Objectives

- Review algorithms
- Programming in Python
  - Data types
  - Expressions
  - Variables
  - Arithmetic

Review

- What is an algorithm?
- What did we learn from the PB&J demonstration?

Review: Parts of an Algorithm

- Input, Output
- Primitive operations
  - What data you have, what you can do to the data
- Naming
  - Identify things we're using
- Sequence of operations
- Conditionals
  - Handle special cases
- Repetition/Loops
- Subroutines
  - Call, reuse similar techniques

An overview for the semester!

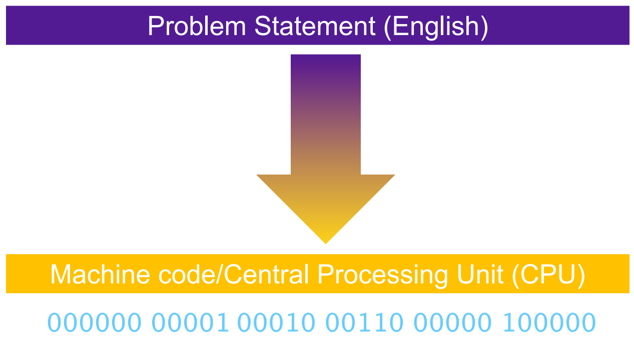
Computational Problem Solving 101

- **Computational Problem:**
  A problem that can be solved by logic
- To solve the problem:
  - Create a **model** of the problem
  - Design an **algorithm** for solving the problem using the model
  - Write a **program** that *implements* the algorithm

Why Do We Need Programming Languages?

- Computers can't understand English
  - Too ambiguous
- Humans can't easily write machine code

Live Jazz!

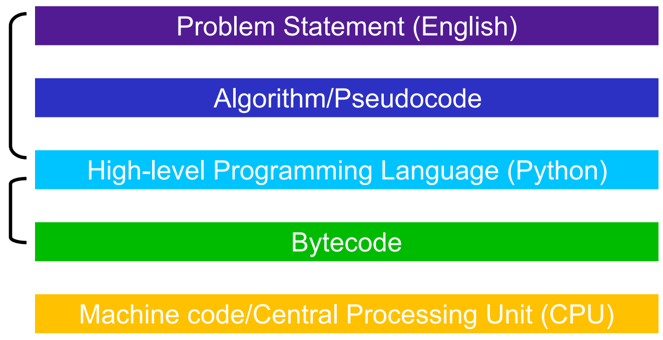

Problem Statement (English)
Machine code/Central Processing Unit (CPU)
000000 00001 00010 00110 00000 100000

Why Do We Need Programming Languages?

- Computers can't understand English
  - Too ambiguous
- Humans can't easily write machine code

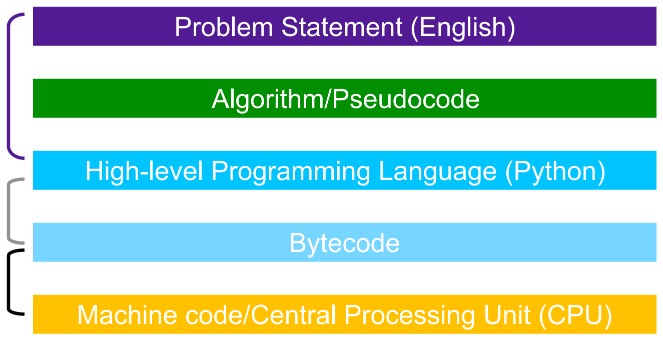
Programmer (YOU!) **translates** from problem to algorithm (solution) to program

Python **interpreter** translates into bytecode


Problem Statement (English)
Algorithm/Pseudocode
High-level Programming Language (Python)
Bytecode
Machine code/Central Processing Unit (CPU)

Why Do We Need Programming Languages?

- Computers can't understand English
  - Too ambiguous
- Humans can't easily write machine code


Problem Statement (English)
Algorithm/Pseudocode
High-level Programming Language (Python)
Bytecode
Machine code/Central Processing Unit (CPU)

Programmer (YOU!) **translates** from problem to *algorithm* (solution) to *program*

Python **interpreter** translates into bytecode

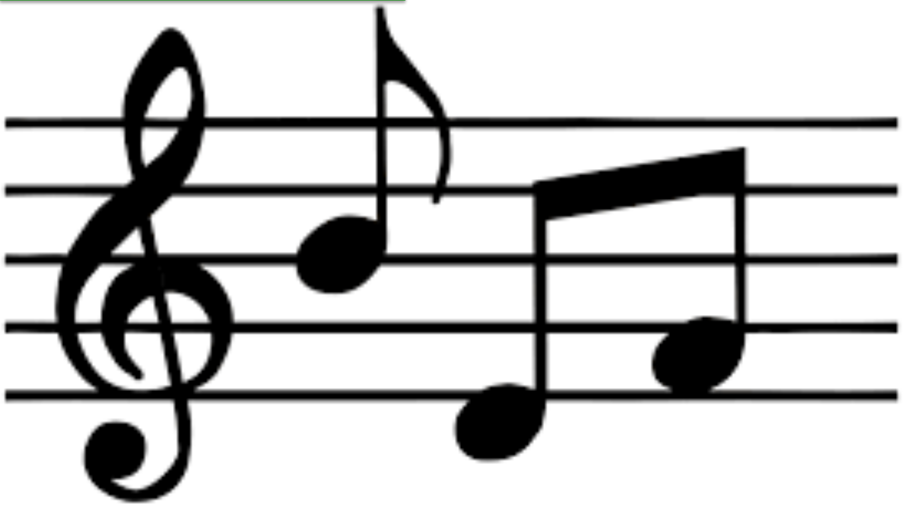
Python **interpreter** executes the bytecode in a "virtual machine"

Programming Languages

- Programming language:
  - Specific rules for what is and isn't allowed
  - Must be exact
  - Computer carries out commands as they are given
- **Syntax**: the symbols given
- **Semantics**: what it means
- Example:
  - III * IV means 3 × 4 which evaluates to 12
- Programming languages are unambiguous

Another Syntax and Semantics Example

What does this syntax mean?



Python Is …

- A ***programming language***
  - 4th most popular programming language, according to Tiobe survey

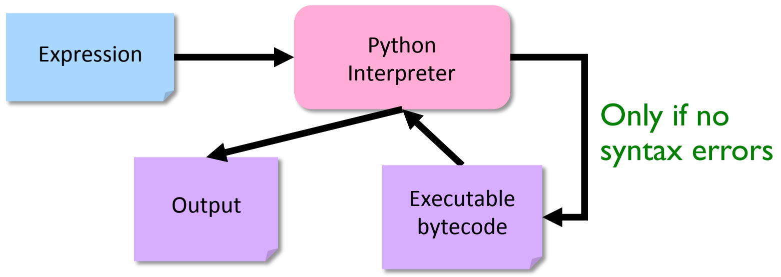
    `http://www.tiobe.com/tiobe-index/`
- An ***interpreter*** (which is a program) that understands and executes Python code

Python Programming Language

- A common *interpreted* programming language
  - Runs on many operating systems
- First released by Guido van Rossum in 1991
- Named after *Monty Python's Flying Circus*
- Minimalist syntax, emphasizes readability
- Flexible, fast, useful language
- Used by scientists, engineers, systems programmers

Python Interpreter

1. Validates Python programming language expression(s)
   - Enforces Python **syntax**
   - Reports **syntax** errors
2. Executes expression(s)
   - Runtime errors (e.g., divide by 0)
   - **Semantic** errors (not what you *meant*)



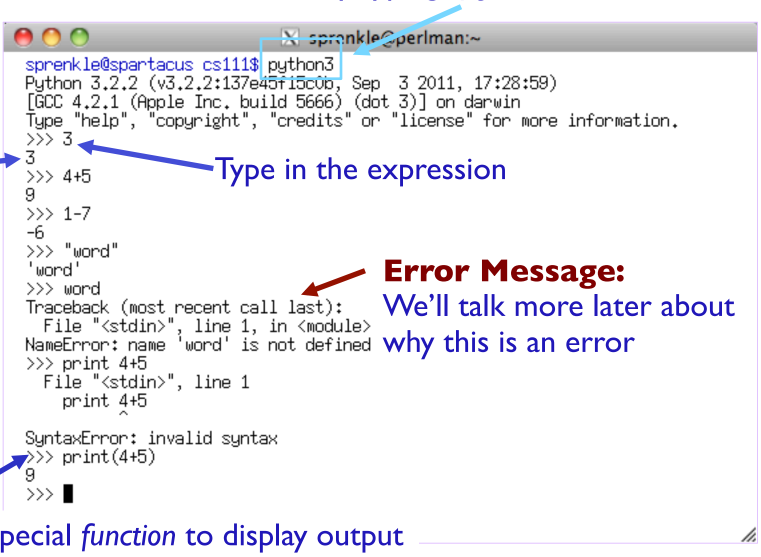
Two Modes to Execute Python Code

- **Interactive**: using the interpreter
  - Try out Python expressions
- **Batch**: execute ***scripts*** (i.e., files containing Python code)
  - What we'll usually write

More on Tuesday in Lab

Interactive Mode

Run by typing "`python3`" in terminal



```
sprenkle@spartacus cs111$ python3
Python 3.2.2 (v3.2.2:137e45f15c0b, Sep  3 2011, 17:28:59)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> 3
3
>>> 4+5
9
>>> 1-7
-6
>>> "word"
'word'
>>> word
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'word' is not defined
>>> print 4+5
  File "<stdin>", line 1
    print 4+5
          ^

SyntaxError: invalid syntax
>>> print(4+5)
9
>>> 
```

Python displays the result

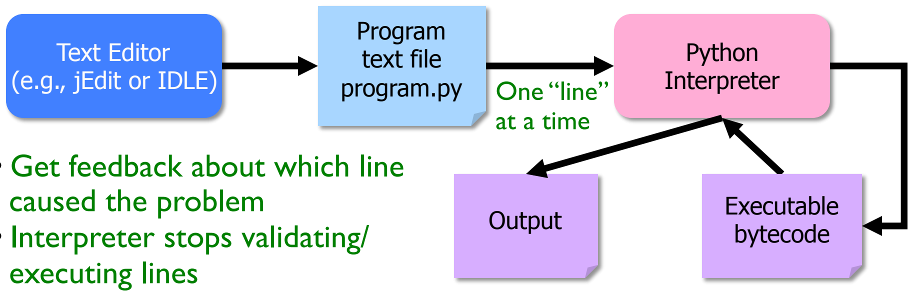
Type in the expression

Error Message:
We'll talk more later about why this is an error

`print`: Special *function* to display output

Batch Mode

1. Programmer types a program/script into a **text editor** (jEdit or IDLE).
2. An interpreter turns each expression into bytecode and then executes each expression



- Get feedback about which line caused the problem
- Interpreter stops validating/ executing lines

Review: Parts of an Algorithm

- Input, **Output**
- Primitive operations
  - What data you have, what you can do to the data
- Naming
  - Identify things we're using
- Sequence of operations
- Conditionals
  - Handle special cases
- Repetition/Loops
- Subroutines
  - Call, reuse similar techniques

Printing Output

- `print` is a special command or a ***function***
  - Displays the result of expression(s) to the terminal
  - Automatically adds a '\n' (carriage return) after it's printed
    - Relevant when have multiple print statements
- $\texttt{print(}\underbrace{\texttt{"Hello, class"}}_{\text{string literal}}\texttt{)}$

Syntax: a set of double quotes
Semantics: represents text

Printing Output

- `print` is a special command
  - Displays the result of expression(s) to the terminal
- $\texttt{print(}\underbrace{\texttt{"Hello, class"}}_{\text{string literal}}\texttt{)}$

`print` automatically adds a `'\n'` (carriage return) after it's printed

- $\texttt{print(}\overbrace{\texttt{"Your answer is"}}^{\text{string literal}}\texttt{, 4*4)}$

Syntax: comma
Semantics: print multiple "things" in one line

Parts of an Algorithm

- Input, Output
- Primitive operations
  - What data you have, what you can do to the data
- Naming
  - Identify things we're using
- Sequence of operations
- Conditionals
  - Handle special cases
- Repetition/Loops
- Subroutines
  - Call, reuse similar techniques

Primitive Data Types

- Primitive data types represent data
  - In PB&J example, our data had **types** slice of bread, PB jar, jelly jar, etc.
- Python provides some basic or ***primitive** data types*
- Broadly, the categories of primitive types are
  - Numeric
  - Boolean
  - Strings

Numeric Primitive Types

Python Data Type	Description	Examples
`int`	Plain integers (32-bit precision)	-214, -2, 0, 2, 100
`float`	Real numbers	.001, -1.234, 1000.1, 0.00, 2.45
`complex`	Imaginary numbers (have real and imaginary part)	1j * 1J → (-1+0j)

How big (or small or precise) can we get?

- Computer cannot represent all values
- Problem: Computer has a **finite** capacity
  - The computer only has so much memory that it can devote to one value.
  - Eventually, reach a cutoff
    - Limits size of value
    - Limits precision of value

PI has more decimals, but we're out of space!

0	0	0	0	0	3	.	1	4	1	5	9	2	6	5

Example: in Python interpreter, .1 + .1 + .1 yields 0.30000000000000004.
* In reality, computers represent data in binary.

Strings: `str`

- Indicated by double quotes " " or single quotes ' '
- Treat what is in the " " or ' ' literally
  - Known as **string literals**
- Examples:
  - "Hello, world!"
  - 'c'
  - "That is Buddy's dog."

Single quote must be inside double quotes*
* Exception later

Booleans: `bool`

- 2 values
  - `True`
  - `False`
- More on these later…

What is the value's type?

Value	Type
`52`	
`-0.01`	
`4+6j`	
`"3.7"`	
`4047583648`	
`True`	
`'false'`	

What is the value's type?

Value	Type
`52`	`int`
`-0.01`	`float`
`4+6j`	`complex`
`"3.7"`	`str`
`4047583648`	`int`
`True`	`boolean`
`'false'`	`str`

Literals

- Pieces of data that are not variables are called ***literals***
  - We've been using these already
- Examples:
  - `4`
  - `3.2`
  - `'q'`
  - `"books"`

Parts of an Algorithm

- Input, Output
- Primitive operations
  - What data you have, what you can do to the data
- Naming
  - Identify things we're using
- Sequence of operations
- Conditionals
  - Handle special cases
- Repetition/Loops
- Subroutines
  - Call, reuse similar techniques

Introduction to Variables

- Variables save data/information
  - Example: first slice of bread or knife A
  - Type of data the variable holds can be any of primitive data types as well as other data types we'll learn about later

- Variables have names, called ***identifiers***

Variable Names/Identifiers

- A variable name (identifier) can be any one word that:
  - Consists of letters, numbers, or _
  - Does *not* start with a number
  - Is not a Python reserved word
    - Examples: `for while def`

- Python is case-sensitive:
  - `change` isn't the same as `Change`

Variable Name Conventions

- **Variables** start with lowercase letter
- Convention: **Constants** (values that won't change) are all capitals
  - (more on this later…)
- Example: Variable for the current year
  - `currentYear`
  - `current_year`
  - `CURRENT_YEAR`
  - ~~`currentyear`~~ Harder to read
  - ~~`current year`~~ No spaces allowed

Naming doesn't matter to computer, matters to humans

Importance of Variable Naming

- Helps you *remember* what the variable represents
- Easier for others to *understand* your program
- Examples:

Info Represented	**Good Variable Name**
A person's first name	`firstName, first_name`
Radius of a circle	`radius`
If someone is employed or not	`isEmployed`

Review: Computational Problem Solving

- **Computational Problem:**
  A problem that can be solved by logic
- To solve the problem:
  - Create a **model** of the problem
  - Design an **algorithm** for solving the problem using the model
  - Write a **program** that *implements* the algorithm

Modeling Information

- How would you ***model*** this information?
- What data type best represents the info?

Info Represented	Data Type	Variable Name
A person's salary		
Sales tax		
If item is taxable		
Course name		
Graduation Year		

Modeling Information

- How would you ***model*** this information?
- What data type best represents the info?

Info Represented	Data Type	Variable Name
A person's salary	int or float	`salary`
Sales tax	float	`salesTax`
If item is taxable	boolean	`isTaxable`
Course name	str	`course_name`
Graduation Year	int	`gradYear`

Variable names are just suggestions,
Many other possible variable names

Assignment Statements

- Variables can be given any value using **=**
  - **Syntax**: `<variable> = <expression>`
  - **Semantics**: `<variable>` is set to value of `<expression>`
- After a variable is set to a value, the variable is said to be ***initialized***
- Examples:

```
month = 1
impt_num = 4.5
monthName = 'January'
```

These are **not** equations!
Read "=" as "is set to"

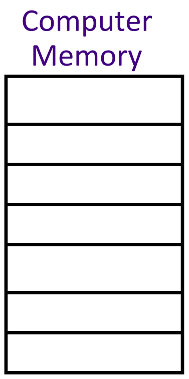
Variables: The Rules

- Only the variable(s) to **left** of the = in the current statement change
  - ➢ We'll usually only have one variable on the left

- **Initialize** a variable **before** using it on the right-hand side (rhs) of a statement

Assignment Statements

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

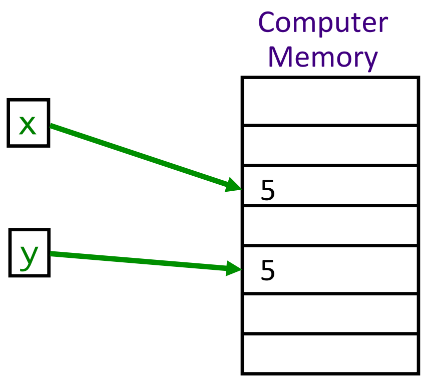


- Statements execute in order, from top to bottom
- Value of **x** does not change because of second assignment statement

Assignment Statements

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

Does a "lookup" in memory to find value of x



- Statements execute in order, from top to bottom
- Value of **x** does not change because of second assignment statement

Numeric Arithmetic Operations

Symbol	Meaning
+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Remainder ("mod")
**	Exponentiation (power)

Arithmetic & Assignment

- You can use the assignment operator (=) and arithmetic operators to do calculations
  1. Calculate right hand side
  2. Assign value to variable
- Remember your order of operations! (PEMDAS)
- Examples:

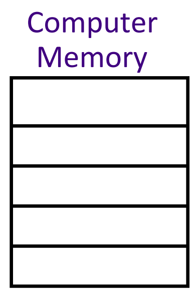
```
x = 4+3*10
y = 3/2.0
z = x+y
```

The right-hand sides are ***expressions***, just like in math.

Arithmetic & Assignment

- Examples:

```
x = 4+3*10
y = 3/2.0
z = x+y
```

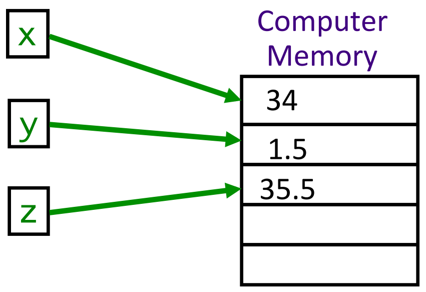


- For last statement
  - need to "lookup" values of x and y
  - computer remembers the result of the expression, not the expression itself

Arithmetic & Assignment

- Examples:

```
x = 4+3*10
y = 3/2.0
z = x+y
```



- For last statement
  - need to "lookup" values of x and y
  - computer remembers the result of the expression, not the expression itself

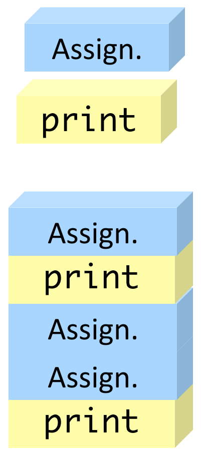
What are the values?

- After executing the following statements, what are the values of each variable?
  - `r = 5`
  - `s = -1 + r`
  - `t = r + s`
  - `s = 2`
  - `r = -7`

How can we verify our answers?

Programming Building Blocks

- Each type of statement is a building block
  - Initialization/Assignment
    - So far: Arithmetic
  - Print
- We can combine them to create more complex programs
  - Solutions to problems



Broader Issue Groups

Introduce yourselves!

Andrew Anna Joseph Lizzie Parker	Ben Ian Jordan Olivia Ryan	Alison Davis Lindsey Mary-Frances Rachel	Chas Chase Findley Kalady Nate	Harris Mac Margaret Robert

Broader CS Issues

- Good summaries!
  - Good English, complete sentences
- Good, thoughtful questions
- Mechanics details
  - Follow instructions on BI Forum about what summary should contain
  - Should be able to edit your own posts
  - Characters from Word
    - Click button "Paste from Word"
    - Don't attach Word documents

"Really?" with Professor Sprenkle

- In *TV Guide*, showrunners of *Once Upon a Time* were asked, "Give us an algorithm for your show."

“Really?” with Professor Sprenkle

- In *TV Guide*, showrunners of *Once Upon a Time* were asked, “Give us an algorithm for your show.”
  - Example (for 1st season): 1 part Snow White + 1 part *Lost* + .5 *Alias*
- They said, “We don’t understand math. That’s why we became writers.”

AI Everywhere

- “An algorithm is, essentially, a brainless way of doing clever things… Brainlessness, in other words, is no impediment to intelligence. ”
- What are examples of algorithms that you do every day?
- What is AI (which is based on algorithms) useful for?
  - What aren’t algorithms useful for?
- What would be some useful algorithms, specific to W&L students?
  - What are problems that are difficult—but useful—to solve?

Extra Credit Opportunities

- Read an article that relates to CS
- Summarize it on the forum under “Extra Credit”
  - 5 pts extra credit on lab grade

Looking Ahead

- Pre-lab assignment due before lab on Tuesday