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Introduction to Computer Science: Programming Methodology

Lecture 4 Function

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Stored (and reused) steps

Program

```
def Hello():  
    print('Hello')  
    print('Funny')
```

```
Hello()  
print('Something in the middle.')
```

```
Hello()
```

Output

```
Hello  
Funny  
Something in the middle.  
Hello  
Funny
```

This reusable paragraph of code is usually called **function**

Python functions

- There are two types of functions in **Python**
 - ✓ **Built-in functions** which are part of Python, such as `print()`, `int()`, `float()`, etc
 - ✓ Functions that we define **ourselves** and then use
- The names of built-in functions are usually considered as **new reserved words**, i.e. we **do not** use them as variable names

Function definition

- In Python, a function is some reusable code which can take **arguments** as input, perform some computations, and then output some results
- Functions are defined using reserved word **def**
- We **call/invoke** a function by using the function name, parenthesis and arguments in an expression

Argument

```
big = max('Hello world')
```

w

Result

```
>>> big = max('Hello world')
>>> print(big)
w
>>> small = min('Hello world')
>>> print(small)
```

max() function

```
>>> big = max('Hello world')  
>>> print big  
'w'
```

A function is some stored code that we use. A function takes some input and produces an output.

"Hello world"
(a string)



max()
function



'w'
(a string)

Guido wrote this code

Building our own functions

- We create a new function using the **def** key word, followed by **optional parameters** in parenthesis
- We **indent** the body of the function
- This defines the function, but **does not execute** the body of the function

A sample code

Program

```
x=5
print('Hello')

def print_lyrics():
    print('I am a lumberjack, and I am okay.')
    print('I sleep all night and I work all day.')

print('Yo')
x=x+2
print(x)
```

Output

```
Hello
Yo
7
```


A sample code

Program

```
x=5
print('Hello')

def print_lyrics():
    print('I am a lumberjack, and I am okay.')
    print('I sleep all night and I work all day.')

print('Yo')
print_lyrics()
x=x+2
print(x)
```

Output

```
Hello
Yo
I am a lumberjack, and I am okay.
I sleep all night and I work all day.
7
```

Argument

- An **argument** is a value we pass into the function as its **input** when we **call** the function
- We use **arguments** so we can **direct** the function to do **different** kinds of work when we call it at **different** times
- We put the **argument** in parenthesis after the **name** of the function

```
big = max('I am the one')
```

argument






Parameters

- A **parameter** is a **variable** which we use in the function definition that is a **'handle'** that allows the code in the function to **access the arguments** for a **particular** function invocation

```
def greet(lang):  
    if lang=='es':  
        print('Hola')  
    elif lang=='fr':  
        print('Bonjour')  
    else:  
        print('Hello')
```

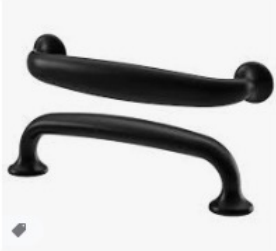
```
>>> greet('en')  
Hello  
>>> greet('es')  
Hola  
>>> greet('fr')  
Bonjour
```

What is a handle?


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Return values

- Often a function will take its **arguments**, do some computation and **return** a value to be used as the value of the function call in the **calling expression**. The **return** keyword is for this purpose.

Program

```
def greet():  
    return 'Hello'  
  
print(greet(), 'Glenn')  
print(greet(), 'Sally')
```

Output

```
Hello Glenn  
Hello Sally
```

Return values

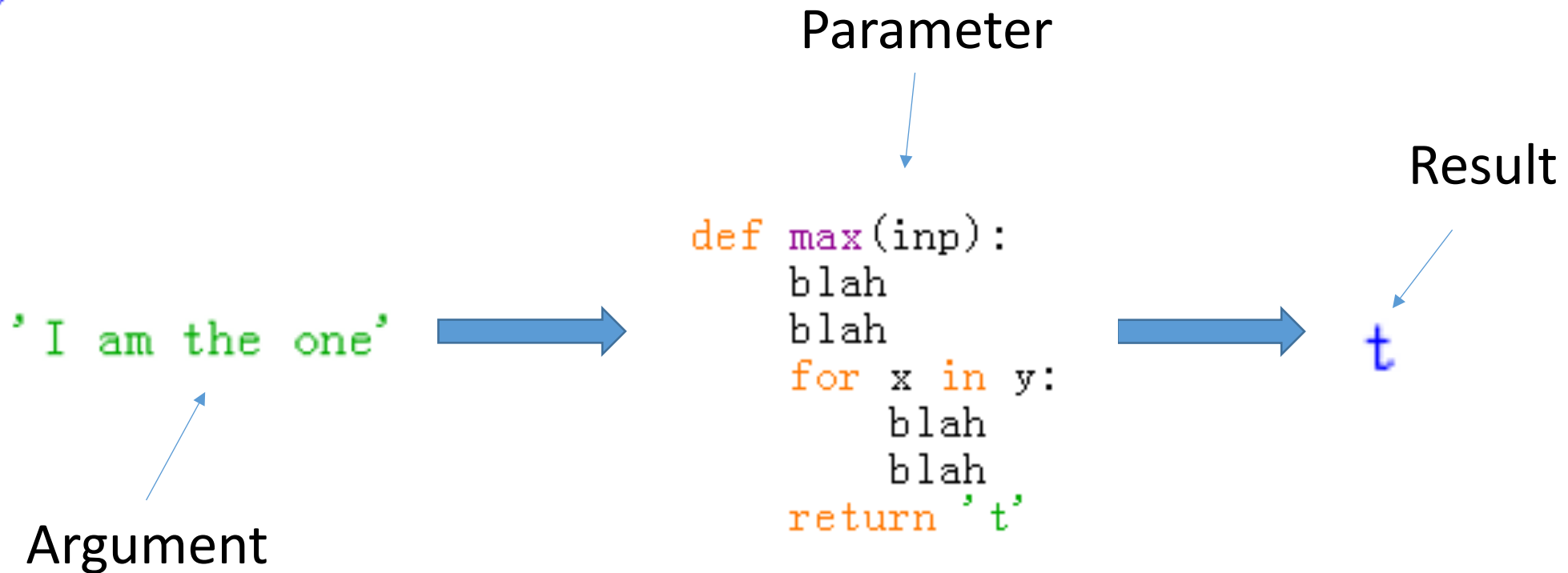
- A fruitful function is one that produces a **result** (or **return value**)
- The **return** statement **ends** the function execution and 'sends back' the **result** of the function

```
def greet(lang):  
    if lang=='es':  
        return 'Hola'  
    elif lang=='fr':  
        return 'Bonjour'  
    else:  
        return 'Hello'
```

```
>>> print(greet('en'), 'Glenn')  
Hello Glenn  
>>> print(greet('es'), 'Sally')  
Hola Sally  
>>> print(greet('fr'), 'Michael')  
Bonjour Michael
```

Argument, parameter, and result

```
>>> big = max(' I am the one')  
>>> print(big)  
t
```



Multiple parameters/arguments

- We can define **more than one** parameter in a function definition
- We simply add **more arguments** when we **call** the function
- We **match** the **number** and **order** of arguments and parameters

```
def AddTwo(a, b):  
    total = a+b  
    return total
```

```
x=AddTwo(3, 5)  
print(x)
```


Void functions

- When a function **does not return** a value, it is called a “**void**” function
- Functions that return values are “fruitful” functions
- Void functions are “not fruitful”

Functions without return

- When a function has **no return statement**, it will return **None**

```
# Print grade for the score
def printGrade(score):
    if score >= 90.0:
        print('A')
    elif score >= 80.0:
        print('B')
    elif score >= 70.0:
        print('C')
    elif score >= 60.0:
        print('D')
    else:
        print('F')

def main():
    score = eval(input("Enter a score: "))
    print("The grade is ", end = " ")
    printGrade(score)

main() # Call the main function
```

Scope of variables

- The **scope** of a variable is the part of program where this variable can be accessed
- A variable created inside a function is referred to as a **local variable**
- **Global variables** are created outside all functions and are accessible to all functions in their scope

```
globalVar = 1
def f1():
    localVar = 2
    print(globalVar)
    print(localVar)
```

```
f1()
print(globalVar)
print(localVar) # Out of scope, so this gives an error
```

Scope of variables

- Different variables may **share a name** if they have **different scopes**

```
x = 1
def f1():
    x = 2
    print(x) # Displays 2
```

```
f1()
print(x) # Displays 1
```

Global variable

- In a function, you can use keyword `global` to specify that a variable is a `global variable`
- Be very careful when define and use global variable

```
x = 1
def increase():
    global x
    x = x + 1
    print(x) # Displays 2
```

```
increase()
print(x) # Displays 2
```

Default argument

- Python allows you to define functions with **default argument values**
- The default argument values will be passed to the function, when it is invoked **without arguments**

```
def printArea(width = 1, height = 2):  
    area = width * height  
    print("width:", width, "\theight:", height, "\tarea:", area)
```

```
printArea() # Default arguments width = 1 and height = 2  
printArea(4, 2.5) # Positional arguments width = 4 and height = 2.5  
printArea(height = 5, width = 3) # Keyword arguments width  
printArea(width = 1.2) # Default height = 2  
printArea(height = 6.2) # Default width = 1
```

Return multiple values

- Python allows a function to return **multiple values**
- The sort function returns two values; when it is invoked, you need to pass the returned values in a **simultaneous assignment**

```
def sort(number1, number2):  
    if number1 < number2:  
        return number1, number2  
    else:  
        return number2, number1  
  
n1, n2 = sort(3, 2)  
print("n1 is", n1)  
print("n2 is", n2)
```

To function or not function...

- Organize your code into paragraphs - capture a complete thought and name it
- Don't repeat yourself – name it to work once and reuse it
- If something goes too complex, break up them into several blocks, and put each of them into a function
- Make a library of common stuffs that you do over and over again – perhaps share with other people

Practice

- Write a **function** to instruct the user to input the working hours and hourly rate, and then **return** the salary. If the working hours exceed 40 hours, then the extra hours received 1.5 times pay.

Practice 2: Personal Income Tax

- A function, to get the tax for a given salary (excluded tax-free parts) in a year.
 - If the salary is less than 36000. It takes 3%
 - If the salary is between 36000 and 144000, it takes **3%** for the part less than 36000; **10%** for the part between 36000 and 144000.
 -

1	0 - 36000	3
2	36000.01 - 144000	10
3	144000.01 - 300000	20
4	300000.01 - 420000	25
5	420000.01 - 660000	30
6	660000.01 - 960000	35
7	960000.01 - ∞	45

```
# import matplotlib.pyplot as plt
```

```
def tax( salary):  
    if salary < 36000:  
        return salary * 0.03  
    elif salary < 144000:  
        return 36000 * 0.03 + (144000 - salary) * 0.1  
    elif salary < 300000:  
        return 36000 * 0.03 + (144000 - 36000) * 0.1 + (300000 - 144000) * 0.2 + (300000 - salary) * 0.25  
    elif salary < 420000:  
        return 36000 * 0.03 + (144000 - 36000) * 0.1 + (300000 - 144000) * 0.2 + (420000 - 36000) * 0.25 + (420000 - salary) * 0.3  
    elif salary < 660000:  
        return 36000 * 0.03 + (144000 - 36000) * 0.1 + (300000 - 144000) * 0.2 + (420000 - 36000) * 0.25 + (660000 - 420000) * 0.3 + (660000 - salary) * 0.35  
    elif salary < 960000:  
        return 36000 * 0.03 + (144000 - 36000) * 0.1 + (300000 - 144000) * 0.2 + (420000 - 36000) * 0.25 + (660000 - 420000) * 0.3 + (960000 - 660000) * 0.35 + (960000 - salary) * 0.45  
    else:  
        return 36000 * 0.03 + (144000 - 36000) * 0.1 + (300000 - 144000) * 0.2 + (420000 - 36000) * 0.25 + (660000 - 420000) * 0.3 + (960000 - 660000) * 0.35 + (salary - 960000) * 0.45  
  
taxes = []  
for s in range(0, 2000000, 10000):  
    the_tax = tax(s)  
    print(s, the_tax, s- the_tax)  
    taxes.append(the_tax)  
# plt.plot(range(0, 2000000, 10000),taxes )
```

String type

- A **string** is a sequence of **characters**
- A string literal uses quotes " or ""
- For strings, + means "concatenate"
- When a string contains numbers, it is still a string
- We can convert numbers in a string into a number using int() or float()

Reading and converting

- We prefer to read data in using strings and then parse and convert the data as we need
- This gives us more control over error situations and/or bad user inputs
- Raw input numbers must be converted from strings

Looking inside strings

- We can get **any character** in a string using an **index** specified in **square brackets**
- The index value must be an **integer** which starts from **zero**
- The index value can be an **expression**

A diagram showing the string 'banana' with each character in a separate box. Below each box is its corresponding index: 'b' at 0, 'a' at 1, 'n' at 2, 'a' at 3, 'n' at 4, and 'a' at 5. The boxes are highlighted with a yellow border.

```
>>> fruit = 'banana'
>>> letter = fruit[1]
>>> print letter
a
>>> n = 3
>>> w = fruit[n - 1]
>>> print w
n
```

Index out of range

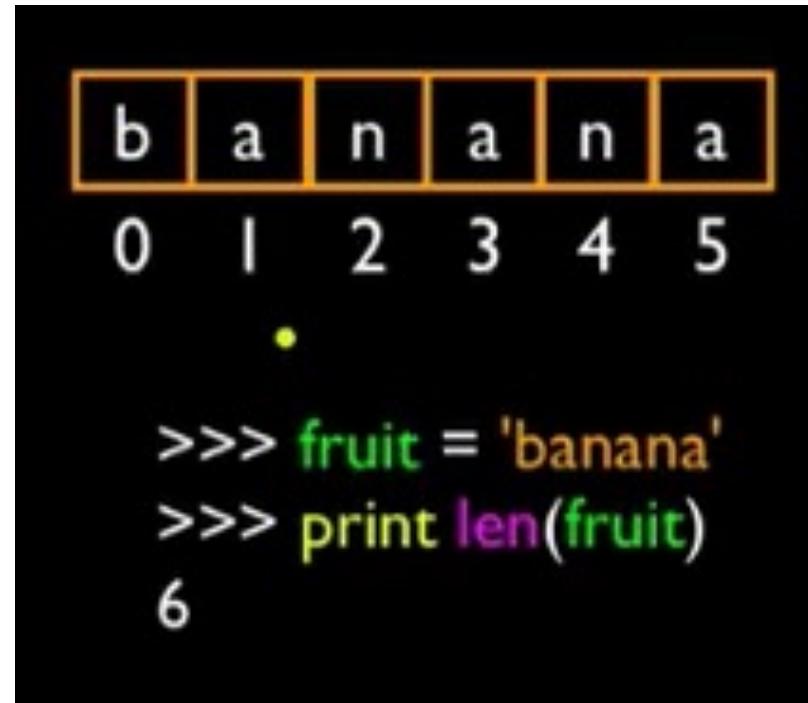
- You will get a **Python error** if you attempt to index beyond the end of a string

```
>>> name = 'Alice'
>>> name[6]
Traceback (most recent call last):
  File "<pyshell#10>", line 1, in <module>
    name[6]
IndexError: string index out of range
```

- Be careful when specifying an index value

Strings have length

- There is a built-in function `len()` which gives us the **length** of a string

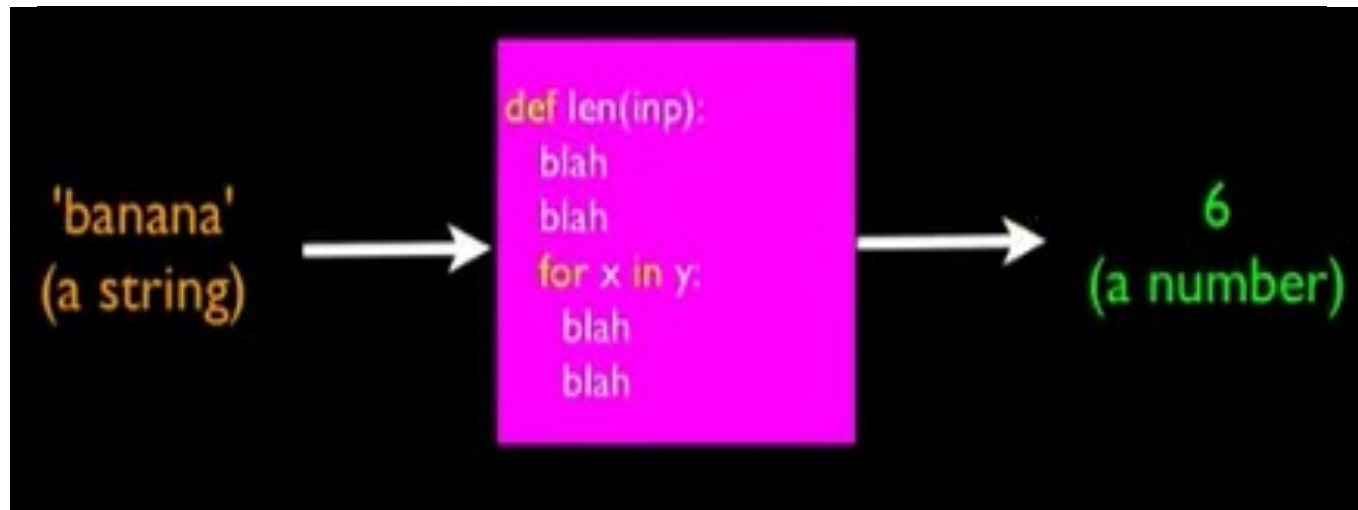


The diagram shows the string 'banana' with each character in a separate box, indexed from 0 to 5. Below this, a Python code snippet demonstrates the use of the `len()` function to determine the length of the string.

```
>>> fruit = 'banana'
>>> print len(fruit)
6
```


Len() function

```
>>> fruit = 'apple'  
>>> length = len(fruit)  
>>> print(length)  
5
```



Looping through strings

- Using a **for** statement, we can easily loop through **each character** in a string

```
fruit = ' I am the one, Morpheus'  
  
n = 0  
for i in fruit:  
    print(n, i)  
    n=n+1  
  
print(' finished' )
```

- String is essentially a **list** in Python

```
0 I  
1  
2 a  
3 m  
4  
5 t  
6 h  
7 e  
8  
9 o  
10 n  
11 e  
12 ,  
13 M  
14 o  
15 r  
16 p  
17 h  
18 e  
19 u  
20 s  
finished
```

Practice

- Write a program to use a **while** statement together with **len()** function to loop through a given string

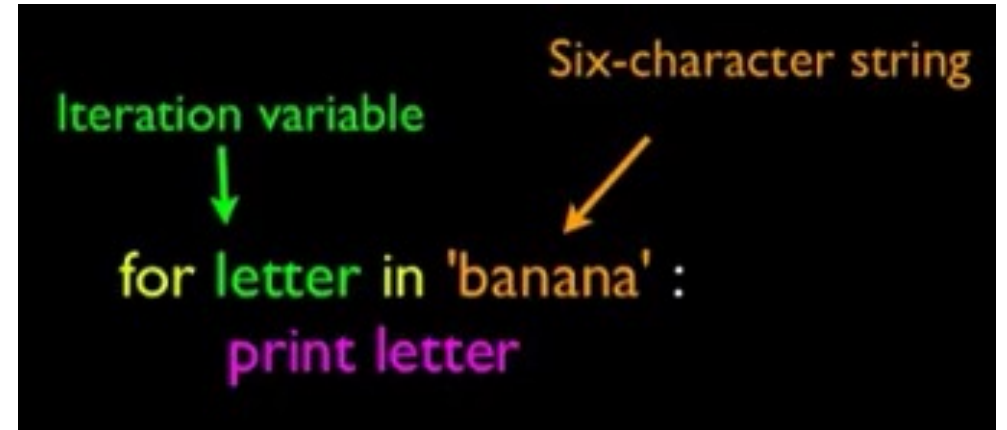
Loop and counting

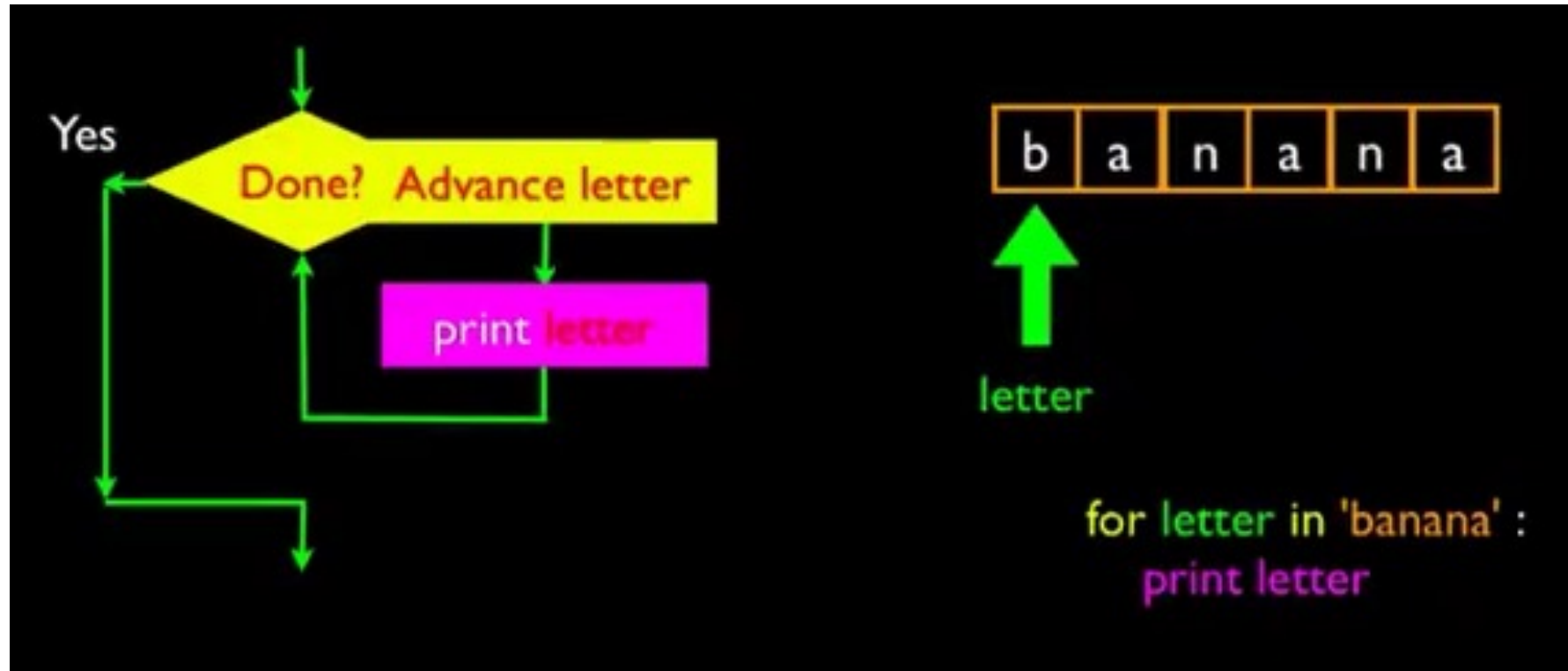
- This is a simple statement that loops through each letter in a string and counts the number of times the loop encounters the 'a' character

```
word = 'banana'
count = 0
for letter in word:
    if letter == 'a':
        count = count + 1
print("The number of 'a' we have seen is:", count)
```

Look deeper into in

- The **iteration variables** “iterates” through the **sequence** (ordered set)
- The **block (body)** of the loop is executed once for each value in the **sequence**
- The **iteration variable** moves through all the values in the sequence





- The iteration variable loops through the string, and the body of the loop is executed once for each character in that string

Slicing strings

- We can also look at any **continuous section** of a string using **colon operator**
- The second number is one beyond the end of the slice – i.e. **“up to but not including”**
- If the second number is beyond the length of the string, it **stops at the end**



```
>>> s = 'Monty Python'
>>> print(s[0:4])
Mont
>>> print(s[6:7])
P
>>> print(s[6:20])
Python
```

Slicing strings

- If we leave off the first or second number of the slice, it is assumed to be the **beginning** or **end** of the string respectively



```
>>> s='Monty Python'
>>> print(s[:6])
Monty
>>> print(s[3:])
ty Python
>>> print(s[:])
Monty Python
....
```


Using 'in' in conditional statement

- The **in** keyword can also be used to check whether one string is in another string
- The **in** expression is a **logical expression** and returns **True** or **False**
- It can be used in **if** or **while** statement

```
>>> fruit = 'banana'
>>> 'n' in fruit
True
>>> 'm' in fruit
False
>>> 'nan' in fruit
True
>>> if 'a' in fruit:
        print('Got cha!')
```

```
Got cha!
```

String library

- Python has a number of **string functions** which are in the **string library**
- These functions are **built-into** every string, we **invoke** them by **appending the function** to the string variable
- These function **do not modify** the original string, instead they return a **new string** altered from the original string

```
greet = 'Hello, Students in CSC1001!'
zap = greet.lower()
print(zap)
```

```
hello, students in csc1001!
```

```
print(greet)
```

```
Hello, Students in CSC1001!
```

```
print('Hello, Alice'.lower())
```

```
hello, alice
```

```
>>> stuff = 'hello world'
>>> type(stuff)
<class 'str'>
>>> dir(stuff)
['__add__', '__class__', '__contains__', '__delattr__', '__dir__', '__doc__', '__eq__', '__format__', '__ge__', '__getattr__', '__getitem__', '__getnewargs__', '__gt__', '__hash__', '__init__', '__iter__', '__le__', '__len__', '__lt__', '__mod__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__repr__', '__rmod__', '__rmul__', '__setattr__', '__sizeof__', '__str__', '__subclasshook__', 'capitalize', 'casefold', 'center', 'count', 'encode', 'endswith', 'expandtabs', 'find', 'format', 'format_map', 'index', 'isalnum', 'isalpha', 'isdecimal', 'isdigit', 'isidentifier', 'islower', 'isnumeric', 'isprintable', 'isspace', 'istitle', 'isupper', 'join', 'ljust', 'lower', 'lstrip', 'maketrans', 'partition', 'replace', 'rfind', 'rindex', 'rjust', 'rpartition', 'rsplit', 'rstrip', 'split', 'splitlines', 'startswith', 'strip', 'swapcase', 'title', 'translate', 'upper', 'zfill']
```

<https://docs.python.org/3/library/stdtypes.html#string-methods>

4.7.1. String Methods

Strings implement all of the [common](#) sequence operations, along with the additional methods described below.

Strings also support two styles of string formatting, one providing a large degree of flexibility and customization (see `str.format()`, [Format String Syntax](#) and [String Formatting](#)) and the other based on C `printf` style formatting that handles a narrower range of types and is slightly harder to use correctly, but is often faster for the cases it can handle ([printf-style String Formatting](#)).

The [Text Processing Services](#) section of the standard library covers a number of other modules that provide various text related utilities (including regular expression support in the `re` module).

`str.capitalize()`

Return a copy of the string with its first character capitalized and the rest lowercased.

`str.casefold()`

Return a casefolded copy of the string. Casefolded strings may be used for caseless matching.

Casefolding is similar to lowercasing but more aggressive because it is intended to remove all case distinctions in a string. For example, the German lowercase letter 'ß' is equivalent to "ss". Since it is already lowercase, `lower()` would do nothing to 'ß'; `casefold()` converts it to "ss".

The casefolding algorithm is described in section 3.13 of the Unicode Standard.

New in version 3.3.

`str.center(width[, fillchar])`

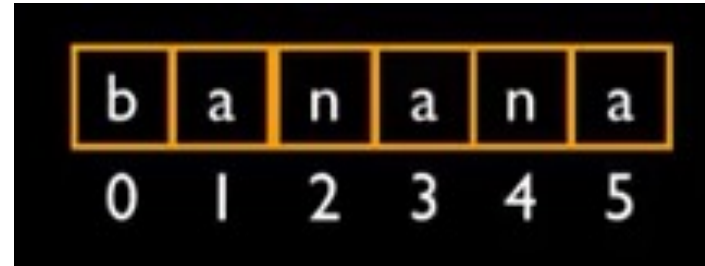
Return centered in a string of length `width`. Padding is done using the specified `fillchar` (default is an ASCII space). The original string is returned if `width` is less than or equal to `len(s)`.

`str.count(sub[, start[, end]])`

Return the number of non-overlapping occurrences of substring `sub` in the range `[start, end]`. Optional arguments `start` and `end` are interpreted as in slice notation.

Searching a string

- We can use the find() function to search for a substring in a string
- find() finds the first occurrence of the target sub-string
- If the sub-string is not found, it returns -1
- Important: the string position starts from 0



```
>>> fruit = 'banana'
>>> pos = fruit.find('na')
>>> print(pos)
2
>>> aa = fruit.find('z')
>>> print(aa)
-1
```

Making everything upper or lower case

- You can convert a string into **upper case** or **lower case**
- Hint: often when we use `find()` to find a substring, we convert the original string into lower case first, so that we don't need to worry about case

```
>>> myStr = 'I am the one, I will beat Matrix'  
>>> newStr = myStr.upper()  
>>> print(newStr)  
I AM THE ONE, I WILL BEAT MATRIX  
>>> newStr = myStr.lower()  
>>> print(newStr)  
i am the one, i will beat matrix
```

Search and replace

- The `replace()` function is like a “search and replace” operation in a word processor
- It **replaces all occurrences** of the search string with the replacement string

```
>>> greet = 'Hello, Bob'
>>> newStr = greet.replace('Bob', 'Jane')
>>> print(newStr)
Hello, Jane
>>> newStr = greet.replace('o', 'X')
>>> print(newStr)
HellX, BXb
>>> newStr = greet.replace('z', 'X')
>>> newStr
'Hello, Bob'
```

Stripping whitespace

- Sometimes we want to take a string and remove **whitespaces** at the beginning and/or end
- `lstrip()` and `rstrip()` to the left and right only
- `strip()` removes **both** beginning and ending whitespaces

```
>>> greet = ' Hello Bob '
```

```
>>> greet.lstrip()
```

```
'Hello Bob'
```

```
>>> greet.rstrip()
```

```
' Hello Bob'
```

```
>>> greet.strip()
```

```
'Hello Bob'
```

```
.....
```

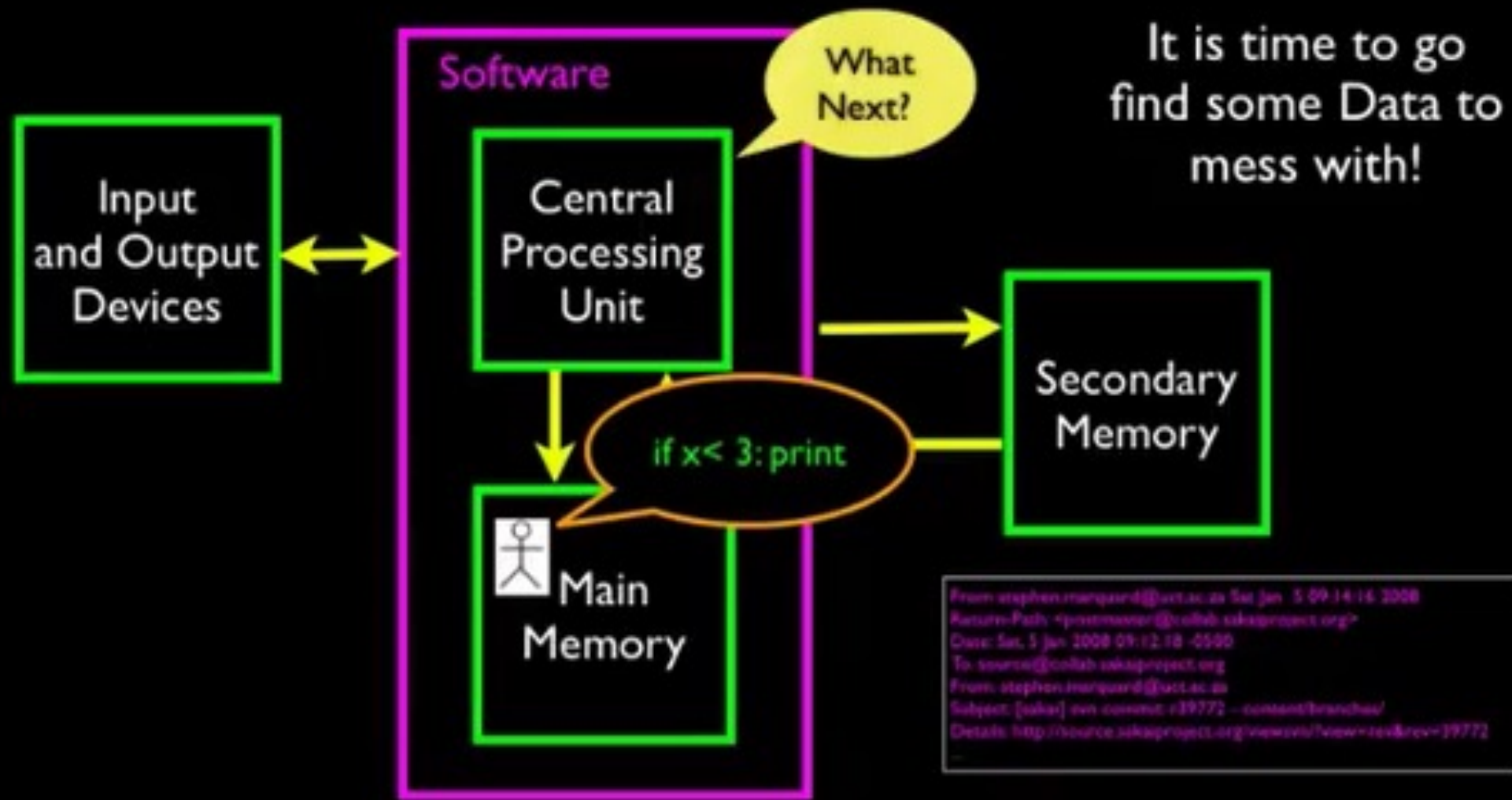

Prefixes

- `startswith()` function checks whether a string is starting with a given string

```
>>> line = 'Please submit your application'
>>> line.startswith('Please')
True
>>> line.startswith('p')
False
```

Example

```
>>> data = 'From stephen.marquard@uct.ac.za Sat Jan 5 09:14:16 2016'  
>>> atpos = data.find('@')  
>>> print(atpos)  
21  
>>> sppos = data.find(' ', atpos)  
>>> print(sppos)  
31  
>>> host = data[atpos+1:sppos]  
>>> print(host)  
uct.ac.za  
...
```



From: stephen.marquard@uct.ac.za Sat Jan 5 09:14:16 2008
Resource-Path: spinnmaster@collab.sakaiproject.org
Date: Sat, 5 Jan 2008 09:12:18 -0500
To: source@collab.sakaiproject.org
From: stephen.marquard@uct.ac.za
Subject: [sakai] svn - commit: r39772 - consent/branches/
Details: <http://source.sakaiproject.org/viewsvn/?view=rev&rev=39772>
-

File processing

- A text file can be thought of as a sequence of lines

```
# Gmail web Start
216.239.38.125 chatenabled.mail.google.com
216.239.38.125 filetransferenabled.mail.google.com
216.239.38.125 gmail.com
216.239.38.125 gmail.google.com
216.239.38.125 googlemail.l.google.com
216.239.38.125 inbox.google.com
216.239.38.125 isolated.mail.google.com
216.239.38.125 m.gmail.com
216.239.38.125 m.googlemail.com
216.239.38.125 mail.google.com
216.239.38.125 www.gmail.com
# Gmail web End
```

Opening files

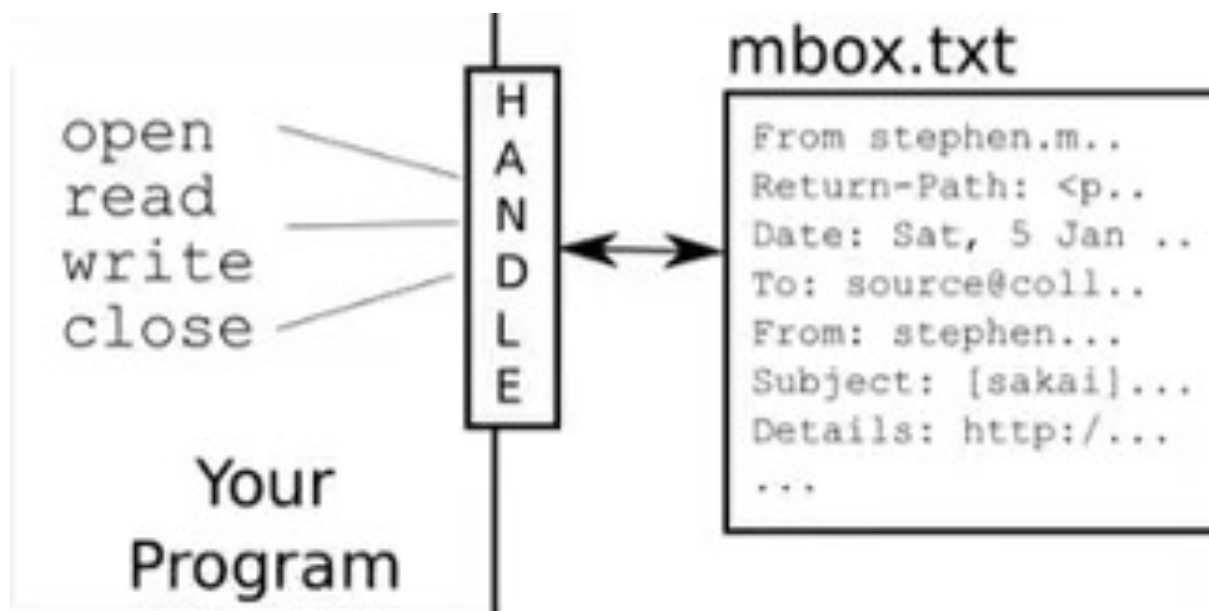
- Before we can read the contents of a file, we must tell Python **which file** we are going to work with and **what we will do** with that file
- This is done with the **open()** function
- Open() returns a “**file handle**” - a variable used to perform operations on files
- Kind of like “File -> Open” in a word processor

Using open()

- `handle = open(filename, mode)`
- Returns a `handle` used to manipulate the file
- `Filename` is a string
- `Mode` is optional, use 'r' if we want to read the file, and 'w' if we want to write to the file

Handle

```
>>> fhand = open('c:\Python35\myhost.txt', 'r')
>>> print(fhand)
<_io.TextIOWrapper name='c:\\Python35\\myhost.txt' mode='r' encoding='cp936' >
```



When files are missing

```
>>> fhand = open('notExisting.txt', 'r')
Traceback (most recent call last):
  File "<pyshell#14>", line 1, in <module>
    fhand = open('notExisting.txt', 'r')
FileNotFoundError: [Errno 2] No such file or directory: 'notExisting.txt'
```


The newline character

- We use a new character to indicate when a line ends called “**newline**”
- We represent it as ‘\n’ in strings
- Newline is still **one** character, not two

```
>>> stuff = 'Hello\nWorld'
>>> stuff
'Hello\nWorld'
>>> print(stuff)
Hello
World
>>> stuff = 'X\nY'
>>> print(stuff)
X
Y
>>> len(stuff)
3
```

File processing

- A text file can be thought of as a **sequence of lines**
- A text file has **newline** at the end of each line

```
# Gmail web Start
216.239.38.125 chatenabled.mail.google.com
216.239.38.125 filetransferenabled.mail.google.com
216.239.38.125 gmail.com
216.239.38.125 gmail.google.com
216.239.38.125 googlemail.l.google.com
216.239.38.125 inbox.google.com
216.239.38.125 isolated.mail.google.com
216.239.38.125 m.gmail.com
216.239.38.125 m.googlemail.com
216.239.38.125 mail.google.com
216.239.38.125 www.gmail.com
# Gmail web End
```

File handle as a sequence

- A file **handle** open for read can be treated as a **sequence of strings** where each line in the file is a string in the sequence
- We can use the **for** statement to loop through a sequence

```
fhand = open('myhost.txt', 'r')  
  
for line in fhand:  
    print(line)  
  
fhand.close()
```

Practice

- Write a program to open a file and count how many lines are included in this file

Reading the whole file

- We can read the whole file into a single string

```
fhand = open('myhost.txt', 'r')
allText = fhand.read()
print('The length of the file:', len(allText))
print('The first 20 characters of the file:', allText[:20])
```

Searching through a file

- We can put an if statement in the for loop to print the lines which satisfy certain conditions

```
fhand = open('myhost.txt', 'r')

for line in fhand:
    if line.startswith('#')==True:
        print(line)

print('finished.')
fhand.close()
```

Writing to a file

- To write a file, use the `open()` function with 'w' argument
- Use the `write()` method to write to the file

```
fhand = open('test.txt', 'w')  
fhand.write('The first line\n')  
fhand.write('The second line\n')  
fhand.write('The third line\n')  
fhand.close()
```

Practice

Read a file and make all letters be lower-cased (to a new file).