YSC2221-1 INTRODUCTION TO PYTHON (GROUP 1)

INFORMATION ABOUT THIS COURSE

Your Lecturer

- CHENG, Ho Lun, Alan, 鄭浩璘
  - Hong Kong
  - UIUC, Duke (USA)
- Hobbies:
  - Teaching
  - 3G: Graphics, Geometry, Games
  - Animation, anime, comics, movies, etc.
- Email:
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  - DO NOT send to `dcschl`
  - DO NOT send codes to me
  - Office: AS6 #05-03
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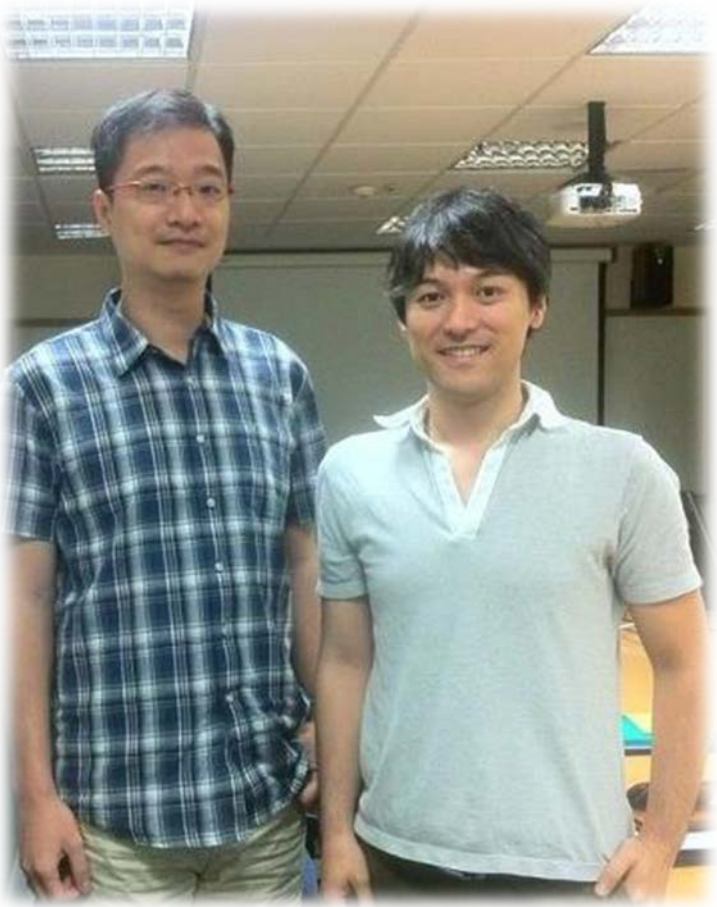


My Other courses

- CS3241 Computer Graphics
- CS4235 Game Development Projects
- CS2020 Data Structure and Algorithm (Accel)
- CS5237 Computational Geometry

Something about yourself

- Where are you from
- What's your major
- Something interesting about yourself
  - or
- What do you want to use Python for

Syllabus

Week 1: Introduction to Python

Week 2: Simple functions and debugging

Week 3: More on functions and Program designs

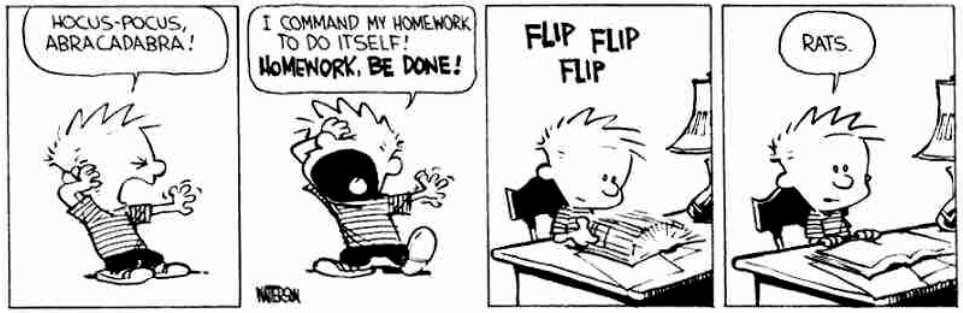
Week 4: Sequences and File I/O

Week 5: Data Visualization and Multi-dimensional Array

Week 6: More Packages

CA

- Lab/homework 30%
  - = 5 x 6%
  - Weekly
- Written Quiz 20%
  - 30th Aug
- Practical test 20%
  - Last Lecture
- Take home exam 30%
  - After all lectures



Today

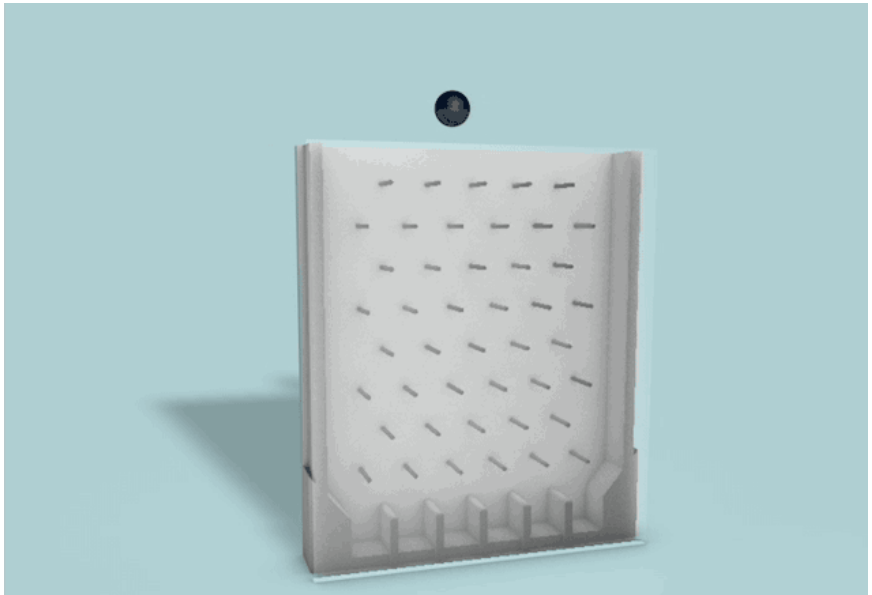
- What is programming about?
- Why Python?

What is programming?

Imagine

Running a Booth

- Dropping a ball from the top and you will get
  - 3: Big prize
  - 2: Medium prize
  - 1: Small prize

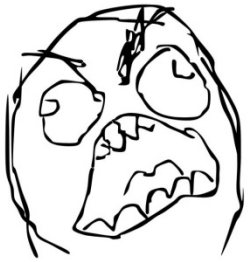


Let's see what we have for prizes

- Giant Teddy Bears
  - X 10

- Water guns
  - X 50

- Candy
  - X 200



Your Job is

- Run the booth until the end of the day or all prizes given out
  - 3: Giant Teddy Bear
  - 2: Water Gun
  - 1: Candy
- What is the potential problem?
- You may run out of Teddy Bears!
  - Or Water guns or candies
- Any suggestion?

Version 1

Let him play the Plinko

If someone strikes a “3”

- Give him a bear

If someone strikes a “2”

- Give him a water gun

If someone strikes a “1”

- Give him one pathetic candy

Version 1.1

Let him play the Plinko

If someone strikes a “3”

- If we have bears
  - Give him a bear

If someone strikes a “2”

- If we have water guns
  - Give him a water gun

If someone strikes a “1”

- If we have candies
  - Give him one pathetic candy

Version 1.2

Let him play the Plinko

If someone strikes a “3”

- If we have bears
  - Give him a bear
- Otherwise
  - Give him a water gun

If someone strikes a “2”

- If we have water guns
  - Give him a water gun

If someone strikes a “1”

- If we have candies
  - Give him one pathetic candy

Version 1.3

Let him play the Plinko

If someone strikes a “3”

- If we have bears
  - Give him a bear
- Otherwise if we have water guns
  - Give him a water gun
- Otherwise
  - Give him a pathetic candy

If someone strikes a “2”

- If we have water guns
  - Give him a water gun

If someone strikes a “1”

- If we have candies
  - Give him one pathetic candy

Version 2

While we have prizes left, we do the following:

Let someone play the Plinko
If he strikes a “3”
    If we have bears
        Give him a bear
    Otherwise let him choose any prize
If someone strikes a “2”
    If we have water guns
        Give him a water gun
    Otherwise give him a candy
If someone strikes a “1”
    If we have candies
        Give him one pathetic candy
    Otherwise, sorry, you don’t even have a pathetic candy

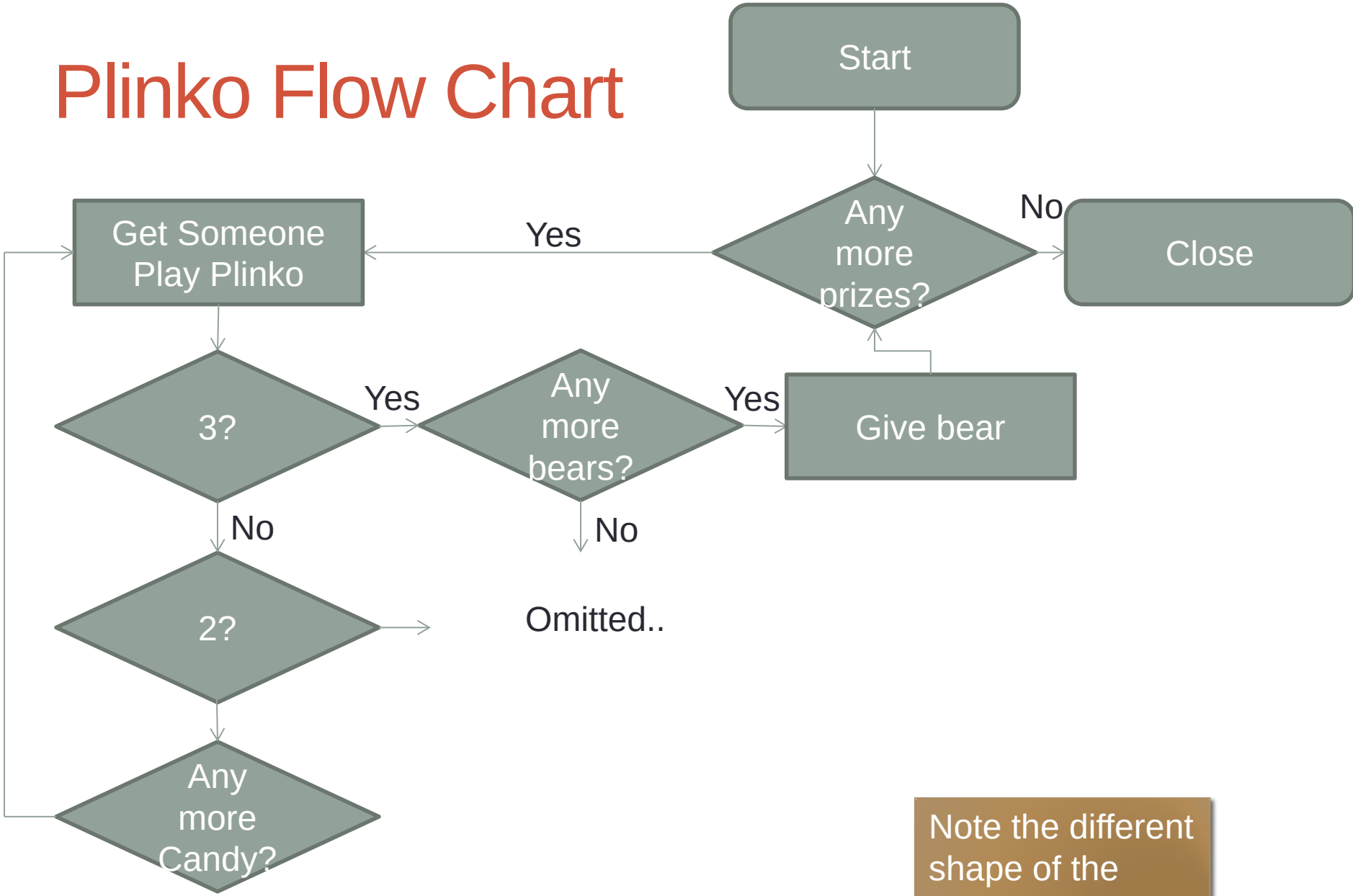
This is called **pseudocode**

But still not perfect

Before Real Coding

- A Program can be expressed by
  - **Pseudocode**
    - An artificial and informal language that helps programmers develop algorithms.
    - "text-based“
  - Or A **Flow Chart**

Plinko Flow Chart



Note the different shape of the bubbles

Choose Your Own Adventure

From Wikipedia, the free encyclopedia

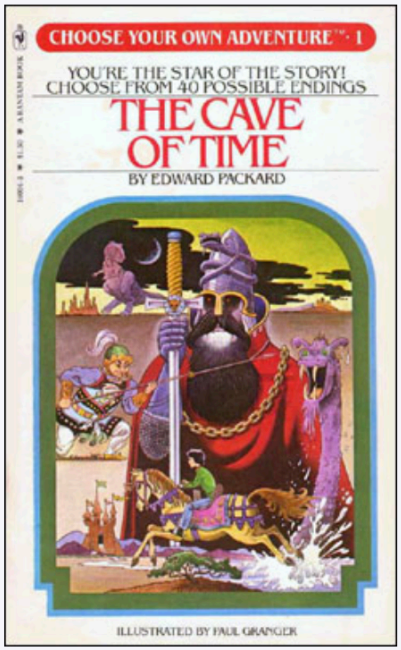
This article is about the trademarked book series. For the genre, see Gamebook. For the TV series, see Lawrence Leung's Choose Your Own Adventure.

Choose Your Own Adventure is a series of children's gamebooks where each story is written from a second-person point of view, with the reader assuming the role of the protagonist and making choices that determine the main character's actions and the plot's outcome. The series was based upon a concept created by Edward Packard and originally published by Constance Cappel's and R. A. Montgomery's Vermont Crossroads Press as the "Adventures of You" series, starting with Packard's *Sugarcane Island* in 1976.[1]

Choose Your Own Adventure, as published by Bantam Books, was one of the most popular children's series during the 1980s and 1990s, selling more than 250 million copies between 1979 and 1998.[2] When Bantam, now owned by Random House, allowed the *Choose Your Own Adventure* trademark to lapse, the series was relaunched by Chooseco, which now owns the trademark. Chooseco does not reissue titles by Packard, who has started his own imprint, U-Ventures.[3]

Contents [hide]

Choose Your Own Adventure



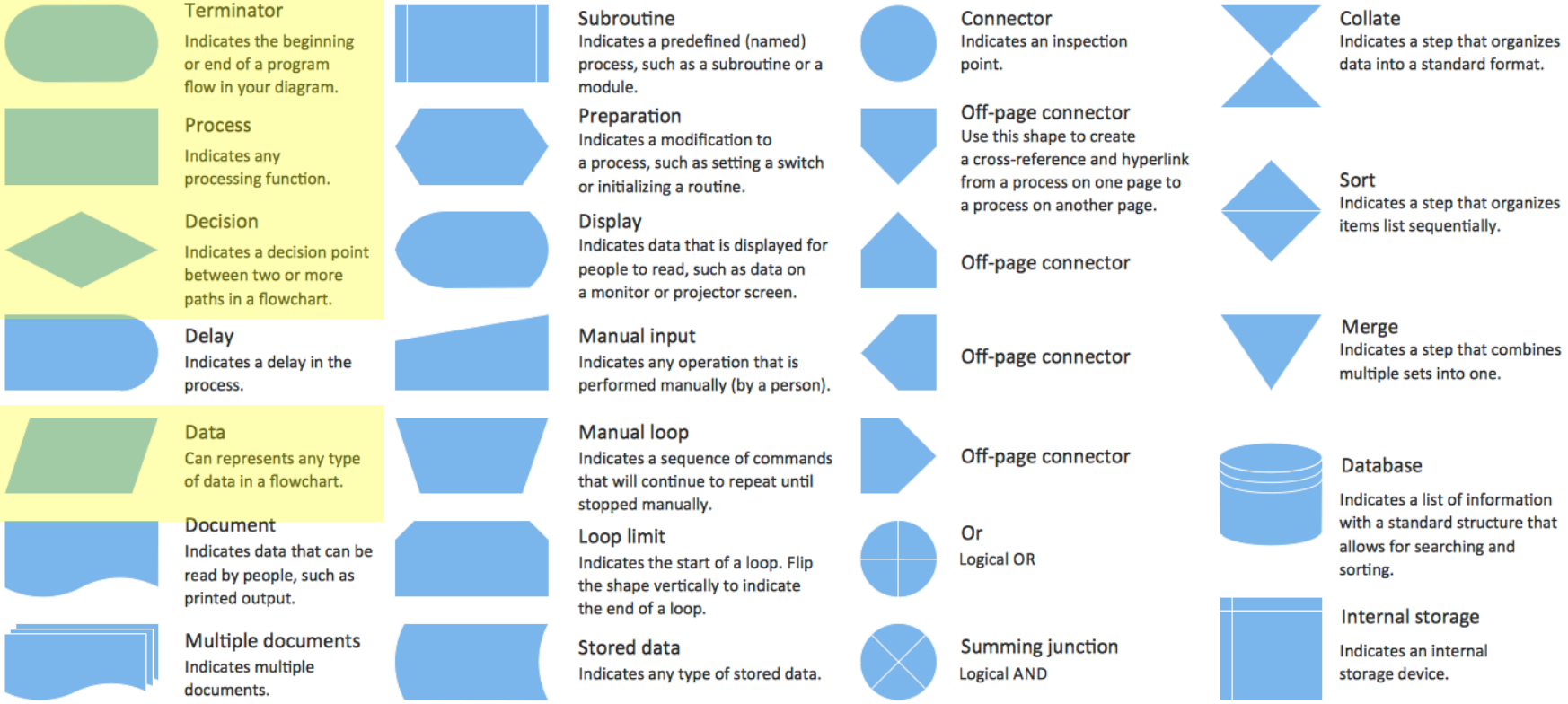
The Cave of Time by Edward Packard, the first book in the series

Cover artist	Paul Granger
Language	English

Format [edit]

Originally created for 7- to 14-year-olds, the books are written in the second person. The protagonist—that is, the reader—takes on a role relevant to the adventure; for example, private investigator, mountain climber, race car driver, doctor, or spy. Stories are generally gender and race neutral, though in some cases, particularly in illustrations, presumption of a male

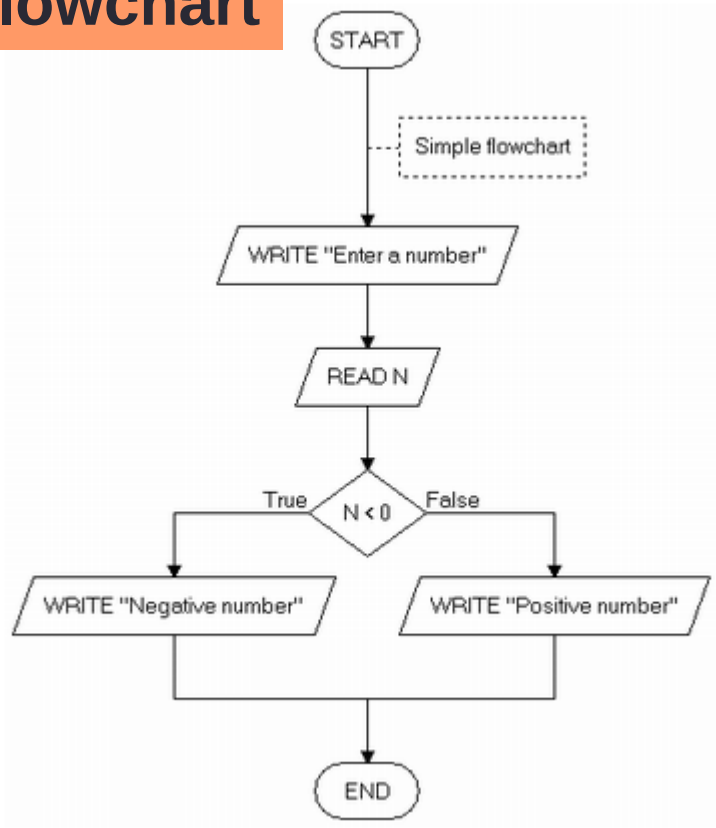
Flow Chart Bubble Types



Algorithm

- Ways of representing an algorithm:

Flowchart



Pseudocode

PSEUDOCODE

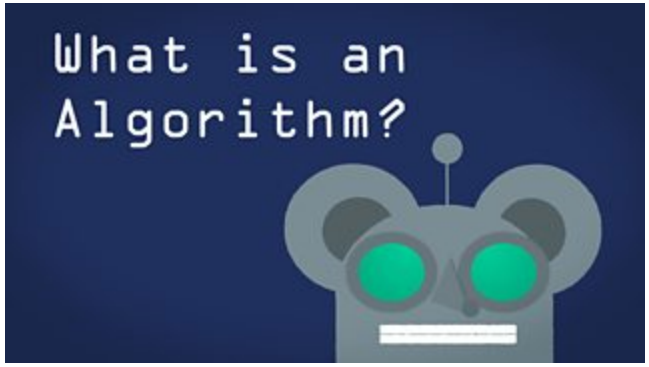
```
set total to zero

get list of numbers

loop through each number in the list
   add each number to total
end loop

if number more than zero
   print "it's positive" message
else
   print "it's zero or less" message
end if
```

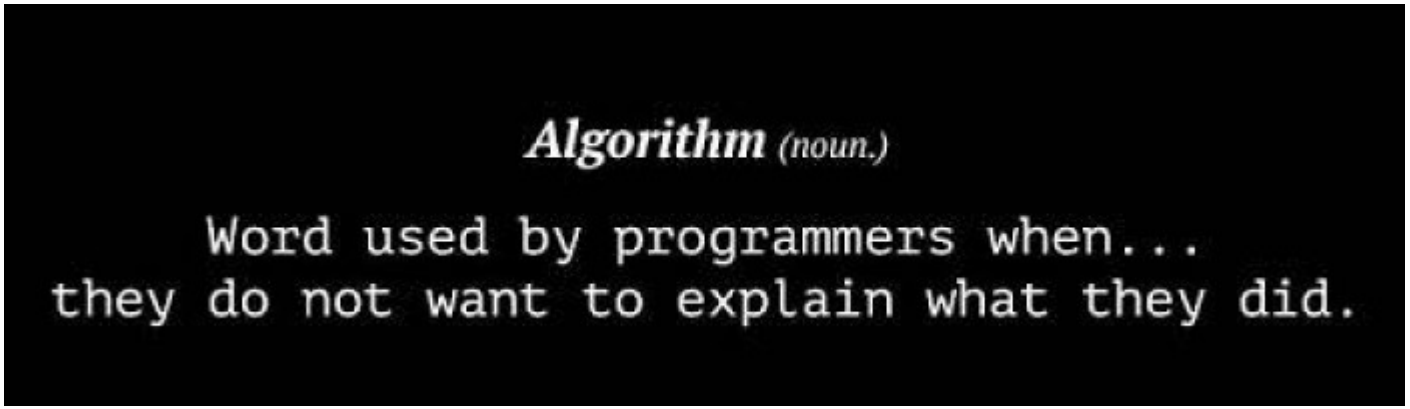
lynda.com

Algorithms

- Named for al-Khwārizmī (780-850)
  - Persian mathematician

- Many ancient algorithms
  - Multiplication: Rhind Papyrus
    - Babylon and Egypt: ~1800BC
  - Euclidean Algorithm: Elements
    - Greece: ~300BC
  - Sieve of Eratosthenes
    - Greece: ~200BC


What is an
Algorithm?


Algorithm (noun.)
Word used by programmers when...
they do not want to explain what they did.

Algorithm (1/3)

- An **algorithm** is a well-defined computational procedure consisting of *a set of instructions*, that takes some value or set of values as *input*, and produces some value or set of values as *output.*

'Algorithm' stems from 'Algoritmi', the Latin form of al-Khwārizmī, a Persian mathematician, astronomer and geographer.
Source: http://en.wikipedia.org/wiki/Algorithm

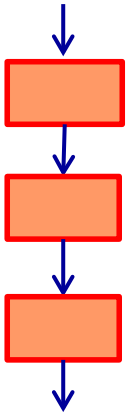
Control Structures

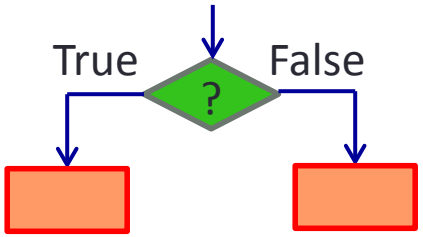
- An algorithm is a set of instructions, which are followed sequentially by default.
- However, sometimes we need to change the default sequential flow.
- We study 3 control structures.

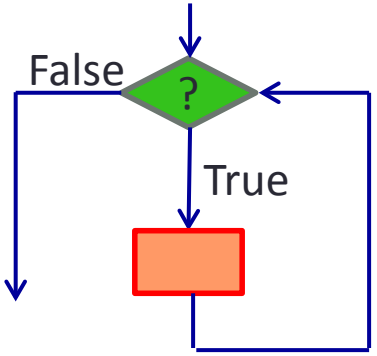
CONTROL STRUCTURES

Control Structures

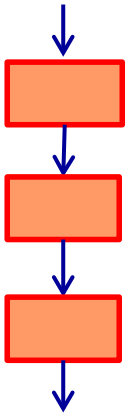
Sequence	• Default
Selection	• Also called branching
Repetition	• Also called loop







Control Structure: Sequence

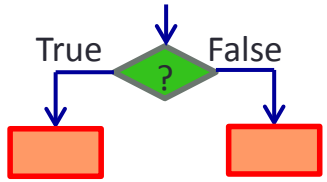


Method 1 Making Vanilla Pound Cake

1. Gather your ingredients. Pound cake is one of the simplest cakes to bake. ...
2. Preheat the oven to 325 degrees.
3. Grease a cake pan. ...
4. Cream the butter and sugar. ...
5. Add the eggs and vanilla. ...
6. Stir in the cake flour. ...
7. Pour the batter into the pan. ..
8. Bake the cake for an hour and 15 minutes.

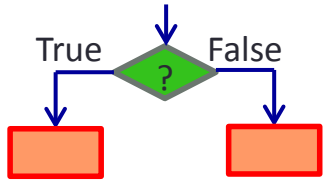
4 Ways to Bake a Cake - wikiHow
www.wikihow.com/**Bake-a-Cake**

Control Structure: Selection



- If the player strikes a “3”
  - Give him a bear
- Else
  - Let him choose a water gun or a candy

Control Structure: Selection



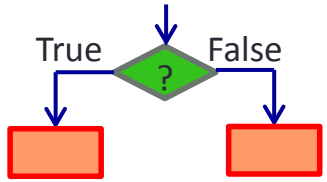

```
If (a condition is true)
  Do A
Else
  Do B
```

Can be MORE THAN one single instruction

- For example:

```
If (I have $1000000000000000)
  Buy a car
  Eat a lot of buffets
  Go travel
  Quit NUS!
Else
  Be good and study
```

Control Structure: Selection




```
If (a condition is true)
  Do A
Else
  Do B
```

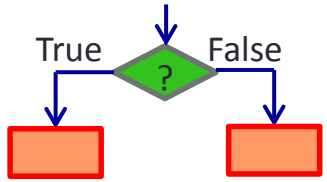
Can be MORE THAN one single instruction

- For example:

```
If (I have $1000000000000000)
  If (I am heartless)
    Buy a car
    Eat a lot of buffets
    Go travel
    Quit NUS!
  Else
       donate all the money to charity
Else
  Be good and study
```

Nested “if”

Control Structure: Selection



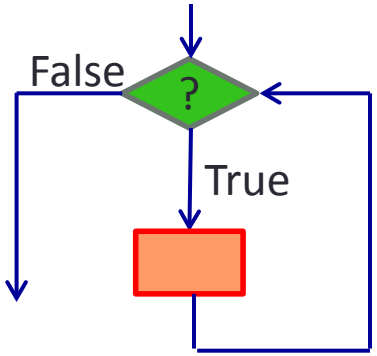

```
If (a condition is true)
  Do A
Else
  Do B
```

Can be **WITHOUT** “else”

- For example:

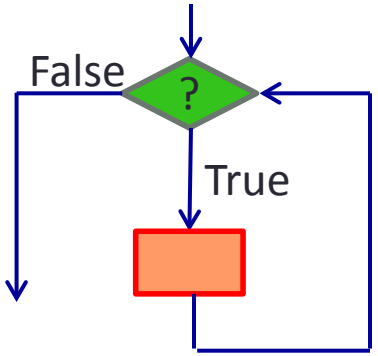
```
If (I have $1000000000000000)
  Buy a car
  Eat a lot of buffets
  Go travel
  Quit NUS!
Else
  Be good and study
```

Control Structure: Repetition



- While there are prizes left
  - Play Plinko and give prizes

Control Structure: Repetition



- While (a condition)
  - Do something

- For example

```
While (I am hungry)
  Eat a bun
```

- Again, can be more than one single instruction

```
While(I have money in bank)
  Take some money out from bank
  Eat an expensive meal
  While(I have money in my wallet)
    Go Shopping
```

Example: Scrabble

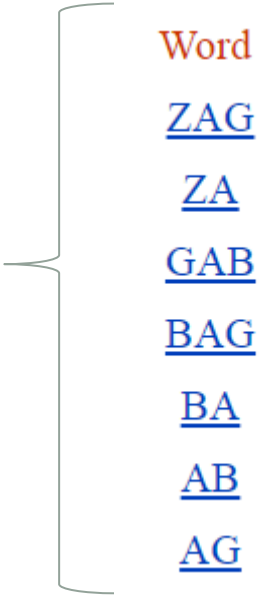
- Let’s say you have four letters in your hands:
  - ‘B’, ‘A’, ‘G’ and ‘Z’
- With points
  - B = 3, A = 1, G = 2, Z = 10
- Assuming I can place any of them on the board
- How do I come up with a valid English word that maximize my points?
- Any ideas?

Layer 1

- Find out every combinations of words formed by the letters
- Calculate the score for every combination and choose the largest one

Layer 1 in Pseudo Code

- For every combination w of { ‘B’, ‘A’, ‘G’, ‘Z’ }
- How?
- Let’s skip it first, assuming we can compute all of the “valid” words in the dictionary, i.e.
  - From scrabblecheat.com
- Let’s store these words in a set called S



Layer 1 in Pseudo Code

- Calculate the score for every word w in the set S
- Choose the largest score

Value	Word
13	ZAG
11	ZA
6	GAB
6	BAG
4	BA
4	AB
3	AG

Layer 2 Pseudo Code

- Let x be any word in S (say the first one)
- And s = the score of x
  - In which, later, I assume s stores the maximum score so far, and x is the word with that score
- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

Layer 2 Pseudo Code

- Let x be any word in S (say the first one)
- And s = the score of x
  - In which, later, I assume s stores the maximum score so far, and x is the word with that score

w	n	x	s
		AG	3

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		AG	3
AG	3	AG	3
AB			
BAG			
GAB			
BA			
ZAG			
ZA			

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		AG	3
AG	3	~~AG~~	~~3~~
AB	4	AB	4
BAG			
GAB			
BA			
ZAG			
ZA			

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		~~AG~~	~~3~~
AG	3	~~AG~~	~~3~~
AB	4	~~AB~~	~~4~~
BAG	6	BAG	6
GAB			
BA			
ZAG			
ZA			

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		~~AG~~	~~3~~
AG	3	~~AG~~	~~3~~
AB	4	~~AB~~	~~4~~
BAG	6	BAG	6
GAB	6	BAG	6
BA			
ZAG			
ZA			

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		~~AG~~	~~3~~
AG	3	~~AG~~	~~3~~
AB	4	~~AB~~	~~4~~
BAG	6	BAG	6
GAB	6	BAG	6
BA	4	BAG	6
ZAG			
ZA			

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		~~AG~~	~~3~~
AG	3	~~AG~~	~~3~~
AB	4	~~AB~~	~~4~~
BAG	6	~~BAG~~	~~6~~
GAB	6	~~BAG~~	~~6~~
BA	4	~~BAG~~	~~6~~
ZAG	13	ZAG	13
ZA			

Layer 2 Pseudo Code

- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

w	n	x	s
		~~AG~~	~~3~~
AG	3	~~AG~~	~~3~~
AB	4	~~AB~~	~~4~~
BAG	6	~~BAG~~	~~6~~
GAB	6	~~BAG~~	~~6~~
BA	4	~~BAG~~	~~6~~
ZAG	13	ZAG	13
ZA	11	ZAG	13

Layer 2 Pseudo Code

- Final answer lies in x and s
  - The word is “ZAG” with a score of 13

w	n	x	s
		~~AG~~	~~3~~
AG	3	~~AG~~	~~3~~
AB	4	~~AB~~	~~4~~
BAG	6	~~BAG~~	~~6~~
GAB	6	~~BAG~~	~~6~~
BA	4	~~BAG~~	~~6~~
ZAG	13	ZAG	13
ZA	11	ZAG	13

How do we generate S?

- Let x be any word in S (say the first one)
- And s = the score of x
  - In which, later, I assume s stores the maximum score so far, and x is the word with that score
- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

Let's leave it for now

Does it Work for Other Sets of Letters?

- Let x be any word in S (say the first one)
- And s = the score of x
  - In which, later, I assume s stores the maximum score so far, and x is the word with that score
- For every combination w in S
  - Calculate the score for w, and store this score in a number n
  - if n > s
    - replace s by n and replace x by w

Yes! If we can generate the set S

What is the difference between

Algorithm vs Program

- Algorithm
  - Ideas
  - Machine independent
- Program
  - The final code on a machine
  - Machine dependent

Research Idea vs Thesis

- Research Idea
  - Can be drawings, sketches, concepts, in any languages
- Thesis
  - Well-written documents in any languages, English, German, Chinese, etc…

Programming Languages History

- https://james-iry.blogspot.sg/2009/05/brief-incomplete-and-mostly-wrong.html

ONE DIV ZERO

AN EXPLORATION OF SOFTWARE DEVELOPMENT.

THURSDAY, MAY 7, 2009

A Brief, Incomplete, and Mostly Wrong History of Programming Languages

1801 - Joseph Marie Jacquard uses punch cards to instruct a loom to weave "hello, world" into a tapestry. Redditers of the time are not impressed due to the lack of tail call recursion, concurrency, or proper capitalization.

1842 - Ada Lovelace writes the first program. She is hampered in her efforts by the minor inconvenience that she doesn't have any actual computers to run her code. Enterprise architects will later relearn her techniques in order to program in UML.

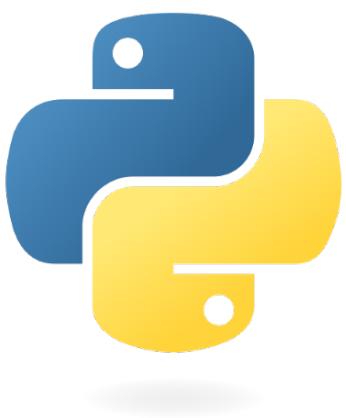
1936 - Alan Turing invents every programming language that will ever

ABOUT ME

JAMES IRY

SAN FRANCISCO, CA, UNITED STATES

AN OVERVIEW OF



python™

Why are we learning Python?

- Clear and readable syntax
- Intuitive
- Natural expression
- Powerful
- Popular & Relevant

- Example: Paypal
  - ASF XML Serialization
    - C++
      - 1580 lines
    - Python
      - 130 lines

Who uses Python?

- Google
- Red Hat
- Dropbox
- Rackspace
- Twitter
- Facebook
- Raspberry Pi
- NASA
- CERN
- ITA
- Yahoo!
- Walt Disney
- IBM
- Reddit
- YouTube

Python Program without Learning

```
a = 1
b = 2
c = a + b
if c < 0:
      print('Yes')
else:
      print('No')
```

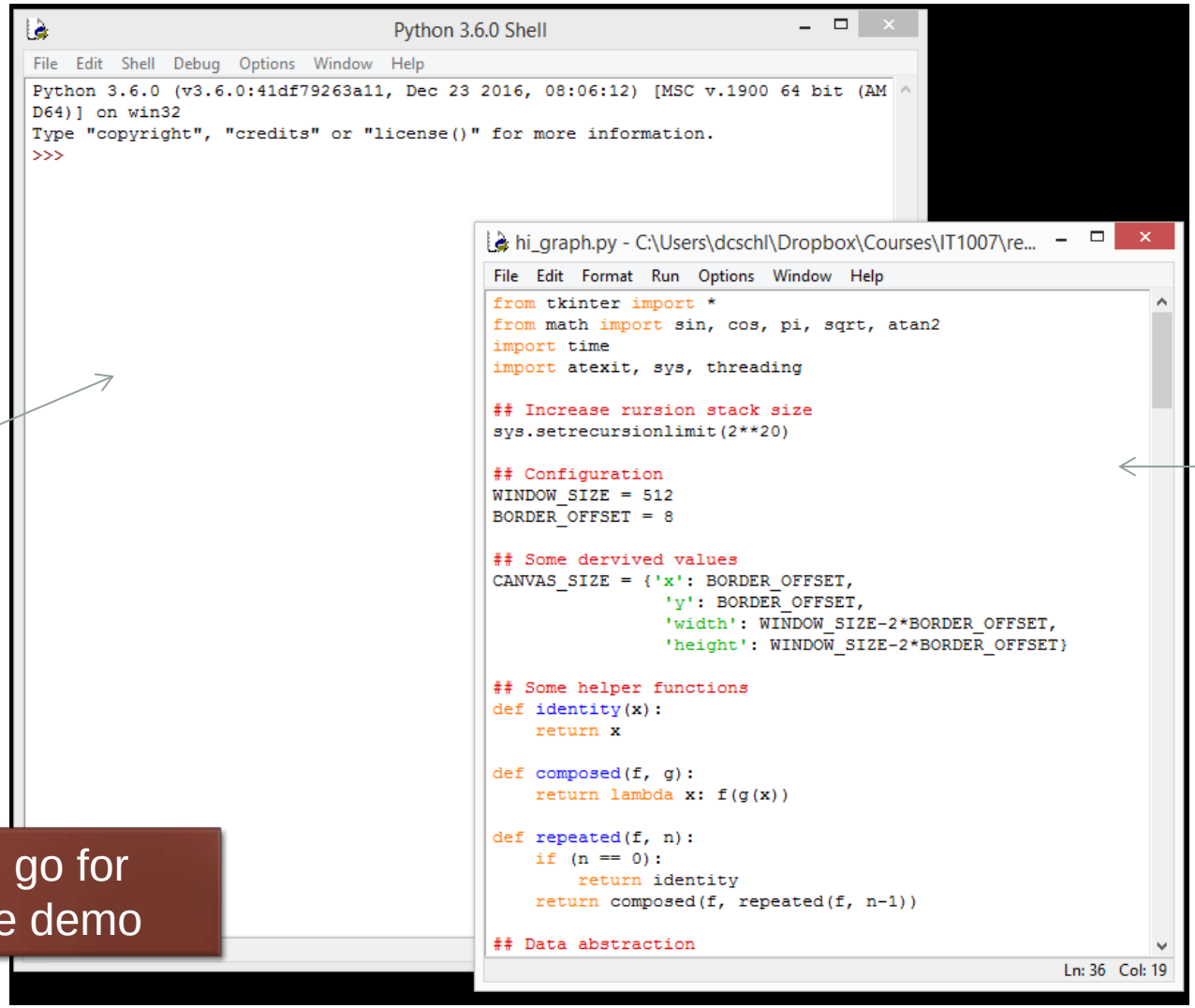
Intuitive!

The Environment: IDLE

- We use **IDLE** as an IDE
  - IDE: Integrated development environment
    - Meaning you can edit your program, run and debug it
    - Many different IDEs for different languages

- IDLE stands for
  - Integrated development and learning environment

A Screenshot of IDLE



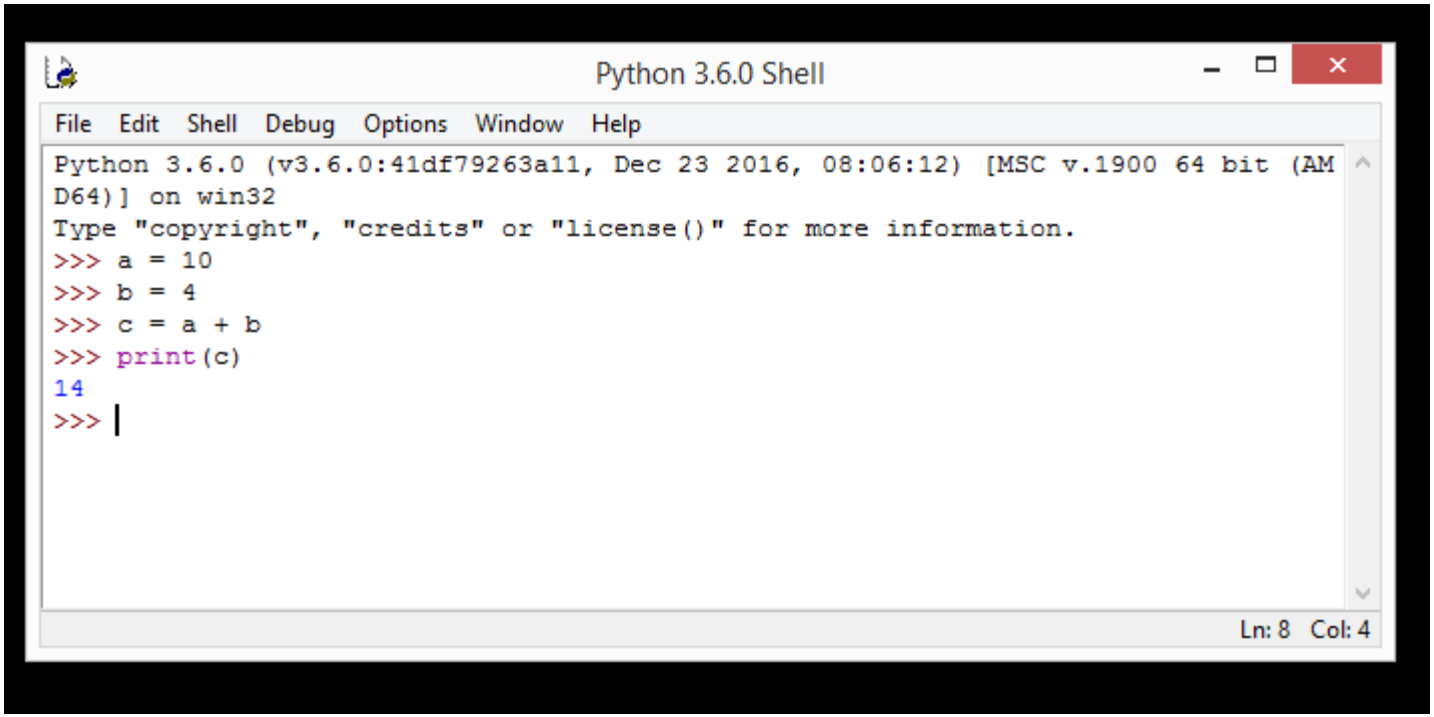
Console
- Input
- output

Editor and Your program

Let's go for some demo

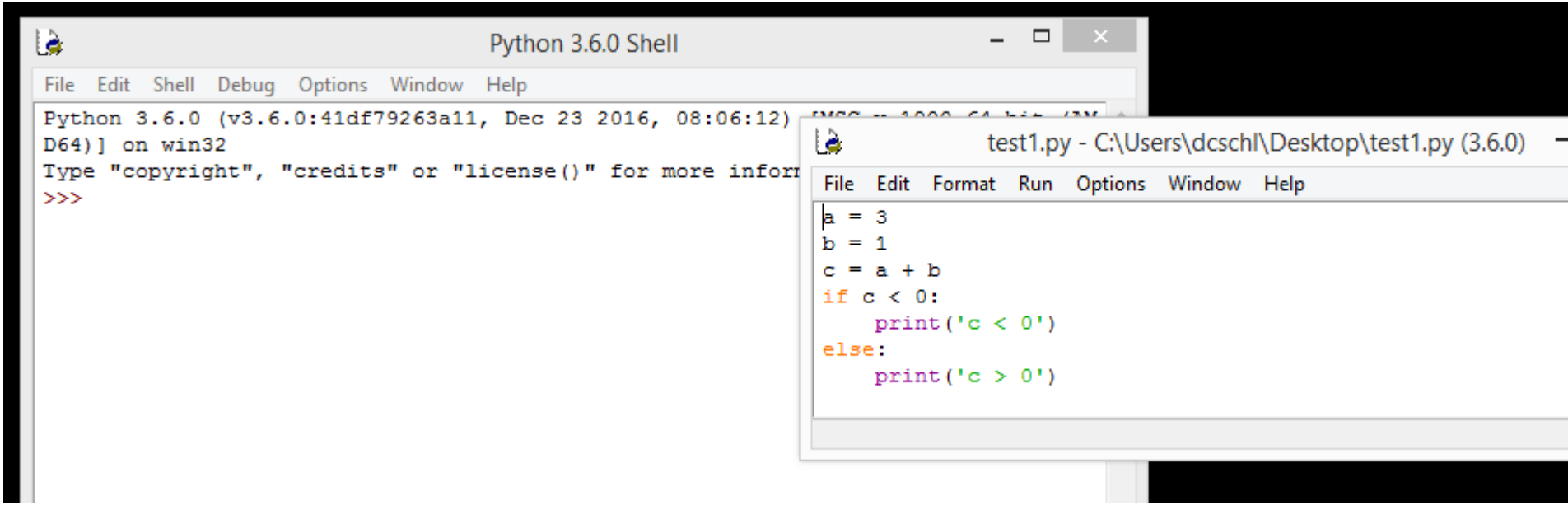
You can

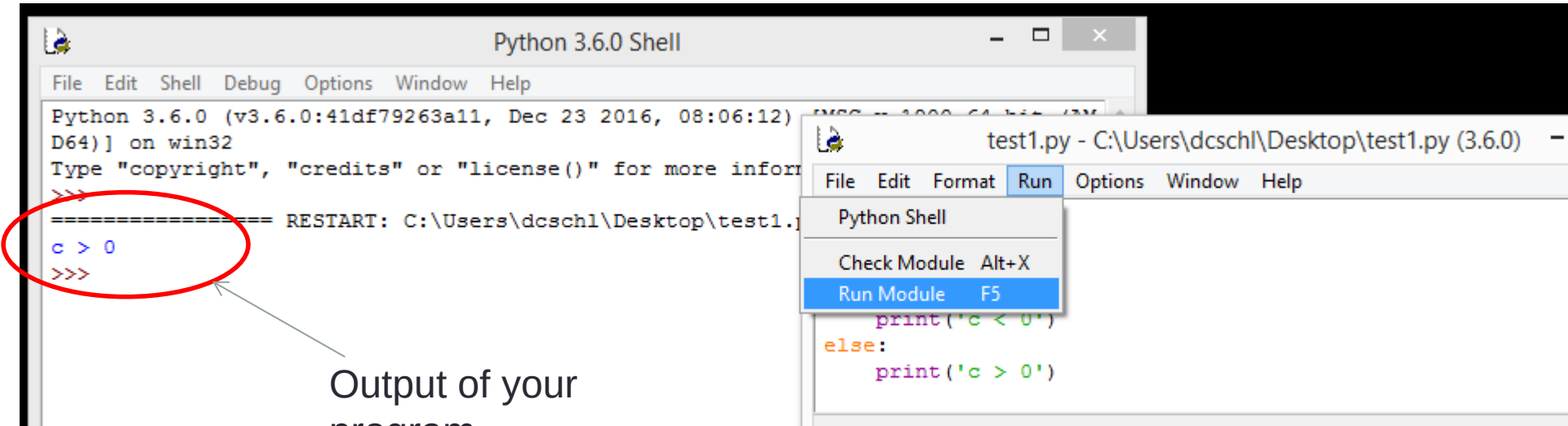
- Directly type into the console



- In which, we seldom do this

Or Run a file


Python 3.6.0 Shell
File Edit Shell Debug Options Window Help
Python 3.6.0 (v3.6.0:41df79263a11, Dec 23 2016, 08:06:12)
D64)] on win32
Type "copyright", "credits" or "license()" for more infor
>>>
test1.py - C:\Users\dcschl\Desktop\test1.py (3.6.0)
File Edit Format Run Options Window Help
a = 3
b = 1
c = a + b
if c < 0:
print('c < 0')
else:
print('c > 0')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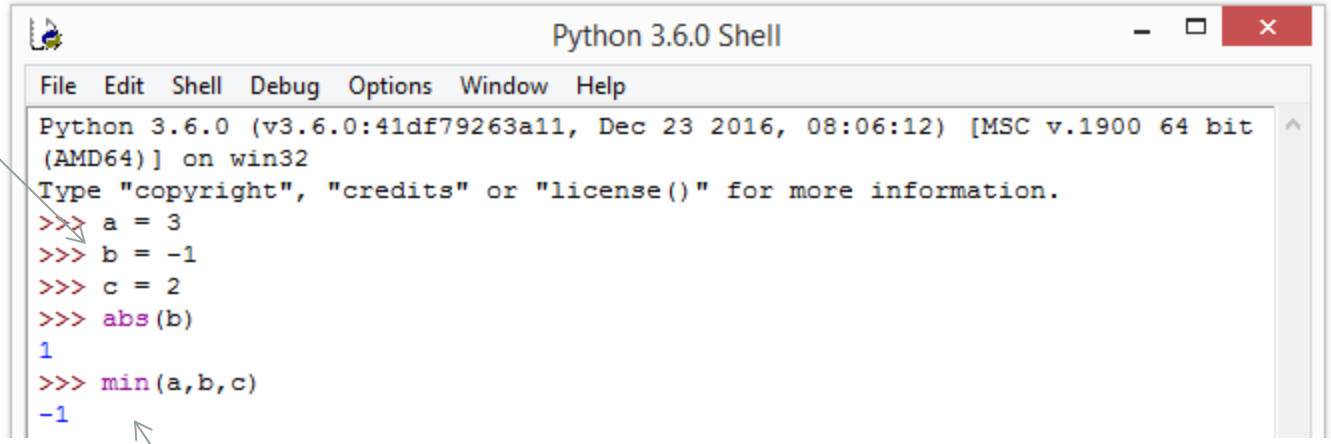
Python 3.6.0 (v3.6.0:41df79263a11, Dec 23 2016, 08:06:12)
D64)] on win32
Type "copyright", "credits" or "license()" for more infor
>>>
========== RESTART: C:\Users\dcschl\Desktop\test1.
c > 0
>>>
Output of your program
test1.py - C:\Users\dcschl\Desktop\test1.py (3.6.0)
File Edit Format Run Options Window Help
Python Shell
Check Module Alt+X
Run Module F5
print('c < 0')
else:
print('c > 0')

Functions and Variables

- We will give more details on this in the next lecture

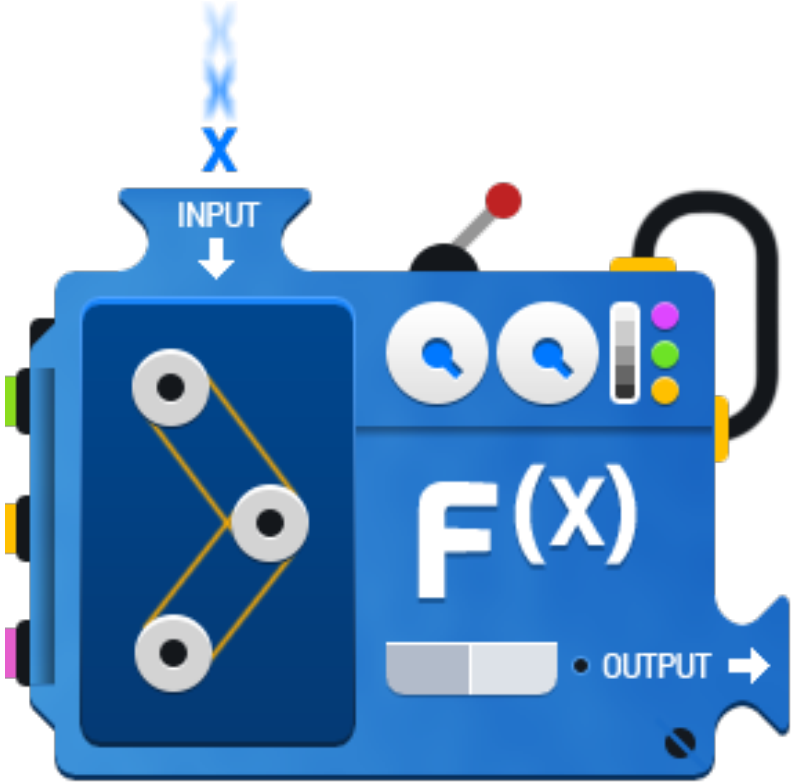
`a, b, c` are variables



`abs()` and `min()` are functions

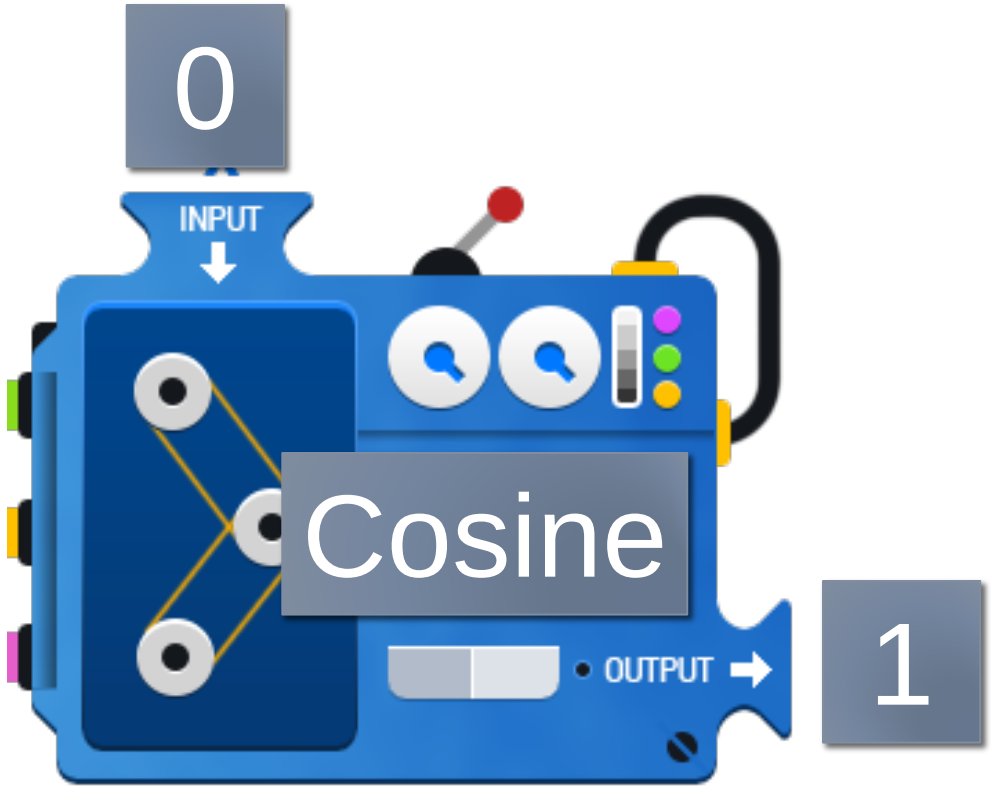
Functions

- A function is like a black box
  - You put in something for the input
  - And it will produce a new thing for the output



For example

- “Cosine” is a function
  - Input 0
  - Output 1

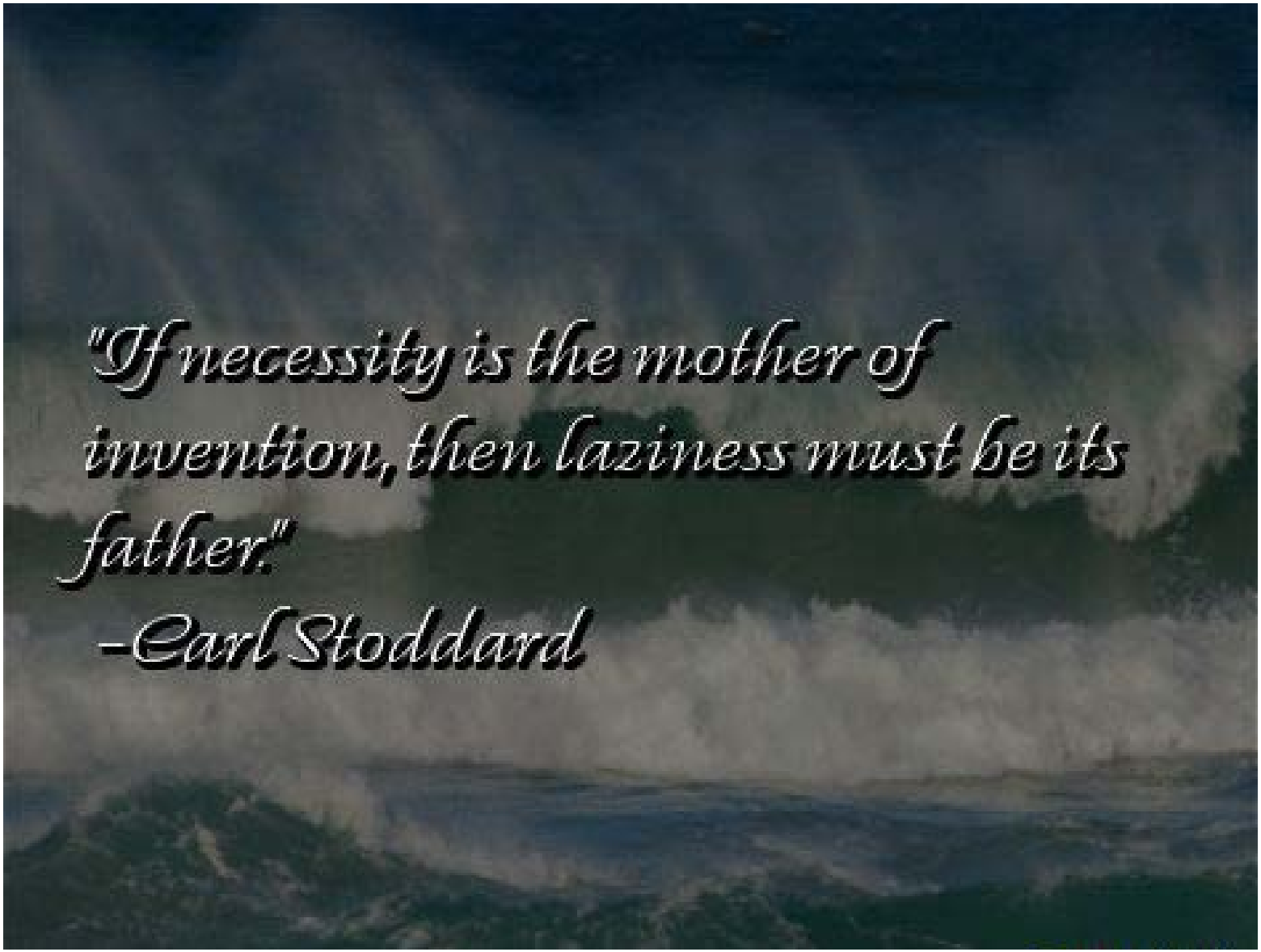


Python Packages

- What if I want to compute cos(π/2)?
  - Do I need to write the code for this?

$$\cos(x) = \underbrace{\frac{1}{0!}}_{n=0} - \underbrace{\frac{x^2}{2!}}_{n=1} + \underbrace{\frac{x^4}{4!}}_{n=2} - \underbrace{\frac{x^6}{6!}}_{n=3} + \underbrace{\frac{x^8}{8!}}_{n=4} + \cdots$$

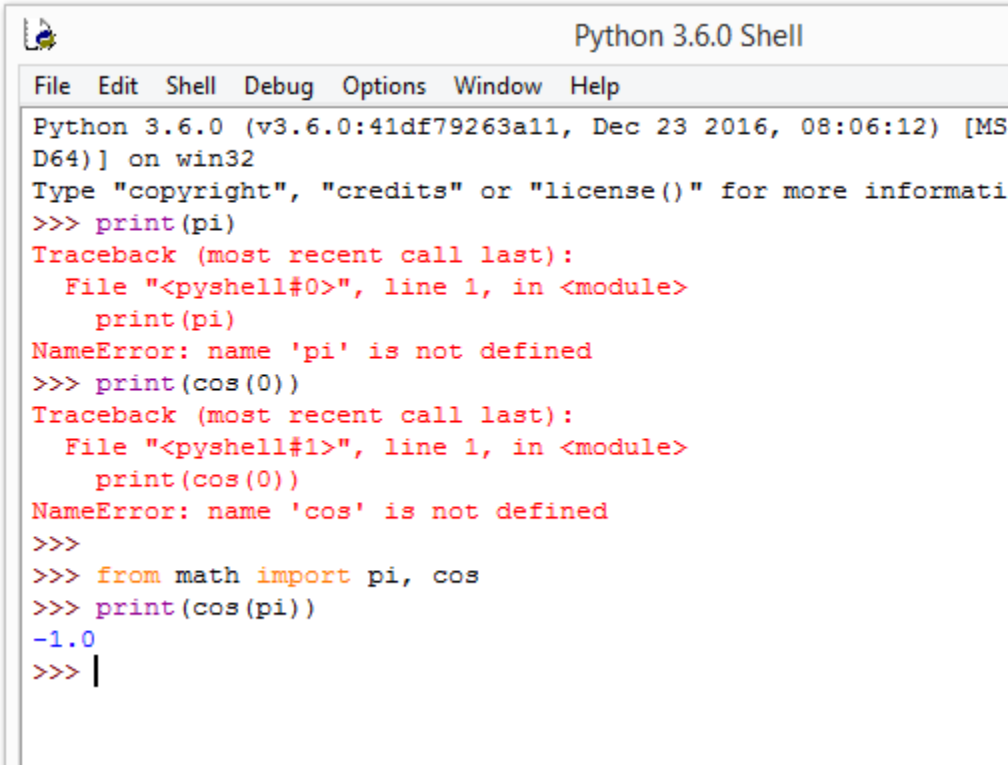
- Or draw a graph
- Or implement some network features?
- Or other complicated tasks?


"If necessity is the mother of invention, then laziness must be its father."
-Earl Stoddard

Different Scenario with Diff. Equipment

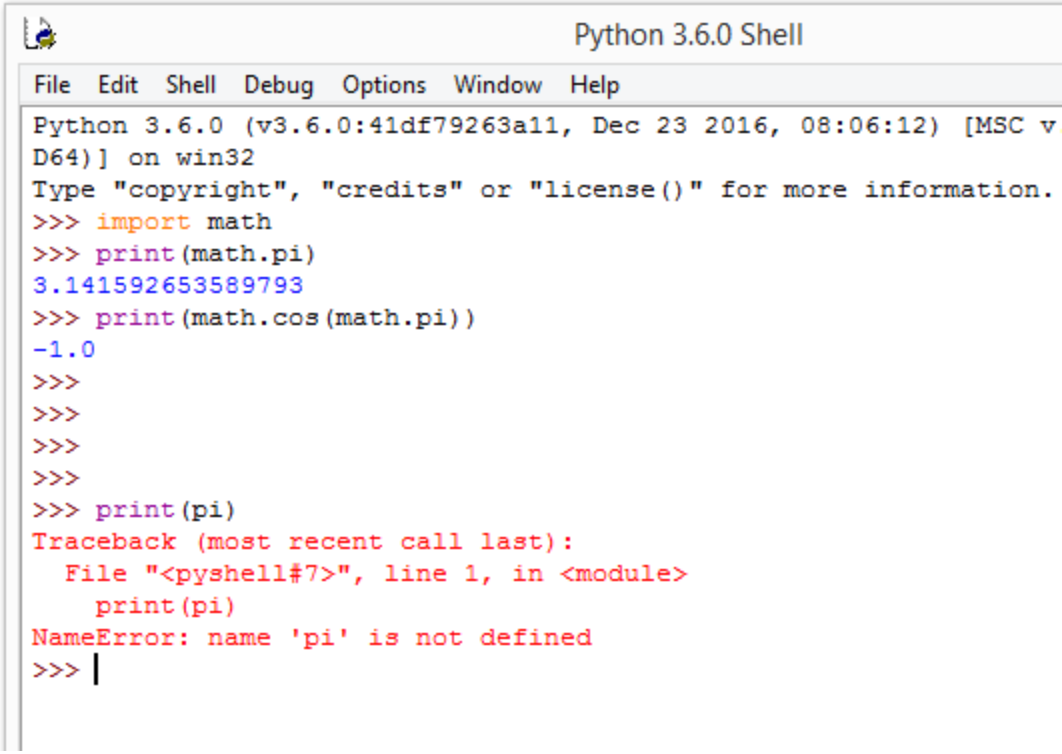
Python Packages

- Import the **function** `cos` and the **constant** `pi` from the math package
  - (Or library)



The Other way to Import cos

- You need at add the prefix "`math.`" before the function
- Otherwise..



Which way should I use?

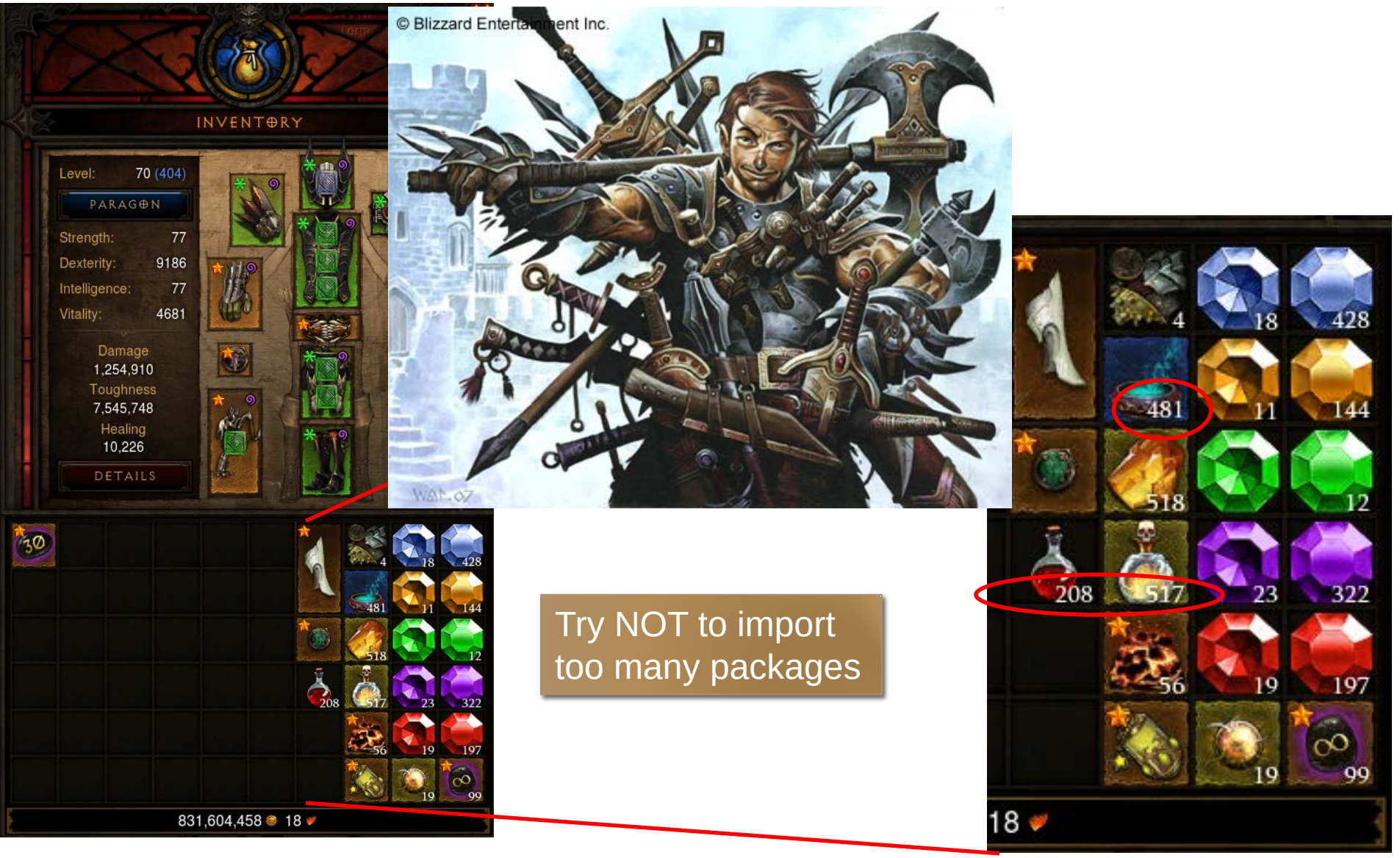
- First, “from math import cos”
  - Make your code shorter
  - Save memory
  - But you need to know exactly which function you have to import

```
>>>
>>> from math import pi, cos
>>> print(cos(pi))
-1.0
>>>
```

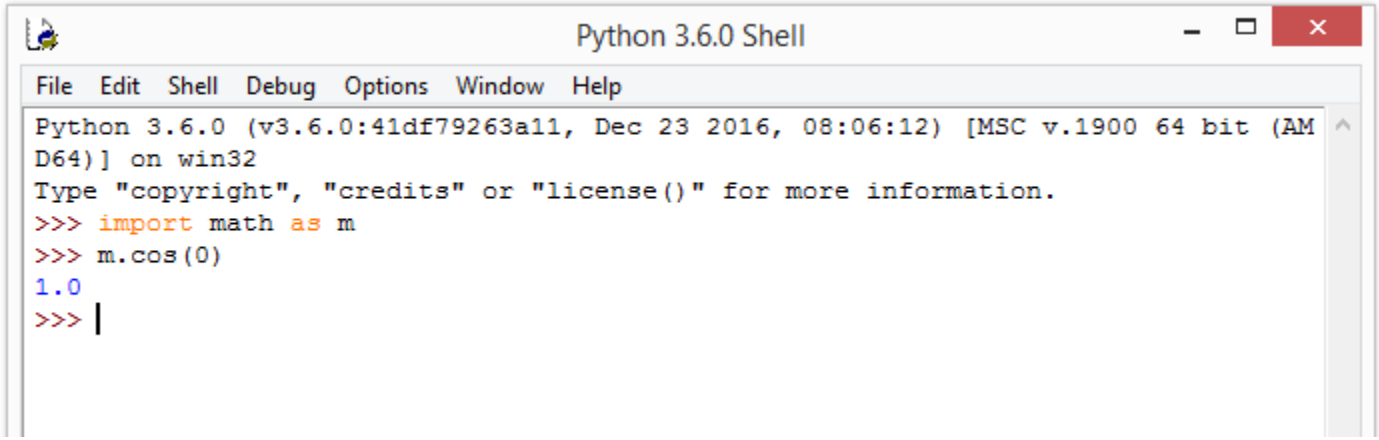
- Second, “import math”
  - You can be more relax to use functions in the whole library
  - But your code will be longer and require more memory

```
>>> import math
>>> print(math.pi)
3.141592653589793
>>> print(math.cos(math.pi))
-1.0
>>>
```

You don't want to be like this in real life

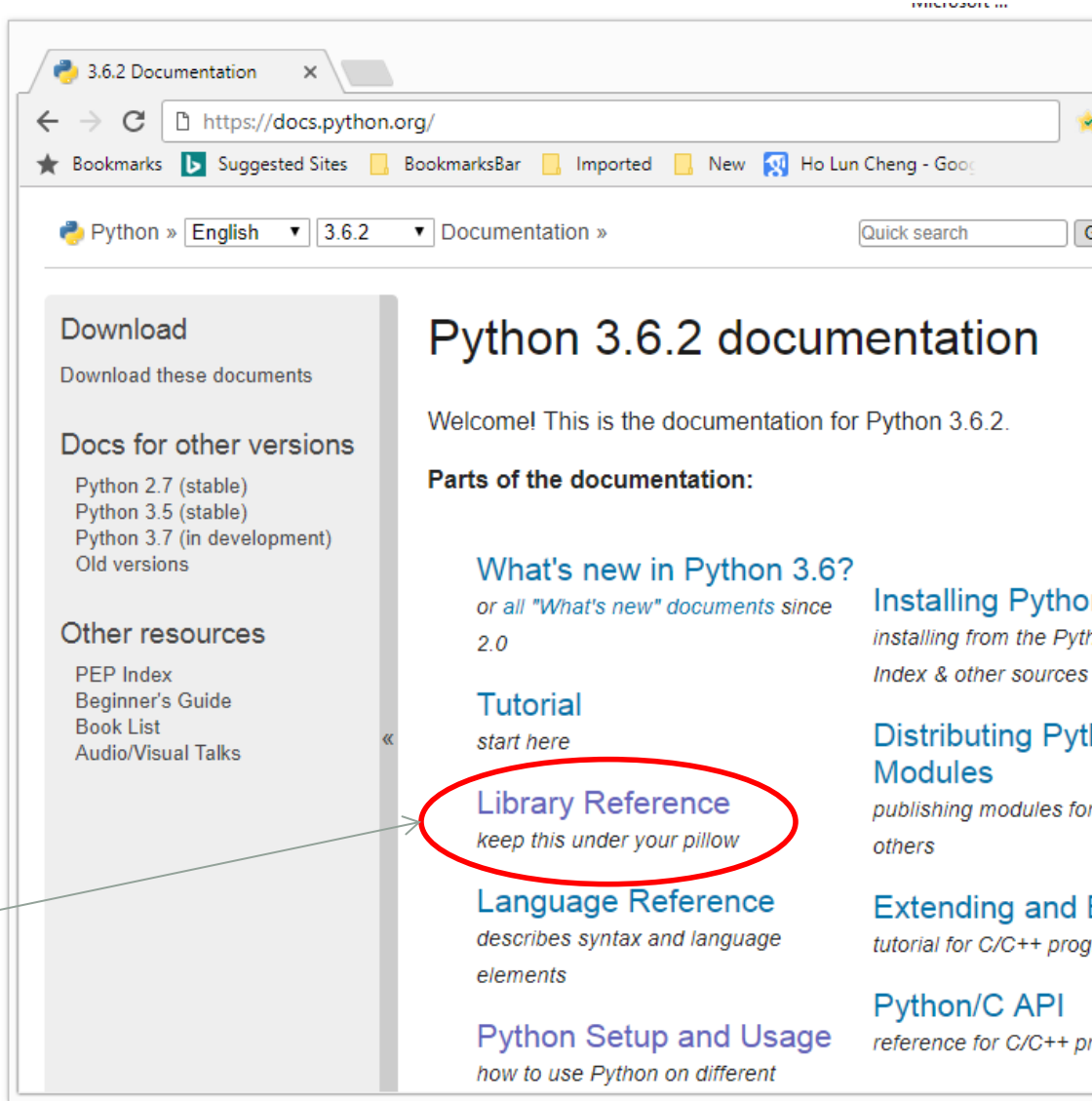


To Avoid Long Name



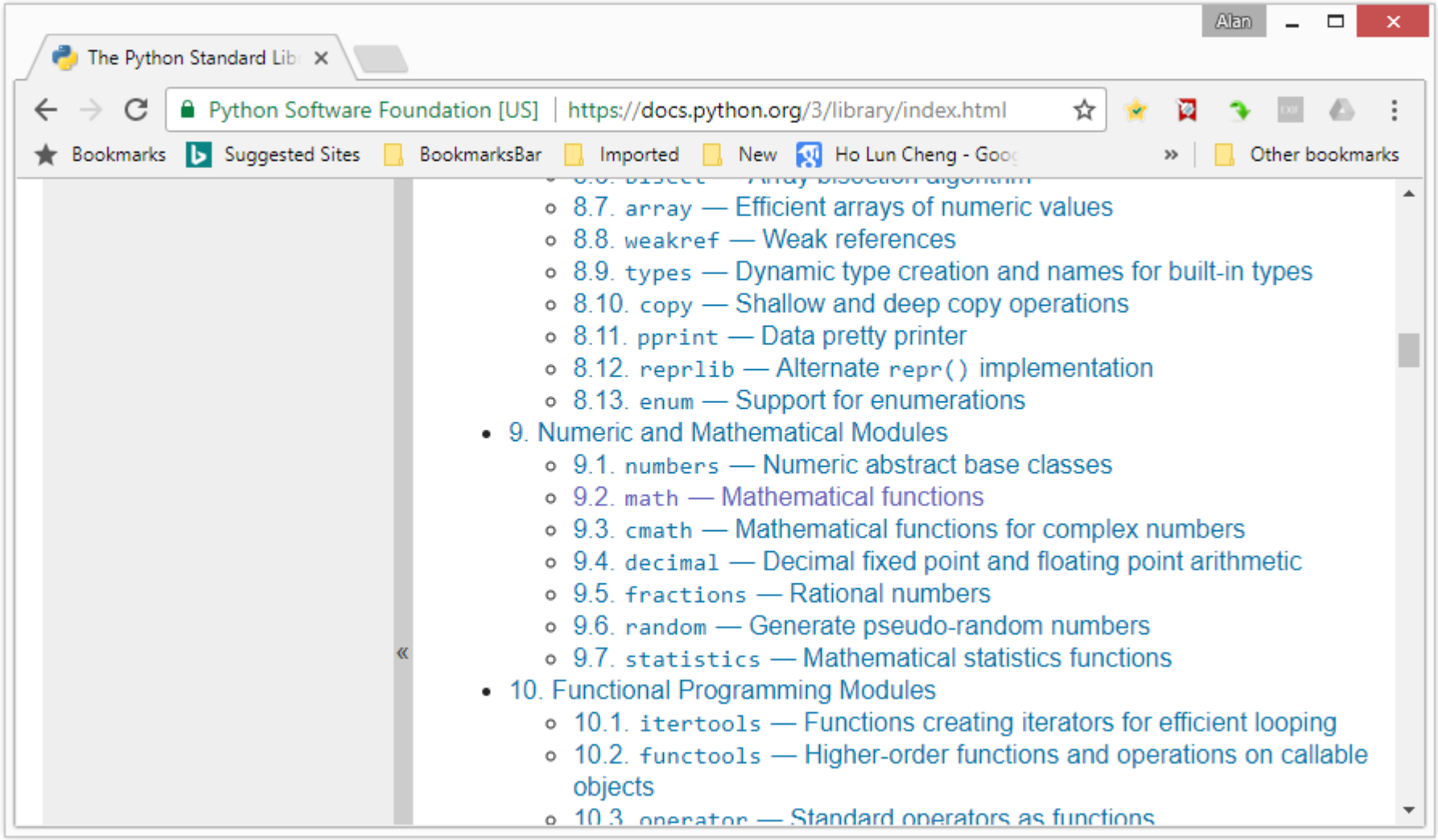
For More Packages

- Visit
  - https://docs.python.org/



Keep this under your pillow

Python Packages



Built-in Functions

- Functions that need **NOT** to be imported

		Built-in Functions		
abs()	dict()	help()	min()	setattr()
all()	dir()	hex()	next()	slice()
any()	divmod()	id()	object()	sorted()
ascii()	enumerate()	input()	oct()	staticmethod()
bin()	eval()	int()	open()	str()
bool()	exec()	isinstance()	ord()	sum()
bytearray()	filter()	issubclass()	pow()	super()
bytes()	float()	iter()	print()	tuple()
callable()	format()	len()	property()	type()
chr()	frozenset()	list()	range()	vars()
classmethod()	getattr()	locals()	repr()	zip()
compile()	globals()	map()	reversed()	__import__()
complex()	hasattr()	max()	round()	
delattr()	hash()	memoryview()	set()	

Variables

- For storage of data

```
>>> x = 3
```

This space is allocated and labeled as “x”. And we store ‘3’ inside

Computer Memory

Variable Naming

- Start with 'a'-'z' or 'A'-'Z' or '_'
- Contain only alphanumeric characters or '_'
- Case sensitive

```
X_1 != x_1
```

- Avoid reserved keywords e.g. `if`
- Python convention: lower case letters separated by '_'
  - e.g. `count_change`

Data Types

8, 45, 123	int
2.71828, 3.14159 , 1.0	float
True, False	bool
“it1007” ‘it1007’	str
	None

Variable Type

```
>>> x = 3
>>> name = “Alan”
```

This space is allocated and labeled as “x”. And we store ‘3’ inside. And can store integers only

This space is allocated and labeled as “name”. And we store “Alan” inside. And can store strings only

The function Type(…)

```
>>> type(123)
<class 'int'>

>>> type('123')
<class 'str'>

>>> type(None)
<class 'None'>
```

Type conversion

```
>>> str(123)
'123'

>>> float('45.2')
45.2

>>> int(23.8)
23

>>> int('cs1010s')
ValueError!
```

Assignments

Doesn't matter if it's quote or double quote

```
>>> abc = 18
>>> my_string = 'This is my string'
>>> x, y = 1, 2
```

Assignments

```
>>> x = 10
>>> x = 2
>>> x = 4
>>> print(x)

???
```

“=“ is different from our usual “equal” in math

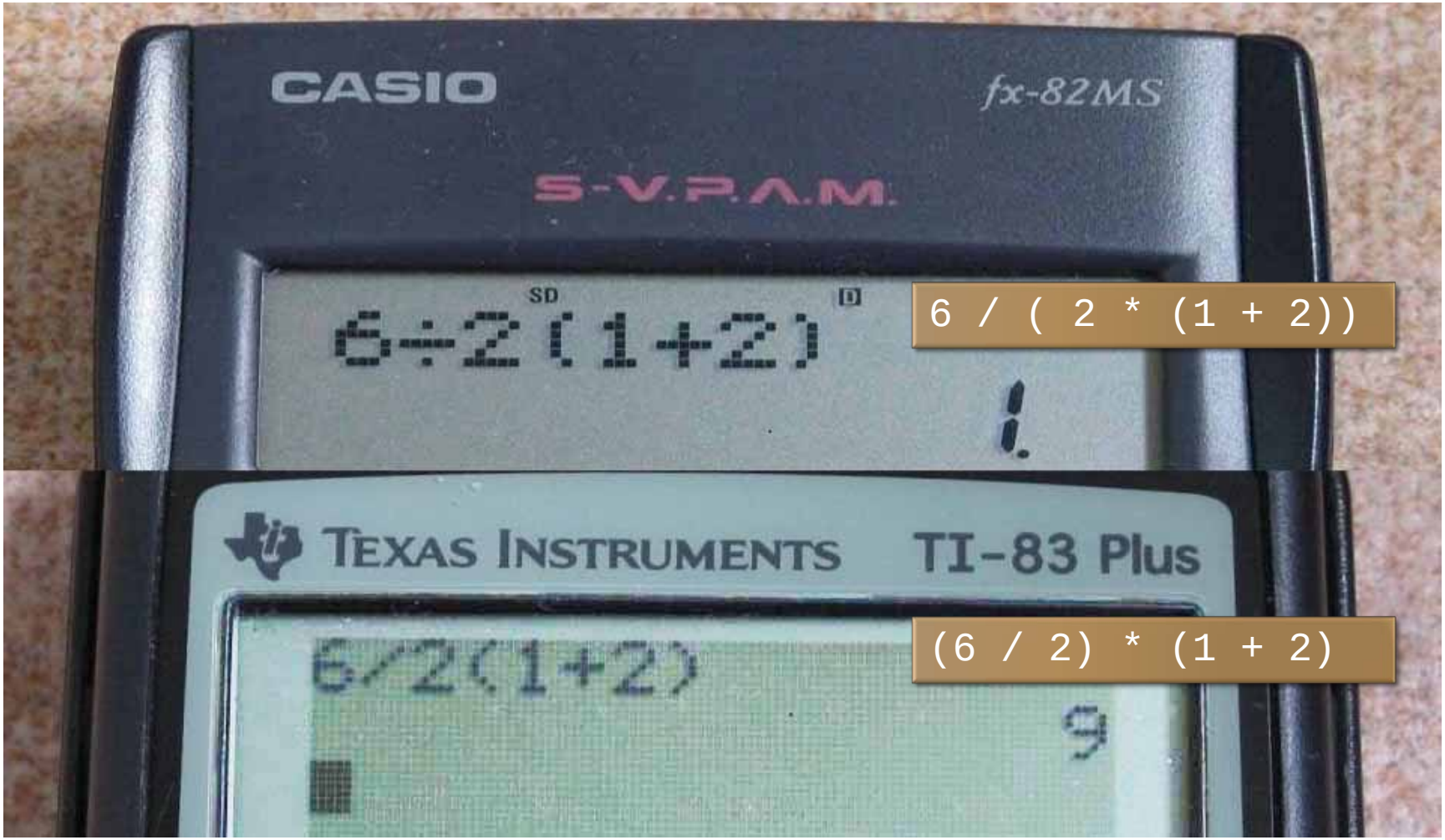
```
>>> a, b, c = 1, 2, 3
>>> a, b, c = c, b, a
>>> print(a, b, c)
???
```

Arithmetic: + - * / ** // %

```
>>> a = 2 * 3
>>> a
6

>>> 2 ** 3
8
```

```
>>> 11 / 3
3.6666666666666665

>>> 11 // 3
3

>>> 11 % 3
2
```

Operator Precedence



Python Operator Precedence

- 6/2*(1+2)
- 3*(1+2)
- 3*(1+2)
- 3*3
- 9

Operator	Description
**	Exponentiation (raise to the power)
~ + -	Complement, unary plus and minus (method names for the last two are +@ and -@)
* / % //	Multiply, divide, modulo and floor division
+ -	Addition and subtraction
>> <<	Right and left bitwise shift
&	Bitwise 'AND'td>
^ |	Bitwise exclusive `OR' and regular `OR'
<= < > >=	Comparison operators
<> == !=	Equality operators
= %= /= //= -= += *= **=	Assignment operators
is is not	Identity operators
in not in	Membership operators
not or and	Logical operators

Boolean: Truth values

- Statements can be either True or False
- `2 > 1` is True
- `5 < 3` is False

Operators

- Comparison:

```
>>> 1 <= 10
True
>>> 5 > 15
False
>>> 5 <= 5
True
```

```
>>> 2 != 3
True
>>> '1' == 1
False
>>> False == False
True
>>> True != True
False
```

The very no. 1 trap for programmers

Operators

- Logic:

```
>>> True or False
True
>>> True and False
False
>>> not False
True
```

- a or b True if either a or b is True
- a and b True if both a and b are True
- not a True if a is not True

Truth Tables

A	NOT A
True	False
False	True

A OR B		A	
		True	False
B	True	True	True
	False	True	False

A AND B		A	
		True	False
B	True	True	False
	False	False	False

Truth Value Revisited

- Python has keywords `True` and `False`
- In Python 3.x, `True` and `False` will be equal to `1` and `0`
- Anything that is not `0` or empty will be evaluated as `True`
- Logic:

```
>>> True and 0
0
>>> not 'abc'
False
>>> 1 or 0
1
```

Today

- Introduction to
  - Programming
    - Psuedocode
    - Flowchart
    - Control Structures
  - Python

- Python Setup guide (Not graded)
  - Lab 00 – Setting Up Pyhton

How to be a good programmer

- What is the different between old and new fighting movies?

Strings

```
>>> s = 'ba'
>>> t = 'ck'
>>> s + t
'back'
>>> t = s + 'na' *
2
>>> t
'banana'
```

```
>>> 'z' in t
False
>>> 'bananb' > t
True
>>> 'banan' <= t
True
>>> 'c' < t
False
```

lexicographical ordering: first the first two letters are compared, and if they differ this determines the outcome of the comparison; if they are equal, the next two letters are compared, and so on, until either sequence is exhausted.

Strings

```
>>> w = ‘banana’
>>> s = w + w
>>> print(s)
‘bananabanana’
>>> s = w*3
>>> print(s)
‘bananabananabanana’
```

```
>>> s = (w+’ ‘)*2
>>> print(s)
‘banana banana ‘
```

Strings

- A String is a sequence of characters
- We can index a string, i.e.

```
>>> s = 'abcd'
>>> s[0]
'a'


>>> s[2]
'c'
```

- The index of the first character is 0

String Slicing (Leave it to next w

Non-inclusive

Default
start = 0
stop = #letters
step = 1

```
    s[start:stop:step]
```

```
>>> s = 'abcdef'
>>> s[0:2]
'ab'

>>> s[1:2]
'b'

>>> s[:2]
'ab'
```

```
>>> s[1:5:3]
'be'

>>> s[::2]
'ace'

>>> s[::-1]
???
```

Strings

```
c = "#"
s = " “

print(" ")
print("   *")
print(s*3 + c)
print(s*2 + c * 3)
print(s + c * 5)
print(s*3 + c)
print(s*2 + c * 3)
print(s + c * 5)
print(c * 7)
print(s*3 + c)
```

```
   *
   #
  ###
 #####
   #
  ###
 #####
#######
   #
```

ASCII Art