# Short Course on Programming

## 2. Fundamental Programming Principles I: Variables, Data Types & Logic

Ronni Grapenthin

**August 28, 2017**

YOU'LL NEVER FIND A PROGRAMMING LANGUAGE THAT FREES YOU FROM THE BURDEN OF CLARIFYING YOUR IDEAS.
BUT I KNOW WHAT I MEAN!

"The Uncomfortable Truths Well",
http://xkcd.com/568 (April 13, 2009)

## How does (computer) programming work?

Well, fist we should clearify terminology here!

What is a programming language?

What is a program?

## Alright, what is it then?

### Definitions (broad sense)

A **programming language** is an unambiguous artificial language that is made up of a set of symbols (vocabulary) and grammatical rules (syntax) to instruct a machine.

A **program** is a set of instructions in one or multiple programming languages that specifies the behavior of a machine.

**Compilation** or **interpretation** is the verification of a program and its translation into machine readable instructions of a specific platform.

## Programming languages . . . continued

Two broad families can be identified:

**Interpreted languages**
An interpreter program is necessary to take in commands, check syntax and translate to machine language at runtime (e.g., Matlab, Unix Shell)

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**Compiled languages**
Programs are translated and saved in machine language. At runtime no additional program is necessary (e.g., C/C++).

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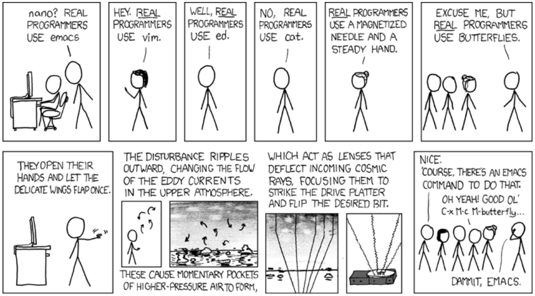
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EXCUSE ME, BUT REAL PROGRAMMERS USE BUTTERFLIES.
THEY OPEN THEIR HANDS AND LET THE DELICATE WINGS FLAP ONCE.
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THESE CAUSE MOMENTARY POCKETS OF HIGHER-PRESSURE AIR TO FORM,
WHICH ACT AS LENSES THAT DEFLECT INCOMING COSMIC RAYS, FOCUSING THEM TO STRIKE THE DRIVE PLATTER AND FLIP THE DESIRED BIT.
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http://www.xkcd.com/378/

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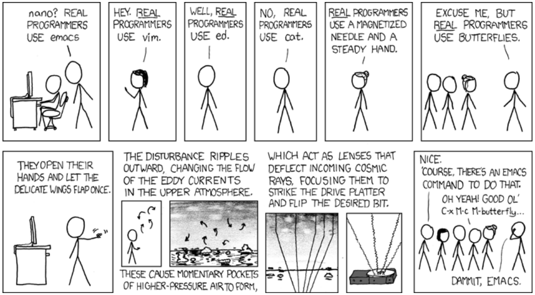
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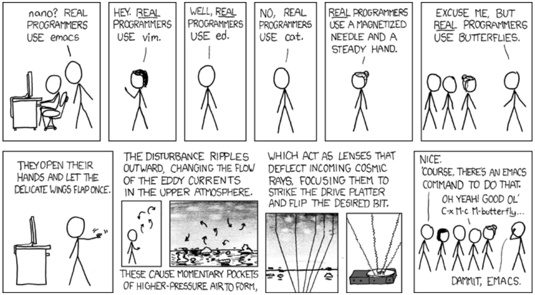
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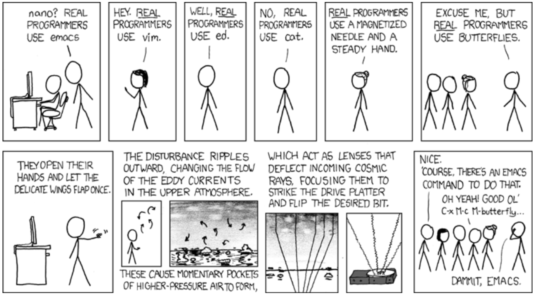
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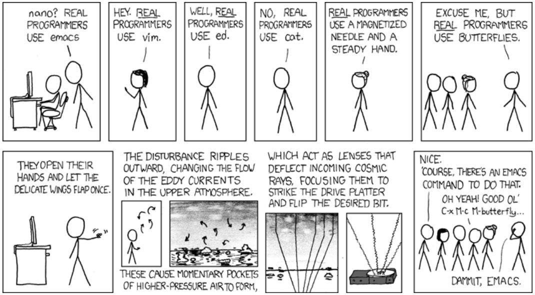
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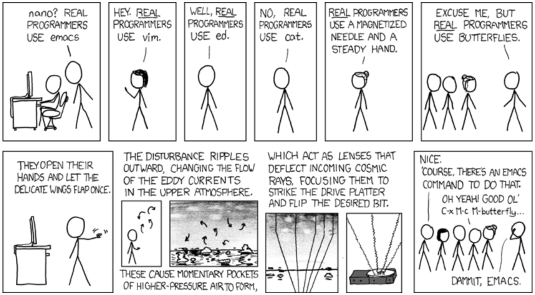
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## Variables (1)

### Definitions – a selection

**Donald Knuth**: A quantity that may possess different values as a program is being executed.
**Mehran Sahami**: A box in which we stuff things – i.e. a box with variable content.
**Wikipedia**: User defined keyword that is linked to a value stored in computer's **memory** (runtime).

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The concept of a **variable** consists of:

- name
- type
- value

## Don’t even think that’s as simple as it sounds . . .

### ‘Hello World’ in Python

```
>>> prnt
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'prnt' is not defined


>>> print

>>> print "Hello
  File "<stdin>", line 1
    print "Hello
               ^
SyntaxError: EOL while scanning string literal


>>> print "Hello Wrld"
Hello Wrld


>>> print "Hello World"
Hello World
```

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```
>>> print "Hello Wrld"
Hello Wrld
```

```
>>> print "Hello World"
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```

### ‘Hello World’ on Shell

```
[glacier:~] grapenthin% ech
ech: Command not found.
```

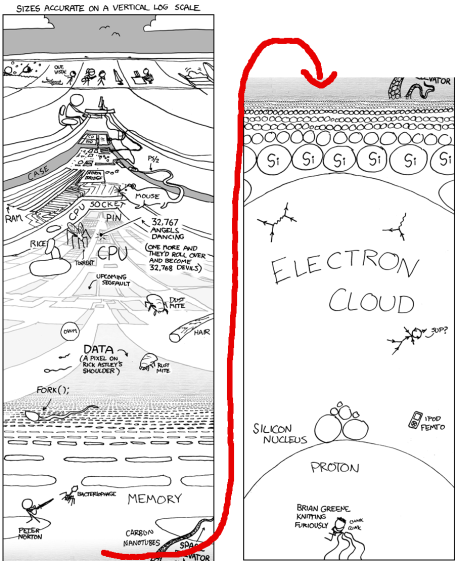
```
[glacier:~] grapenthin% echo
```

```
[glacier:~] grapenthin% echo "Hello
Unmatched ".
```

```
[glacier:~] grapenthin% echo "Hello Wrld"
Hello Wrld
```

```
[glacier:~] grapenthin% echo "Hello World"
Hello World
```

## Memory interlude



“Depth”,
http://xkcd.com/485 (September 16, 2009)

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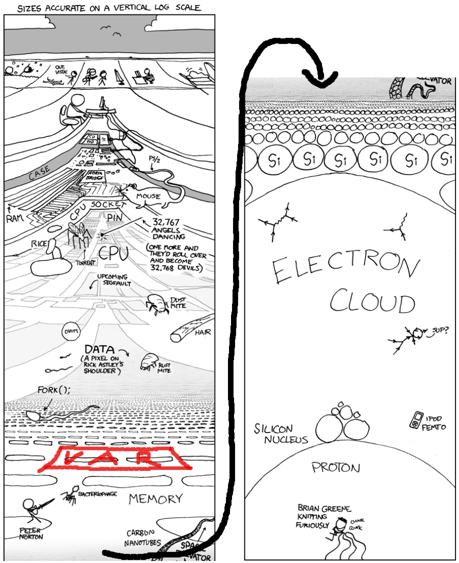

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## Variables (2) – name

USE VALID NAME: follow programming language rules – Python variable names must **begin with a letter**, followed by any **combination of letters, digits, and underscores**. Uppercase different from lowercase. Don't use reserved keywords!

USE MEANINGFUL NAMES, i.e. names that speak:

'`lengthGlacier`' or '`glacier_length`' ... **Don't use** '`a`' – avoid ambiguity (Unless following a paper, textbook)

USE CONSITENT FORMATTING, i.e.: '`my_cool_var`' vs. '`myCoolVar`' –supports reading

Many style guides exist – punchline: use meaningful names, be consistent (that's hard enough)!

## Variables (3) – type

**What is a type?** – Think of sets of numbers in math: $\mathbb{N}, \mathbb{R}, \mathbb{Z}, \ldots$ The type refers to how **values** are being represented in a computer's memory, i.e. the meaning of each bit, and how many bits are necessary

### Two kinds of Types

- primitive, built-in types – for Python e.g.: `'boolean'`, `'int'`, `'float'`, `'complex'` (important for `print` function)
- non-primitive (built-in or self made) – sequences, iterators, classes, ... `https://docs.python.org/2.7/library/stdtypes.html`

### Types in Programming Languages

- some languages, e.g. Python, Shells, Matlab are weakly typed: implicit type conversions (OR one type can be treated as another)
- this is nice at first, occasionally this leads to nasty/hard to fix problems (e.g. string interpreted as number, etc.)

## Variables (4) – value

### Value

- a value of the type of the variable: `23, 3.1415926..., false`
- i.e., the thing we stuff in the box
- can/should change during the runtime of the program, otherwise use a constant (if possible)

### Declaring a variable and Assigning a value:

**In General:** `(type) name = value;` or `(type) name = expression;`

**Python:** `myNewVar=10;` **TC-Shell** (differs) `set myNewVar = 10;`
Access to the values (de-referencing):
**Python:** use `myNewVar;` **TC-Shell** (differs) use '`$`': `$myNewVar`

### What's that?

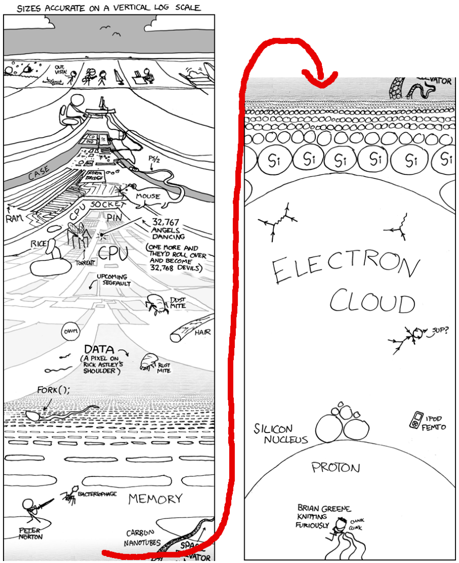
```
myNewVar = myNewVar + 1;
```

## Advanced Variables: Vectors and Matrices (1)

### Array variables

- are lists, vectors, matrices of data (1 to n dimensional – book keeping can become a hassle)
- therefore instead of one value they hold a **list of values**
- linked to a chunk of memory (a sequence of boxes)
- access by index number
- Difference between Python List and Numpy array!
- Shells allow only vectors.

# Memory interlude (2)



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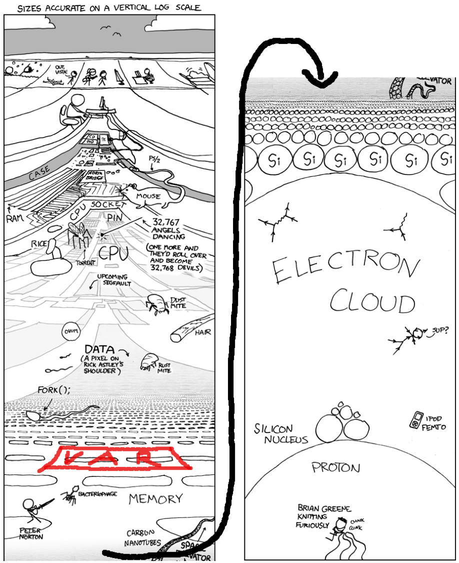

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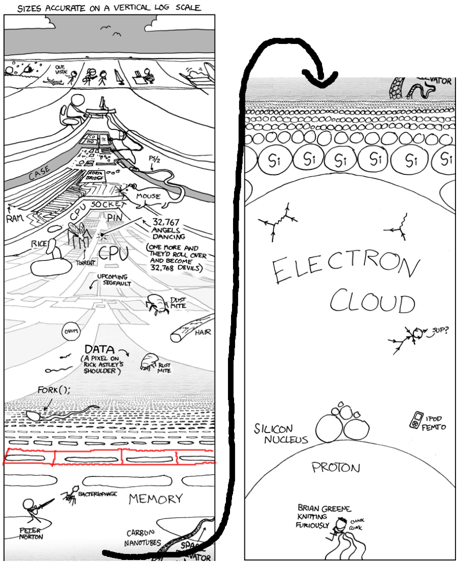

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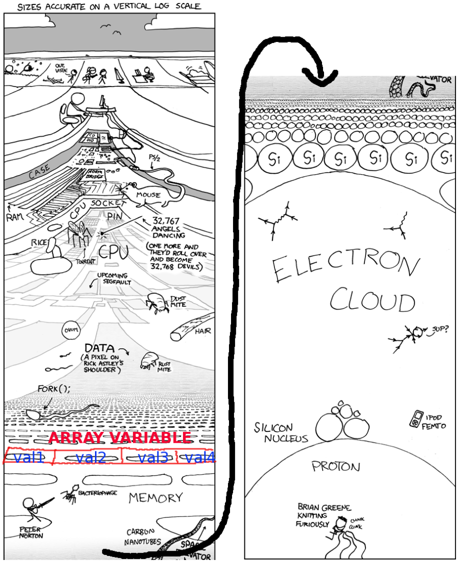

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## Advanced Variables: Vectors and Matrices (2)

### Example: Numeric Vector

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| index: | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| vector: | 12 | 23.3 | 23.3 | nan | nan | 1 | 42 | 42.1 | 23 | 5 | nan | nan | 0 | 0 | 0 |

## Advanced Variables: Vectors and Matrices (2)

### Example: Numeric List

| index: | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| vector: | 12 | 23.3 | 23.3 | nan | nan | 1 | 42 | 42.1 | 23 | 5 | nan | nan | 0 | 0 | 0 |

### Example: String

| index: | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sting: | h | e | l | l | o |  | w | o | r | l | d | ! | ! | ! | ! |

```
>>> x="hello world!!!!"
>>> x(1)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'str' object is not callable
>>> x[1]
'e'
```

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Use logic to connect multiple conditions and test for certain cases (0 is false, 1 is true):

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### Examples

- ‘Friday Beer’ if **not** younger than 21 **and** it is Friday.

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### Examples

- ‘Friday Beer’ if **not** younger than 21 **and** it is Friday.
- ‘Discard data’ if outlier **or** affected by unmodeled processes.