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# File I/O and Subroutines

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# Lecture Topics

- Writing data to text files.
- Reading data from text files.
- Appending data to text files.
- Subroutines
- Global and Local Variables
- Parameters and Arguments
- Recursion

# Colors/Fonts

- Global Variable Names – Brown
- Local Variable Names – Lt Blue
- Literals – Blue
- Keywords – Orange
- Operators/Punctuation – Black
- Functions – Purple
- Parameters – Gold
- Comments – Gray
- Modules – Pink

Source Code – **Consolas**
Output – Courier New

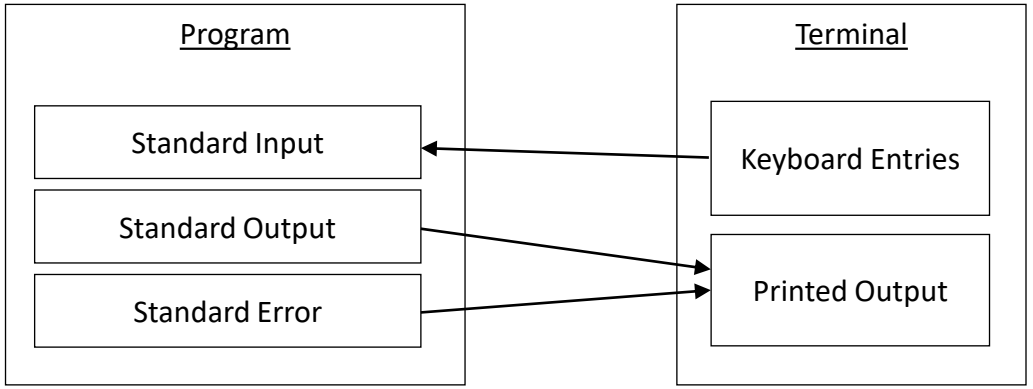
# What are files?

- A ***file*** is stream of binary, digital information typically kept on a long-term storage device.
  - Word documents, Powerpoint presentations, and PDFs are all examples of different types of files.

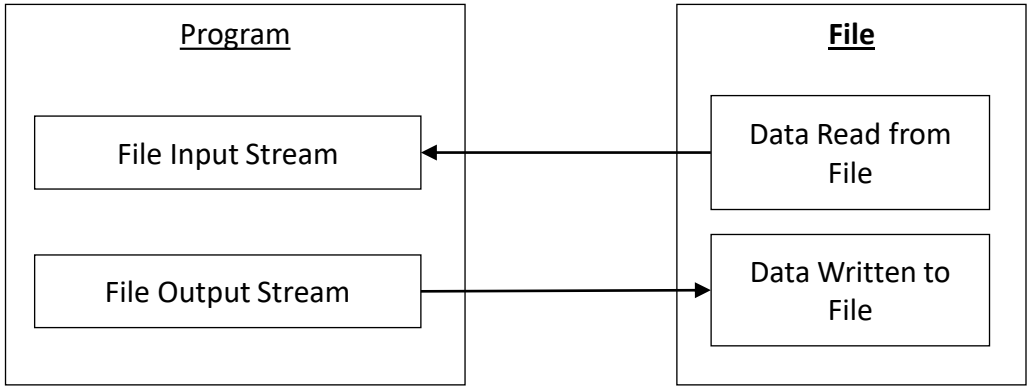
- Can be used as an input data stream. (“Reading a file”)

- Can be used as an output data stream. (“Writing to a file”)

# Standard Data Streams (Shown Previously)



# File Data Streams



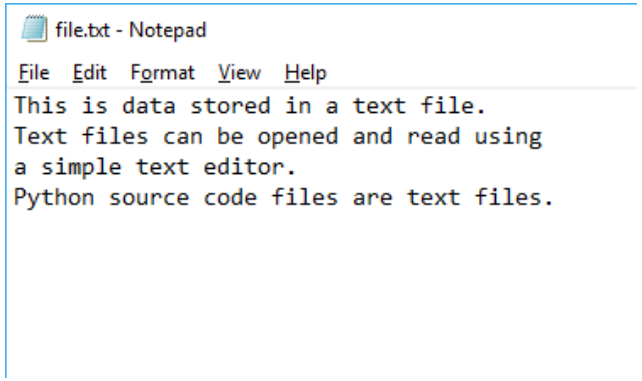
# Extensions

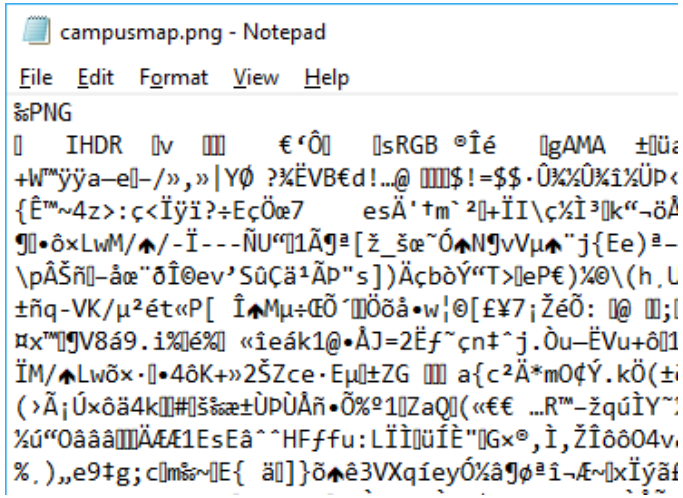
- A file has a name which normally includes an extension.
  - Textfile**.txt**
  - WordDocument**.docx**

- You can have files without extensions.
  - Extensions are primarily used by the operating system, so it knows what program to use to open and read the file.
  - Some programs will only accept files with certain extensions.

# Types of Files

- Text Files
  - The binary information contained in the file is encoded with ASCII plaintext.
  - Can be opened in any text editor (like Notepad.)
  - “Human readable”
- Data Files
  - Files that are not stored in plaintext, like images and compiled programs.
  - Normally cannot be opened in any text editor.
  - Raw binary- “Computer readable”

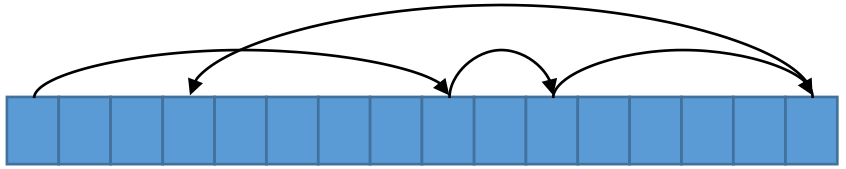


# File Access

- Using ***sequential access***, data is read/accessed from the beginning of the file through the end of the file.

- Using ***direct access***, data can be accessed from any location in the file.
  - A topic discussed in CSCI 112



# Opening a File

- To open a (text file) data stream in Python, use its built-in **open** function.

- The open function accepts two arguments: The file's name and the mode in which the file is being used.
  - Both arguments are strings.

```
my_text_file = open(filename, mode)
```

- The object returned by the open function is a file object.

# Specifying the File's name/path

- If the file you wish to access is in the same folder as the Python program opening the file, you only need to supply the file's name.

```
my_text_file = open("file.txt", mode)
```

- If the file is in a subfolder, you'll need to supply the path to the file beginning with the subfolder's name.

```
my_text_file = open("subfolder\\subfolder2\\file.txt", mode)
```

  - Remember, a backslash in a String literal indicates an escape sequence.

# Specifying the File's name/path

- If the file is in an entirely different folder, you'll need to supply the full path to the file (beginning with the drive letter on Windows).

```
my_text_file = open("C:\\path\\to\\the\\file.txt", mode)
```

# Writing Data to a Text File

- Specifying "w" as the mode will open the file in write mode.

```
my_output_file = open("output.txt", "w")
```

- In write mode, data can be written to the file.
  - If the specified file ***does not*** already exist (you want to make a new file) Python will create it.
  - If the specified file ***does*** exist, its contents will be **ERASED**.

# Saving a File

- To when you are finished writing to the output stream, call the **close** function.

- This will save the file.
  - If you do not close the stream, the information you wrote will not be saved.

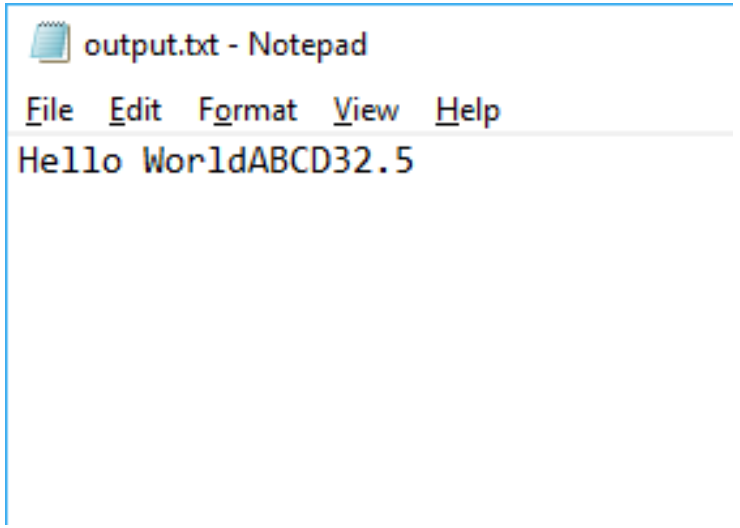
```
my_output_file.close()
```

# Writing Data to a New Text File

- Once the stream is open, we can write data to the file.

- A file's **write** function will write string values to the file.
  - If the data is numeric (ints or floats) be sure to typecast the data to string form.

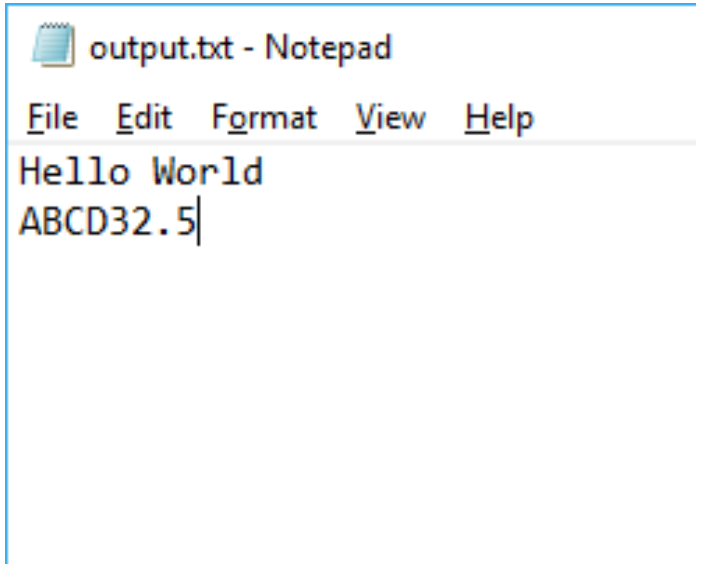
```
my_output_file = open("output.txt", "w")
my_output_file.write("Hello World")
my_output_file.write("ABCD")
my_output_file.write(str(32.5))
my_output_file.close()
```



# Writing Data to a New Text File

- The write function does not add line feeds after each function call.
- To add line feeds, add (or concatenate) **\n** to the end of the line.

```
my_output_file = open("output.txt", "w")
my_output_file.write("Hello World\n")
my_output_file.write("ABCD")
my_output_file.write(str(32.5))
my_output_file.close()
```



# Reading Data from a Text File

- Specifying "r" as the mode will open the stream in read-only mode.

```
my_text_file = open("file.txt", "r")
```

- No data can be written to a file opened in read-only mode.

# Closing a File

- To when you are finished reading from the input stream, call the **close** function.

- Python can't have two instances of the same file open.
  - Always close your file when you are done reading from it.

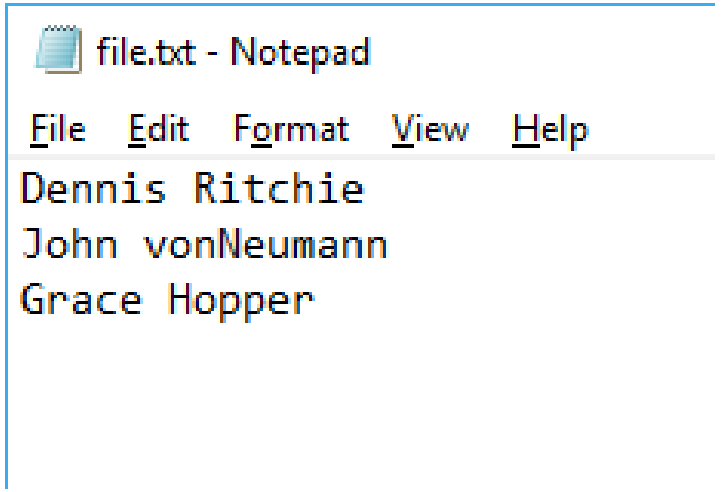
```
my_text_file.close()
```

# Reading Data from a Text File

- Once the file is opened in read mode, we can read the contents of the file.
- To read a file, line-by-line, use the file's readline function.
  - The function will return a string containing the next line in the file.

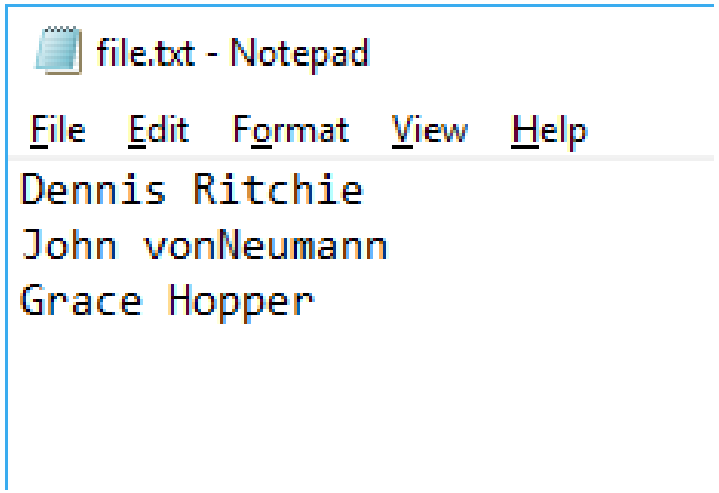
```
my_text_file = open("file.txt", "r")
line1 = my_text_file.readline()
print(line1)
my_text_file.close()
```

```
Dennis Ritchie
```



# Reading Data from a Text File

```
my_text_file = open("file.txt", "r")
line1 = my_text_file.readline()
line2 = my_text_file.readline()
line3 = my_text_file.readline()
print(line1)
print(line2)
print(line3)
my_text_file.close()
```



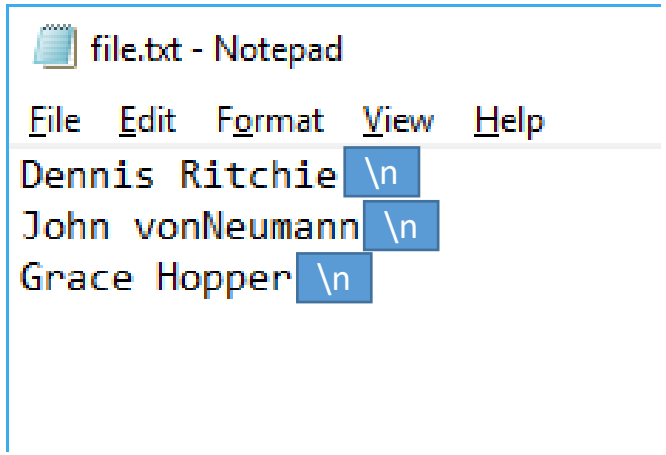

```
Dennis Ritchie

John vonNeumann

Grace Hopper
```

# Reading Data from a Text File

- The extra lines are the result of the non-character line feed (**\n**) at the end of each line in the file.




```
my_text_file = open("file.txt", "r")
line1 = my_text_file.readline()
line2 = my_text_file.readline()
line3 = my_text_file.readline()
print(line1)
print(line2)
print(line3)
my_text_file.close()
```

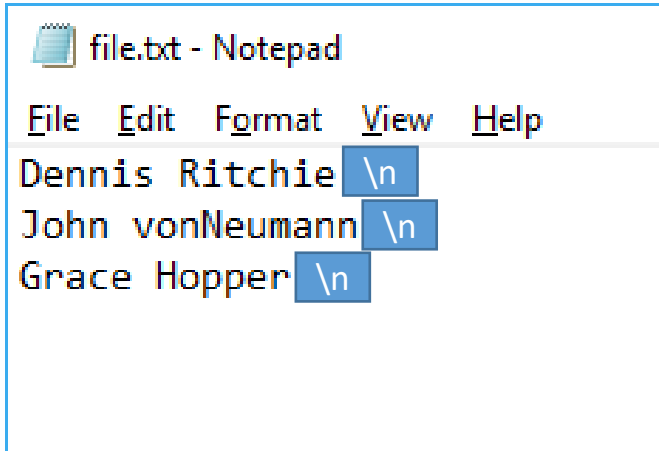
```
Dennis Ritchie

John vonNeumann

Grace Hopper
```

# Reading Data from a Text File

- To strip away the line feed, we can use the string's **rstrip** function.

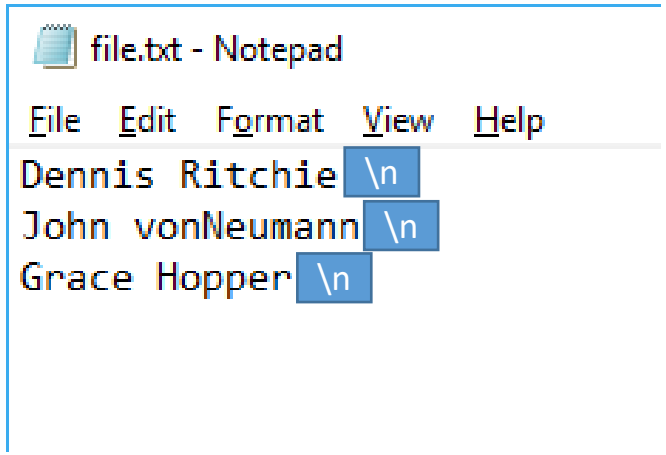



```
my_text_file = open("file.txt", "r")
line1 = my_text_file.readline().rstrip("\n")
line2 = my_text_file.readline()
line3 = my_text_file.readline()
print(line1)
print(line2)
print(line3)
my_text_file.close()
```

```
Dennis Ritchie
John vonNeumann

Grace Hopper
```

# Reading Data from a Text File




```
my_text_file = open("file.txt", "r")
line1 = my_text_file.readline().rstrip("\n")
line2 = my_text_file.readline().rstrip("\n")
line3 = my_text_file.readline().rstrip("\n")
print(line1)
print(line2)
print(line3)
my_text_file.close()
```

```
Dennis Ritchie
John vonNeumann
Grace Hopper
```

# Reading Data from a Text File

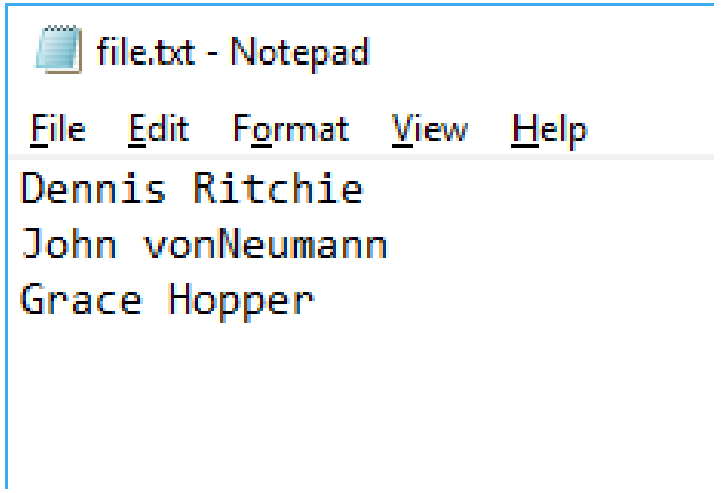
- A for loop can be used to read through a file sequentially.

```
my_text_file = open("file.txt", "r")

for line in my_text_file :
  print(line.rstrip("\n"))

my_text_file.close()
```

```
Dennis Ritchie
John vonNeumann
Grace Hopper
```



# Appending Data to a Text File

- Specifying "a" as the mode will open an output stream in append mode.

```
my_existing_file = open("output.txt", "a")
```

- In append mode, data can be written to a new or existing file.
  - If the file does not already exist, Python will create it.
  - If the file does exist, the file will be opened and wait for more data to be written to the end of the file.

- Be sure to close the file when you are finished appending to it.

# Appending Data to a Text File

- Once the file is open, we can continue writing data to the file.

```
my_output_file = open("output.txt", "a")
my_output_file.write("More data\n")
my_output_file.write("and more data!")
my_output_file.close()
```

# Subroutines

- A ***subroutine*** is a group of self-contained instructions that are executed when called.
  - A **function** is a subroutine that returns data when called.

```
my_existing_file = input("Enter your name: ")
```

  - A **procedure** is a subroutine that does not return data when called.

```
print("Hello World!")
```

  - A **method** is a subroutine (function or procedure) that is part of a software object.

```
some_string.replace("Monday", "Tuesday")
```

- All four terms are generally used interchangeably.
  - These are the correct definitions, though.

# Creating Subroutines

- Subroutines begin with the keyword **def** (short for define.)
- A parameter list is optional (but the parentheses are not.)
- Subroutine names follow the same rules as variables.

```
def name(parameter list):
    #code that will be
    #executed
```

Indent one tab.

# Creating a Procedure

- In Python, a subroutine must be defined before it can be called.

```
def test_procedure():
  print("Hello World")

test_procedure()
```

```
Hello World
```

# Procedures

```
def say_goodbye() :
  print("Goodbye World")

def say_hello() :
  print("Hello World")

say_ hello()
say_ goodbye()
```

4

2

1

3

```
Hello World
Goodbye World
```

# Creating a Function

- Functions are like procedures, except they return data when called.
- The return keyword is used to give data back when the function is called.

```
def print_total():
    total = 5 + 6
    return total

value = print_total()
print(value)
```

```
11
```

# Procedures and Functions

```
def print_total():
    total = 5 + 6
    return total

def say_hello() :
  print("Hello World")

say_hello()
value = print_total()
print(value)
```

4

2

1

3

```
Hello World
11
```

# Global Variables

- A ***global variable*** is a variable that exists outside of any one subroutine.

- Global variables are normally declared at the beginning of the source code file.
  - Although, subroutines can access a global variable regardless of where it is declared.

# Global Variables

```
global_variable = 3

def test1() :
  print("global_variable test1:", global_variable)
  test2()

def test2() :
  print("global_variable test2:", global_variable)

test1()
```

```
global_variable test1: 3
global_variable test2: 3
```

# Local Variables

- A ***local variable*** is a variable exists only inside of a function.
- Local variables are inaccessible to code outside of the function.
- Where a variable can be used is called its ***scope***.

# Local Variables

```
global_variable = 3

def test() :
    local_variable = 8.6
    print("global_variable:", global_variable)
    print("local_variable:", local_variable)

test()
```

Scope of global_variable

Scope of local_variable

```
global_variable: 3
local_variable: 8.6
```

# Global Variables Declared Locally

- A local variable can be made global using the **global** keyword.
  - Its declaration and assignment must be on separate lines.

```
global my_variable
my_variable = 75.4
```

# Global Variables Declared Locally

```
global_variable = 3

def test() :
  local_variable = 8.6
  global my_variable
  my_variable = 75.4
  print("global_variable:", global_variable)
  print("local_variable:", local_variable)
  print("my_variable:", my_variable)

print("global_variable:", global_variable)
print("my_variable:", my_variable)
test()
```

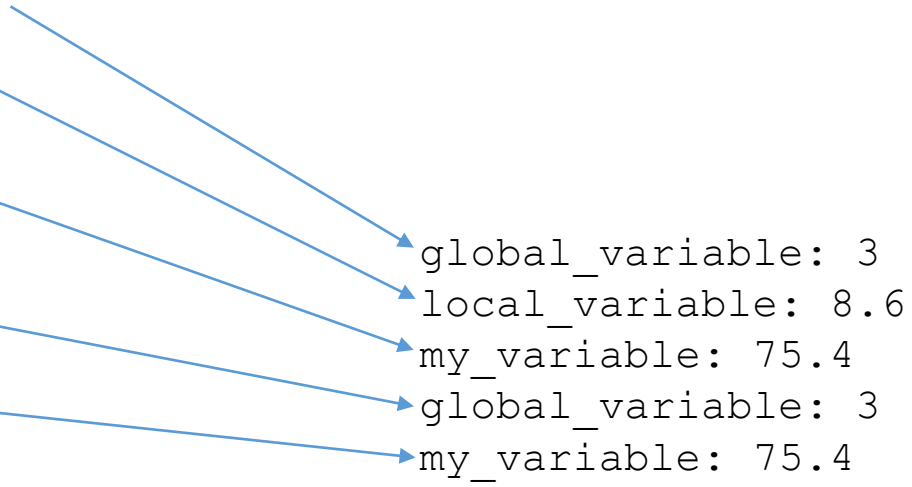
Will not work because its containing function has not been called yet.

# Global Variables Declared Locally

```
global_variable = 3

def test() :
  local_variable = 8.6
  global my_variable
  my_variable = 75.4
  print("global_variable:", global_variable)
  print("local_variable:", local_variable)
  print("my_variable:", my_variable)

test()
print("global_variable:", global_variable)
print("my_variable:", my_variable)
```



# Global Variables Declared Locally

```
global_variable = 3

def test1() :
  local_variable = 8.6
  global my_variable
  my_variable = 75.4
  print("global_variable:", global_variable)
  print("local_variable:", local_variable)
  print("my_variable:", my_variable)
  test2()

def test2() :
  print("my_variable:", my_variable)

test1()
```

```
global_variable: 3
local_variable: 8.6
my_variable: 75.4
my_variable: 75.4
```

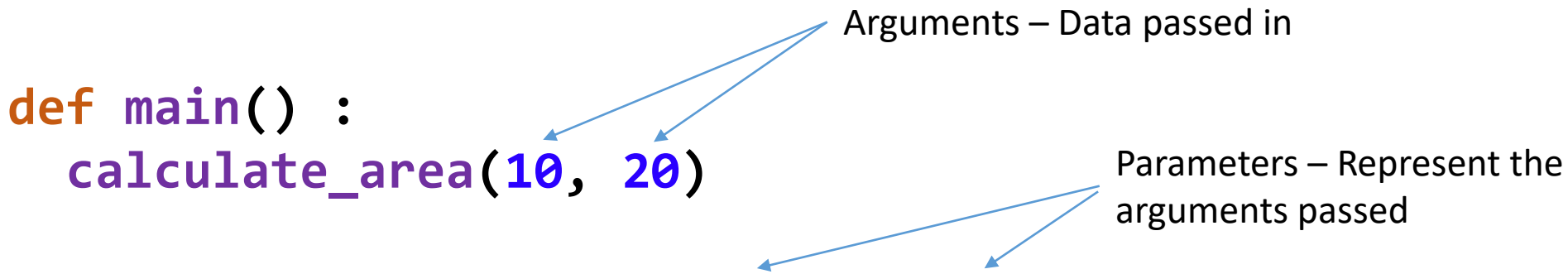
# Parameters and Arguments

- Subroutines have the ability to accept arguments.
  - ***Arguments*** are data passed to a function

```
round(original_number)
format(temp, "f")
```

- The variables used in the source code of a function to represent the arguments are called ***parameters***.

# Parameters and Arguments




```
def main() :
  calculate_area(10, 20)

def calculate_area(length_in, width_in) :
  area = length_in * width_in
  print("The area is", area)

main()
```

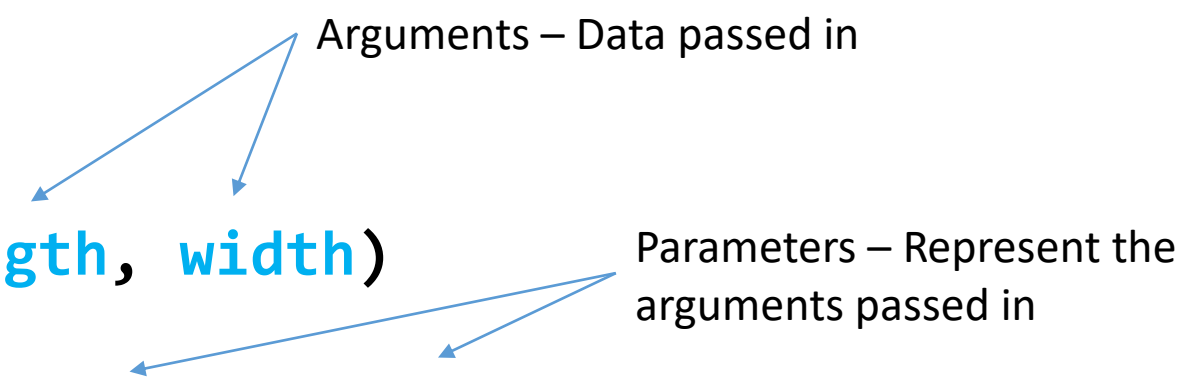
```
The area is 200
```

# Parameters and Arguments

```
def main() :
  length = 10
  width = 20
  calculate_area(length, width)

def calculate_area(length_in, width_in) :
  area = length_in * width_in
  print("The area is", area)

main()
```




```
The area is 200
```

# Parameters and Arguments

- The number of arguments must match the number of parameters.

```
def main() :
  calculate_area(10)

def calculate_area(length_in, width_in) :
  area = length_in * width_in
  print("The area is", area)

main()
```

Error

# Parameters and Arguments

```
def main() :
  area = calculate_area(10, 20)
  print("The area is" + str(area))

def calculate_area(length_in, width_in) :
  area = length_in * width_in
  return area

main()
```

```
The area is 200
```

Note: The main procedure's local variable area and the calculate_area function's local variable area are two **different** variables.

They can have the same name because they are local to their respective function.

# Parameters and Arguments

- Functions can have more than one return statement.

```
def main() :
  eligible = can_vote(22)
  print("Eligible to vote:", ("Yes" if eligible else "No"))

def can_vote(age_in) :
  if age_in >= 18 :
    return True
  else :
    return False

main()
```

In-line If Statement

```
Eligible to vote: Yes
```

# Recursion

- A ***recursive*** function is a function that calls itself.
  - Without any logic controlling the number of times it calls itself, it will call itself forever.

```
def main() :
  hello()

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

main()
```

```
Hello World
Hello World
Hello World
Hello World
Hello World
…
```

# Recursion

- Any task that can be completed using a repetitive algorithm can be solved using a recursive algorithm (and vice versa.)

```
def hello() :
  while True :
    print("Hello World")

hello()
```

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

hello()
```

# Recursion

- A function that prints a count down using a repetitive algorithm.

```
def main() :
  countdown(3)

def countdown(number_in) :
  for number in range(number_in, 0, -1) :
    print(number)

main()
```

```
3
2
1
```

# Recursion

- A similar function that again uses a repetitive algorithm.

```
def main() :
  countdown(3)

def countdown(number_in) :
  number = number_in
  while number > 0 :
    print(number)
    number -= 1

main()
```

```
3
2
1
```

# Recursion

- A function that uses a recursive algorithm to print the count down.

```
def main() :
  countdown(3)

def countdown(number_in) :
  if number_in > 0 :
    print(number_in)
    countdown(number_in - 1)

main()
```

```
3
2
1
```

# Recursion

```
def main() :
    countdown(3)

def countdown(number_in) :
  if number_in > 0 :
    print(number_in)
    countdown(number_in - 1)

main()
```

3

```
def countdown(number_in) :
  if number_in > 0 :
    print(number_in)
    countdown(number_in - 1)
```

2

```
def countdown(number_in) :
  if number_in > 0 :
    print(number_in)
    countdown(number_in - 1)
```

1

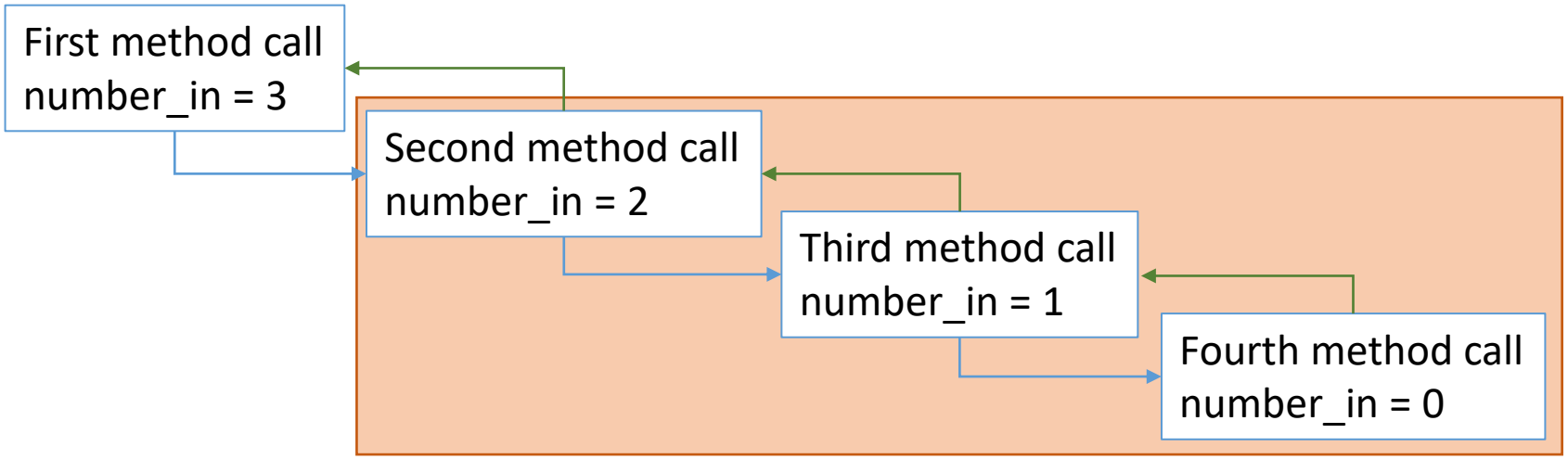
```
def countdown(number_in) :
  if number_in > 0 :
    print(number_in)
    countdown(number_in - 1)
```

0

```
3
2
1
```

# Recursion

- The number of times a function calls itself is the ***depth*** of recursion.




- In the previous example, the depth of recursion is 3 since the countdown function calls itself a total of three times.

# Using Recursion to Solve a Factorial

- In mathematics, the notation *n!* represents the factorial of some number, *n*.
- The factorial of a non-negative number is defined by the following rules:
  - If n = 0  n! = 1
  - If n > 0  n! = n * n-1 * n-2 * … * 1

  - Examples:
    - 0! = 1
    - 1! = 1
    - 3! = 3 * 2 * 1 = 6
    - 6! = 6 * 5 * 4 * 3 * 2 * 1 = 720

# Using Recursion to Solve a Factorial

- A function that uses a repetitive algorithm to return the factorial of a number.
  - 3! = 3 * 2 * 1 = 6

```
def main() :
   answer = factorial(3)
   print("3! =", number))

def factorial(n) :
   result = 1
   for number in range(n, 0, -1) :
      result *= number
   return result

main()
```

```
3! = 6
```

# Using Recursion to Solve a Factorial

- Let's rewrite n! so we think of it as a function call than a mathematical expression:
  - The **base case** is when n = 0
  - The **recursive case** is when n > 0
  - If n = 0  factorial(n) = 1
  - If n > 0  factorial(n) = n * n-1 * n-2 * … * 1
    = **n * factorial(n-1)**

  - Examples:
    - factorial(0) = 1
    - factorial(1) = 1 * factorial(0) = 1 * 1 = 1
    - factorial(2) = 2 * factorial(1) = 2 * 1 = 2
    - factorial(3) = 3 * factorial(2) = 3 * 2 = 6

# Using Recursion to Solve a Factorial

- A recursive function that returns the factorial of a number
  - Base Case: n = 0

```
def main() :
  answer = factorial(0)
  print("0! = " + str(answer))

def factorial(n) :
  if n > 0 :
    #Recursive Case
    return n * factorial(n - 1)
  else :
    #Base Case
    return 1

main()
```

```
0! = 1
```

# Using Recursion to Solve a Factorial

- Recursive Case: n > 0

```
def main() :
  answer = factorial(3)
  print("3! =", answer)

def factorial(n) :
  if n > 0 :
    #Recursive Case
    return n * factorial(n - 1)
  else :
    #Base Case
    return 1

main()
```

3

```
3! = 6
```

2

```
def factorial(n) :
  if n > 0 :
    #Recursive Case
    return n * factorial(n - 1)
  else :
    #Base Case
    return 1
```

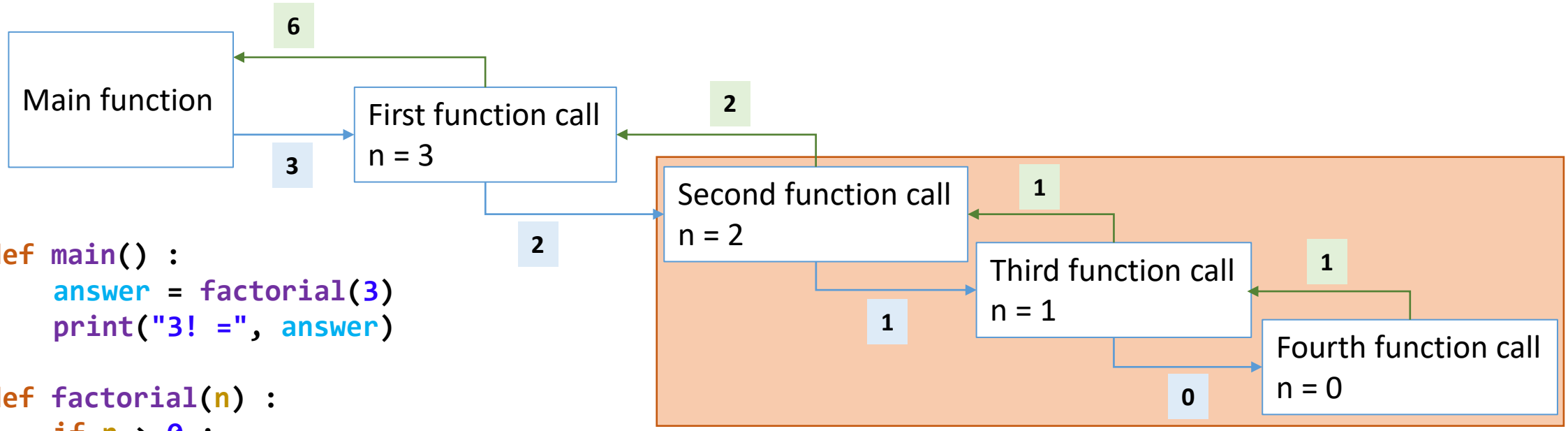
1

```
def factorial(n) :
  if n > 0 :
    #Recursive Case
    return n * factorial(n - 1)
  else :
    #Base Case
    return 1
```

0

```
def factorial(n) :
  if n > 0 :
    #Recursive Case
    return n * factorial(n - 1)
  else :
    #Base Case
    return 1
```

# Using Recursion to Solve a Factorial




```
def main() :
    answer = factorial(3)
    print("3! =", answer)

def factorial(n) :
    if n > 0 :
        #Recursive Case
        return n * factorial(n - 1)
    else :
        #Base Case
        return 1

main()
```