc’ is a static semantic error

Aspects of Languages

- Semantics – what is the meaning associated with a syntactically correct string of symbols with no static semantic errors
  - English – can be ambiguous
    - “They saw the man with the telescope.”
  - Programming languages – always has exactly one meaning
    - But meaning (or value) may not be what programmer intended

Where Can Things Go Wrong?

- Syntactic errors
  - Common but easily caught by computer
- Static semantic errors
  - Some languages check carefully before running, others check while interpreting the program
  - If not caught, behavior of program is unpredictable
- Programs don't have semantic errors, but meaning may not be what was intended
  - Crashes (stops running)
  - Runs forever
  - Produces an answer, but not programmer's intent

Our Goal

- Learn the syntax and semantics of a programming language

- Learn how to use those elements to translate “recipes” for solving a problem into a form that the computer can use to do the work for us

- Computational modes of thought enable us to use a suite of methods to solve problems

Dimensions of a Programming Language
Low-level vs. High-level

- Distinction according to the level of abstraction

- In low-level programming languages (e.g. Assembly), the set of instructions used in computations are very simple (nearly at machine level)

- A high-level programming language (e.g. Python, C, Java) has a much richer and more complex set of primitives.

Dimensions of a Programming Language
General vs. Targeted

- Distinction according to the range of applications

- In a general programming language, the set of primitives support a broad range of applications.

- A targeted programming language aims at a very specific set of applications.
  - **e.g.**, MATLAB (matrix laboratory) is a programming language specifically designed for numerical computing (matrix and vector operations)

Dimensions of a Programming Language
Interpreted vs. Compiled

- Distinction according to how the source code is executed

- In interpreted languages (e.g. LISP), the source code is executed directly at runtime (by the interpreter).
  - Interpreter control the flow of the program by going through each one of the instructions.

- In compiled languages (e.g. C), the source code first needs to be translated into an object code (by the compiler) before the execution.

Programming Language Paradigms

- **Functional**
  - Treats computation as the evaluation of mathematical functions (e.g. Lisp, Scheme, Haskell, etc.)
- **Imperative**
  - Describes computation in terms of statements that change a program state (e.g. FORTRAN, BASIC, Pascal, C, etc.)
- **Logical (declarative)**
  - Expresses the logic of a computation without describing its control flow (e.g. Prolog)
- **Object oriented**
  - Uses "objects" – data structures consisting of data fields and methods together with their interactions – to design applications and computer programs (e.g. C++, Java, C#, Python, etc.)

Programming Language Paradigms

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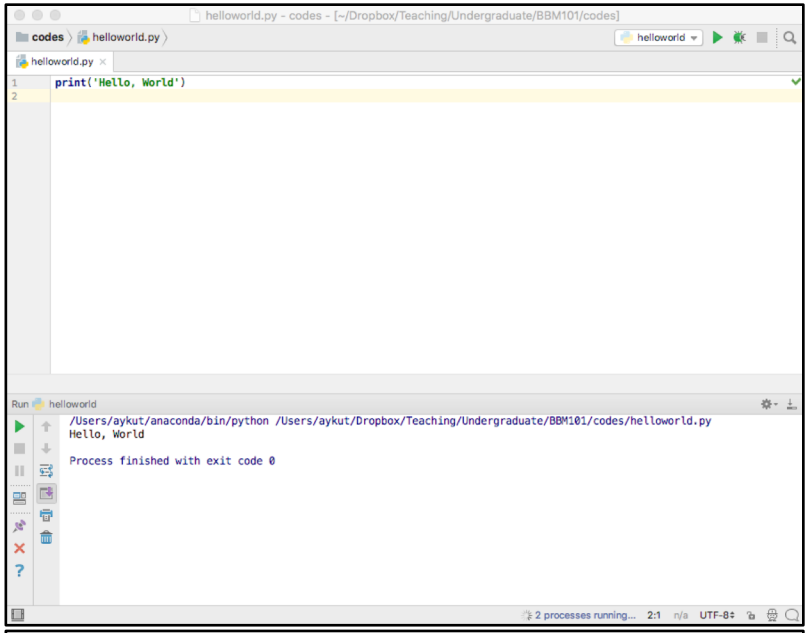
Lecture Overview

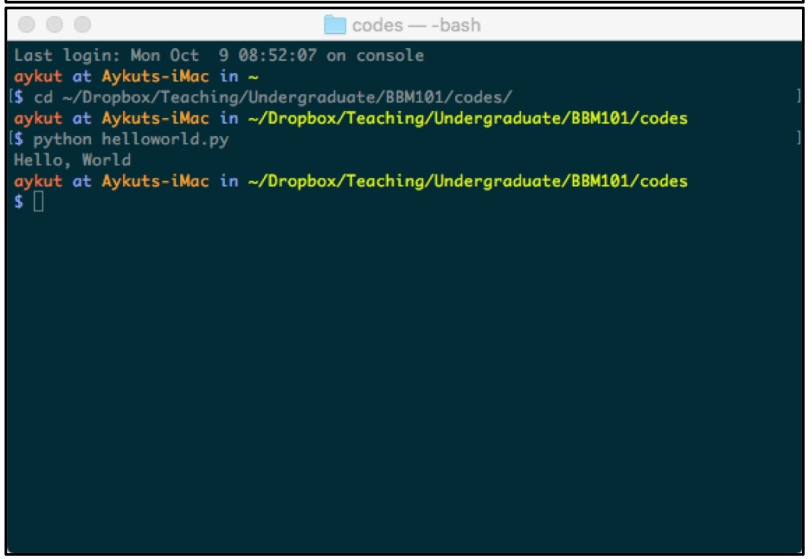
- Programming languages (PLs)

- Introduction to Python and Programming

Programming in Python

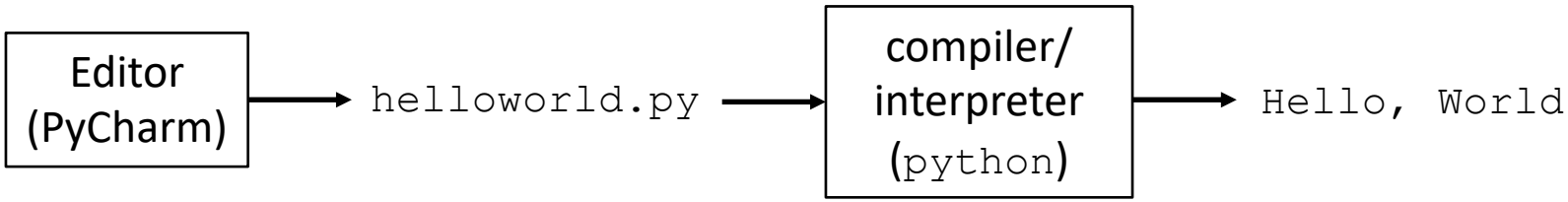
- Our programming environment
  - Python programming language
  - PyCharm, an integrated development environment (IDE)
  - Terminal





Programming in Python

- To program in Python
  - Compose a program by typing it into a file named, say, `helloworld.py`
  - Run (or execute) the program by typing `python helloworld.py` in the terminal window



Input and Output

- Bird's-eye view of a Python program

  - **Input types:** command-line arguments, standard input, file input
  - **Output types:** standard output, file output, graphical output, audio output

Input and Output

- Command-line arguments are the inputs we list after a program name when we run the program

```
$ python my_program.py arg_1 arg_2 ... arg_n
```

- The command-line arguments can be accessed within a program, such as `my_program.py` above, via the array (aka list) `sys.argv`[1] as `sys.argv[1], sys.argv[2], . . . , sys.argv[n]`

- The name of the program (`my_program.py`) is stored in `sys.argv[0]`

[1] The `sys` module provides access to variables and functions that interact with the Python interpreter

Input and Output

useargument.py

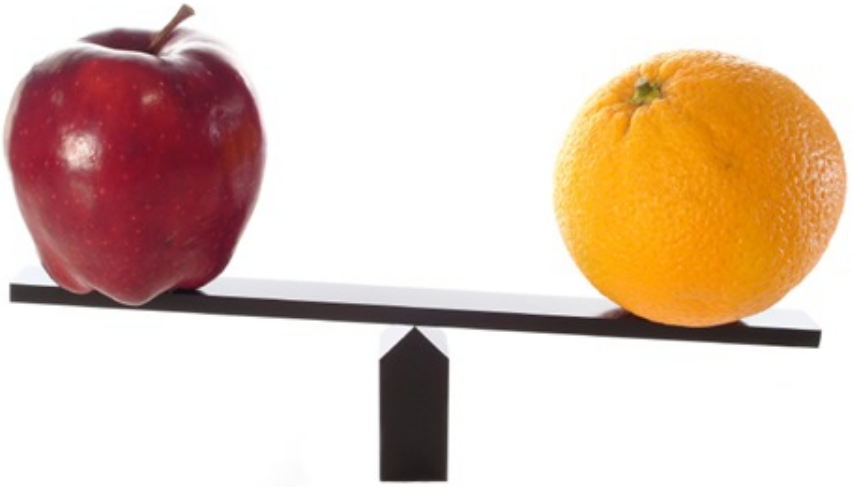
```
import sys

print('Hi, ', end='')
print(sys.argv[1], end='')
print('. How are you?')
```

```
$ python useargument.py Alice
Hi, Alice. How are you?
$ python useargument.py Bob
Hi, Bob. How are you?
$ python useargument.py Carol
Hi, Carol. How are you?
```

1. Python is like a calculator

2. A variable is a container

3. Different types cannot be compared



4. A program is a recipe

CORNBREAD

Colvin Run Mill Corn Bread

1 cup cornmeal
1 cup flour
½ teaspoon salt
4 teaspoons baking powder
3 tablespoons sugar
1 egg
1 cup milk
¼ cup shortening (soft) or vegetable oil

Mix together the dry ingredients. Beat together the egg, milk and shortening/oil. Add the liquids to the dry ingredients. Mix quickly by hand. Pour into greased 8x8 or 9x9 baking pan. Bake at 425 degrees for 20-25 minutes.

1. Python is Like a Calculator

You Type E*xpressions*. Python Computes Their V*alues*.

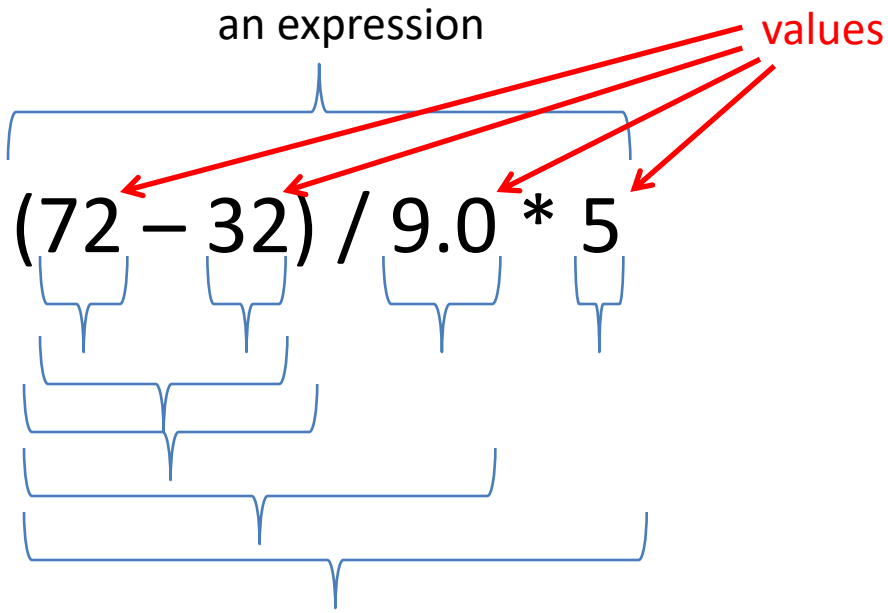
- 5
- 3+4
- 44/2
- 2**3
- 3*4+5*6
- (72 – 32) / 9 * 5

Python has a natural and well-defined set of precedence rules that fully specify the order in which the operators are applied in an expression

- For arithmetic operations, multiplication and division are performed before addition and subtraction
- When arithmetic operations have the same precedence, they are left associative, with the exception of the exponentiation operator **, which is right associative
- We can use parentheses to override precedence rules

An Expression is Evaluated From the Inside Out

- How many expressions are in this Python code?



(**72** – **32**) / **9.0** * **5**

(**40**) / **9.0** * **5**

40 / **9.0** * **5**

4.44 * **5**

22.2

Another Evaluation Example

(72 – 32) / (9.0 * 5)

(40) / (9.0 * 5)

40 / (9.0 * 5)

40 / (45.0)

40 / 45.0

.888

2. A Variable is a Container

A variable is a name associated with a data-type value

Variables Hold Values

- Recall variables from algebra:
  - Let x = 2 …
  - Let y = x …

- To assign a variable, use "*varname* = *expression*"

```
pi = 3.14
pi
var = 6*10**23
22 = x          # Error!
```

No output from an assignment statement

- Not all variable names are permitted!

- Variable names must only be one word (as in no spaces)
- Variable names must be made up of only letters, numbers, and underscore (_)
- Variable names cannot begin with a number

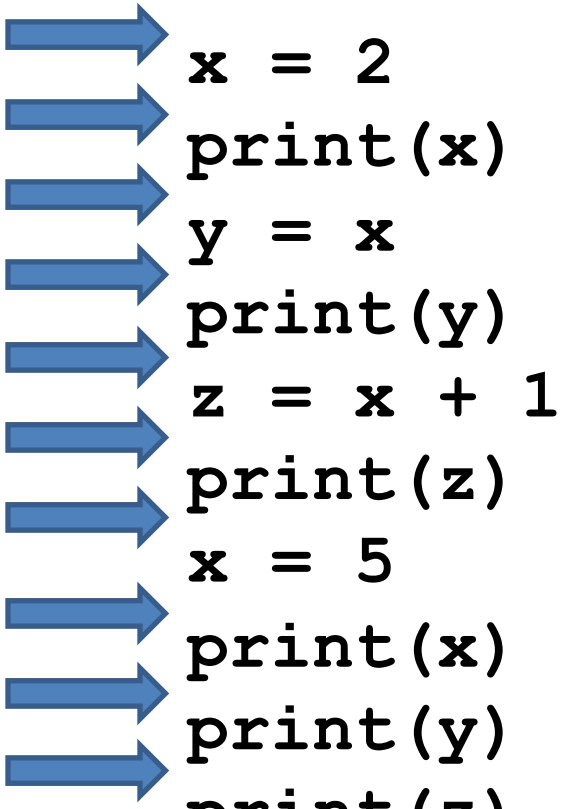
Changing Existing Variables ("re-binding" or "re-assigning")

```
x = 2
x
y = 2
y
x = 5
x
y
```

- "=" in an assignment is not a promise of eternal equality
  - This is different than the mathematical meaning of "="
- Evaluating an expression gives a new (copy of a) number, rather than changing an existing one

How an Assignment is Executed

1. Evaluate the right-hand side to a value
2. Store that value in the variable



```
x = 2
print(x)
y = x
print(y)
z = x + 1
print(z)
x = 5
print(x)
print(y)
print(z)
```

State of the computer:

x: ~~2~~ 5

y: 2

z: 3

Printed output:

```
2
2
3
5
2
3
```

To visualize a program's execution:

http://pythontutor.com

More Expressions: Conditionals (value is `True` or `False`)

```
22 > 4      # condition, or conditional
22 < 4      # condition, or conditional
22 == 4     …
x = 100     # Assignment, not conditional!
22 = 4      # Error!
x >= 5
x >= 100
x >= 200
not True
not (x >= 200)
3<4 and 5<6
4<3 or 5<6
temp = 72
water_is_liquid = (temp > 32 and temp < 212)
```

Numeric operators: **+**, *****, ******
Boolean operators: **not**, **and**, **or**
Mixed operators: **<**, **>=**, **==**

More Expressions: strings

- A string represents **text**
  - `'Python'`
  - `myString = "BBM 101-Introduction to Programming"`
  - `""`
- Empty string is not the same as an unbound variable
  - `""` and ‘’ are the same
- We can specify tab, newline, backslash, and single quote characters using escape sequences `'\t'`, `'\n'`, `'\\'`, and `'\''`, respectively

Operations:

- **Length:**
  - `len(myString)`
- **Concatenation:**
  - `"Hacettepe" + " " + ' University'`
- **Containment/searching:**
  - `'a' in myString`
  - `"a" in myString`

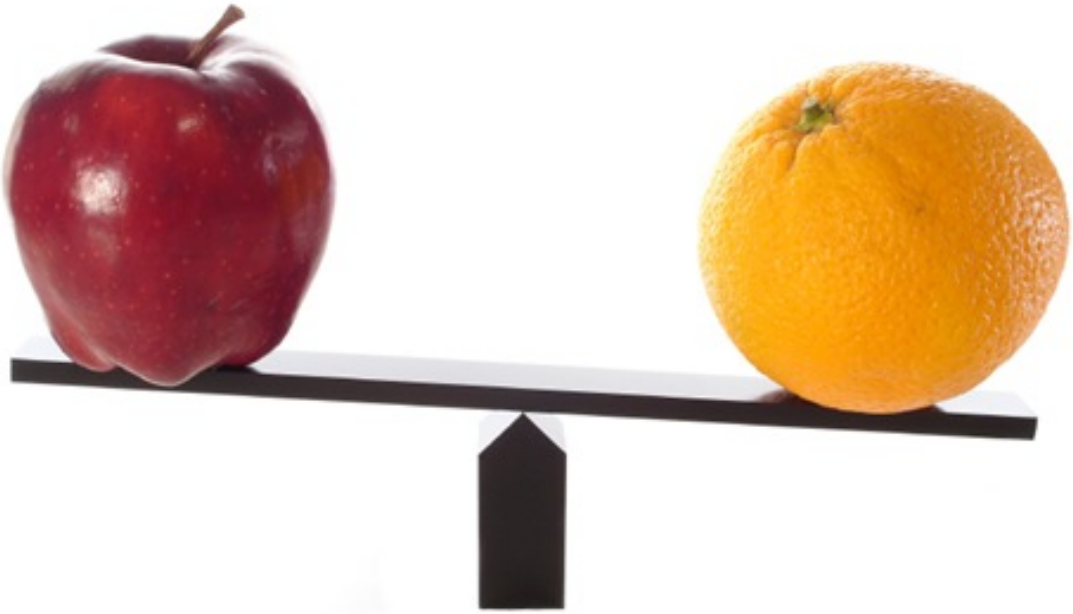
Strings

```
ruler1 = '1'
ruler2 = ruler1 + ' 2 ' + ruler1
ruler3 = ruler2 + ' 3 ' + ruler2
ruler4 = ruler3 + ' 4 ' + ruler3
print(ruler1)
print(ruler2)
print(ruler3)
print(ruler4)
```

```
1
1 2 1
1 2 1 3 1 2 1
1 2 1 3 1 2 1 4 1 2 1 3 1 2 1
```

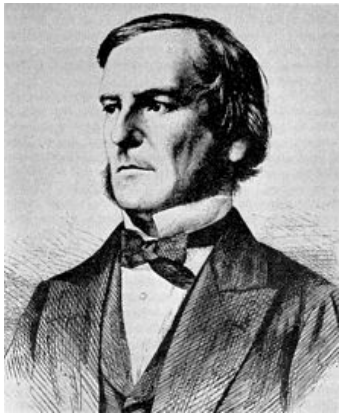
3. Different Types cannot be Compared

```
anInt = 2
aString = "Hacettepe"
anInt == aString                    # Error
```



Types of Values

- Integers (**`int`**): **`-22`**, **`0`**, **`44`**
  - Arithmetic is exact
  - Some funny representations: **`12345678901L`**
- Real numbers (**`float`**, for "floating point"): **`2.718`**, **`3.1415`**
  - Arithmetic is approximate, e.g., **`6.022*10**23`**
- Strings (**`str`**): **`"I love Python"`**, **`" "`**
- Truth values (**`bool`**, for "Boolean"): **`True`**, **`False`**



George Boole

Operations Behave differently on Different Types

```
3.0 + 4.0
3 + 4
3 + 4.0
"3" + "4"          # Concatenation
3 + "4"            # Error
3 + True           # Error
```

Moral: Python only *sometimes* tells you when you do something that does not make sense.

Operations on Different Types

	Python 3.5	Python 2.x
`15.0 / 4.0`	`3.75`	`3.75`
`15 / 4`	`3.75`	`3`
`15.0 / 4`	`3.75`	`3.75`
`15 / 4.0`	`3.75`	`3.75`
`15.0 // 4.0`	`3.0`	
`15 // 4`	`3`	
`15.0 // 4`	`3.0`	
`15 // 4.0`	`3.0`	

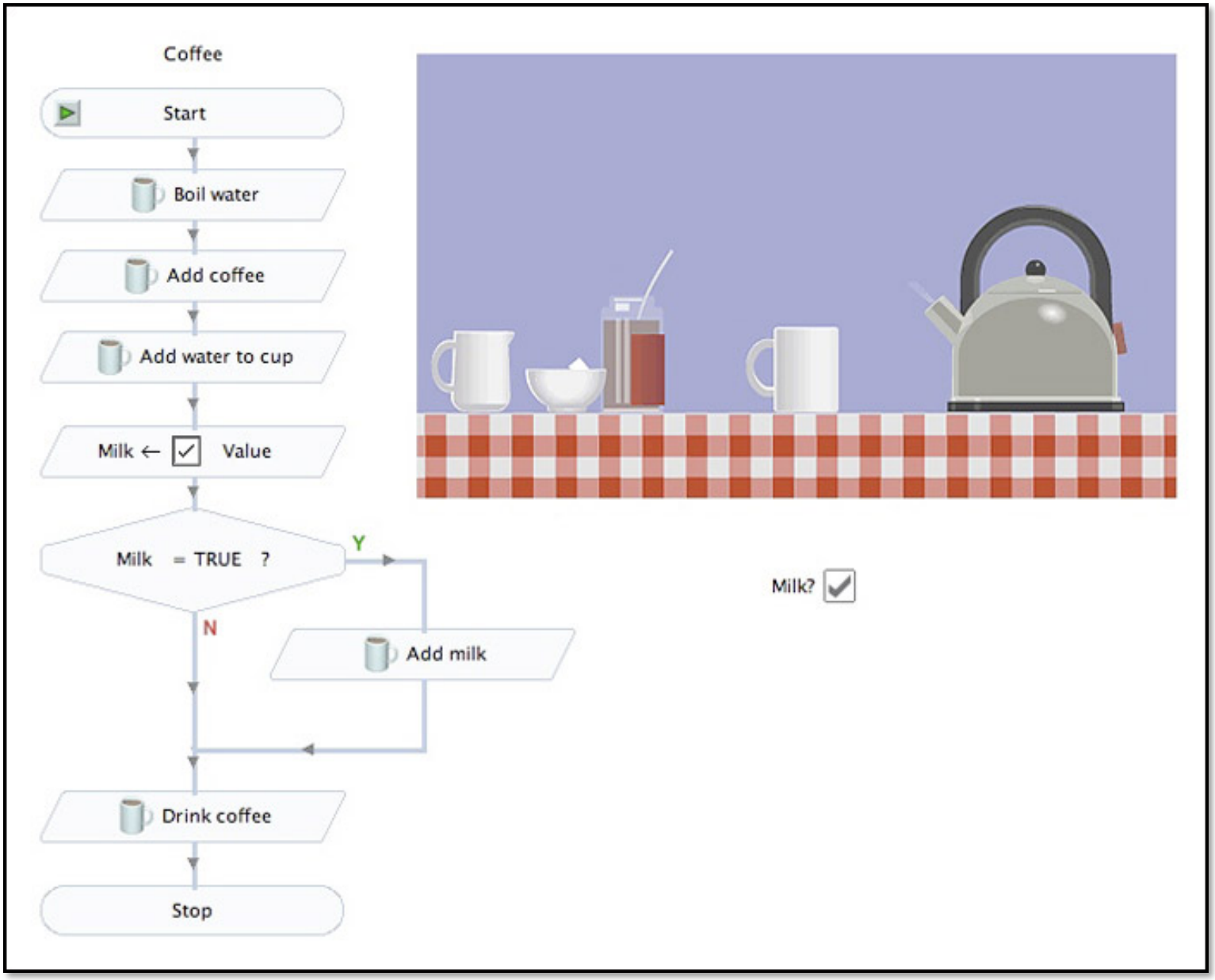
Before Python version 3.5, operand used to determine the type of division.

/ : Division
//: Integer Division

Type Conversion

```
float(15)          15.0
int(15.0)          15
int(15.5)          15
int("15")          15
str(15.5)          15.5
float(15) / 4      3.75
```

A Program is a Recipe



Design the Algorithm Before Coding

- We should think (design the algorithm) before coding
- Algorithmic thinking is the logic. Also, called problem solving
- Coding is the syntax
- Make this a habit
- Some students do not follow this practice and they get challenged in all their courses and careers!

What is a Program?

- A program is a sequence of instructions
- The computer executes one after the other, as if they had been typed to the interpreter
- Saving your work as a program is better than re-typing from scratch

```
x = 1
y = 2
x + y
print(x + y)
print("The sum of", x, "and", y, "is", x+y)
```

The `print()` Statement

- The **`print`** statement always prints one line
  - The next print statement prints below that one
- Write 0 or more expressions after **`print`**, separated by commas
  - In the output, the values are separated by spaces
- Examples:

```
x = 1
y = 2
print(3.1415)
print(2.718, 1.618)
print()
print(20 + 2, 7 * 3, 4 * 5)
print("The sum of", x, end="")
print(" and", y, "is", x+y)
```

```
3.1415
2.718 1.618

22 21 20
The sum of 1 and 2 is 3
```

To avoid newline

Exercise: Convert Temperatures

- Make a temperature conversion chart as the following
- Fahrenheit to Centigrade, for Fahrenheit values of: -40, 0, 32, 68, 98.6, 212
- C = (F - 32) × 5/9
- Output:

```
Fahrenheit Centigrade
-40 -40.0
0 -17.7778
32 0.0
68 20.0
98.6 37.0
212 100.0
```

- You have created a Python program!
- (It doesn't have to be this tedious, and it won't be.)

Expressions, Statements, and Programs

- An expression evaluates to a value

```
3 + 4
pi * r**2
```

- A statement causes an effect

```
pi = 3.14159
print(pi)
```

- Expressions appear within other expressions and within statements

```
(fahr - 32) * (5.0 / 9)
print(pi * r**2)
```

- A statement may *not* appear within an expression

```
3 + print(pi)      # Error!
```

- A program is made up of statements
  - A program should do something or communicate information

1. Python is like a calculator

2. A variable is a container

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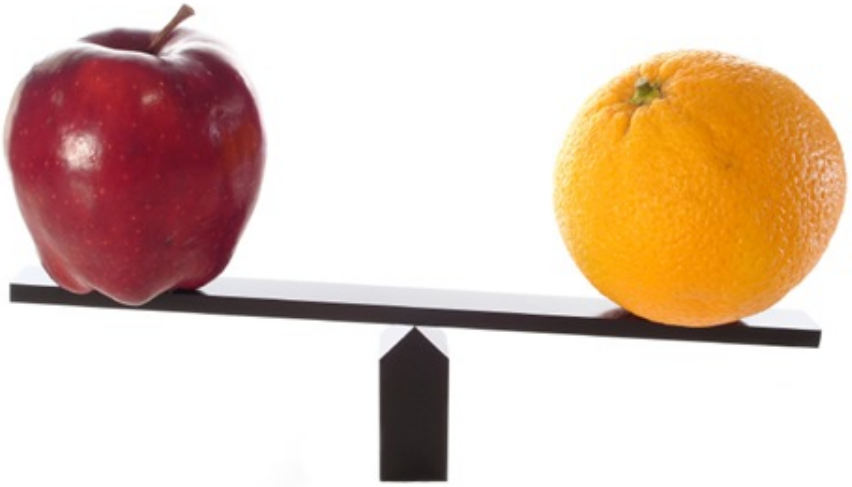


4. A program is a recipe

Programming Languages

- A programming language is a “language” to write programs in, such as Python, C, C++, Java

- The concept of programming languages are quite similar

- Python:

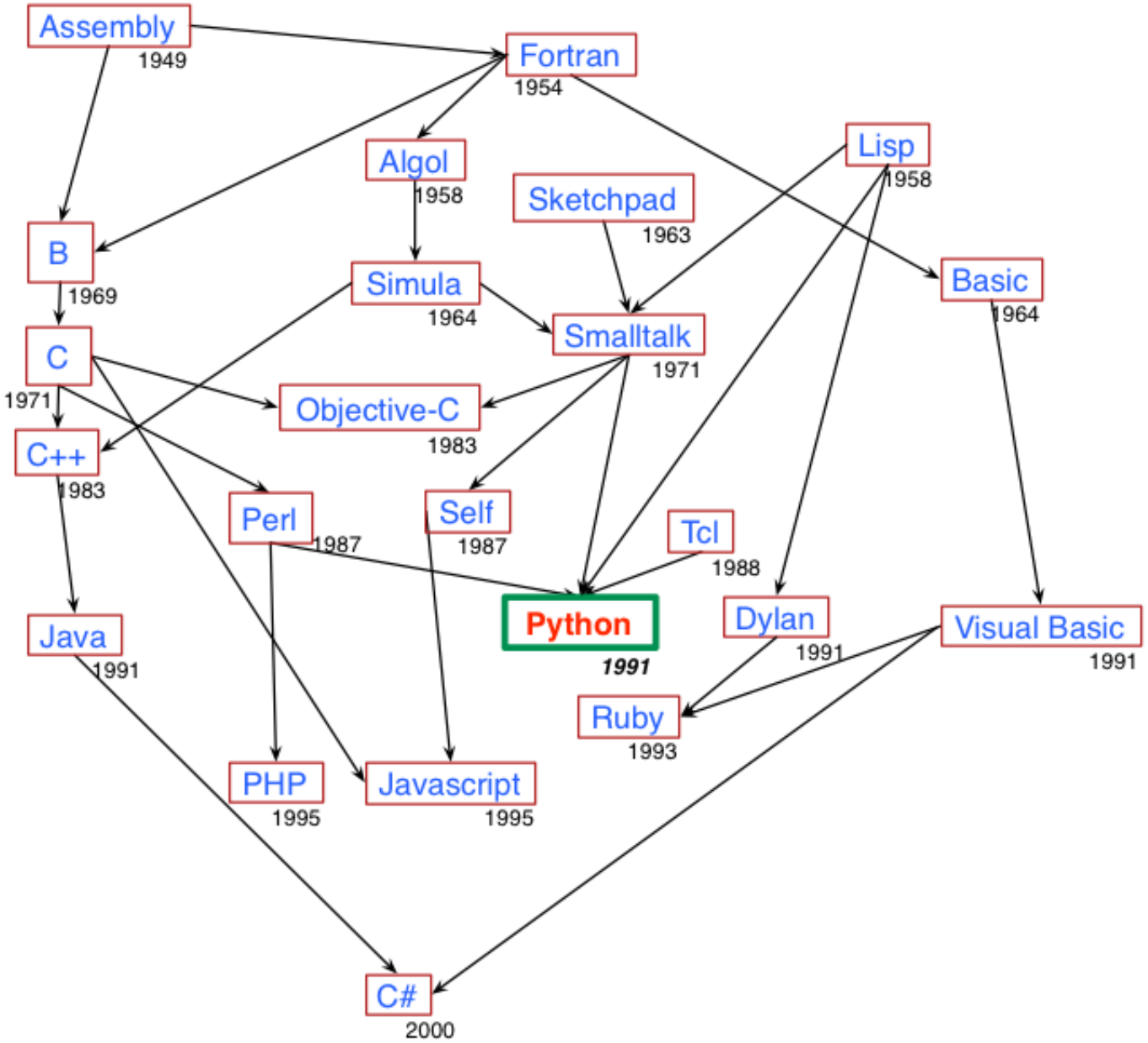
```
print("Hello, World!")
```

- Java:

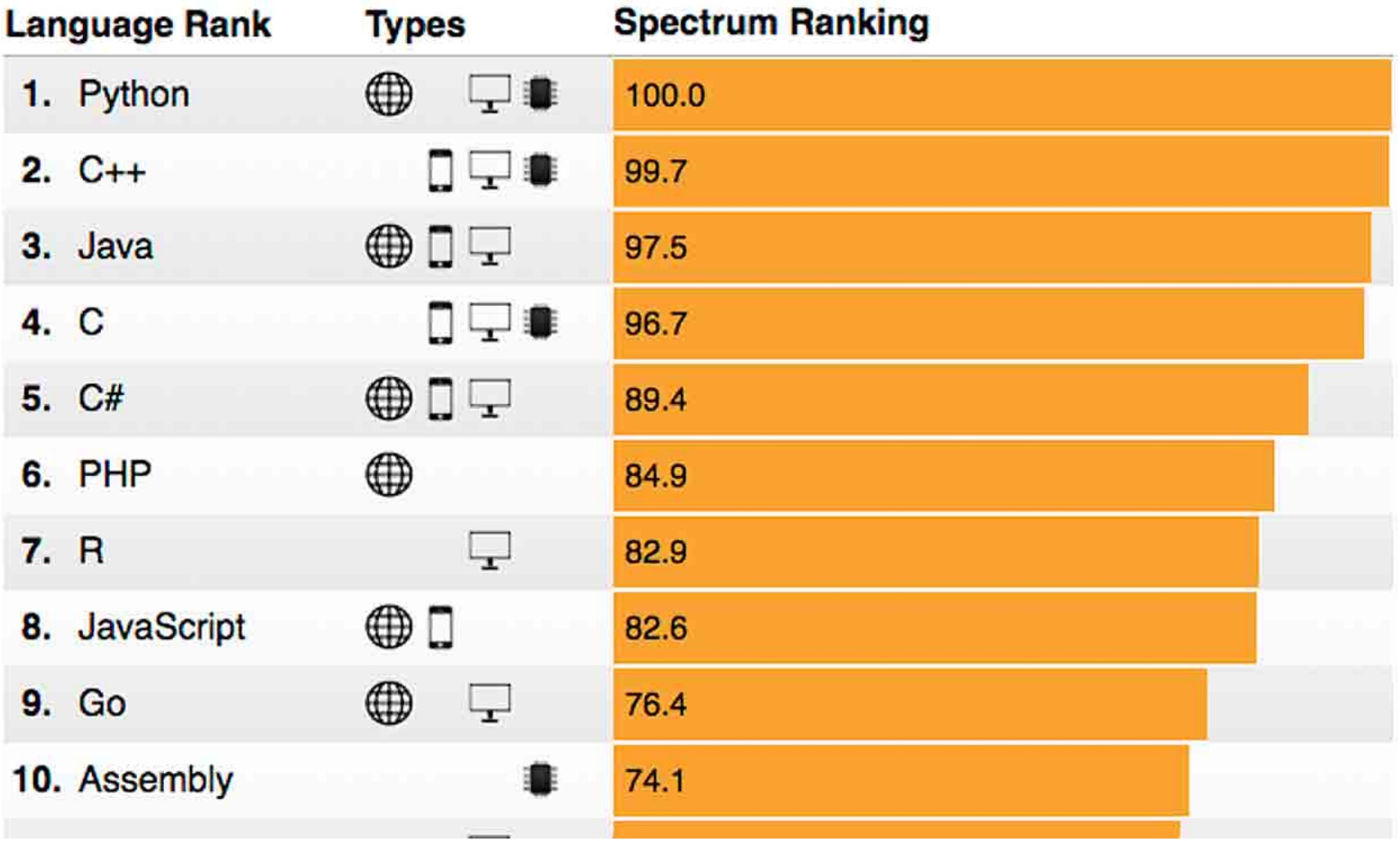
```
public static void main(String[] args) {
    System.out.println("Hello, World!");
}
```

- Python is simpler! That’s why we are learning it first ☺

Evolution of Programming Languages



The 2017 Top Programming Languages



- https://spectrum.ieee.org/at-work/innovation/the-2018-top-programming-languages

WHICH PROGRAMMING LANGUAGE

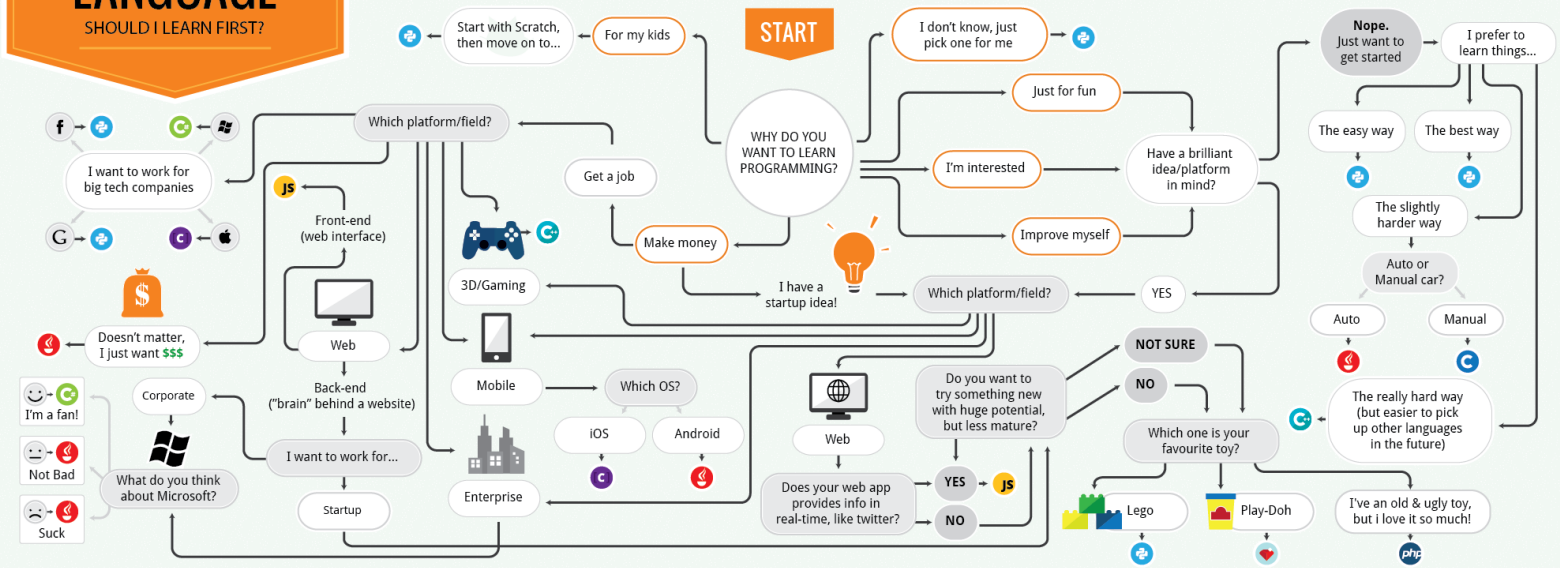
SHOULD I LEARN FIRST?

WHAT IS PROGRAMMING?

Writing very specific instructions to a very dumb, yet obedient machine.

LANGUAGES

PYTHON · JAVA · C · PHP · C++ · JAVASCRIPT · C# · RUBY · OBJECTIVE-C



THE LORD OF THE RINGS ANALOGY TO PROGRAMMING LANGUAGES

Python
The Ent

DIFFICULTY

Help little Hobbits (beginners) to understand programming concepts

Help Wizards (computer scientists) to conduct researches

Widely regarded as the best programming language for beginners

Easiest to learn

Widely used in scientific, technical & academic field, i.e. Artificial Intelligence

You can build website using Django, a popular Python web framework

POPULARITY

USED TO BUILD: YouTube, Instagram, Spotify

AVG. SALARY: $107,000

Java
Gandalf

DIFFICULTY

Wants peace & works with everyone (portable)

Very popular on all platforms, OS, and devices due to its portability

One of the most in demand & highest paying programming languages

Slogan: write once, work everywhere

POPULARITY

USED TO BUILD: Gmail, Minecraft, Most Android Apps, Enterprise applications

AVG. SALARY: $102,000

C
One Ring

DIFFICULTY

The power of C is known to them all

Everyone wants to get its Power

Lingua franca of programming language

One of the oldest and most widely used language in the world

Popular language for system and hardware programming

A subset of C++ except the little details

POPULARITY

USED TO BUILD: Operating systems and hardware

AVG. SALARY: $102,000

C++
Saruman

DIFFICULTY

Everyone thinks that he is the good guy

But once you get to know him, you will realize he wants the power, not good deeds

Complex version of C with a lot more features

Widely used for developing games, industrial and performance-critical applications

Learning C++ is like learning how to manufacture, assemble, and drive a car

Recommended only if you have a mentor to guide you

POPULARITY

USED TO BUILD: Operating systems, hardware, and browsers

AVG. SALARY: $104,000

JavaScript
Hobbit

DIFFICULTY

Frequently underestimated (powerful)

Well-known for the slow, gentle life of the Shire (web browsers)

"Java and Javascript are similar like Car and Carpet are similar" - Greg Hewgill

Most popular clients-side web scripting language

A must learn for front-end web developer (HTML and CSS as well)

One of the hottest programming language now, due to its increasing popularity as server-side language (node.js)

POPULARITY

USED TO BUILD: Paypal, front-end of majority websites

AVG. SALARY: $99,000

C#
Elf

DIFFICULTY

Beautiful creature (language), used to stay in their land, Rivendell (Microsoft Platform), but recently started to open up to their neighbours (open source)

A popular choice for enterprise to create websites and Windows application using .NET framework

Can be used to build website with ASP.NET, a web framework from Microsoft

Similar to Java in basic syntax and some features

POPULARITY

USED TO BUILD: Enterprise and Windows applications

AVG. SALARY: $94,000

Ruby
Man (Middle Earth)

DIFFICULTY

Very emotional creature

They (some Ruby developers) feel they are superior & need to rule the Middle Earth

Mostly known for its popular web framework, Ruby on Rails

Focuses on getting things done

Designed for fun and productive coding

Best for fun and personal projects, startups, and rapid development

POPULARITY

USED TO BUILD: Hulu, Groupon, Slideshare

AVG. SALARY: $107,000

PHP
Orc

DIFFICULTY

Ugly guy (language) and doesn't respect the rules (inconsistent and unpredictable)

Big headache to those (developers) to manage them (codes)

Yet still dominates the Middle-earth (most popular web scripting language)

Suitable for building small and simple sites within a short time frame

Supported by almost every web hosting services with lower price

POPULARITY

USED TO BUILD: Wordpress, Wikipedia, Flickr

AVG. SALARY: $89,000

Objective-C
Smaug

DIFFICULTY

Lonely and loves gold

Primary language used by Apple for Mac OS X & iOS

Choose this if you want to focus on developing iOS or OS X apps only

Consider to learn Swift (newly introduced by Apple in 2014) as your next language

POPULARITY

USED TO BUILD: Most iOS Apps and part of Mac OS X

AVG. SALARY: $107,000

http://carlcheo.com/startcoding