香港中文大學（深圳）
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Introduction to Computer Science: Programming Methodology

Lecture 4 Function

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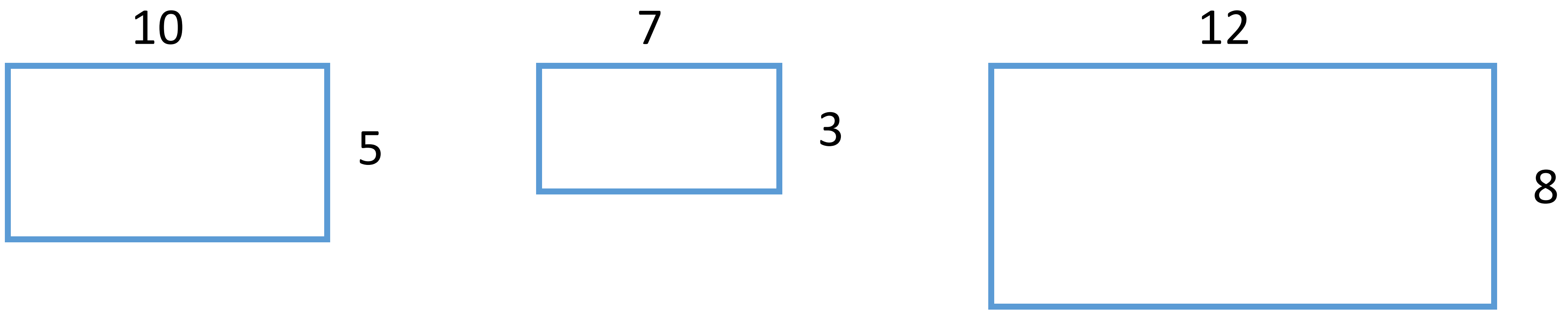
Function Basics

Exercise

Imagine you need to calculate the area of multiple rectangles throughout your program. Print the areas of the following rectangles.



A Python Script

```python
# Calculate area of rectangle 1
length1 = 10
width1 = 5
area1 = length1 * width1
print(f"Area of rectangle 1: {area1}")

# Calculate area of rectangle 2
length2 = 7
width2 = 3
area2 = length2 * width2
print(f"Area of rectangle 2: {area2}")

# Calculate area of rectangle 3
length3 = 12
width3 = 8
area3 = length3 * width3
print(f"Area of rectangle 3: {area3}")
```

A Python Script

```python
# Calculate area of rectangle 1
length1 = 10
width1 = 5
area1 = length1 * width1
print(f"Area of rectangle 1: {area1}")

# Calculate area of rectangle 2
length2 = 7
width2 = 3
area2 = length2 * width2
print(f"Area of rectangle 2: {area2}")

# Calculate area of rectangle 3
length3 = 12
width3 = 8
area3 = length3 * width3
print(f"Area of rectangle 3: {area3}")
```

Same Pattern Applies!

Can we define a template and reuse it?

A Better Solution

```
def calculate_rectangle_area(length,width):
return length * width

# Calculate area of rectangle 1
area1 = calculate_rectangle_area(10, 5)
print(f"Area of rectangle 1: {area1}")

# Calculate area of rectangle 2
area2 = calculate_rectangle_area(7, 3)
print(f"Area of rectangle 2: {area2}")

# Calculate area of rectangle 3
area3 = calculate_rectangle_area(12, 8)
print(f"Area of rectangle 3: {area3}")
```

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 a function

Python functions

- There are (mainly) 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

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

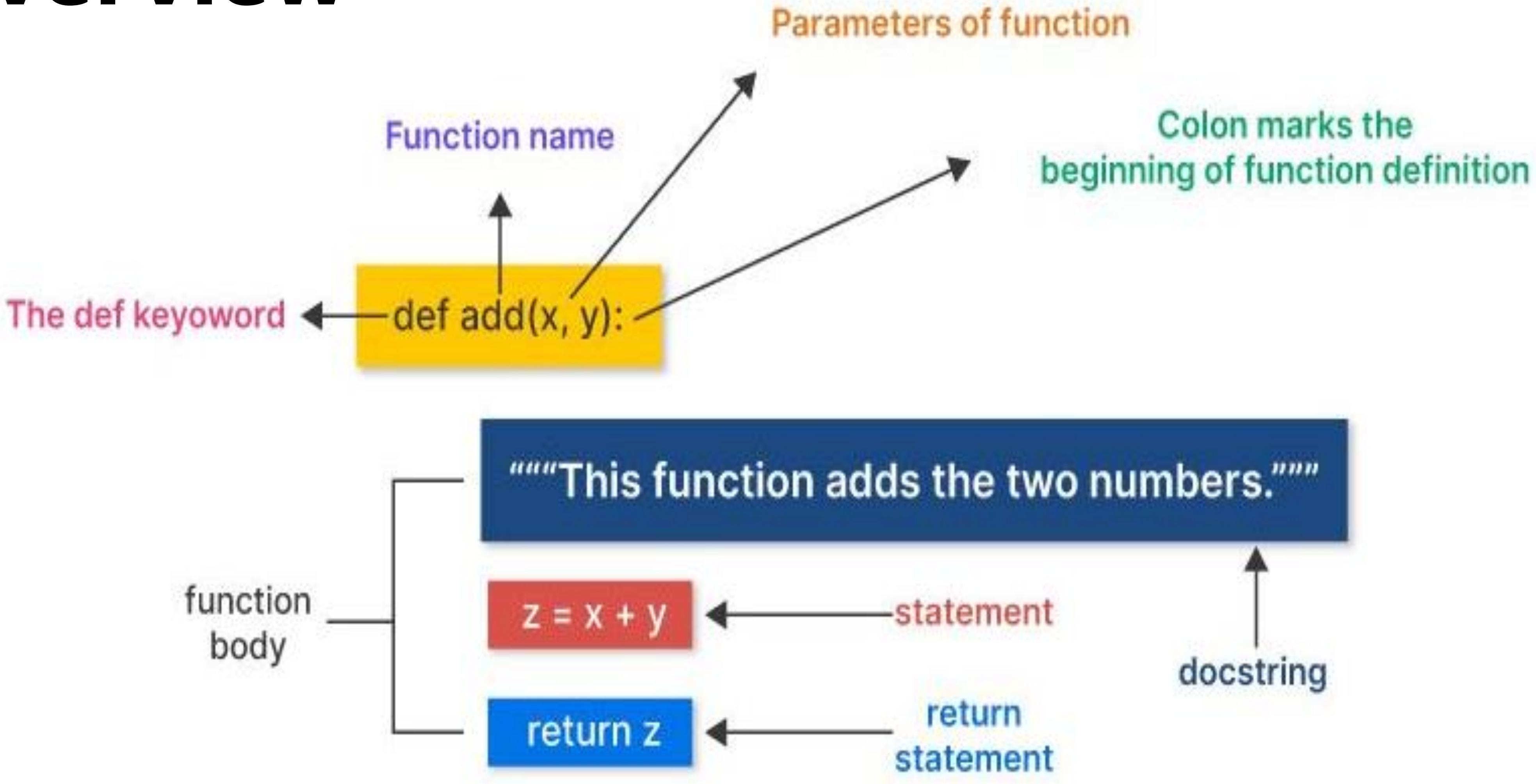
Program

```
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
```

Overview


Parameters of function
Function name
Colon marks the beginning of function definition
The def keyoword
def add(x, y):
"""This function adds the two numbers."""
function body
z = x + y
statement
docstring
return z
return statement

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
```

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)

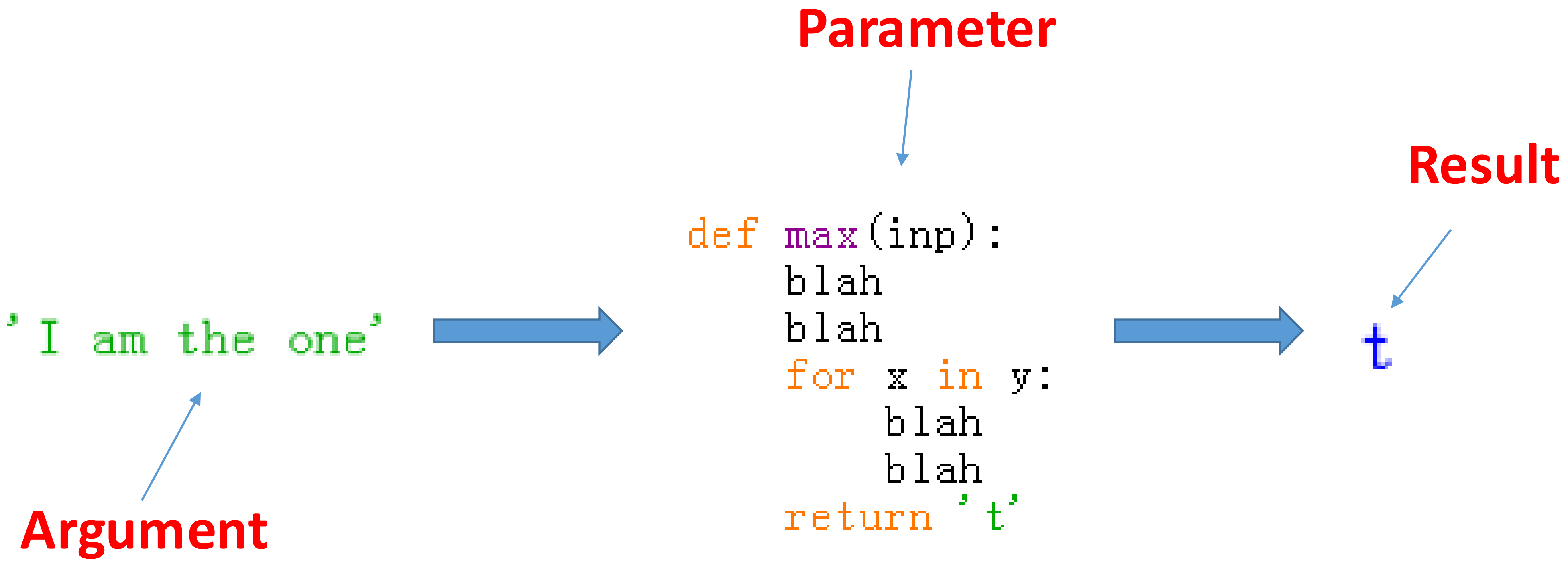
- The return statement ends the function execution and 'sends back' the result of the function

```
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
```



```
def max(inp):
    blah
    blah
    for x in y:
        blah
        blah
    return '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

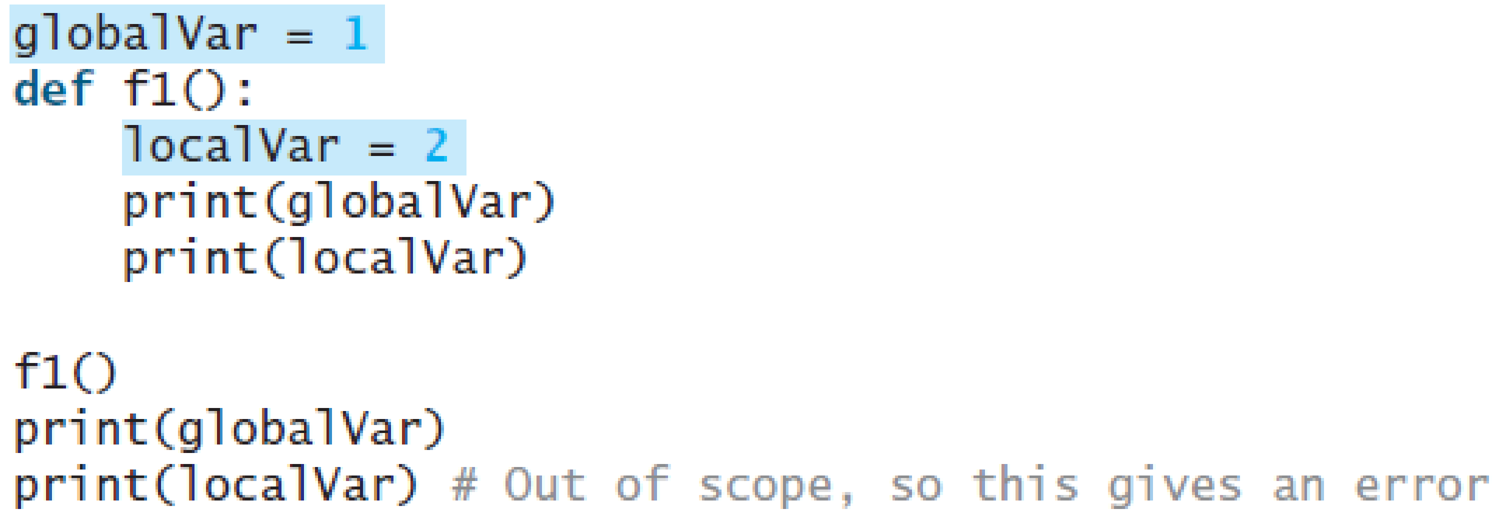
```
# Print grade for the score
def printGrade(score):
    if score >= 90.0:
        print('A')
    elif score >= 80.0:
        print('B')
    elif score >= 70.0:
        print('C')
    elif score >= 60.0:
        print('D')
    else:
        print('F')

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

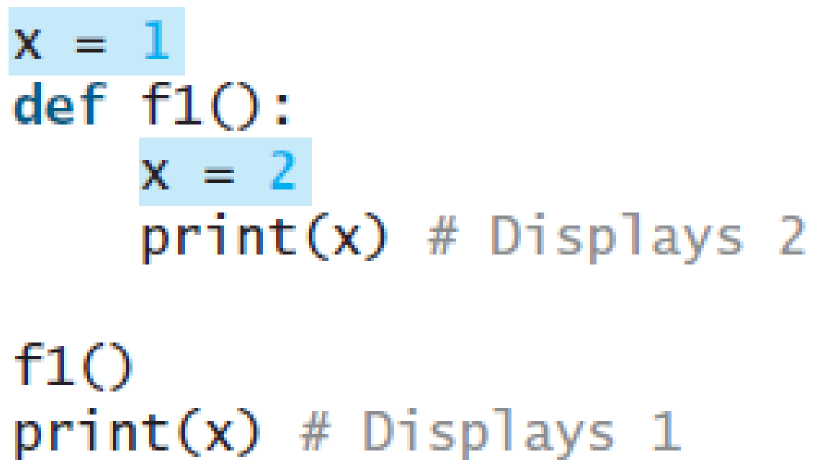
- Global variables are created outside all functions and are accessible to all functions in their scope



```
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

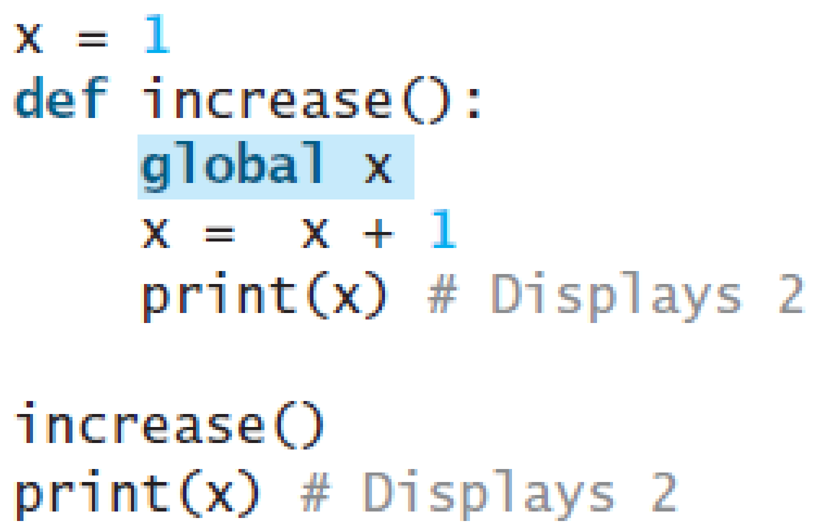


```
x = 1
def f1():
    x = 2
    print(x) # Displays 2

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

Global variable

- In a function, you can use keyword global to specify that a variable is a global variable

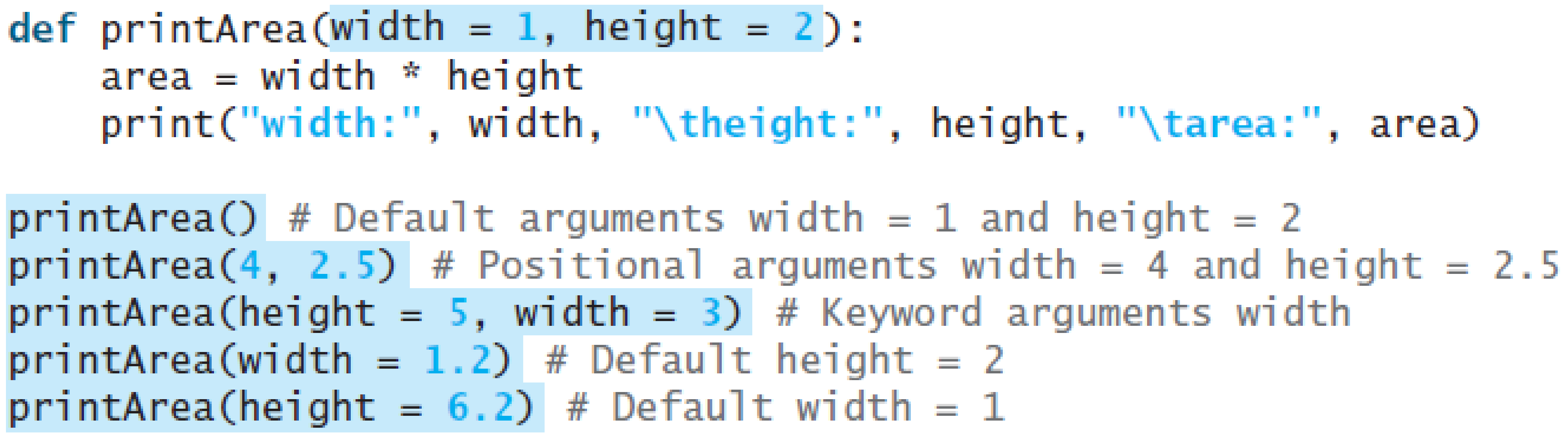
- Be very careful when define and use global variable



```
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

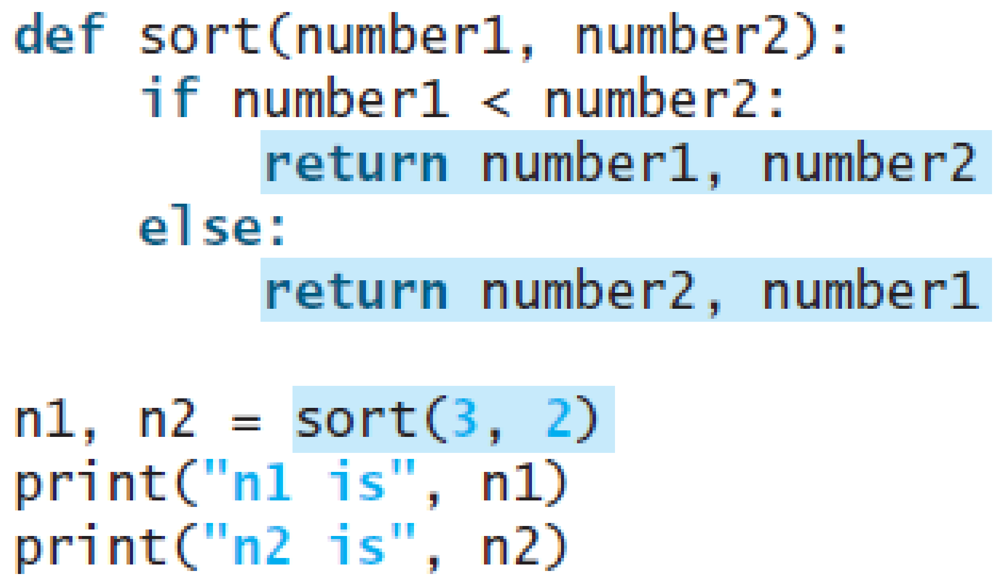


```
def printArea(width = 1, height = 2):
    area = width * height
    print("width:", width, "\theight:", height, "\tarea:", area)

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



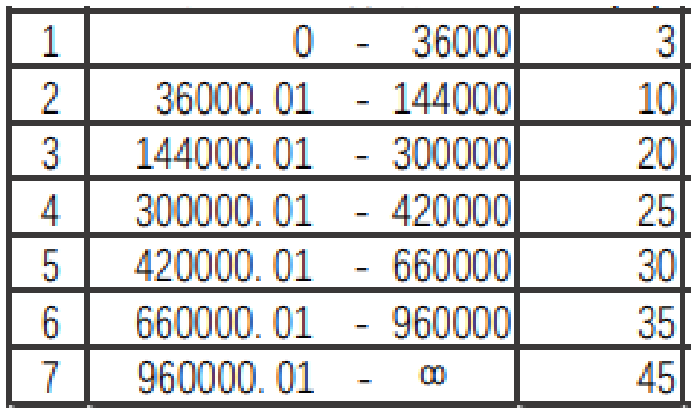
```
def sort(number1, number2):
    if number1 < number2:
        return number1, number2
    else:
        return number2, number1

n1, n2 = sort(3, 2)
print("n1 is", n1)
print("n2 is", n2)
```

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 Methods

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

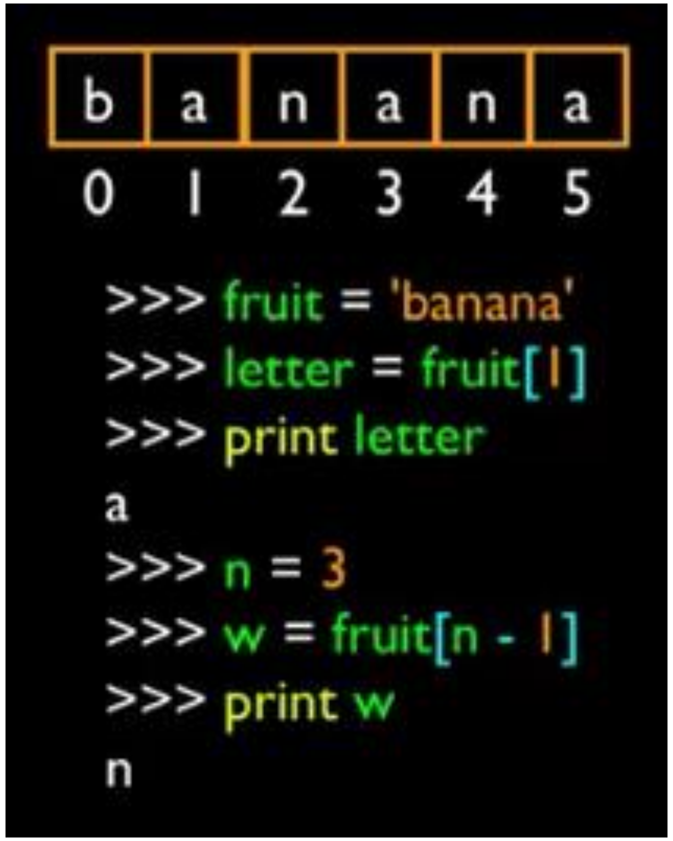
- We prefer to read data in using strings and then parse and convert the data as we need

- 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

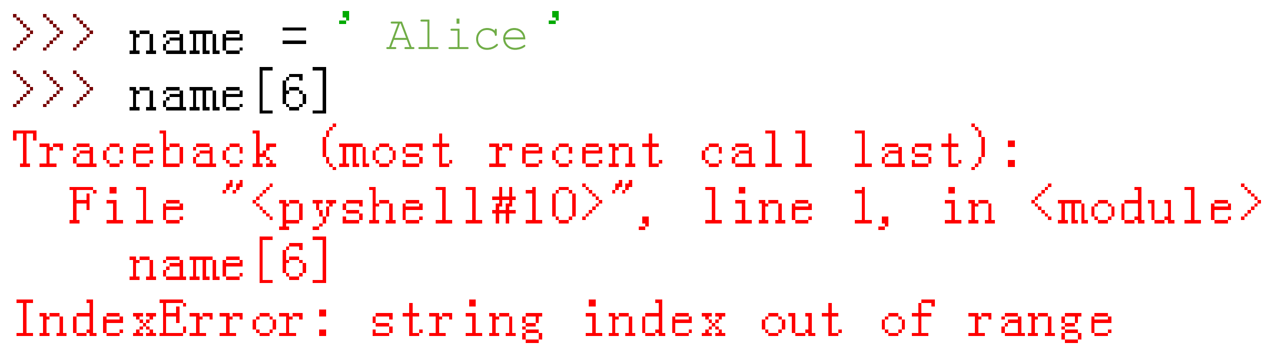


```
>>> fruit = 'banana'
>>> letter = fruit[1]
>>> print letter
a
>>> n = 3
>>> w = fruit[n - 1]
>>> print w
n
```

Index out of range

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

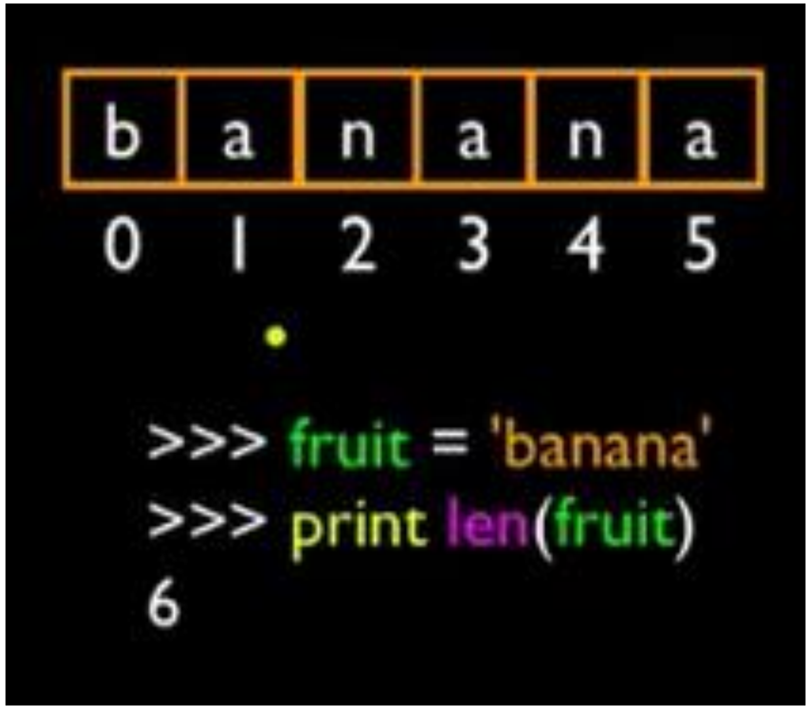
- Be careful when specifying an index value



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

Strings have length

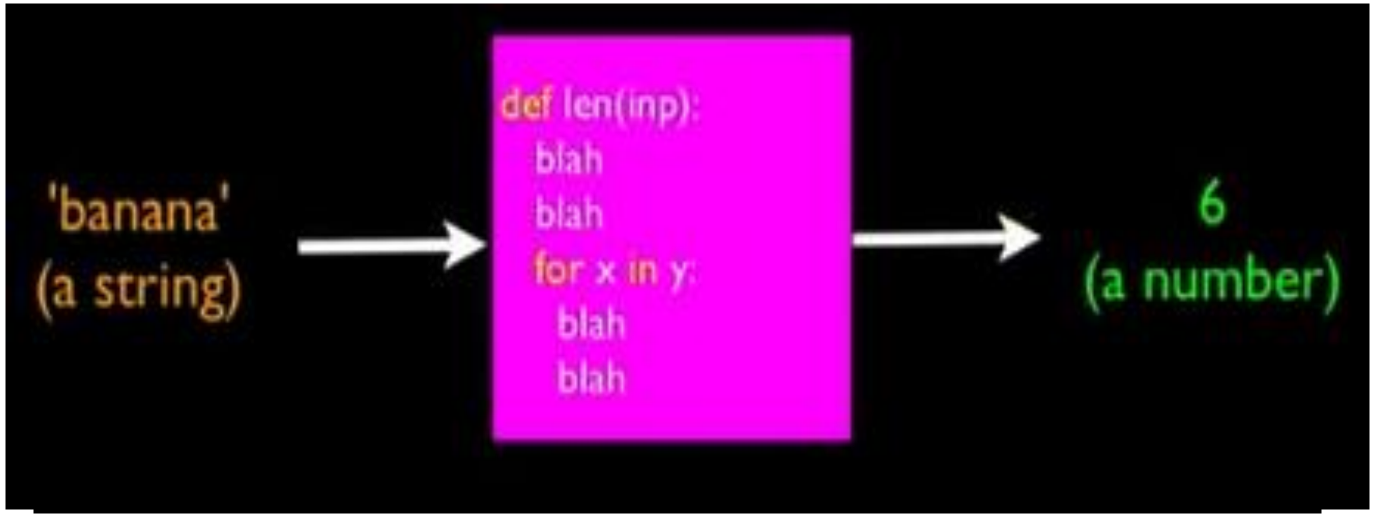
- There is a built-in function len() which gives us the length of a string



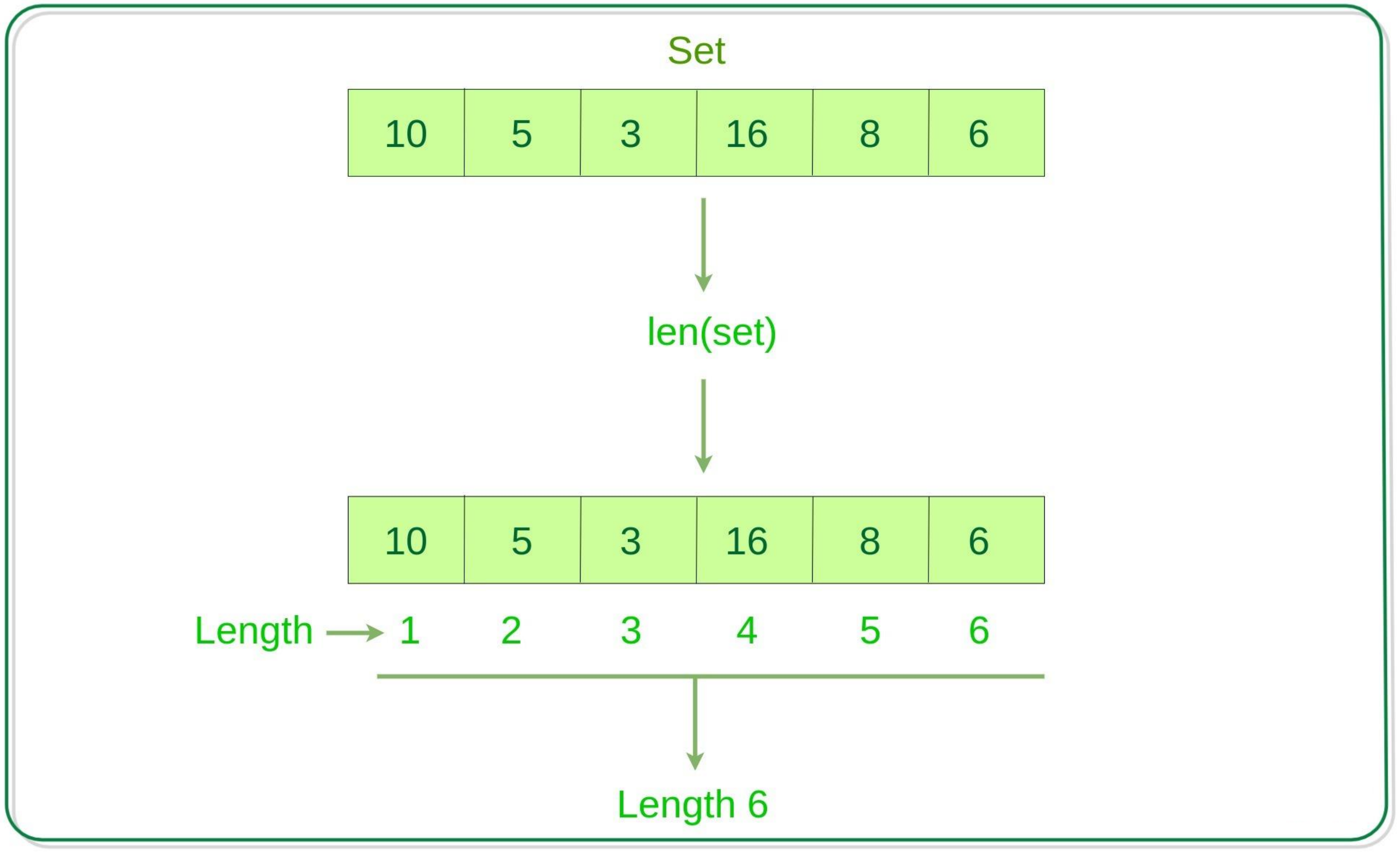
```
>>> fruit = 'banana'
>>> print len(fruit)
6
```

len() function

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



len() function



`len(object)`

- Returns the **length** of the given string, array, list, tuple, dictionary, or any other iterable or container object.
- The type of the return value is an integer that represents the number of elements in this iterable.

➡ *Calls* `object.__len__()`

```
>>> friends = ['Alice', 'Bob', 'Carl', 'Ann']
>>> len(friends)
4
>>> friends.extend([1, 2, 3])
>>> len(friends)
7
```

Looping through strings

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

- String is essentially a list in Python

```
fruit = 'I am the one,Morpheus'

n = 0
for i in fruit:
    print(n, i)
    n=n+1

print('finished')
```

```
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.

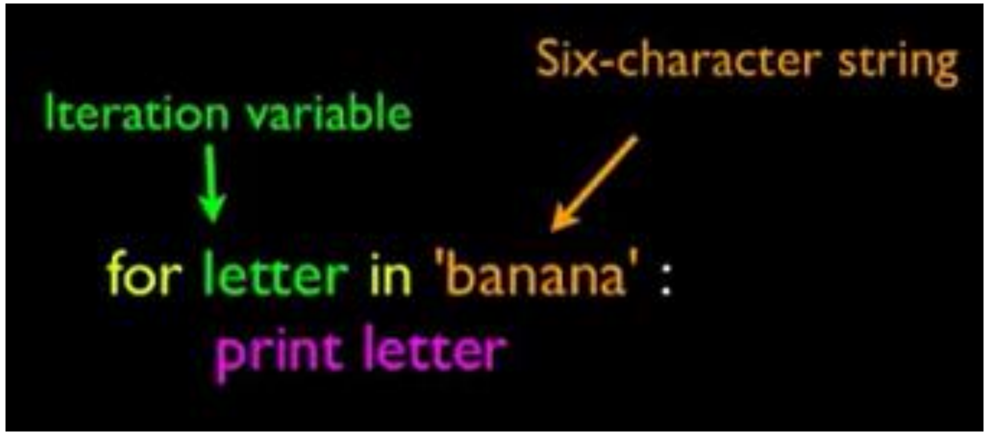
Loop and counting

- 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

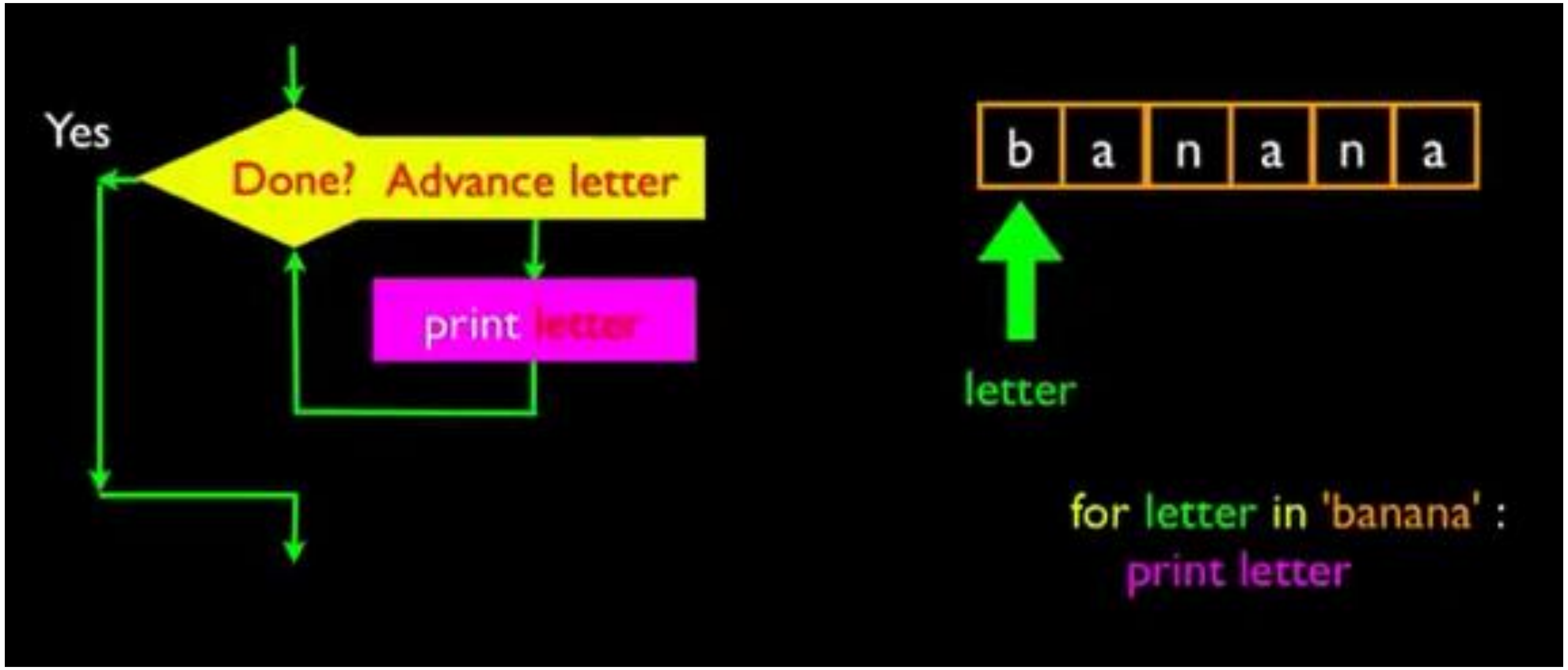
```
word = 'banana'
count = 0
for letter in word:
    if letter=='a':
        count = count+1
print("The number of 'a' we have seen is:",count)
```

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



```
for letter in 'banana' :
    print letter
```



```
for letter in 'banana' :
    print letter
```

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

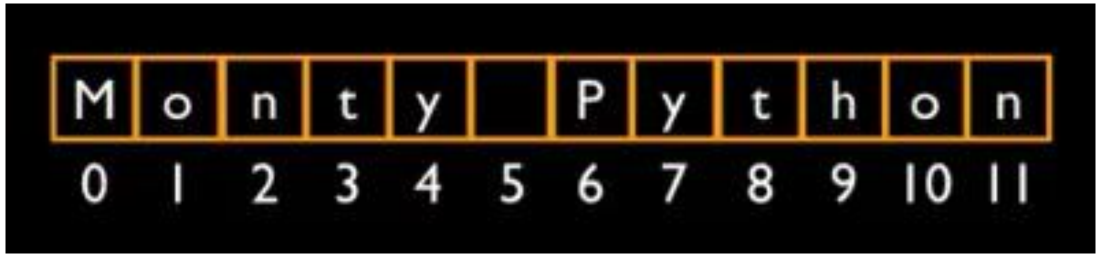
Using ‘in’ in conditional statement

- 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!
```

Slicing strings

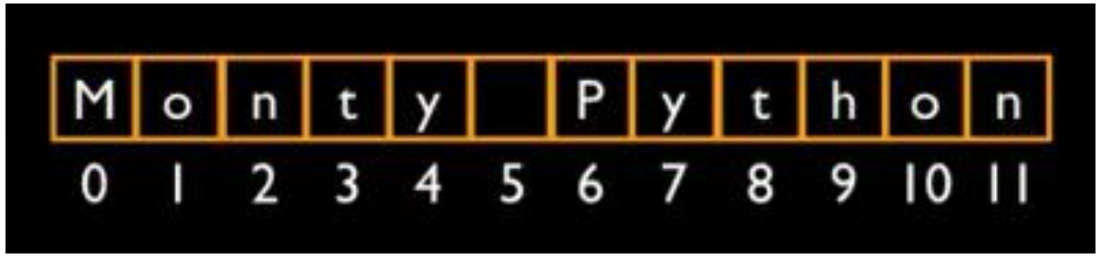
- We can also look at any continuous section of a string using colon operator
- The second number is one beyond the end of the slice – i.e. "up to but not including"
- If the second number is beyond the length of the string, it stops at the end

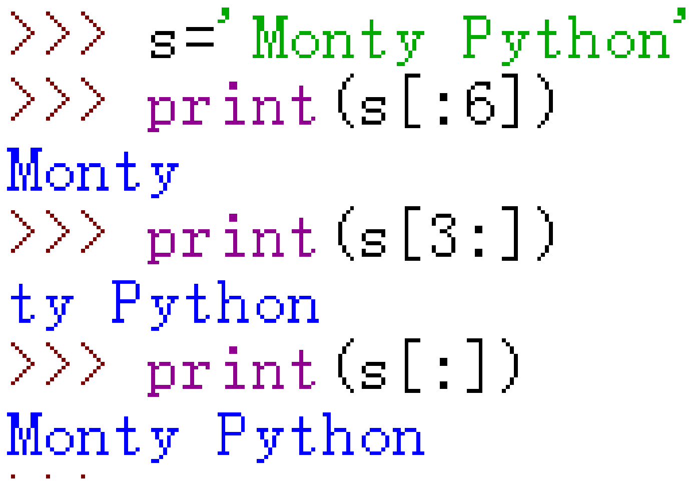


```
>>> s = 'Monty Python'
>>> print(s[0:4])
Mont
>>> print(s[6:7])
P
>>> print(s[6:20])
Python
```

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





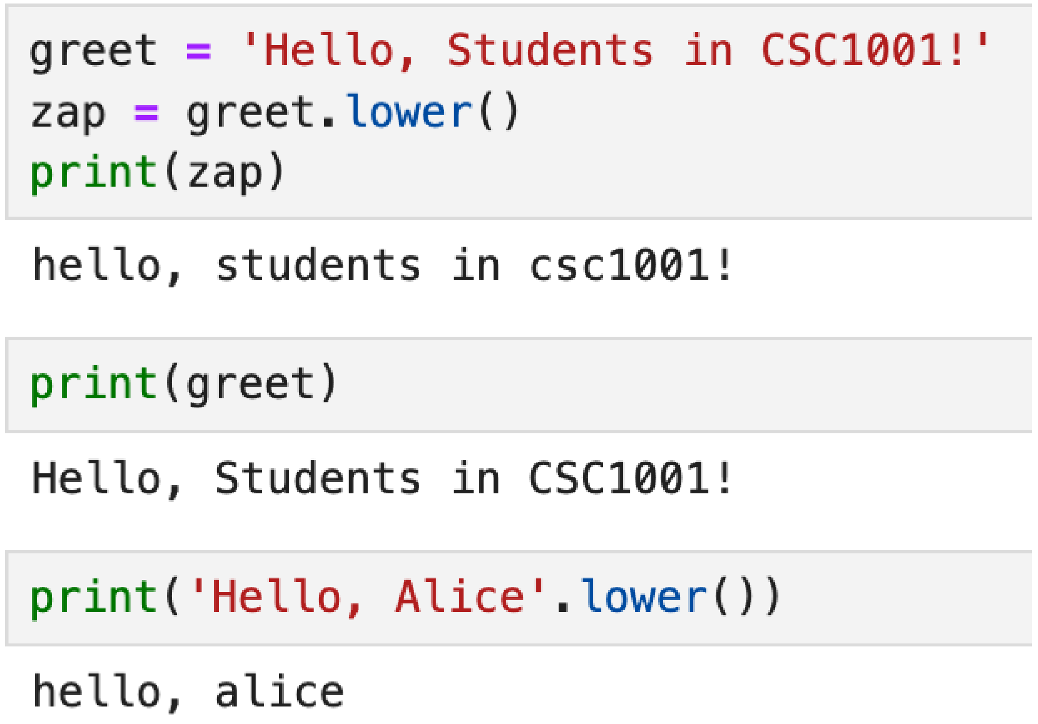
```
>>> s='Monty Python'
>>> print(s[:6])
Monty
>>> print(s[3:])
ty Python
>>> print(s[:])
Monty Python
```

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



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

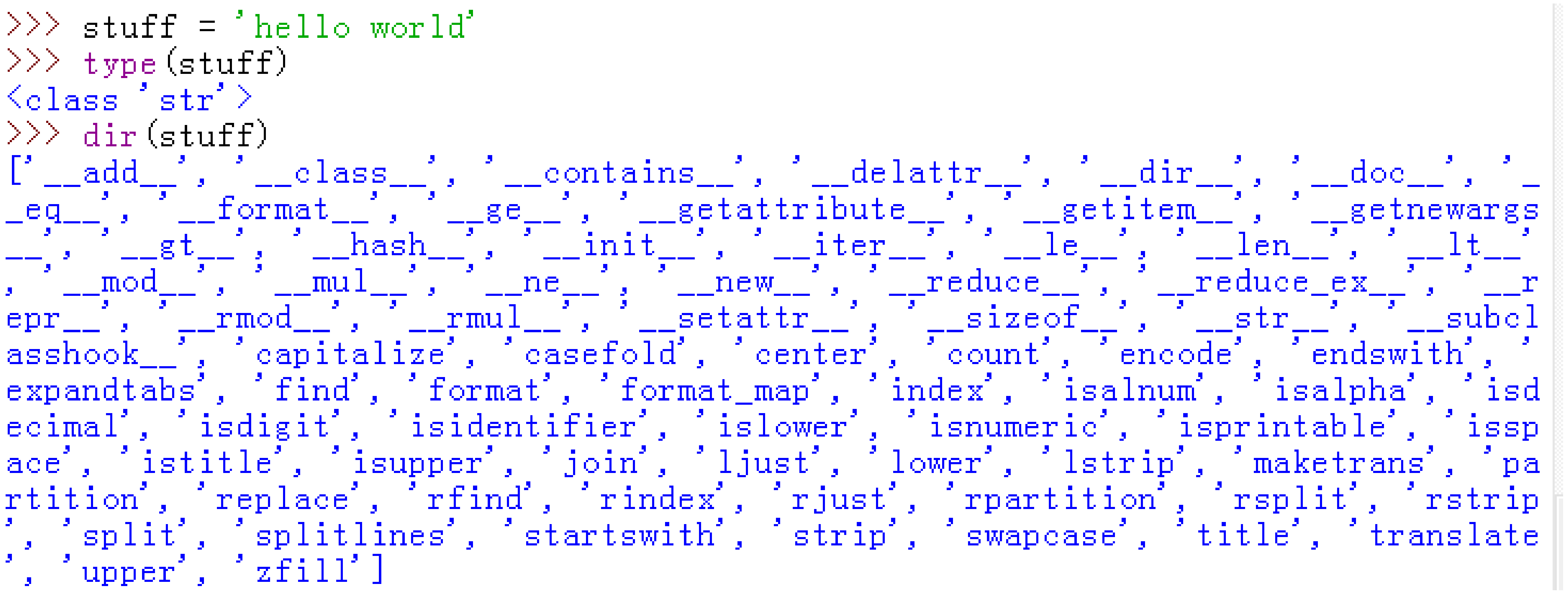
```
hello, students in csc1001!
```

```python
print(greet)
```

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

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

```
hello, alice
```



```
>>> stuff = 'hello world'
>>> type(stuff)
<class 'str'>
>>> dir(stuff)
['__add__', '__class__', '__contains__', '__delattr__', '__dir__', '__doc__', '_
_eq__', '__format__', '__ge__', '__getattribute__', '__getitem__', '__getnewargs
__', '__gt__', '__hash__', '__init__', '__iter__', '__le__', '__len__', '__lt__'
, '__mod__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__r
epr__', '__rmod__', '__rmul__', '__setattr__', '__sizeof__', '__str__', '__subcl
asshook__', 'capitalize', 'casefold', 'center', 'count', 'encode', 'endswith', '
expandtabs', 'find', 'format', 'format_map', 'index', 'isalnum', 'isalpha', 'isd
ecimal', 'isdigit', 'isidentifier', 'islower', 'isnumeric', 'isprintable', 'issp
ace', 'istitle', 'isupper', 'join', 'ljust', 'lower', 'lstrip', 'maketrans', 'pa
rtition', '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*])

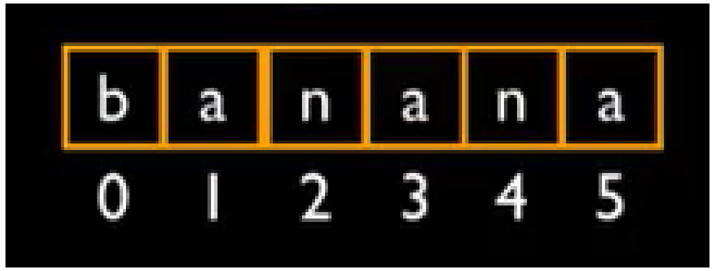
Return centered in a string of length *width*. Padding is done using the specified *fillchar* (default is an ASCII space). The original string is returned if *width* is less than or equal to `len(s)`.

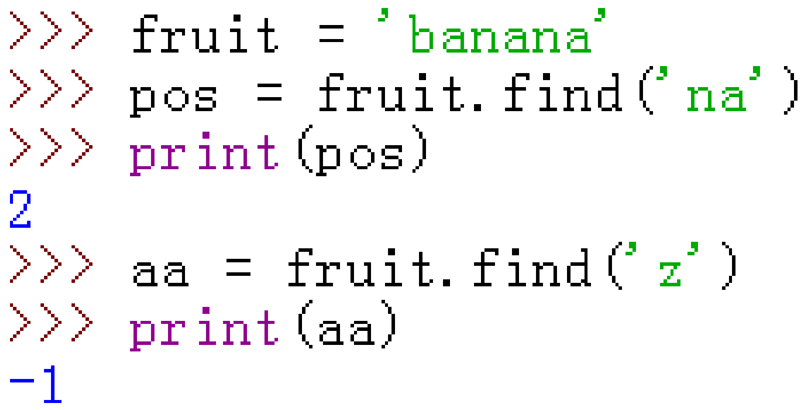
`str.`**`count`**(*sub*[, *start*[, *end*]])

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



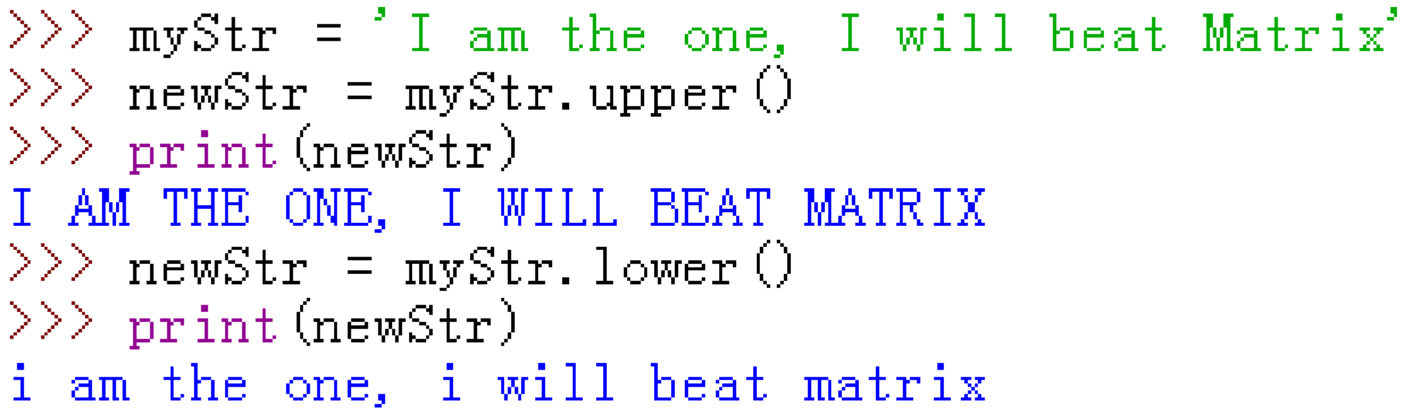


```
>>> fruit = 'banana'
>>> pos = fruit.find('na')
>>> print(pos)
2
>>> aa = fruit.find('z')
>>> print(aa)
-1
```

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

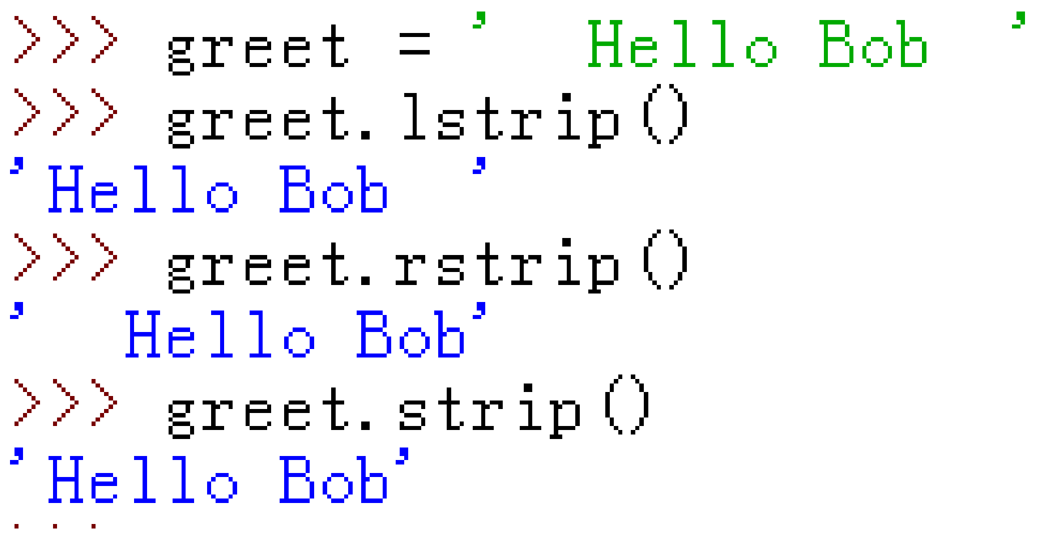
```
>>> greet = 'Hello, Bob'
>>> newStr = greet.replace('Bob', 'Jane')
>>> print(newStr)
Hello, Jane
>>> newStr = greet.replace('o','X')
>>> print(newStr)
HellX, BXb
>>> newStr = greet.replace('z','X')
>>> newStr
'Hello, Bob'
```

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

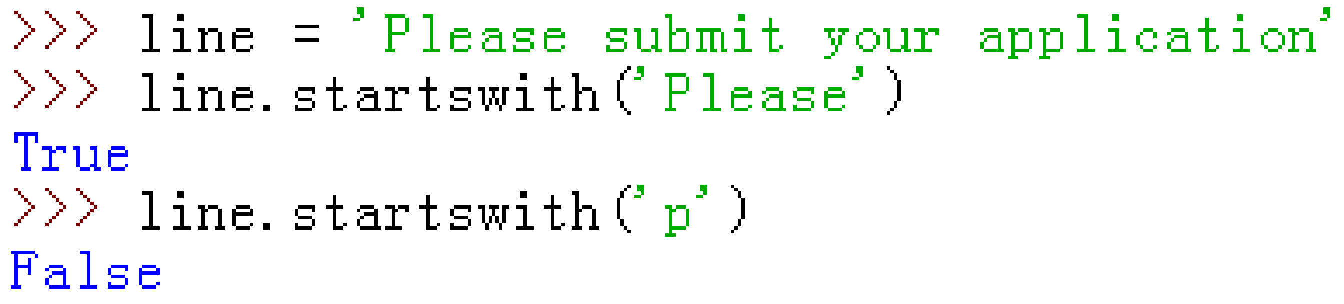
- strip() removes both beginning and ending whitespaces



```
>>> 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



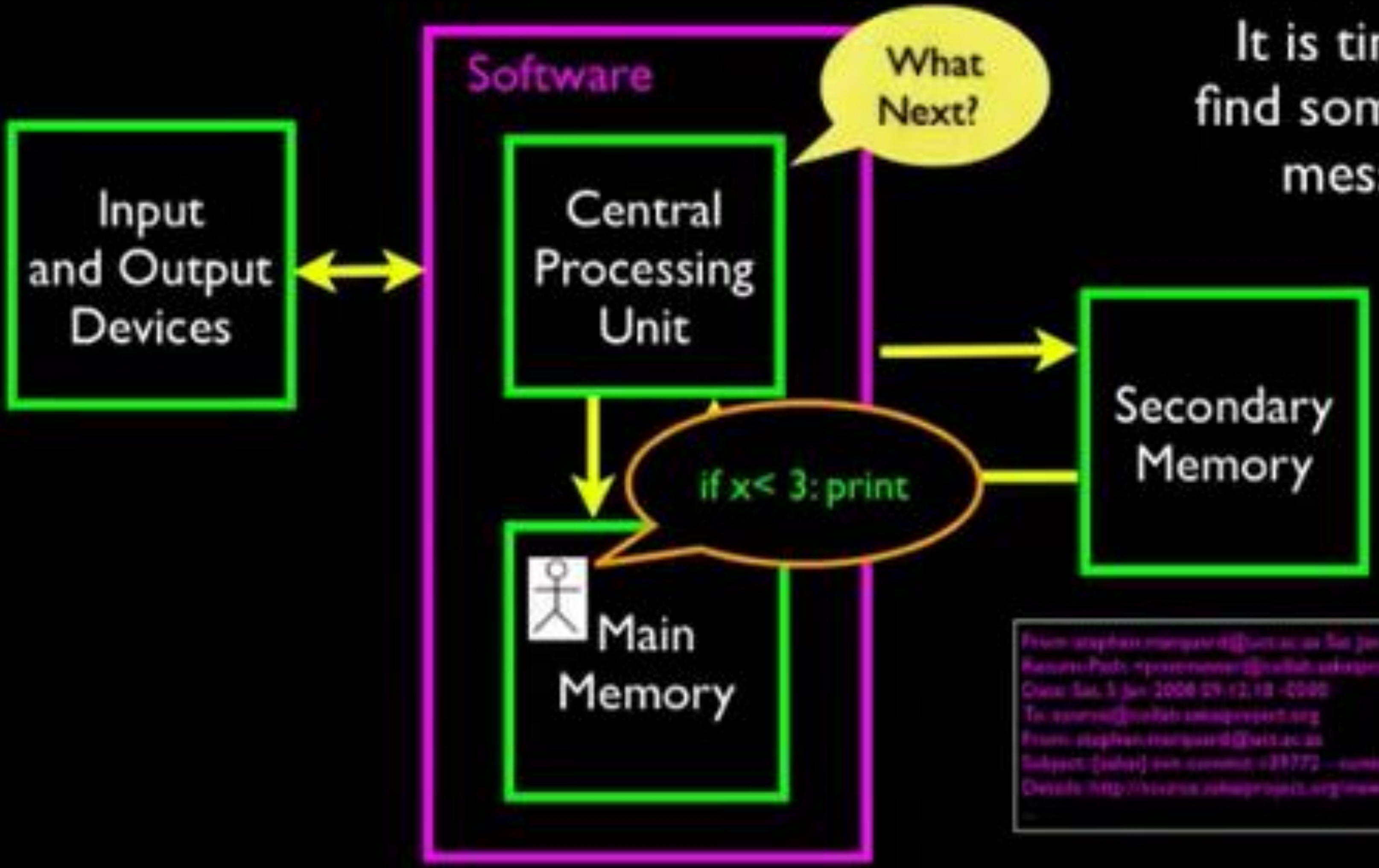
```
>>> line = 'Please submit your application'
>>> line.startswith('Please')
True
>>> line.startswith('p')
False
```

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
```

File Operations

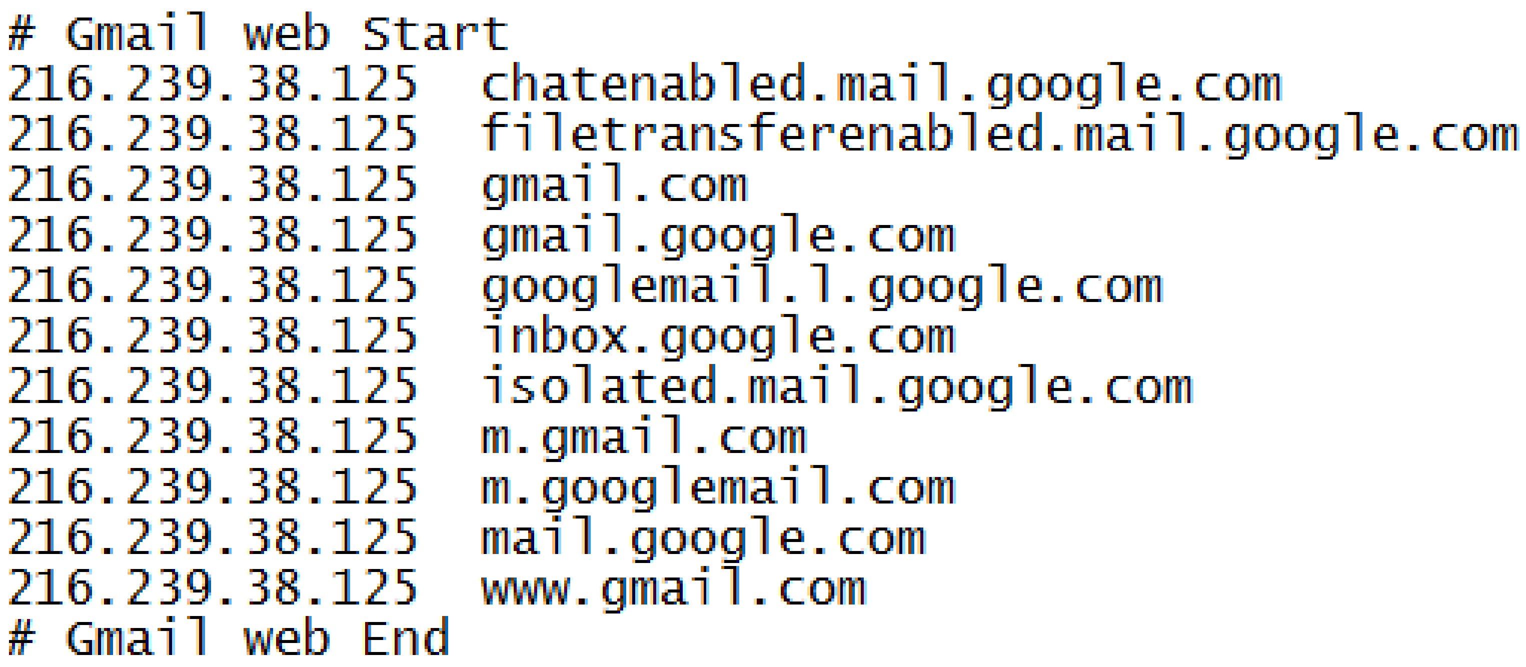
It is time to go find some Data to mess with!



```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
Return-Path: <postmaster@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 - content/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)

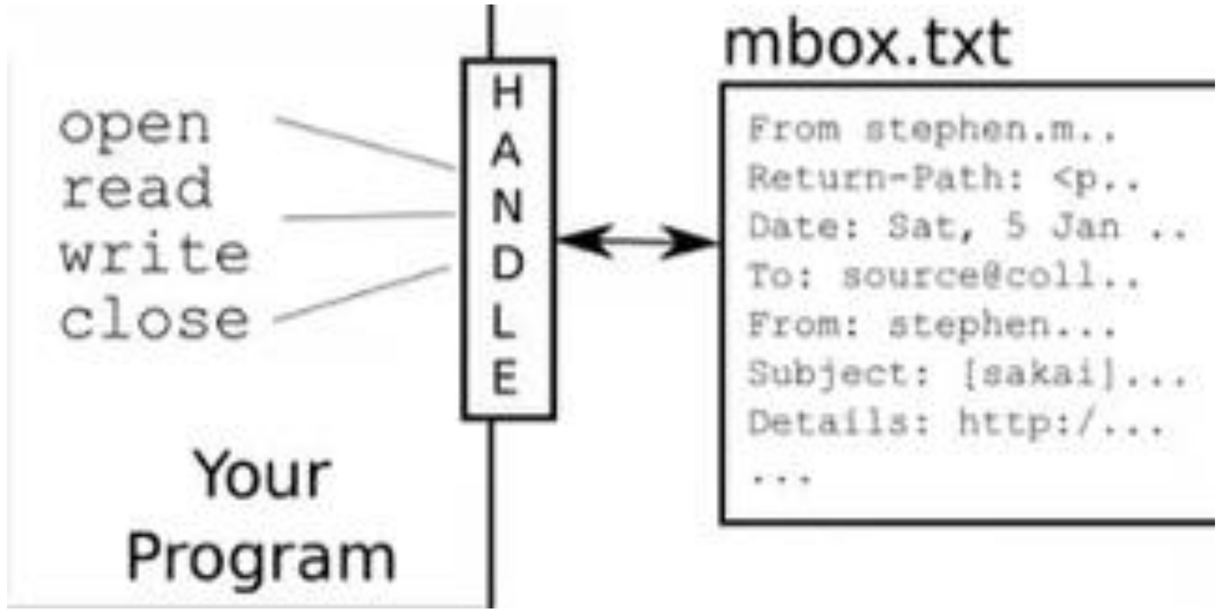
- Returns a handle used to manipulate the file

- 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 **(‘r’, ‘w’, ‘a’**, ‘r+’, ‘w+’, ‘a+’, more for binary files …)

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'
```

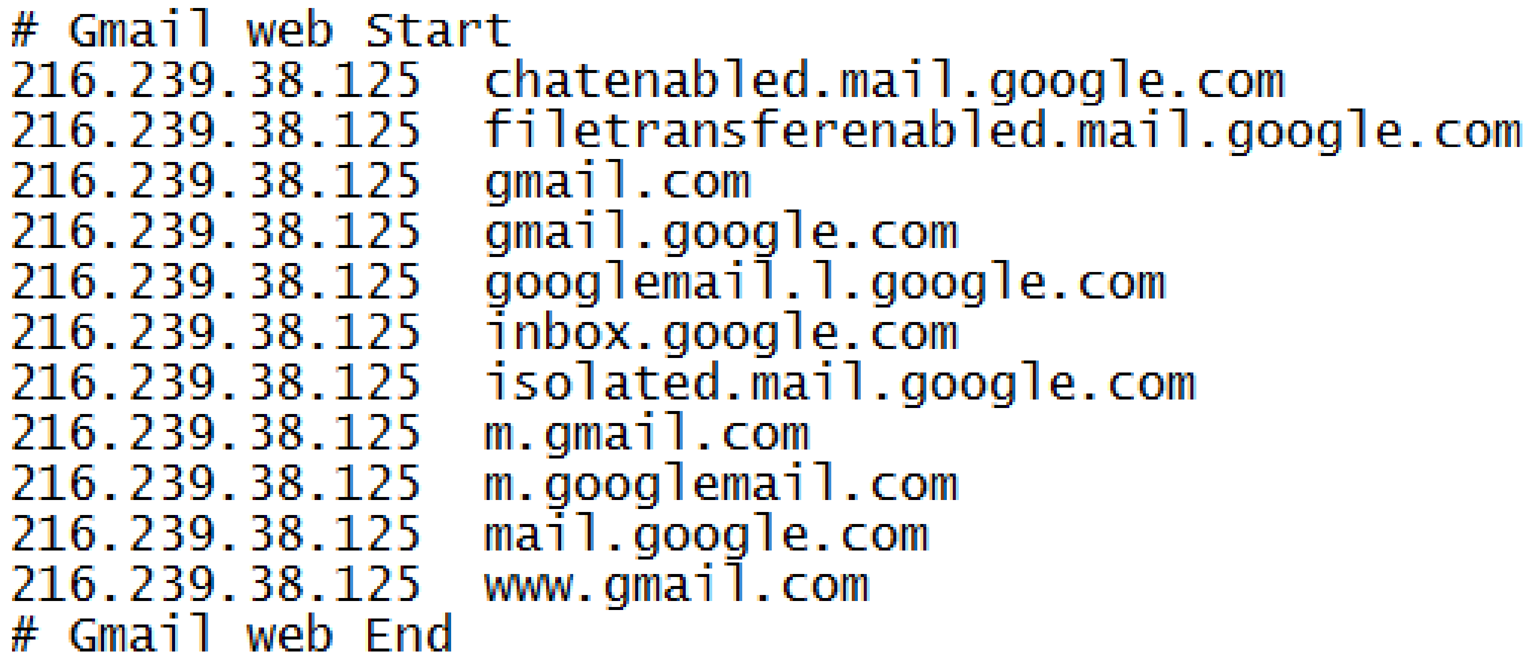
The newline character

- 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).