Programming in Python

SSD Course 2022

The Programming Cycle

Write/Edit

Run
with some input

OK?

NO

YES

NO

More
Inputs?

YES

Now let me ask something..

- Why to learn Python?
- What would you use Python for?

History

- Started by Guido Van Rossum as a hobby
- Now widely spread
- Open Source! Free!
- Versatile

Guido Van Rossum by Doc Searls on Flickr
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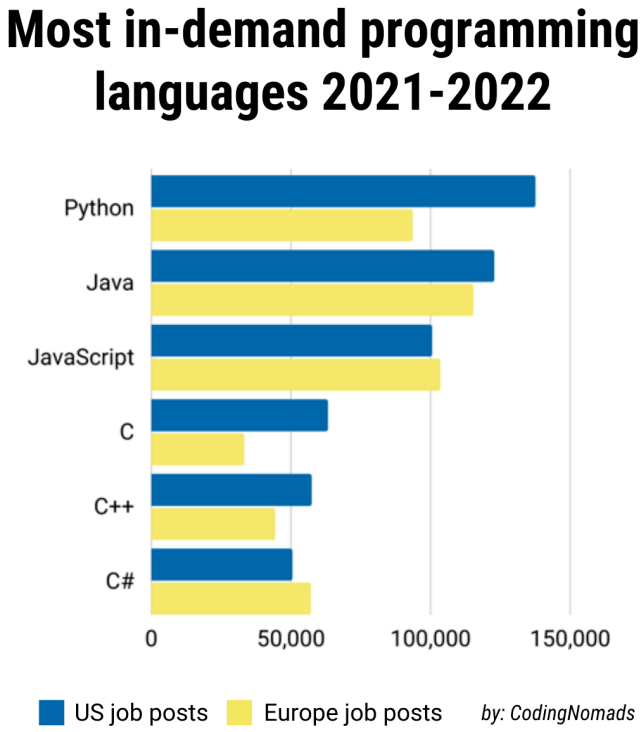


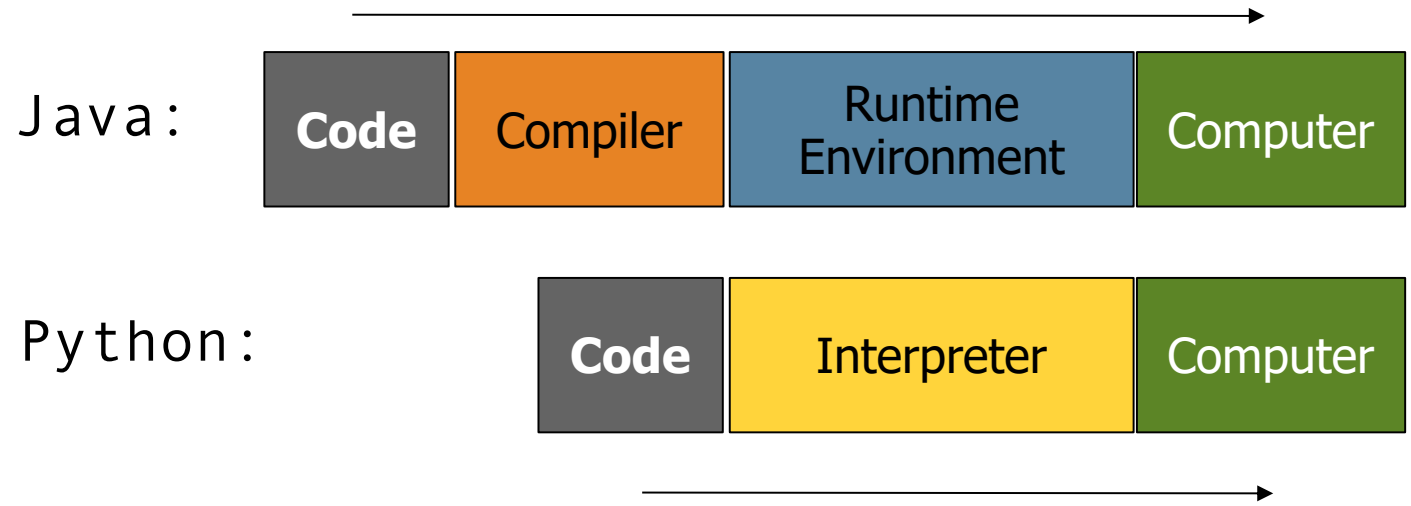
Brief Introduction

Python is an interpreted, high-level and general-purpose programming language. Created by Guido van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects.[28]

https://en.wikipedia.org/wiki/Python_(programming_language)

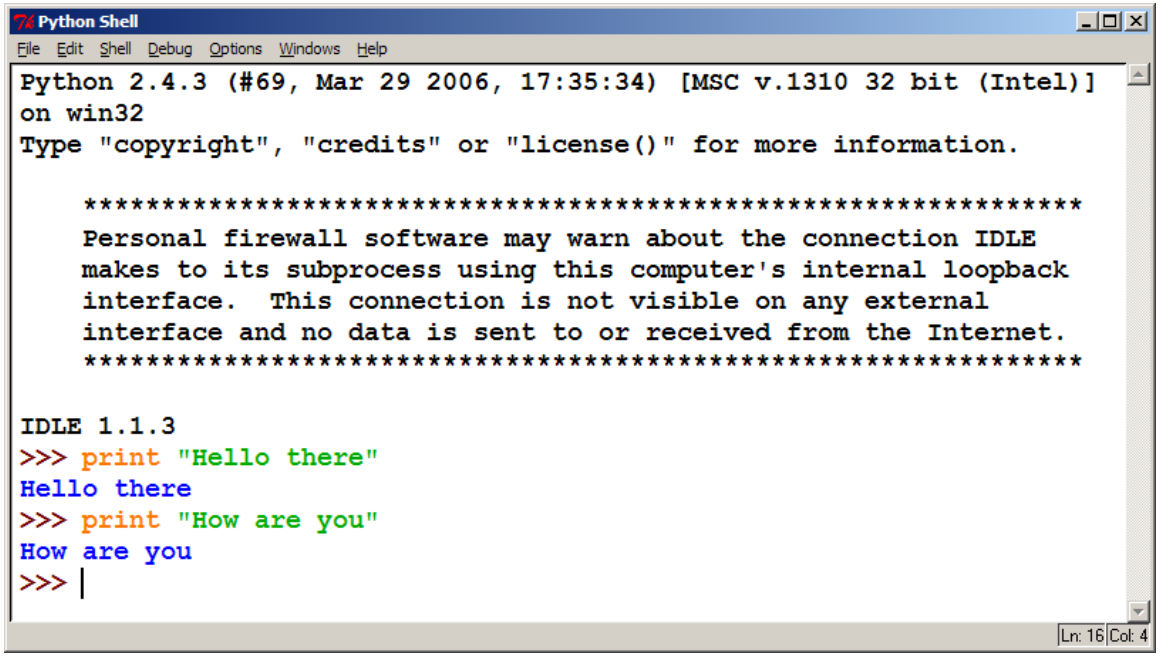
Interpreted Languages

- **interpreted**
  - Not compiled like Java
  - Code is written and then directly executed by an **interpreter**
  - Type commands into interpreter and see immediate results



The Python Interpreter

- Allows you to type commands one-at-a-time and see results
- A great way to explore Python's syntax
  - Repeat previous command: Alt+P



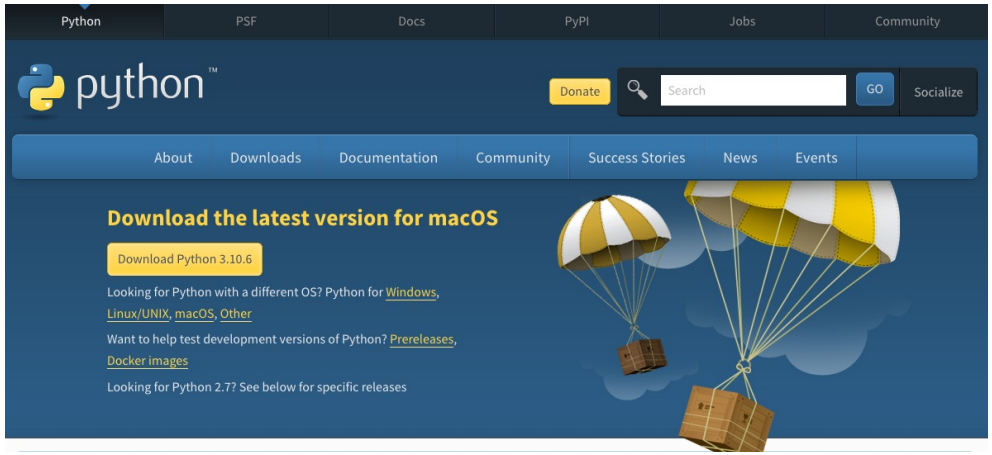
Python today

- Developed a large and active scientific computing and data analysis community
- Now one of the most important languages for
  - Data science
  - Machine learning
  - General software development
- Packages: NumPy, pandas, matplotlib, SciPy, scikit-learn

Installing Python

Windows:

- Download Python from http://www.python.org
- Install Python.
- Run **Idle** from the Start Menu.
- IDLE is Python's Integrated Development and Learning Environment.



Mac OS X:

- Python is already installed.
- Open a terminal and run `python` or run Idle from Finder.

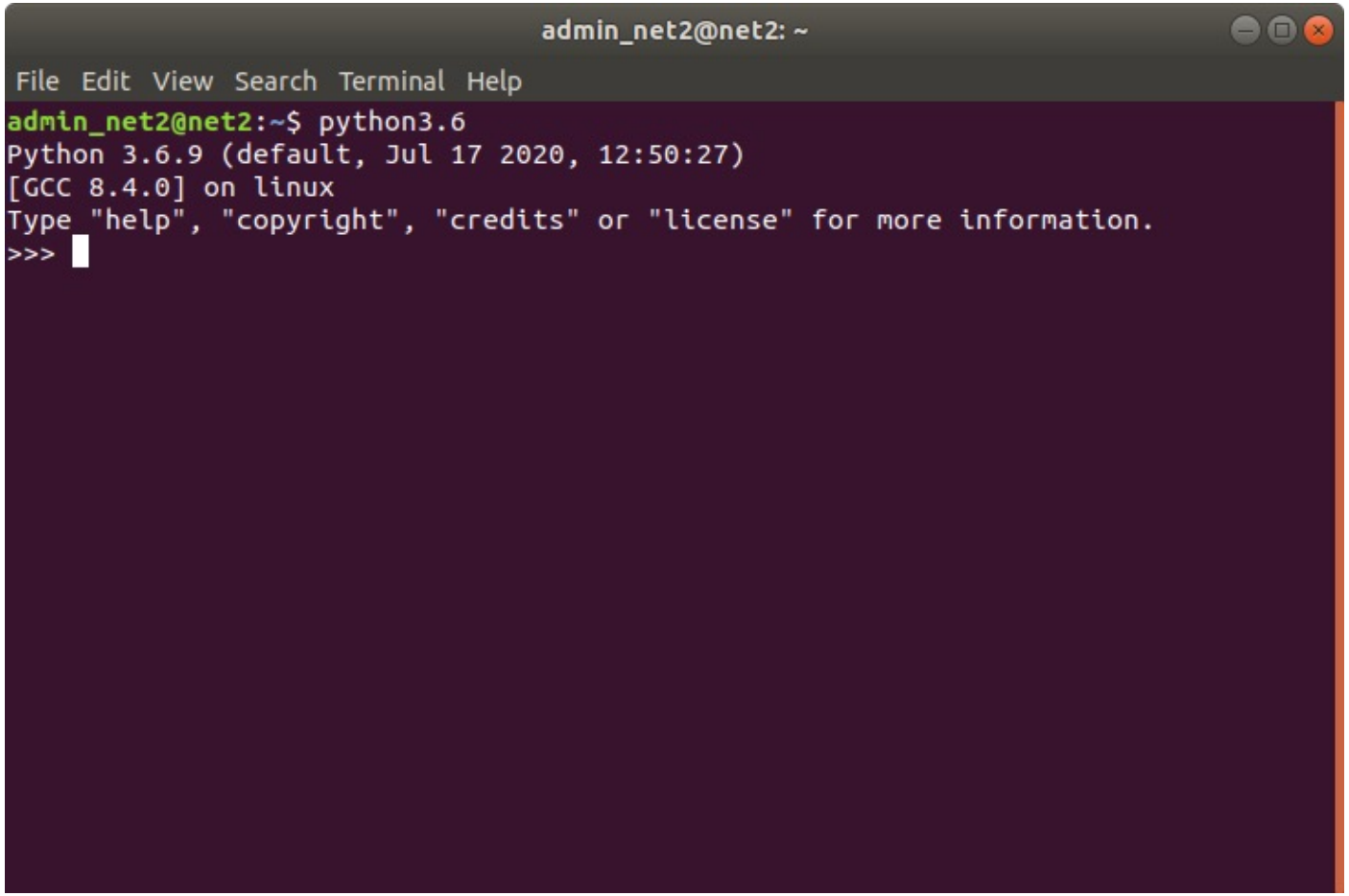
Linux:

- Chances are you already have Python installed. To check, run `python` from the terminal.
- If not, install from your distribution's package system.

Three Modes

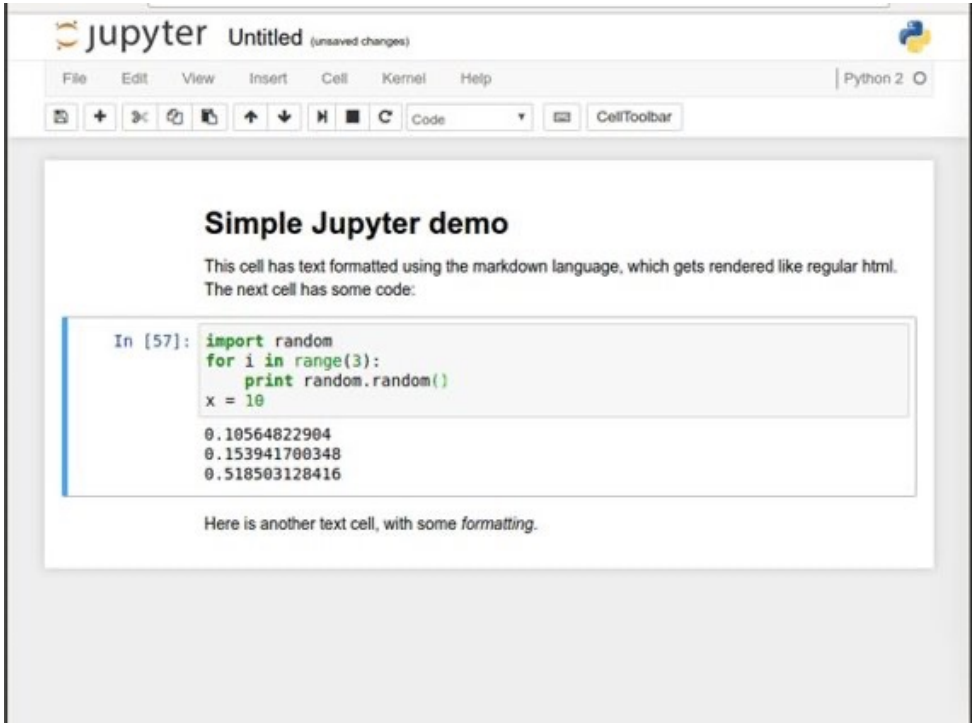
1. Shell Prompt (regular)
2. Ipython (prompt and Jupyter notebook)
   - Python can be run interactively (interactive shell)
   - Used extensively in research
3. Python scripts
   - What if we want to run more than a few lines of code?
   - Then we must write text files in .py

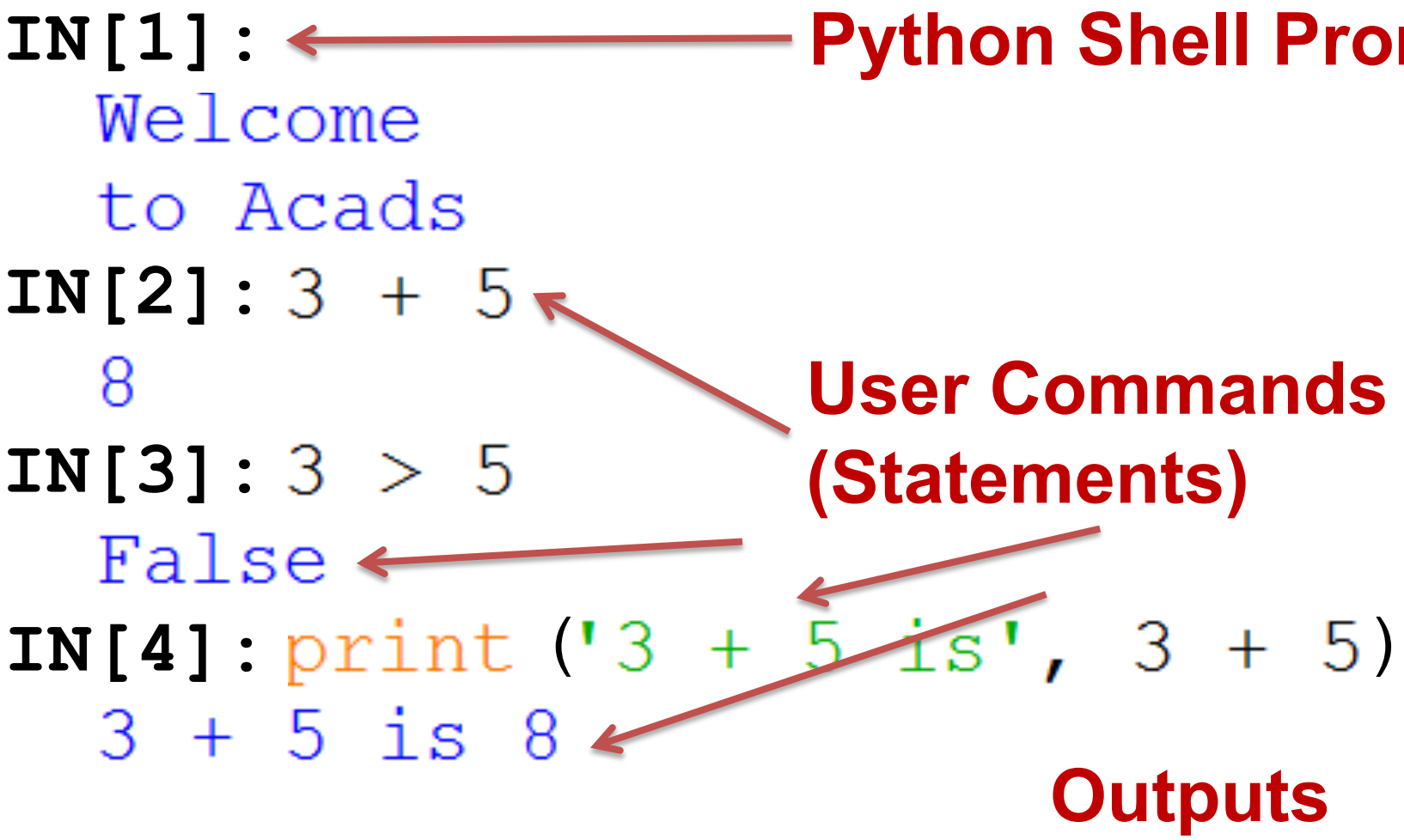
Python Shell Prompt



Jupyter Notebook

- Easy to use environment
- Web-based
- Combines both text and code into one
- Come with a great number of useful packages

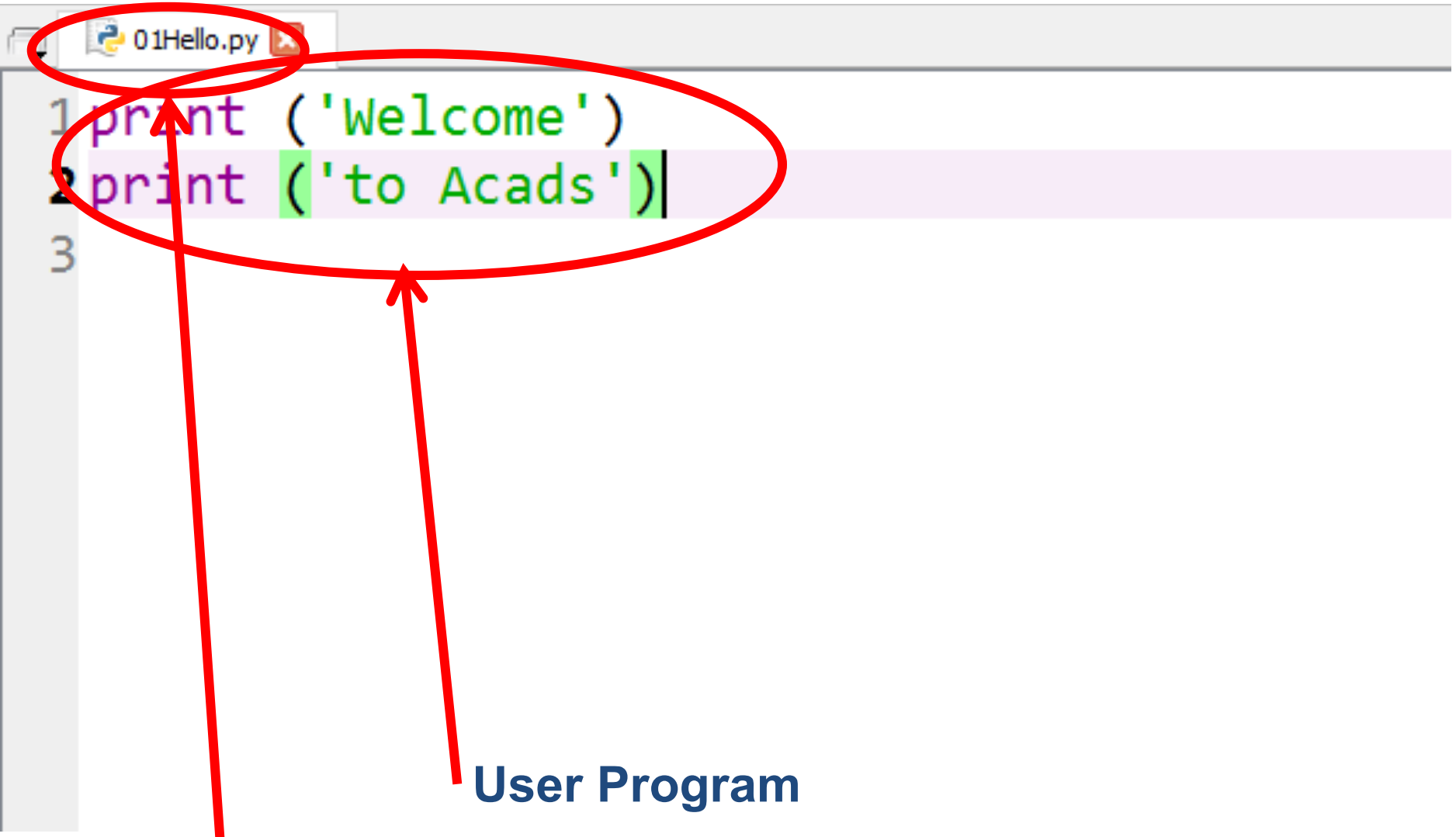




Python Shell is Interactive

Interacting with Python Programs

- Python program communicates its results to user using print
- Most useful programs require information from users
  - Name and age for a travel reservation system
- Python 3 uses input to read user input as a string (str)


01Hello.py
1 print ('Welcome')
2 print ('to Acads')
3
User Program
Filename, preferred extension is py

input

- Take as argument a string to print as a prompt
- Returns the user typed value as a string
  - details of how to process user string later

```
IN[1]: age =      input('How old are you?')

IN[2]:

IN[3]:
```

Our First Python Program

- Python does not have a `main` method like Java
  - The program's main code is just written directly in the file
- Python statements do not end with semicolons

hello.py

```
1  print("Hello, world!")
```

The `print` Statement

`print("`**`text`**`")`
`print()` (a blank line)

– Escape sequences such as `\"`
– Strings can also start/end with `'`

comments.py

```
1  print("Hello, world!")
2  print()
3  print("Suppose two swallows \"carry\" it together.")
4  print('African or "European" swallows?')
```

Comments

- Syntax:

  # comment text (one line)

comments.py

```
1  # SSD Course, CSE, Monsoon 2022
2  # This program prints important messages.
3  print("Hello, world!")
4  print()                          # blank line
5  print("Suppose two swallows \"carry\" it together.")
6  print('African or "European" swallows?')
```

Whitespace Significance

- Python uses indentation to indicate blocks, instead of { }
  - Makes the code simpler and more readable
  - In Java, indenting is optional. In Python, you **must** indent.

hello2.py

```
1  # Prints a helpful message.
2  def hello():
3      print("Hello, world!")
4      print("How are you?")
5
6  # main (calls hello twice)
7  hello()
8  hello()
```

Elements of Python

- A Python program is a sequence of **definitions** and **commands (statements)**
- Commands manipulate **objects**
- Each object is associated with a **Type**
- **Type:**
  - A set of values
  - A set of operations on these values
- **Expressions**: An operation (combination of objects and **operators**)

Types in Python

- **int**
  - Bounded integers, e.g. 732 or -5
- **float**
  - Real numbers, e.g. 3.14 or 2.0
- **str**
  - Strings, e.g. ‘hello’ or ‘C’

Type	Declaration	Example	Usage
Integer	int	`x = 124`	Numbers without decimal point
Float	float	`x = 124.56`	Numbers with decimcal point
String	str	`x = "Hello world"`	Used for text
Boolean	bool	`x = True` or `x = False`	Used for conditional statements
NoneType	None	`x = None`	Whenever you want an empty variable

Types in Python

- **Scalar**
  - Indivisible objects that do not have internal structure
  - **int** (signed integers), **float** (floating point), **bool** (Boolean), ***NoneType***
    - NoneType is a special type with a single value
    - The value is called **None**
- **Non-Scalar**
  - Objects having internal structure
  - **str** (strings)

Example of Types

```
In [14]: type(500)
Out[14]: int

In [15]: type(-200)
Out[15]: int

In [16]: type(3.1413)
Out[16]: float

In [17]: type(True)
Out[17]: bool

In [18]: type('Hello Class')
Out[18]: str

In [19]: type(3!=2)
Out[19]: bool
```

Type Conversion (Type Cast)

- Conversion of value of one type to other
- We are used to int ↔ float conversion in Math
  - Integer 3 is treated as float 3.0 when a real number is expected
  - Float 3.6 is truncated as 3, or rounded off as 4 for integer contexts
- Type names are used as type converter functions

Type Conversion Examples

```
In [20]: int(2.5)
Out[20]: 2

In [21]: int(2.3)
Out[21]: 2

In [22]: int(3.9)
Out[22]: 3

In [23]: float(3)
Out[23]: 3.0

In [24]: int('73')
Out[24]: 73

In [25]: int('Acads')
Traceback (most recent call last):

  File "<ipython-input-25-90ec37205222>", line 1, in <module>
    int('Acads')

ValueError: invalid literal for int() with base 10: 'Acads'
```

Note that float to int conversion is truncation, not rounding off

```
In [26]: str(3.14)
Out[26]: '3.14'

In [27]: str(26000)
Out[27]: '26000'
```

Type Conversion and Input

```
In [11]: age = input('How old are you? ')

How old are you? 35

In [12]: print ('In 5 years, your age will be', age + 5)
Traceback (most recent call last):

  File "<ipython-input-12-7fb7a9e926c2>", line 1, in <module>
    print ('In 5 years, your age will be', age + 5)

TypeError: Can't convert 'int' object to str implicitly

In [13]: print ('In 5 years, your age will be', int(age) + 5)
In 5 years, your age will be 40
```

Quick question!

```
x = "10"
y = "20"
x + y
```

What will be the result?

Operators

- Arithmetic

+	-	*	//	/	%	**

- Comparison

==	!=	>	<	>=	<=

- Assignment

=	+=	-=	*=	//=	/=	%=	**=

- Logical

and	or	not

- Bitwise

&	|	^	~	>>	<<

- Membership

in	not in

- Identity

is	is not

Variables

- A name associated with an object
- Assignment used for binding

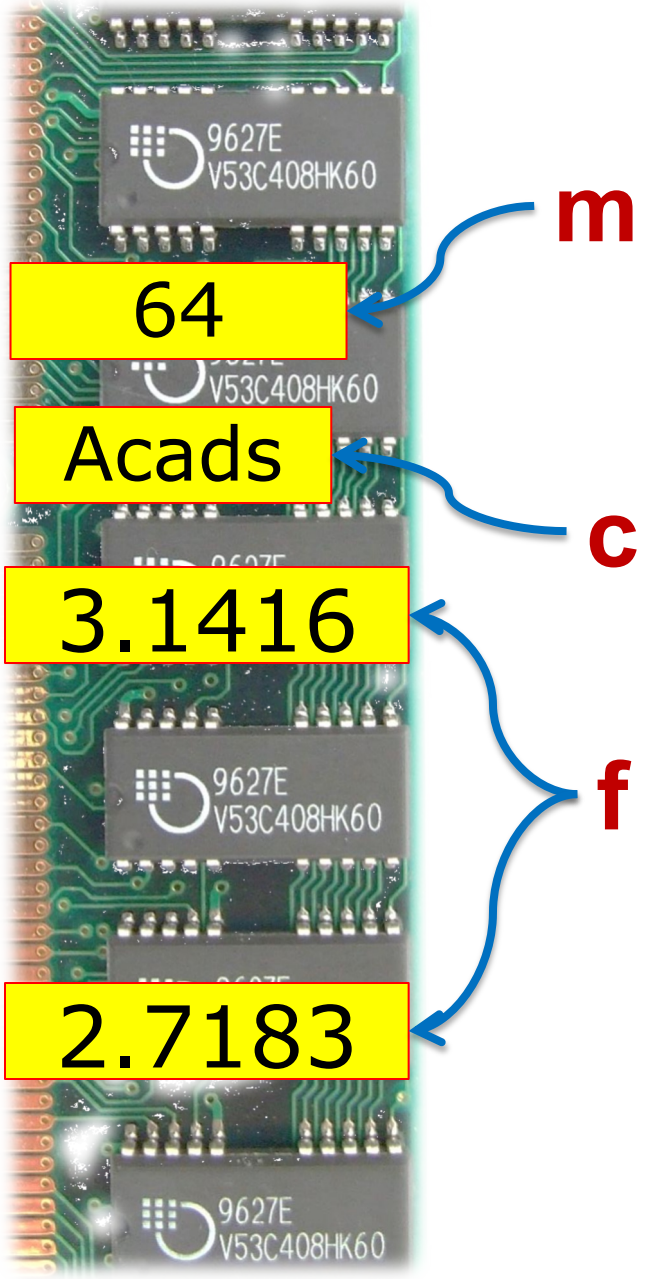
m = 64;

c = ‘Acads’;

f = 3.1416;

- Variables can change their bindings

f = 2.7183;



Assignment Statement

- A simple assignment statement

  Variable = Expression;

- Computes the value (object) of the expression on the right hand side expression (RHS)
- Associates the name (variable) on the left hand side (LHS) with the RHS value
- = is known as the assignment operator.

Multiple Assignments

- Python allows multiple assignments

```
x, y = 10, 20
```

Binds x to 10 and y to 20

- Evaluation of multiple assignment statement:
  - All the expressions on the RHS of the = are first evaluated **before any binding happens**.
  - Values of the expressions are bound to the corresponding variable on the LHS.

```
x, y = 10, 20
x, y = y+1, x+1
```

x is bound to 21 and y to 11 at the end of the program

Programming using Python

Operators and Expressions

Binary Operations

Op	Meaning	Example	Remarks
+	Addition	9+2 is 11	
		9.1+2.0 is 11.1	
-	Subtraction	9-2 is 7	
		9.1-2.0 is 7.1	
*	Multiplication	9*2 is 18	
		9.1*2.0 is 18.2	
/	Division	9/2 is 4.25	In Python3
		9.1/2.0 is 4.55	Real div.
//	Integer Division	9//2 is 4	
%	Remainder	9%2 is 1	

The // operator

- Also referred to as “integer division”
- Result is a whole integer (floor of real division)
  - But the type need not be int
  - the integral part of the real division
  - rounded towards minus infinity ($-\infty$)
- Examples

9//4 is 2	**(-1)//2 is -1**	**(-1)//(-2) is 0**
1//2 is 0	**1//(-2) is -1**	**9//4.5 is 2.0**

The % operator

- The remainder operator % returns the remainder of the result of dividing its first operand by its second.

9%4 is 1	**(-1)%2 is 1**	**(-1)//(-2) is 0**
9%4.5 is 0.0	**1%(-2) is 1**	**1%0.6 is 0.4**

Ideally: x == (x//y)*y + x %y

Programming using Python

Conditional Statements

if-else statement

- Compare two integers and print the min.

```
if  x < y:
        print (x)
else:
        print (y)
print ('is the minimum')
```

1. Check if x is less than y.
2. If so, print x
3. Otherwise, print y.

Indentation

- Indentation is **important** in Python
  - grouping of statement (block of statements)
  - no explicit brackets, e.g. { }, to group statements

```
x,y = 6,10

if x < y:
    print (x)
else:
    print (y)
    print('the min')
```

skipped

Run the program

6

10

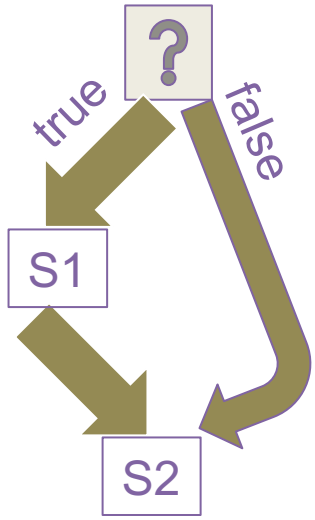
Output

6

if statement (no else!)

- General form of the if statement

```
if boolean-expr :
        S1
S2
```

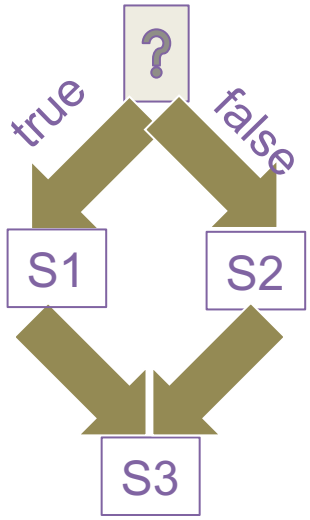


- Execution of if statement
  - First the expression is evaluated.
  - If it evaluates to a **true** value, then S1 is executed and then control moves to the S2.
  - If expression evaluates to **false**, then control moves to the S2 directly.

if-else statement

- General form of the if-else statement

```
if boolean-expr :
        S1
else:
        S2
S3
```



- Execution of if-else statement
  - First the expression is evaluated.
  - If it evaluates to a **true** value, then S1 is executed and then control moves to S3.
  - If expression evaluates to **false**, then S2 is executed and then control moves to S3.
  - S1/S2 can be **blocks** of statements!

Nested if, if-else

```
if a <= b:
        if a <= c:
            …
        else:
            …
else:
        if b <= c) :
            …
        else:
            …
```

Elif

- A special kind of nesting is the chain of if-else-if-else-… statements
- Can be written elegantly using if-elif-..-else

```
if cond1:
        s1
else:
    if cond2:
        s2
    else:
        if cond3:
            s3
        else:
            …
```

```
if cond1:
        s1
elif cond2:
    s2
elif cond3:
    s3
elif  …
else
     last-block-of-stmt
```

Summary of if, if-else

- if-else, nested if's, elif.
- Multiple ways to solve a problem
  - –issues of readability, maintainability
  - –and efficiency

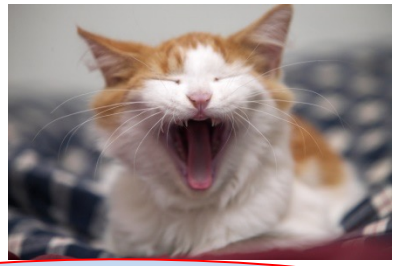
Quick Question

- What is the value of expression:

(5<2) and (3/0 > 1)

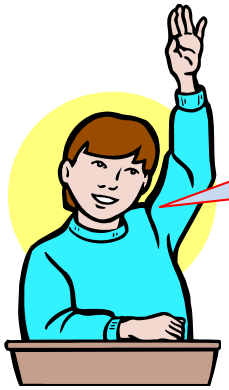
a) Run time crash/error

b) I don't know / I don't care



c) False

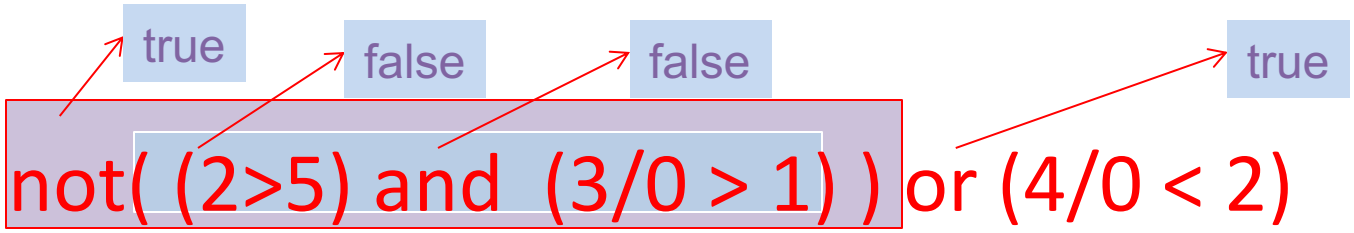
d) True



The correct answer is **False**

Short-circuit Evaluation

- Do not evaluate the second operand of binary short-circuit logical operator if the result can be deduced from the first operand
  - Also applies to nested logical operators



Evaluates to true

3 Factors for Expr Evaluation

- **Precedence**
  - Applied to two different class of operators
  - + and *, - and *, and and or, …
- **Associativity**
  - Applied to operators of same class
  - * and *, + and -, * and /, …
- **Order**
  - Precedence and associativity **identify the operands** for each operator
  - **Not which operand is evaluated first**
  - Python evaluates expressions from left to right
  - While evaluating an assignment, the right-hand side is evaluated before the left-hand side.

Class Quiz

- What is the output of the following program:

```
y = 0.1*3
if y != 0.3:
    print ('Launch a Missile')
else:
    print ("Let's have peace")
```

Launch a Missile

Caution about Using Floats

- Representation of *real numbers* in a computer can not be exact
  - Computers have limited memory to store data
  - *Between any two distinct real numbers, there are infinitely many real numbers.*
- On a typical machine running Python, there are 53 bits of precision available for a Python float

Caution about Using Floats

- The value stored internally for the decimal number 0.1 is the binary fraction

  0.0001100110011001100110011001100110011001100110011001100110011010

- Equivalent to decimal value

  0.1000000000000000055511151231257827021181583404541015625

- Approximation is similar to decimal approximation 1/3 = 0.333333333...
- No matter how many digits you use, you have an approximation

Comparing Floats

- Because of the approximations, comparison of floats is not exact.
- **Solution?**
- Instead of

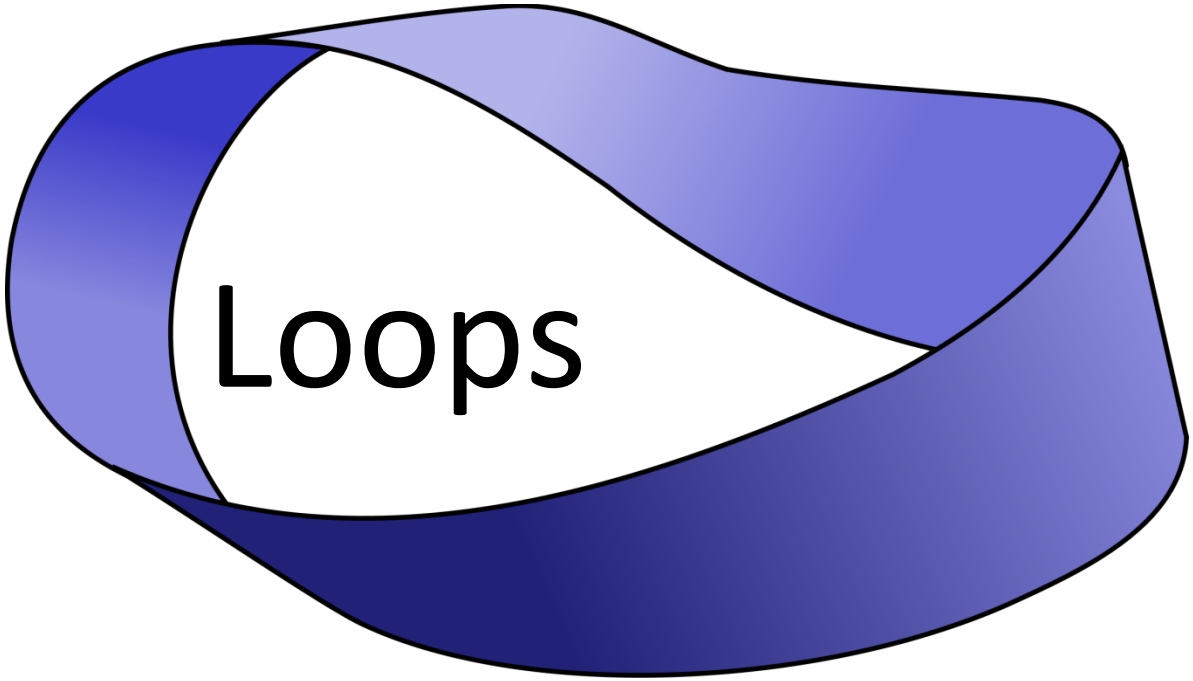
  x == y

  use

  abs(x-y) <= epsilon

  where epsilon is a suitably chosen small value

Programming using Python

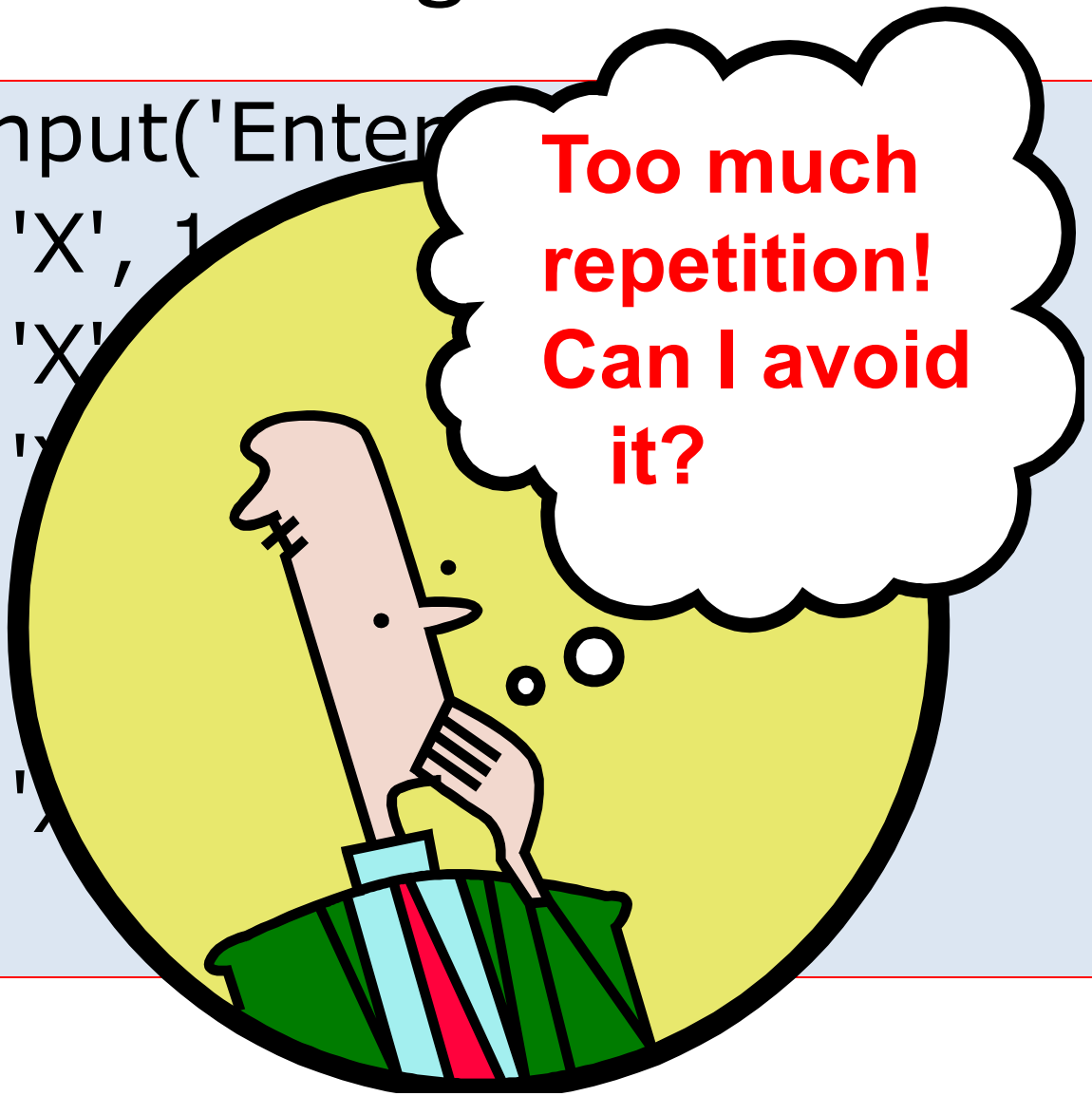


Printing Multiplication Table

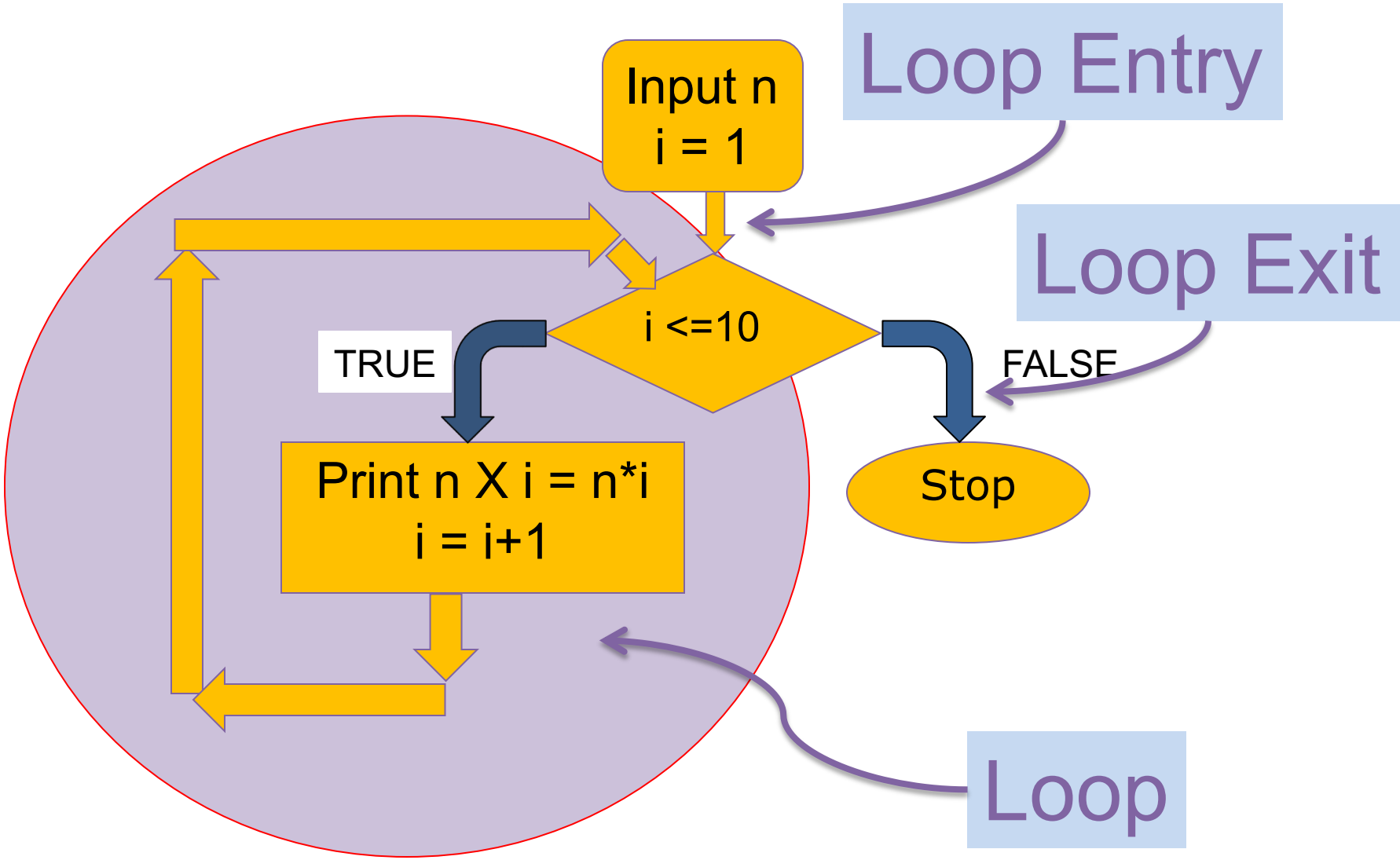
5	X	1	=	5
5	X	2	=	10
5	X	3	=	15
5	X	4	=	20
5	X	5	=	25
5	X	6	=	30
5	X	7	=	35
5	X	8	=	40
5	X	9	=	45
5	X	10	=	50

Program…

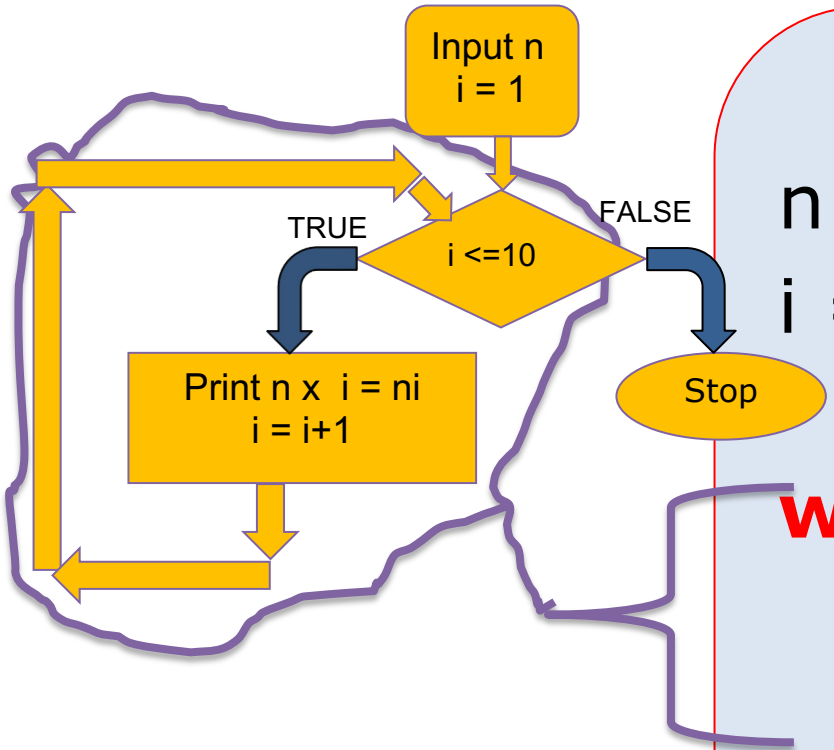
```
n = int(input('Enter
print (n, 'X', 1
print (n, 'X'
print (n, '
print (n,
print (n,
print (n, '
....
```



Printing Multiplication Table



Printing Multiplication Table

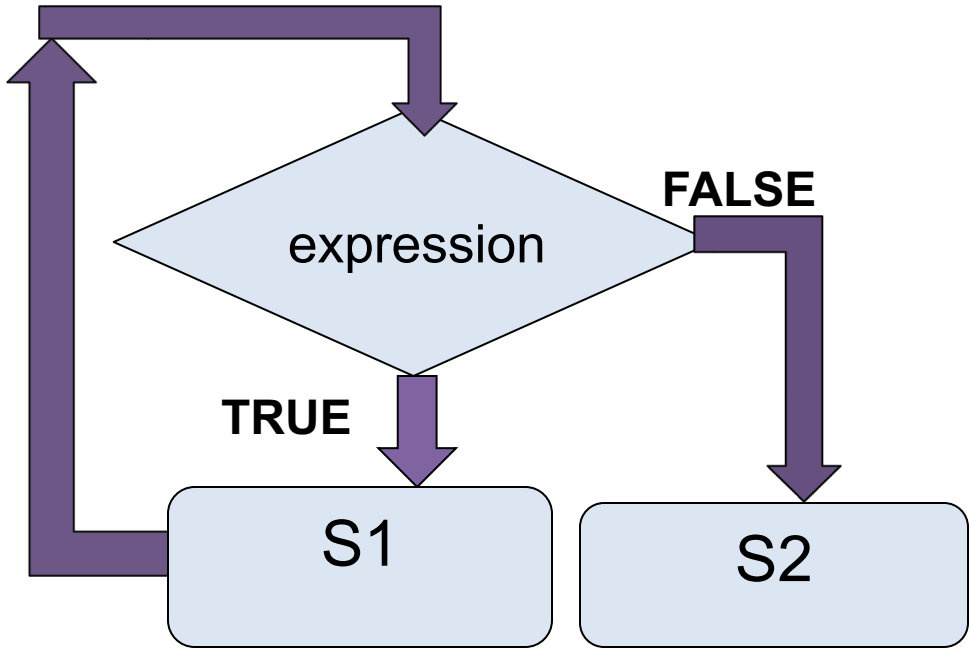



```
n = int(input('n=? '))
i = 1

while (i <= 10) :
    print (n ,'X', i, '=', n*i)
    i = i + 1
print ('done')
```

While Statement

```
while (expression):
        S1
S2
```



1. Evaluate expression
2. If TRUE then
   a) execute statement1
   b) goto step 1.
3. If FALSE then execute statement2.

For Loop

- Print the sum of the reciprocals of the first 100 natural numbers.

```
rsum=0.0# the reciprocal sum

# the for loop
for i in range(1,101):
    rsum = rsum + 1.0/i
print ('sum is', rsum)
```

For loop in Python

- General form

```
for variable in sequence:
    stmt
```

range

- range(s, e, d)
  - generates the list:

    [s, s+d, s+2*d, …, s+k*d]

    where s+k*d < e <= s+(k+1)*d
- range(s, e) is equivalent to range(s, e, 1)
- range(e) is equivalent to range(0, e)

Exercise: What if d is negative? Use python interpreter to find out.

Quiz

- What will be the output of the following program

```
# print all odd numbers < 10
i = 1
while i <= 10:
    if i%2==0: # even
        continue
    print (i, end=' ')
    i = i+1
```

Continue and Update Expr

- Make sure continue does not bypass update-expression for while loops

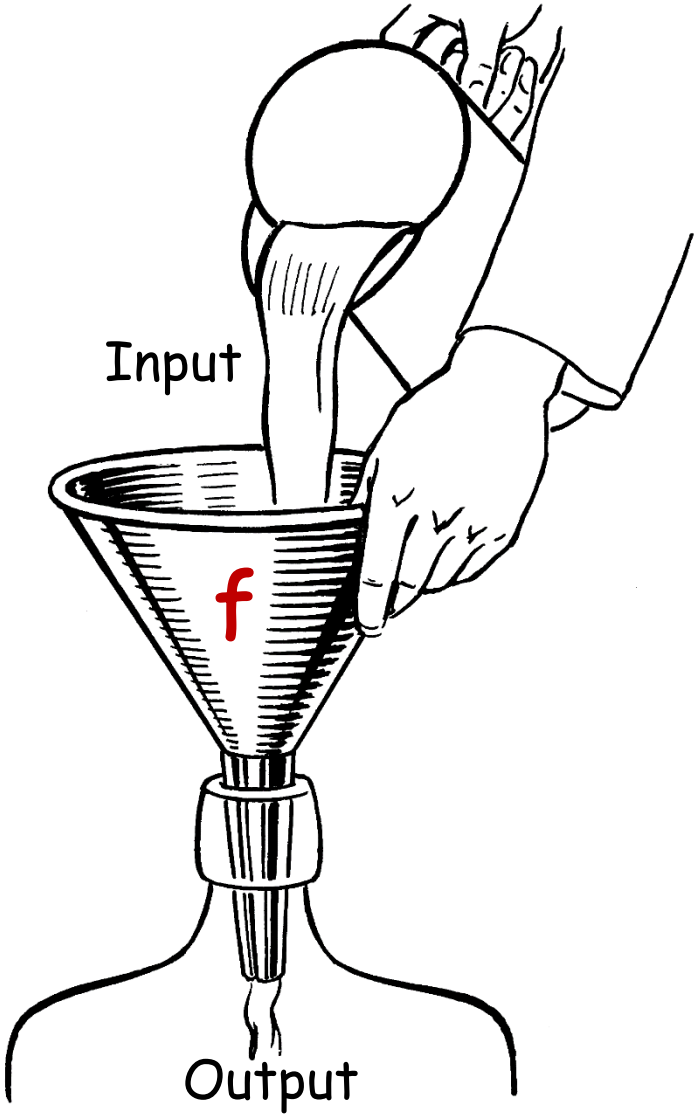
```
# print all odd numbers < 10
i = 1
while i <= 10:
    if i%2==0: # even
        continue
    print (i, end=' ')
    i = i+1
```

i is not incremented when even number encountered. Infinite loop!!

Programming using Python

f(unctions)

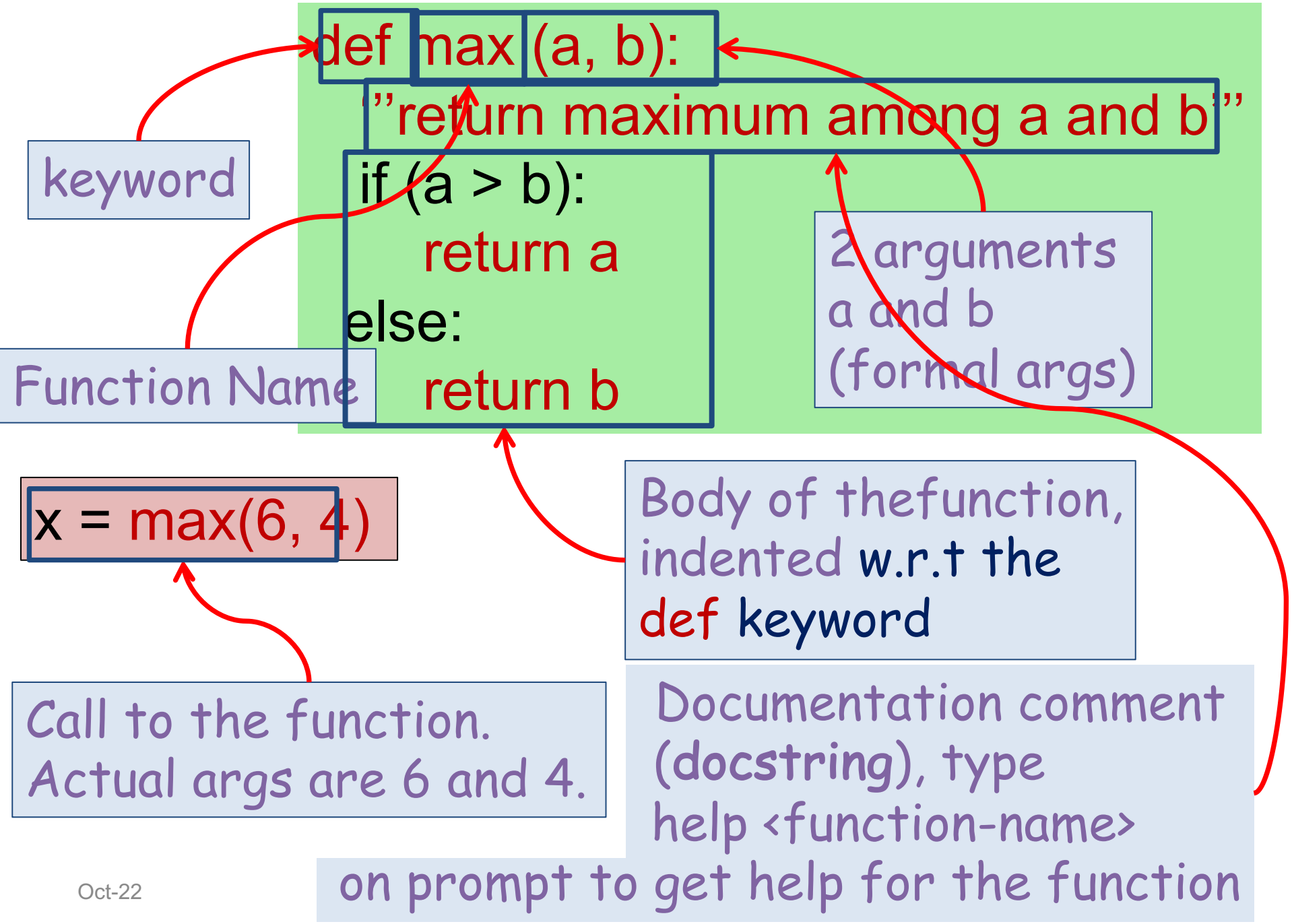
Parts of a function



Python built-in functions

		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()	

To find out how they work:
https://docs.python.org/3.3/library/functions.html


def max (a, b):
"""return maximum among a and b"""
if (a > b):
return a
else:
return b
keyword
Function Name
2 arguments
a and b
(formal args)
x = max(6, 4)
Body of thefunction,
indented w.r.t the
def keyword
Call to the function.
Actual args are 6 and 4.
Documentation comment
(docstring), type
help <function-name>
on prompt to get help for the function

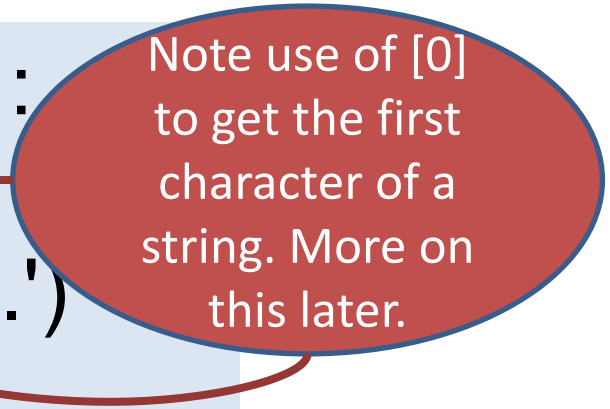
```
def max (a, b):
   '''return maximum among a and b'''
   if (a > b):
       return a
  else:
       return b
```

```
In[3] : help(max)
Help on function max in module __main__:

max(a, b)
    return maximum among a and b
```

Keyword Arguments

```
def printName(first, last, initials) :
    if initials:
        print (first[0] + '. ' + last[0] + '.')
    else:
        print (first, last)
```



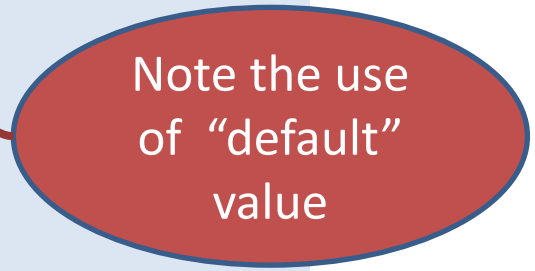
Call	Output
printName('Acads', 'Institute', False)	Acads Institute

Keyword Arguments

- Parameter passing where formal is bound to actual using formal's name
- Can mix keyword and non-keyword arguments
  - All non-keyword arguments precede keyword arguments in the call
  - Non-keyword arguments are matched by position (order is important)
  - Order of keyword arguments is not important

Default Values

```
def printName(first, last, initials=False) :
    if initials:
        print (first[0] + '. ' + last[0] + '.')
    else:
        print (first, last)
```



Call	Output
printName('Acads', 'Institute')	Acads Institute

Default Values

- Allows user to call a function with fewer arguments
- Useful when some argument has a fixed value for most of the calls
- All arguments with default values must be at the end of argument list
  - non-default argument can not follow default argument

Globals

- Globals allow functions to communicate with each other indirectly
  - Without parameter passing/return value
- Convenient when two seemingly “far-apart” functions want to share data
  - No *direct* caller/callee relation
- If a function has to update a global, it must re-declare the global variable with global keyword.

Globals

```
PI = 3.14
def perimeter(r):
    return 2 * PI * r
def area(r):
    return PI * r * r
def update_pi():
    global PI
    PI = 3.14159
```

```
>>> print(area (100))
31400.0
>>> print(perimeter(10))
62.800000000000004
>>> update_pi()
>>> print(area(100))
31415.999999999996
>>> print(perimeter(10))
62.832
```

defines PI to be of float type with value 3.14. PI can be used across functions. Any change to PI in update_pi will be visible to all due to the use of global.

Programming with Python

STRINGS
TUPLES
LISTS

Strings

- Strings in Python have type str
- They represent sequence of characters
  - Python does not have a type corresponding to character.
- Strings are enclosed in single quotes(') or double quotes(“)
  - Both are equivalent
- Backslash (\) is used to escape quotes and special characters

Strings

```
>>> name='intro to python'
>>> descr='acad\'s first course'
>>> name
'intro to python'
>>> descr
"acad's first course"
```

- More readable when print is used

```
>>> print descr
acad's first course
```

Length of a String

- len function gives the length of a string

```
>>> name='intro to python'
>>> empty=''
>>> single='a'
>>> len(name)
15
>>> len(single)
1
>>> len(empty)
0
>>> special='1\n2'
>>> len(special)
3
```

\n is a **single** character: the special character representing newline

Concatenate and Repeat

- In Python, + and * operations have special meaning when operating on strings
  - + is used for concatenation of (two) strings
  - * is used to repeat a string, an int number of time
  - Function/Operator Overloading

Concatenate and Repeat

```
>>> details = name + ', ' + descr
>>> details
"intro to python, acad's first course"

>>> print punishment
I won't fly paper airplanes in class

>>> print punishment*5
I won't fly paper airplanes in class
I won't fly paper airplanes in class
I won't fly paper airplanes in class
I won't fly paper airplanes in class
I won't fly paper airplanes in class
```

Quick question!

Do you see anything wrong with this block?

```
str1 = "which means it has even more than"
str2 = 76
str3 = "quirks"
print(str1 + str2 + str3)
```

```
---------------------------------------------------------------------------
----
TypeError                                 Traceback (most recent call l
ast)
<ipython-input-2-3be15a6244a4> in <module>()
      2 str2 = 76
      3 str3 = " quirks"
----> 4 print(str1 + str2 + str3)

TypeError: must be str, not int
```

Another more generic way to fix it

```
str1 = "It has"
str2 = 76
str3 = "methods!"
print(str1, str2, str3)
```

```
It has 76 methods!
```

If we comma separate statements in a print function, we can have different variables printing!

Placeholders

- A way to interleave numbers is

```
pi = 3.14159 # Pi
d = 12756 # Diameter of eath at equator (in km)
c = pi*d # Circumference of equator

#Print using +, and casting
print("Earth's diameter at equator: " + str(d) + "km. Equator's circumference:" + str(c) + "km.")
#Print using several arguments
print("Earth's diameter at equator:", d, "km. Equator's circumference:", c, "km.")
#Print using .format
print("Earth's diameter at equator: {:.1f} km. Equator's circumference: {:.1f} km.".format(d, c))
```

```
Earth's diameter at equator: 12756km. Equator's circumference:40074.12204km.
Earth's diameter at equator: 12756 km. Equator's circumference: 40074.12204 km.
Earth's diameter at equator: 12756.0 km. Equator's circumference: 40074.1 km.
```

- Elegant and easy

Indexing

- Strings can be indexed
- First character has index 0

```
>>> name='Acads'
>>> name[0]
'A'
>>> name[3]
'd'
>>> 'Hello'[1]
'e'
```

Indexing

- Negative indices start counting from the right
- Negatives indices start from -1
- -1 means last, -2 second last, ...

```
>>> name='Acads'
>>> name[-1]
's'
>>> name[-5]
'A'
>>> name[-2]
'd'
```

Indexing

- Using an index that is too large or too small results in "index out of range" error

```
>>> name='Acads'
>>> name[50]

Traceback (most recent call last):
  File "<pyshell#136>", line 1, in <module>
    name[50]
IndexError: string index out of range
>>> name[-50]

Traceback (most recent call last):
  File "<pyshell#137>", line 1, in <module>
    name[-50]
IndexError: string index out of range
```

Slicing

- To obtain a substring
- s[start:end] means substring of s starting at index start and ending at index end-1
- s[0:len(s)] is same as s
- Both start and end are optional
  - If start is omitted, it defaults to 0
  - If end is omitted, it defaults to the length of string
- s[:] is same as s[0:len(s)], that is same as s

Slicing

```
>>> name='Acads'
>>> name[0:3]
'Aca'
>>> name[:3]
'Aca'
>>> name[3:]
'ds'
>>> name[:3] + name[3:]
'Acads'
>>> name[0:len(name)]
'Acads'
>>> name[:]
'Acads'
```

More Slicing

```
>>> name='Acads'
>>> name[-4:-1]
'cad'
>>> name[-4:]
'cads'
>>> name[-4:4]
'cad'
```

Understanding Indices for slicing

A	c	a	d	s	
0	1	2	3	4	5
-5	-4	-3	-2	-1	

Out of Range Slicing

A	c	a	d	s
0	1	2	3	4
-5	-4	-3	-2	-1

- Out of range indices are ignored for slicing
- when start and end have the same sign, if start >=end, empty slice is returned


```
>>> name='Acads'
>>> name[4:50]
's'
>>> name[40:50]
''
>>> name[-50:20]
'Acads'
>>> name[-50:-20]
''
>>> name[50:20]
''
>>> name [1:-1]
'cad'
```

Can we remove a character from string?

Tuples

- A tuple consists of a number of values separated by commas

```
>>> t = 'intro to python', 'amey karkare', 101
>>> t[0]
'intro to python'
>>> t[2]
101
>>> t
('intro to python', 'amey karkare', 101)
>>> type(t)
<type 'tuple'>
```

- Empty and Singleton Tuples

```
>>> empty = ()
>>> singleton = 1,  # Note the comma at the end
```

Nested Tuples

- Tuples can be nested

```
>>> course = 'Python', 'Amey', 101
>>> student = 'Prasanna', 34, course
>>> student
('Prasanna', 34, ('Python', 'Amey', 101))
```

- Note that course tuple is copied into student.
  - Changing course does not affect student

```
>>> course = 'Stats', 'Adam', 102
>>> student
('Prasanna', 34, ('Python', 'Amey', 101))
```

Length of a Tuple

- len function gives the length of a tuple

```
>>> course = 'Python', 'Amey', 101
>>> student = 'Prasanna', 34, course
>>> empty = ()
>>> singleton = 1,
>>> len(empty)
0
>>> len(singleton)
1
>>> len(course)
3
>>> len(student)
3
```

More Operations on Tuples

- Tuples can be concatenated, repeated, indexed and sliced

```
>>> course1
('Python', 'Amey', 101)
>>> course2
('Stats', 'Adams', 102)
>>> course1 + course2
('Python', 'Amey', 101, 'Stats', 'Adams', 102)
>>> (course1 + course2)[3]
'Stats'
>>> (course1 + course2)[2:7]
(101, 'Stats', 'Adams', 102)
>>> 2*course1
('Python', 'Amey', 101, 'Python', 'Amey', 101)
```

Unpacking Sequences

- Strings and Tuples are examples of sequences
  - Indexing, slicing, concatenation, repetition operations applicable on sequences
- Sequence Unpacking operation can be applied to sequences to get the components
  - *Multiple assignment* statement
  - LHS and RHS must have equal length

Unpacking Sequences

```
>>> student
('Prasanna', 34, ('Python', 'Amey', 101))
>>> name,roll,regdcourse=student
>>> name
'Prasanna'
>>> roll
34
>>> regdcourse
('Python', 'Amey', 101)
>>> x1,x2,x3,x4 = 'amey'
>>> print(x1,x2,x3,x4)
a m e y
```

Lists

- Ordered sequence of values
- Written as a sequence of comma-separated values between square brackets
- Values can be of different types
  - usually the items all have the same type

```
>>> lst = [1,2,3,4,5]
>>> lst
[1, 2, 3, 4, 5]
>>> type(lst)
<type 'list'>
```

Lists

- List is also a sequence type
  - Sequence operations are applicable

```
>>> fib = [1,1,2,3,5,8,13,21,34,55]
>>> len(fib)
10
>>> fib[3] # Indexing
3
>>> fib[3:] # Slicing
[3, 5, 8, 13, 21, 34, 55]
```

Lists

- List is also a sequence type
  - Sequence operations are applicable

```
>>> [0] + fib # Concatenation
[0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55]
>>> 3 * [1, 1, 2] # Repetition
[1, 1, 2, 1, 1, 2, 1, 1, 2]
>>> x,y,z = [1,1,2] #Unpacking
>>> print (x, y, z )
1 1 2
```

More Operations on Lists

- L.append(x)
- L.extend(seq)
- L.insert(i, x)
- L.remove(x)
- L.pop(i)
- L.pop()
- L.index(x)
- L.count(x)
- L.**sort**()
- L.**reverse**()

x is any value, seq is a sequence value (list, string, tuple, …),
i is an integer value

Mutable and Immutable Types

- Tuples and List types look very similar
- However, there is one major difference: Lists are **mutable**
  - Contents of a list can be modified
- Tuples and Strings are **immutable**
  - Contents can not be modified

Summary of Sequences

Operation	Meaning
seq[i]	i-th element of the sequence
len(seq)	Length of the sequence
seq1 + seq2	Concatenate the two sequences
num*seq seq*num	Repeat seq num times
seq[start:end]	slice starting from **start**, and ending at **end-1**
e in seq	True if e is present is seq, False otherwise
e not in seq	True if e is not present is seq, False otherwise
for e in seq	Iterate over all elements in seq (e is bound to one element per iteration)

Sequence types include String, Tuple and List.
Lists are mutable, Tuple and Strings immutable.

Programming with Python

Sets and Dictionaries

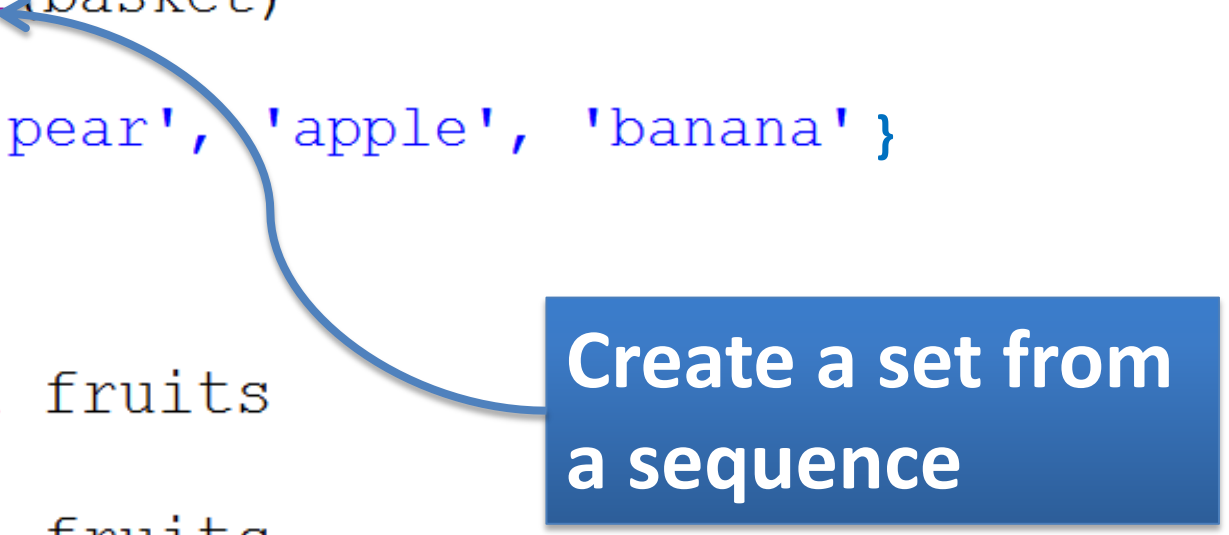
Sets

- An unordered collection with no duplicate elements
- Supports
  - membership testing
  - eliminating duplicate entries
  - Set operations: union, intersection, difference, and symmetric difference.

Sets

```
>>> basket = ['apple', 'orange', 'apple', 'pear', 'o
range', 'banana']
>>> fruits = set(basket)
>>> fruits
    {'orange', 'pear', 'apple', 'banana'}
>>> type(fruits)
        set

 >>> 'apple' in fruits
 True
 >>> 'mango' in fruits
 False
```



Set Operations

```
>>> A=set('acads')
>>> B=set('institute')
>>> A
    {'a', 's', 'c', 'd'}
>>> B
    {'e', 'i', 'n', 's', 'u', 't'}
>>> A - B # Set difference
    {'a', 'c', 'd'}
>>> A | B # Set Union
    {'a', 'c', 'e', 'd', 'i', 'n', 's', 'u', 't'}
>>> A & B # Set intersection
    {'s'}
>>> A ^ B # Symmetric Difference
set(['a', 'd', 'c', 'e', 't', 'i', 'u', 'n'])
```

Dictionaries

- Unordered set of *key:value* pairs,
- Keys have to be unique
- Key:value pairs enclosed inside curly braces {...}
- Empty dictionary is created by writing {}
- Dictionaries are mutable
  - add new key:value pairs,
  - change the pairing
  - delete a key (and associated value)

Operations on Dictionaries

Operation	Meaning
len(d)	Number of key:value pairs in d
d.keys()	List containing the keys in d
d.values()	List containing the values in d
k in d	True if key k is in d
d[k]	Value associated with key k in d
d.get(k, v)	If k is present in d, then d[k] else v
d[k] = v	Map the value v to key k in d (replace d[k] if present)
del d[k]	Remove key k (and associated value) from d
for k in d	Iterate over the keys in d

Operations on Dictionaries

```
>>> capital = {'India':'New Delhi', 'USA':'Washingto
n DC', 'France':'Paris', 'Sri Lanka':'Colombo'}
>>> capital['India'] # Get an existing value
'New Delhi'
>>> capital['UK'] # Exception thrown for missing key

Traceback (most recent call last):
  File "<pyshell#130>", line 1, in <module>
    capital['UK'] # Exception thrown for missing key
KeyError: 'UK'
>>> capital.get('UK', 'Unknown') # Use of default
value with get
'Unknown'
>>> capital['UK']='London' # Add a new key:val pair
>>> capital['UK'] # Now it works
'London'
```

Operations on Dictionaries

```
>>> capital.keys()
['Sri Lanka', 'India', 'UK', 'USA', 'France']
>>> capital.values()
['Colombo', 'New Delhi', 'London', 'Washington DC',
'Paris']
>>> len(capital)
5
>>> 'USA' in capital
True
>>> 'Russia' in capital
False
>>> del capital['USA']
>>> capital
{'Sri Lanka': 'Colombo', 'India': 'New Delhi', 'UK':
'London', 'France': 'Paris'}
```

Operations on Dictionaries

```
>>> capital['Sri Lanka'] = 'Sri Jayawardenepura Kotte' # Wikipedia told me this!
>>> capital
{'Sri Lanka': 'Sri Jayawardenepura Kotte', 'India': 'New Delhi', 'UK': 'London', 'France': 'Paris'}
```

```
>>> countries = []
>>> for k in capital:
        countries.append(k)
```

 # Remember: for ... in iterates over keys only

```
>>> countries.sort() # Sort values in a list
>>> countries
['France', 'India', 'Sri Lanka', 'UK']
```

Dictionary Construction

- The dict constructor: builds dictionaries directly from *sequences of key-value pairs*

```
>>> airports=dict([('Mumbai', 'BOM'), ('Delhi', 'Del
'),('Chennai', 'MAA'), ('Kolkata', 'CCU')])
>>> airports
{'Kolkata': 'CCU', 'Chennai': 'MAA', 'Delhi': 'Del',
'Mumbai': 'BOM'}
```

Programming with Python

File I/O

File I/O

- Files are persistent storage
- Allow data to be stored beyond program lifetime
- The basic operations on files are
  - open, close, read, write
- Python treat files as sequence of lines
  - sequence operations work for the data read from files

File I/O: open and close

open(filename, mode)

- While opening a file, you need to supply
  - The name of the file, including the path
  - The mode in which you want to open a file
  - Common modes are r (read), w (write), a (append)
- Mode is optional, defaults to r
- open(..) returns a file object
- close() on the file object closes the file
  - finishes any buffered operations

File I/O: Example

```
>>> players = open('tennis_players', 'w')
>>>
>>>
>>>
>>>
>>>
>>> players.close() # done with writing
```

- Do some writing
- How to do it?
  - see the next few slides

File I/O: read, write and append

- Reading from an open file returns the contents of the file
  - as **sequence** of lines in the program
- Writing to a file
  - IMPORTANT: If opened with mode 'w', **clears** the existing contents of the file
  - Use append mode ('a') to preserve the contents
  - Writing happens at the end

File I/O: Examples

```
>>> players = open('tennis_players', 'w')
>>> players.write('Roger Federar\n')
>>> players.write('Rafael Nadal\n')
>>> players.write('Andy Murray\n')
>>> players.write('Novak Djokovic\n')
>>> players.write('Leander Paes\n')
>>> players.close() # done with writing

>>> countries = open('tennis_countries', 'w')
>>> countries.write('Switzerland\n')
>>> countries.write('Spain\n')
>>> countries.write('Britain\n')
>>> countries.write('Serbia\n')
>>> countries.write('India\n')

>>> countries.close() # done with writing
```

File I/O: Examples

```
>>> print(players)
<closed file 'tennis_players', mode 'w' at 0x
031A48B8>
>>> print(countries)
<closed file 'tennis_countries', mode 'w' at
0x031A49C0>

>>> n = open('tennis_players', 'r')
>>> c = open('tennis_countries', 'r')
>>> n
<open file 'tennis_players', mode 'r' at 0x03
1A4910>
>>> c
<open file 'tennis_countries', mode 'r' at 0x
031A4A70>
```

```
>>> pn = n.read() # read all players
>>> pn
'Roger Federar\nRafael Nadal\nAndy Murray\nNo
vak Djokovic\nLeander Paes\n'
>>> print(pn)
Roger Federar
Rafael Nadal
Andy Murray
Novak Djokovic
Leander Paes

>>>
>>> n.close()
```

File I/O: Examples

```
>>> n = open('tennis_players', 'r')
>>> c = open('tennis_countries', 'r')
>>> pn, pc = [], []
>>> for l in n:
    pn.append(l[:-1]) # ignore '\n'

>>> n.close()
>>> for l in c:
    pc.append(l[:-1])
>>> c.close()
```

Note the use of for ... in for sequence

```
>>> print(pn, '\n', pc)
['Roger Federar', 'Rafael Nadal', 'Andy Murra
y', 'Novak Djokovic', 'Leander Paes']
['Switzerland', 'Spain', 'Britain', 'Serbia',
'India']
```

File I/O: Examples

```
>>> name_country = []
>>> for i in range(len(pn)):
        name_country.append((pn[i], pc[i]))


>>> print(name_country )
[('Roger Federar', 'Switzerland'), ('Rafael N
adal', 'Spain'), ('Andy Murray', 'Britain'),
('Novak Djokovic', 'Serbia'), ('Leander Paes'
, 'India')]
>>> n2c = dict(name_country)
>>> print(n2c)
{'Roger Federar': 'Switzerland', 'Andy Murray
': 'Britain', 'Leander Paes': 'India', 'Novak
Djokovic': 'Serbia', 'Rafael Nadal': 'Spain'}
>>> print(n2c['Leander Paes'])
India
```

Error Handling

- Avoid crashing of program
- Handle errors graciously

```
import csv
path = 'C:/Users/Abhinav/Desktop/IIIT_Pyton/missing.csv'
f = open(path, 'r')
row = csv.reader(f)
header = next(row)
for line in row:
    try:
        part1 = line[2].strip("'")
        part2 = line[3].strip("'")
    except ValueError as err:
        print("Bad Data: ", err)
        continue
    partM = int(part1) * float(part2)
    print(partM)
f.close()
```

Argument syntax

Variable and keyword arguments

```
def function(name, address="abcd"):
```

Arbitrary arguments (non-keyword)

```
def hypervolume(*length):
    a = 1
    for v in length:
        a *= v
    print(a)
```

Keyword arguments

```
def tag(name, **kwargs):
    print(name)
    print(kwargs)
tag('img', src="iiir.jpg", alt="knowledge",border=1)
```

Lambda Function

- **lambda** function is called an anonymous function. It is a single expression with implicit return.
- It can have any number of arguments but only one expression

lambda arguments : expression

```
d = {'apple': 18, 'orange': 20, 'banana': 5, 'rotten tomato': 1}
sorted(d.items(), key=lambda x: x[1])
```

High Order Functions

- We can use functions as data (objects) same as int, string, float etc.
- This is very useful when people write code that take functions as input

```
>>> def add(x,y):
        def add_closure():
                print('Adding {} + {} = {}'.format(x,y,x+y))
                return x+y
        return add_closure

>>> a = add(2,3)
>>> a()
Adding 2 + 3 = 5
5
```

```
>>> import time
>>> def after(second,func):
        time.sleep(second)
        func()


>>> def hello():
        print("Hello World")


>>> after(5,hello)
Hello World
```

- Closures : add_closure() do not take x,y. It just captures these x, y. This is called closure.

Programming using Python

Modules and Packages

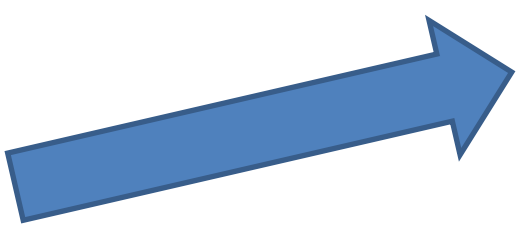
Modules

- As program gets longer, need to organize them for easier access and easier maintenance.
- Reuse same functions across programs without copying its definition into each program.
- Python allows putting definitions in a file
  - use them in a script or in an interactive instance of the interpreter
- Such a file is called a *module*
  - definitions from a module can be *imported* into other modules or into the *main* module

Modules

- A module is a file containing Python definitions and statements.
- The file name is the module name with the suffix .py appended.
- Within a module, the module's name is available in the global variable __name__.

Modules Example



fib.py - C:\

File Edit Format Run Options Window Help

```
# Module for fibonacci numbers

def fib_rec(n):
    '''recursive fibonacci'''
    if (n <= 1):
        return n
    else:
        return fib_rec(n-1) + fib_rec(n-2)
```

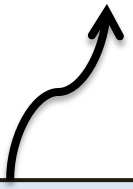
Modules Example

```
def fib_rec(n):
    '''recursive fibonacci'''
    if (n <= 1):
        return n
    else:
        return fib_rec(n-1) + fib_rec(n-2)

def fib_iter(n):
    '''iterative fibonacci'''
    cur, nxt = 0, 1
    for k in range(n):
        cur, nxt = nxt, cur+nxt
    return cur

def fib_upto(n):
    '''given n, return list of fibonacci
    numbers <= n'''
    cur, nxt = 0, 1
    lst = []
    while (cur < n):
        lst.append(cur)
        cur, nxt = nxt, cur+nxt
    return lst
```

```
>>> import fib
>>> fib.fib_upto(5)
[0, 1, 1, 2, 3]
>>> fib.fib_rec(10)
55
>>> fib.fib_iter(20)
6765
>>> fib.__name__
'fib'
```



Within a module, the module's name is available as the value of the global variable __name__.

Importing Specific Functions

- To import specific functions from a module

```
>>> from fib import fib_upto
>>> fib_upto(6)
[0, 1, 1, 2, 3, 5]
>>> fib_iter(1)

Traceback (most recent call last):
  File "<pyshell#16>", line 1, in <module>
    fib_iter(1)
NameError: name 'fib_iter' is not defined
```

- This brings only the imported functions in the current symbol table
  - No need of modulename. (absence of `fib.` in the example)

Importing ALL Functions

- To import *all* functions from a module, in the current symbol table

```
>>> from fib import *
>>> fib_upto(6)
[0, 1, 1, 2, 3, 5]
>>> fib_iter(8)
21
```

- This imports all names except those beginning with an underscore (_).

`__main__` in Modules

- When you run a module on the command line with

  ```
  python fib.py <arguments>
  ```

  the code in the module will be executed, just as if you imported it, but with the `__name__` set to "__main__".
- By adding this code at the end of your module

  ```
  if __name__ == "__main__":
      ... # Some code here
  ```

  you can make the file usable as a script as well as an importable module

`__main__` in Modules

```
if __name__ == "__main__":
    import sys
    print (fib_iter(int(sys.argv[1])))
```

- This code parses the command line only if the module is executed as the “main” file:

```
$ python fib.py 10
55
```

- If the module is imported, the code is not run:

```
>>> import fib
>>>
```

Package

- A Python package is a collection of Python modules.
- Another level of *organization.*
- *Packages* are a way of structuring Python's module namespace by using *dotted module names*.
  - The module name A.B designates a submodule named B in a package named A.
  - The use of dotted module names saves the authors of multi-module packages like NumPy or SciPy from having to worry about each other's module names.

Importing Module

- Python comes up with built-in functions – print(), len(), input()
- It also comes up with set if modules called standard library.
- These can be embedded in code. But you must import it in order to be able to use it.
- Example – random module, math module and so on.
- Alternative form of import statement is composed of from keyword.
  - eg from random import *
  - with this form you need not need the random. prefix

```
>>> import random
>>> for i in range(10):
        print(random.randint(1,10))
```

A **sound** Package

```
sound/                          Top-level package
      __init__.py               Initialize the sound package
      formats/                  Subpackage for file format conversions
              __init__.py
              wavread.py
              wavwrite.py
              aiffread.py
              aiffwrite.py
              auread.py
              auwrite.py
              ...
      effects/                  Subpackage for sound effects
              __init__.py
              echo.py
              surround.py
              reverse.py
              ...
      filters/                  Subpackage for filters
              __init__.py
              equalizer.py
              vocoder.py
              karaoke.py
              ...
```

https://docs.python.org/3/tutorial/modules.html

A **sound** Package

```
sound/                          Top-level package
      __init__.py               Initialize the sound package
      formats/                  Subpackage for file format conversions
              __init__.py
              wavread.py
              wavwrite.py
              aiffread.py
              aiffwrite.py
              auread.py
              auwrite.py
              ...
      effects/                  Subpackage for sound effects
              __init__.py
              echo.py
              surround.py
              reverse.py
              ...
      filters/                  Subpackage for filters
              __init__.py
              equalizer.py
              vocoder.py
              karaoke.py
              ...
```

What are these files names?

https://docs.python.org/3/tutorial/modules.html

`__init.py__`

- The `__init__.py` files are required to make Python treat directories containing the file as packages.
- This prevents directories with a common name, such as `string`, unintentionally hiding valid modules that occur later on the module search path.
- `__init__.py` can just be an empty file
- It can also execute initialization code for the package

Importing Modules from Packages

```
sound/                          Top-level package
      __init__.py               Initialize the sound package
      formats/                  Subpackage for file format conversions
              __init__.py
              wavread.py
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              aiffread.py
              aiffwrite.py
              auread.py
              auwrite.py
              ...
      effects/                  Subpackage for sound effects
              __init__.py
              echo.py
              surround.py
              reverse.py
              ...
      filters/                  Subpackage for filters
              __init__.py
              equalizer.py
              vocoder.py
              karaoke.py
              ...
```

https://docs.python.org/3/tutorial/modules.html

Importing Modules from Packages

`import sound.effects.echo`

- Loads the submodule `sound.effects.echo`
- It must be referenced with its full name:

```
sound.effects.echo.echofilter(
    input, output,
    delay=0.7, atten=4
)
```

Importing Modules from Packages

```
from sound.effects import echo
```

- This also loads the submodule `echo`
- Makes it available without package prefix
- It can be used as:

```
echo.echofilter(
    input, output,
    delay=0.7, atten=4
)
```

Importing Modules from Packages

```
from sound.effects.echo import echofilter
```

- This loads the submodule `echo`, but this makes its function `echofilter()` directly available.

```
echofilter(input, output,
           delay=0.7, atten=4)
```

Popular Packages

- pandas, numpy, scipy, matplotlib, …
- Provide a lot of useful functions