Chapter 4: Functions

Instructor: Dr. Murat Tunc

Lecture 4

November 30th, 2021

Last Week (Summary)

boolean Data Type

- A variable that holds a boolean value is known as a **boolean variable**

- The boolean data type is used to declare boolean variables

- A boolean expression evaluates to **True** or **False**

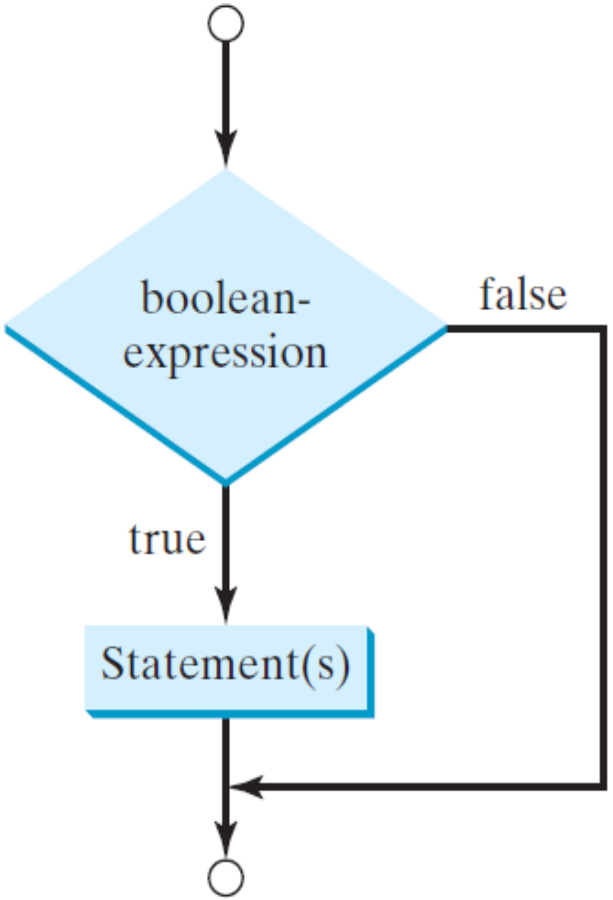
```
b = 1 > 2  # b is assigned the value False
```

Relational Operators

Operator	Mathematics Symbol	Name	Example (radius is 5)	Result
<	<	less than	`radius < 0`	`false`
<=	≤	less than or equal to	`radius <= 0`	`false`
>	>	greater than	`radius > 0`	`true`
>=	≥	greater than or equal to	`radius >= 0`	`true`
==	=	equal to	`radius == 0`	`false`
!=	≠	not equal to	`radius != 0`	`true`

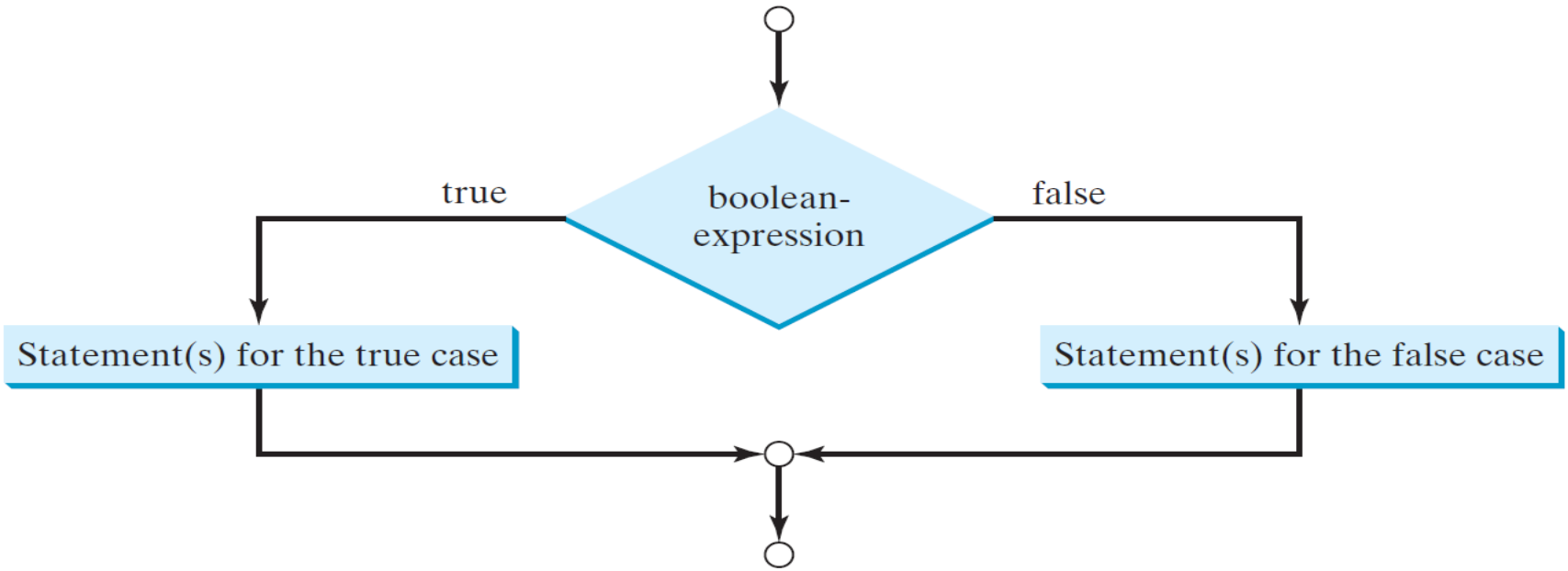
One-way if Statements

```
if boolean-expression:
    statement(s)
```



Two-way **if-else** statements

```
if boolean-expression:
    statement(s)-for-the-true-case
else:
    statement(s)-for-the-false-case
```



Logical Operators

Operator	Description
not	logical negation
and	logical conjunction
or	logical disjunction

Truth Table for Operator **and**

p_1	p_2	p_1 **and** p_2	**Example (assume age = 24, weight = 140)**
false	false	false	age <= 18 **and** weight < 140 is false
false	true	false	age <= 18 **and** weight == 140 is false
true	false	false	age > 18 **and** weight > 140 is false
true	true	true	age > 18 **and** weight >= 140 is true

Truth Table for Operator **or**

p_1	p_2	p_1 **or** p_2	**Example (assume age = 24, weight = 140)**
false	false	false	age < 18 **or** weight >= 150 is false
false	true	true	age < 18 **or** weight >= 130 is true
true	false	true	age > 18 **or** weight >= 150 is true
true	true	true	age > 18 **or** weight >= 130 is true

Practice Exercise 1

Write a program that

1) **prompts** the user to enter a movie's IMDB rating (0 to 10 – may include decimal, like 3.5) and Metascore (0 to 100 - integer), and
2) **checks** whether the movie is recommended to watch

Hint: Recommend if rating > 7.0 & Metascore > 60

Practice Exercise 1 - Answer

```
# Practice Exercise 1

# Step 1: Read in the IMDB rating and metascore

IMDBRating = float(input("Please input IMDB rating of a movie (0 to 10) and press Enter:"))

metascore = int(input("Please input IMDB rating of a movie (0 to 100 - integer) and press Enter:"))

# Step 2: Recommend the movie if the rating > 7.0 and metascore > 60

if IMDBRating > 7.0 and metascore > 60:
    print("This movie is recommended to watch!")
else:
    print("This movie is not recommended to watch!")
```

```
Please input IMDB rating of a movie (0 to 10) and press Enter: 7.6
Please input IMDB rating of a movie (0 to 100 - integer) and press Enter: 63
This movie is recommended to watch!
```

Practice Exercise 2

Write a program that

1) **prompts** the user to enter the day, month and year he/she was born, and
2) **displays** whether he/she can legally purchase beer in US

- Give me a beer, please.
- Can I see an ID? 6.12.1999
- I'm sorry, but I cannot sell you a beer.

Practice Exercise 2 - Answer

```
# Practice Exercise 2

# Step 1: Read in the day, month and year

print("Give me a beer please!")

print("Can I see an ID?")

dayOfBirth = int(input("Please input the day of your birthday and press Enter:"))

monthOfBirth = int(input("Please input the month of your birthday and press Enter:"))

yearOfBirth = int(input("Please input the year of your birthday and press Enter:"))

# Step 2: Check whether the user can legally purchase beer in US

if yearOfBirth < 1999 or (yearOfBirth == 1999 and monthOfBirth < 12) or \
    (yearOfBirth == 1999 and monthOfBirth == 12 and dayOfBirth <= 2):
    print("Here is your beer!")
else:
    print("I'm sorry, I cannot sell you a beer!")
```

```
Give me a beer please!
Can I see an ID?
Please input the day of your birthday and press Enter: 6
Please input the month of your birthday and press Enter: 12
Please input the year of your birthday and press Enter: 1999
I'm sorry, I cannot sell you a beer!
```

Chapter 4: Functions

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Functions – Motivating Problem

- Find the absolute difference between two numbers
  - 3 and 10
  - 22 and 65
  - 83 and 99

A Tedious Way

```
num1 = 3
num2 = 10
if num1 > num2:
    absoluteDifference = num1 - num2
else:
    absoluteDifference = num2 - num1
print("The absolute difference is", absoluteDifference)
```

```
num1 = 22
num2 = 65
if num1 > num2:
    absoluteDifference = num1 - num2
else:
    absoluteDifference = num2 - num1
print("The absolute difference is", absoluteDifference)
```

```
num1 = 83
num2 = 99
if num1 > num2:
    absoluteDifference = num1 - num2
else:
    absoluteDifference = num2 - num1
print("The absolute difference is", absoluteDifference)
```

Observation

- Computing the absolute difference in all the 3 cases is very similar **except** that the **starting and ending integers** are different

- It would be nice if we could write a **common code** once and **reuse** it

- We can do this by defining a '**function**'

Solution - Functions

myDifference(x, y)
A **function** that returns the absolute difference between two numbers (x and y)

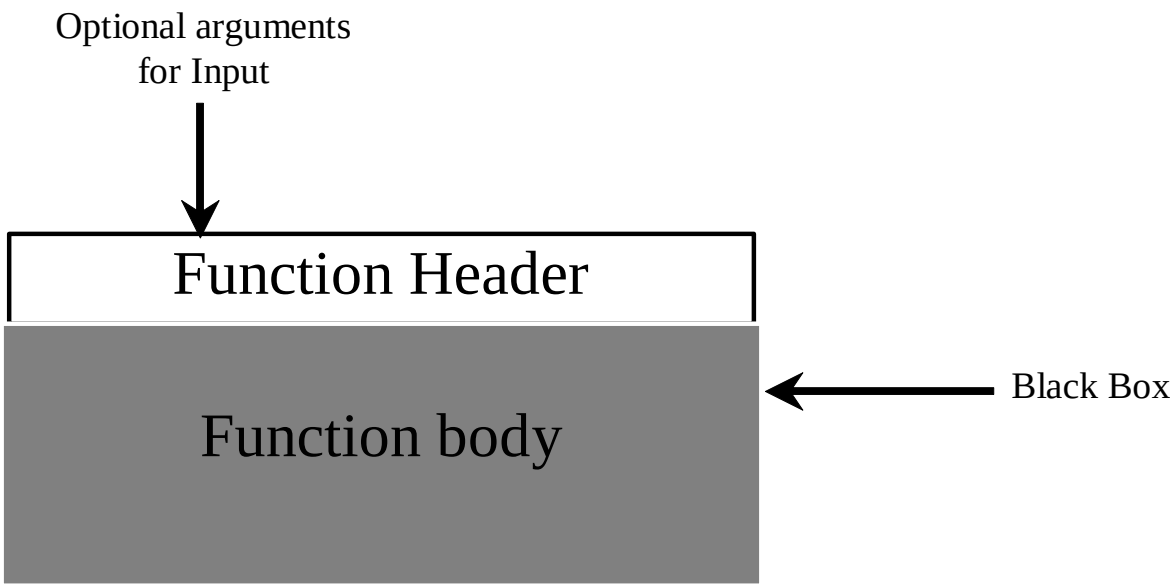
```
print("The absolute difference between 3 and 10 is",myDifference(3, 10))
print("The absolute difference between 22 and 65 is",myDifference(22,65))
print("The absolute difference between 83 and 99 is",myDifference(83,99))
```

Solution - Functions

```
def myDifference(num1, num2):
        if num1 > num2:
                absoluteDifference = num1 – num2
        else:
                absoluteDifference = num2 – num1
        return absoluteDifference

print( myDifference( num1, num2 ) )
```

Function Abstraction

- You can think of the function body as a **black box** that contains the detailed implementation for the function



Introduction to Functions

- Functions can be used to define **reusable** code, **organize**, and **simplify** coding

- Some built-in **funtion** (defined in the Python library) that we have already used:
  - **print( )**
  - **input( )**
  - **pow(,)**

- How do we create **our own function**?

Defining a function

Invoking a function

Defining a Function

- A function definition consists of
  - function **name**
  - **parameters**
  - body

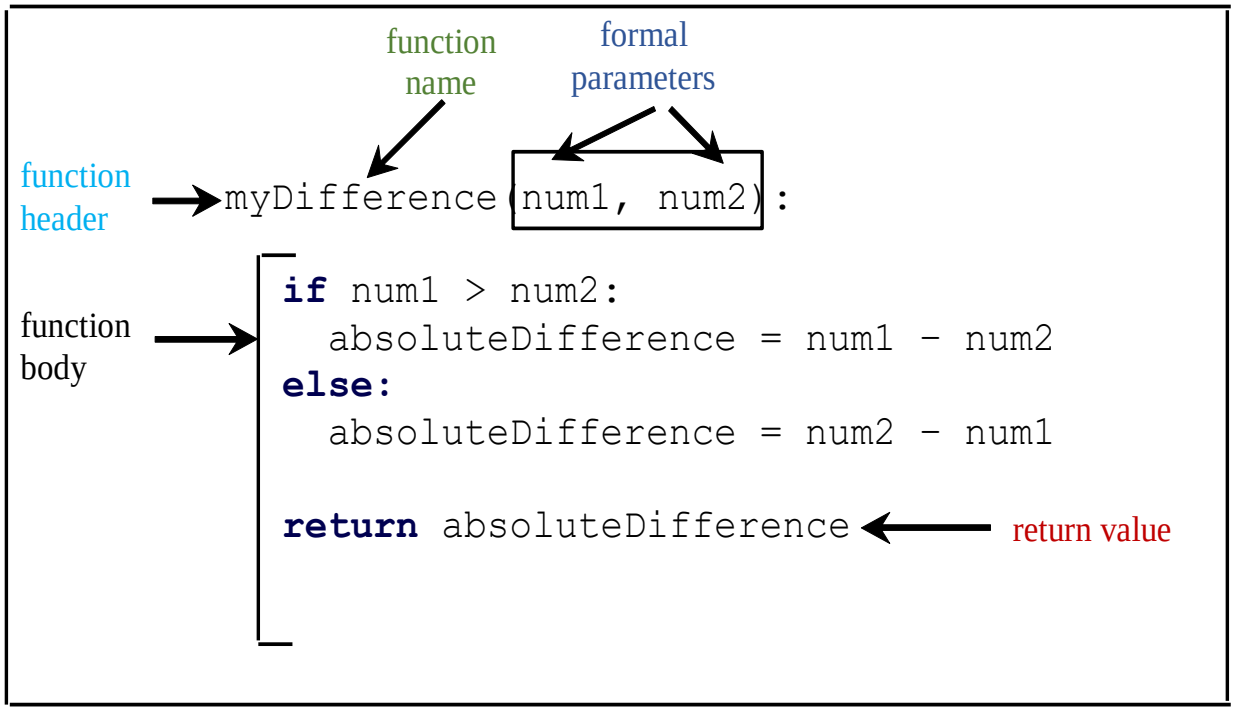
- Syntax:

```
functionName (list of parameters):
        # function body
```

Defining a Function

- A function is a collection of statements that are grouped together to perform an operation

Define a function



Invoke a function

```
print(myDifference(3,10)
```

actual parameters (arguments)

Defining a function - Function Signature

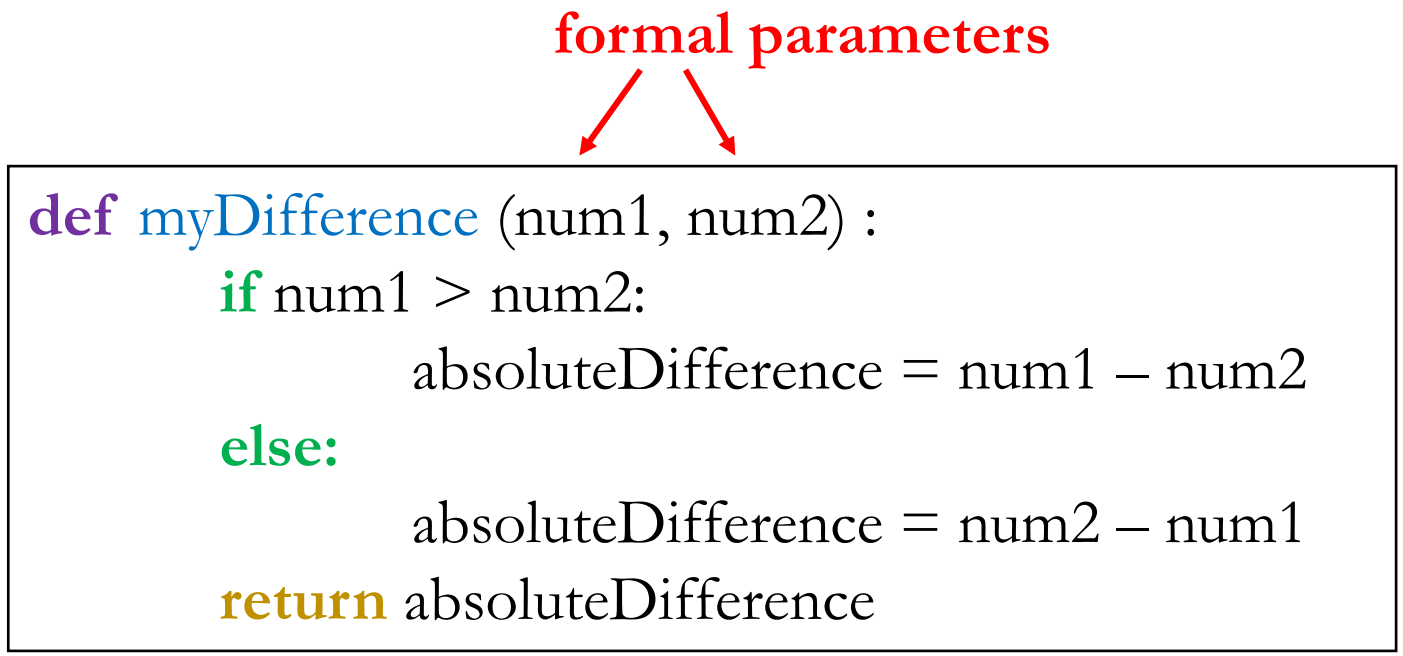
- **Function signature** is the combination of the **function name** and the **parameter list**

Function signature

```
def myDifference (num1, num2) :
        if num1 > num2:
                absoluteDifference = num1 – num2
        else:
                absoluteDifference = num2 – num1
        return absoluteDifference
```

Defining a Function - Formal Parameters

- The variables defined in the function header are known as **formal parameters**



Defining a function

Invoking a function

Invoking a Function - Actual Parameters

- When a function is **invoked**, you pass a value to the parameter. This value is referred to as **actual parameter** or **argument**

```
def myDifference (num1, num2) :
        if num1 > num2:
                absoluteDifference = num1 – num2
        else:
                absoluteDifference = num2 – num1
        return absoluteDifference
```

diffVariable = myDifference(3, 10)

Actual parameters (arguments)

Parameters

- The variables defined in the **function header** are known as **formal parameters** or simply parameters
- A parameters is like a **placeholder**: when a function is invoked, you **pass actual value** of the parameter
- This value is referred to as the **actual parameter** or argument
- Parameters are **optional**; that is a function may contain no parameters

Invoking a Function – Return Value

- A function **may or may not return** a value

```
def myDifference (num1, num2) :
        if num1 > num2:
                absoluteDifference = num1 – num2
        else:
                absoluteDifference = num1 – num2
        return absoluteDifference
```

Return value →

Review Exercise 1

What is the value of **integer** ?

```
def myInteger(num1, num2):
        return num2 - num1
integer = myInteger (5, 14)
```

Ans: integer = 9

Why: myInteger is invoked with actual parameters of 5 and 14
myInteger returns value of 14 – 5
integer = 9

Review Exercise 2

What is the value of **integer** ?

```
def myInteger(num2, num1):
        return num2 % num1
integer = myInteger (5, 14)
```

Ans: integer = 5

Why: myInteger is invoked with actual parameters of 5 and 14

myInteger returns a value of 5 % 14

% means remainder - 5 divided by 14 - remainder is 5

integer = 5

Review Exercise 3

What is the value of **integer** ?

```
def myInteger(num1, num2):
        return num2 / num1
integer = myInteger (5, 14)
```

Ans: integer = 2.8

Why: myInteger is invoked with actual parameters of 5 and 14
myInteger returns a value of 14 / 5
14 divided by 5 is 2.8
integer = 2.8

Review Exercise 4

What is the value of **integer** ?

```
def myInteger(num1, num2):
        return num2 // num1
integer = myInteger (5, 14)
```

Ans: integer = 2

Why: myInteger is invoked with actual parameters of 5 and 14

// means integer division

14 divided by 5 is 2.8, integer part is 2

integer = 2

Value-returning function
Void function

Return Value Type

- A function that returns a value is called as a **value-returning function**
- A function terminates when a return statement is executed
- A function that does not return a value is called as a **void function**

Value-returning functions

```
def getGrade (score):
        if (score >= 90.0):
                return "A"
        elif (score >= 80.0):
                return "B"
        elif (score >= 70.0):
                return "C"
        elif (score >= 60.0):
                return "D"
        else:
                return "F"
print("The grade is", getGrade (78.5))
```

Void functions

```
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")
print("The grade is")
printGrade (78.5)
```

Review Exercise 5

What is the value of **integer** ?

```
def myInteger (num1, num2):
        print(num2 / num1)
integer = myInteger (5, 14)
```

Ans: None

Why: myInteger function does not return a value

integer is defined, but it's value is not set

integer = None

Review Exercise 6

What does the following prints on the console?

```
def myPrint (string, number):
        print(string + number)
myPrint (5, 14)
```

Ans: 19

Why: string is an integer variable and stores a value of 5

number = 14

print(5 + 14 **)** , which prints 19

Review Exercise 7

What does the following prints on the console?

```
def myPrint (string, number):
        print(string, number)
myPrint (5, 14)
```

Ans: 5 14

Why: string is an integer variable and stores a value of 5

number = 14

print(5, 14 **)** , prints 5 14

Review Exercise 8

What does the following prints on the console?

```
def myPrint (string, number):
        print(string + number)
myPrint ("5", 14)
```

Ans: Error

Why: string is "5", number is 14

"5" + 14 is error

Since "5" is text (i.e. string), whereas 14 is a number

Classroom Exercise

Write a program that

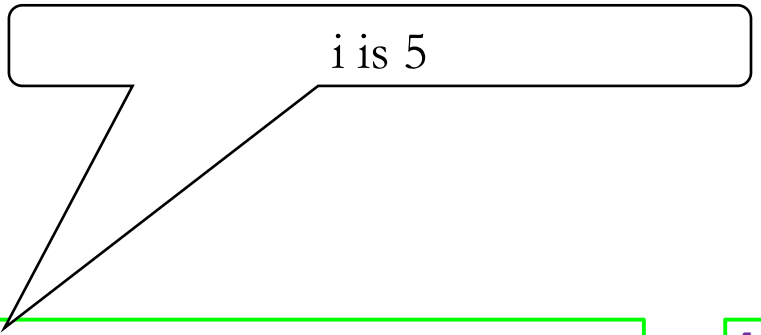
1) asks the user to **enter two integers**: num1 and num2, and
2) **invokes a function** that takes two integers
3) The function returns **true** if the first number is greater than the second, else returns **false**
4) The program prints whether num1 is greater than num2

Answer

```
def myComparison (num1, num2):
    result = False
    if num1 > num2:
        result = True
    return result


num1 = int ( input( "Please input an integer and press Enter") )
num2 = int ( input( "Please input an integer and press Enter") )
if myComparison(num1, num2):
    print("The first number is greater!")
else:
    print("The second number is greater or equal!")
```

Invoking / Calling a function

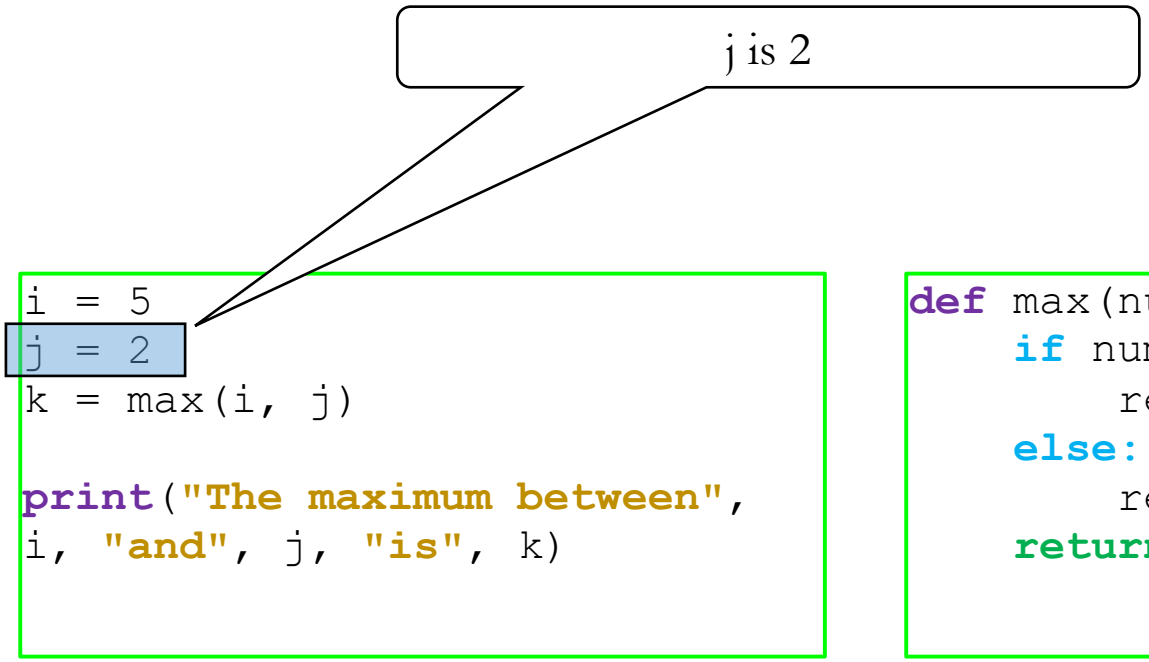
Trace Function Invocation



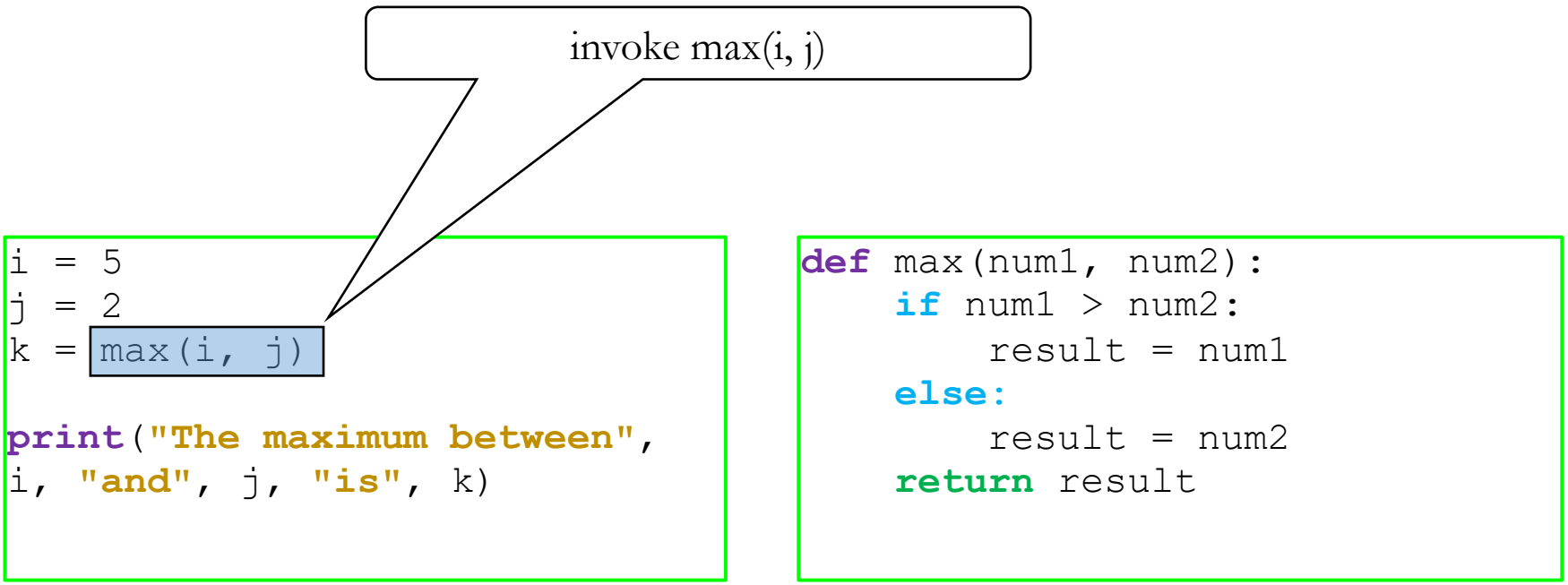

```
i = 5
j = 2
k = max(i, j)

print("The maximum between",
i, "and", j, "is", k)
```

```
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

Trace Function Invocation



Trace Function Invocation



Trace Function Invocation

invoke max(i, j)
Pass the value of i to num1
Pass the value of j to num2

```
i = 5
j = 2
k = max(i, j)

print("The maximum between",
i, "and", j, "is", k)
```

```
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

Trace Function Invocation

(num1 > num2) is **true**
since num1 is 5 and num2 is 2

```
i = 5
j = 2
k = max(i, j)

print("The maximum between",
i, "and", j, "is", k)
```

```
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

Trace Function Invocation

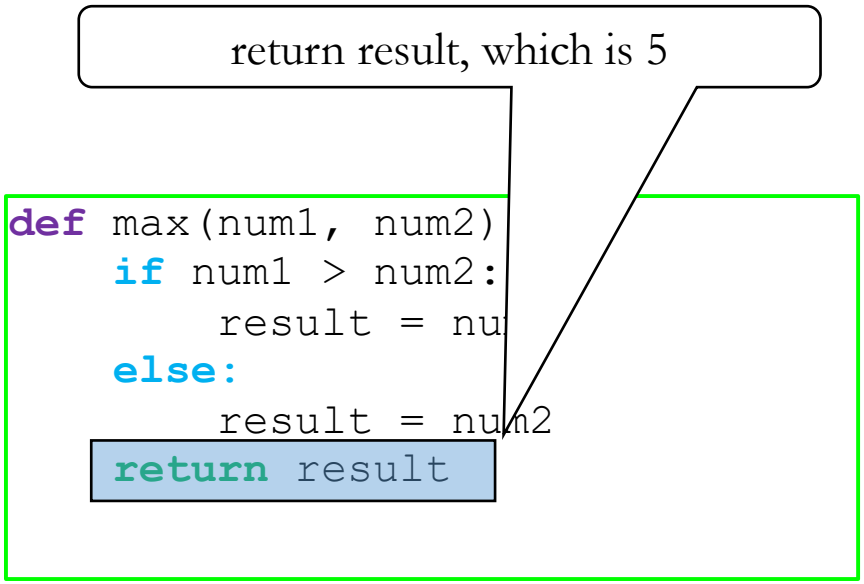
```
i = 5
j = 2
k = max(i, j)

print("The maximum between",
i, "and", j, "is", k)
```

```
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

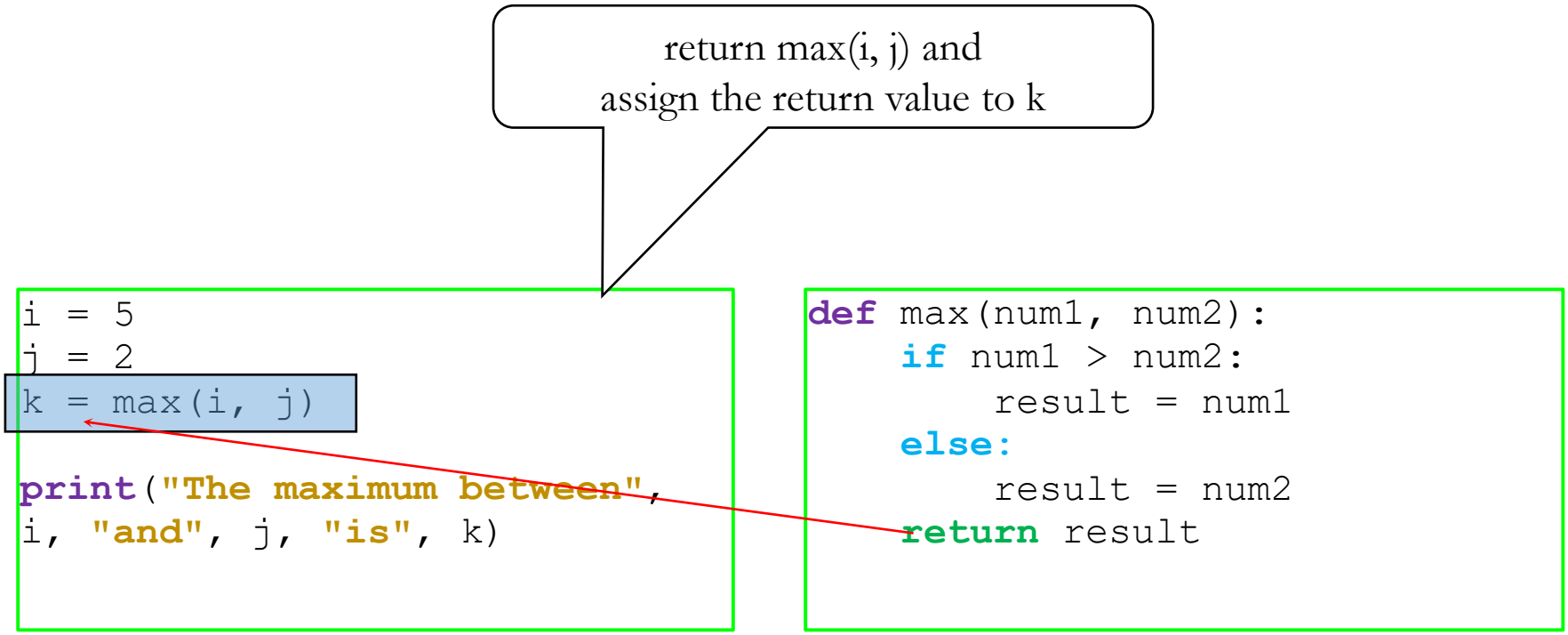
result is 5

Trace Function Invocation

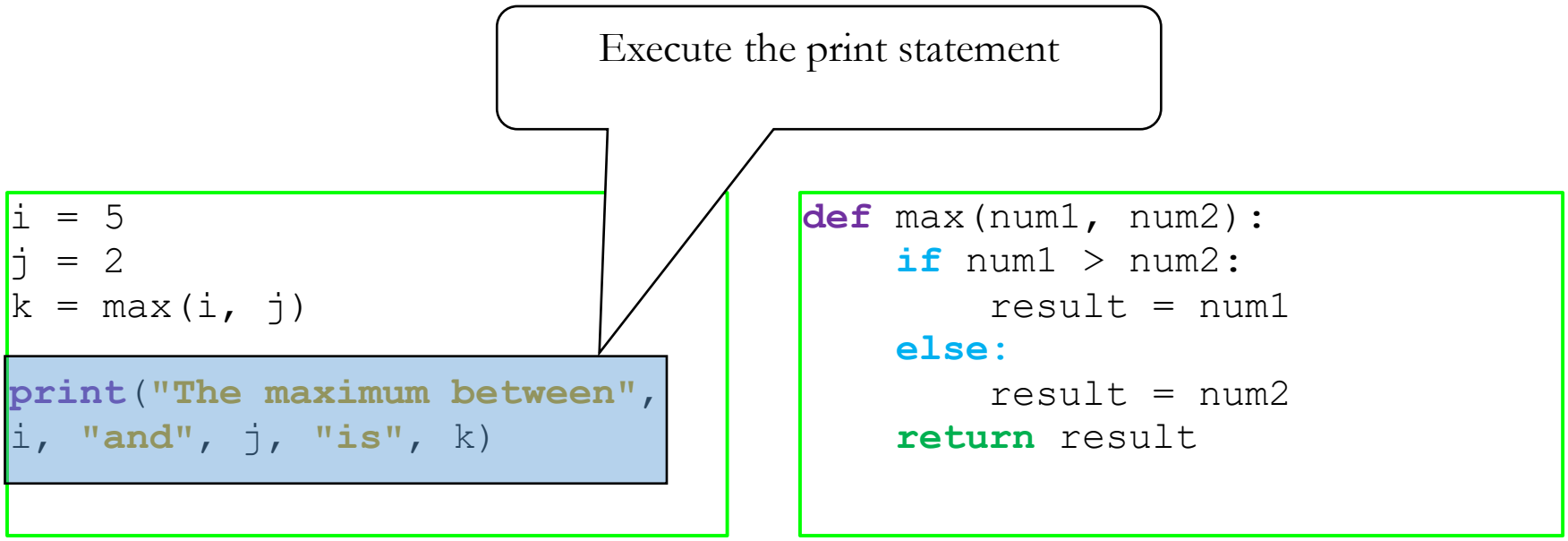
```
i = 5
j = 2
k = max(i, j)

print("The maximum between",
i, "and", j, "is", k)
```



Trace Function Invocation



Trace Function Invocation



Review Exercise 9 – Is this OK ?

Is the following code OK – runs without error?

```
def mySum (num1) :
        num1 += 2
        num2 += 5
        return num1 + num2
value = mySum (10, 2)
```

Ans: Error --- num2 is not defined

Why: num2 is not defined in function header

Review Exercise 10 – Is this OK ?

Is the following code OK – runs without error?

```
def mySum (num1, num2) :
        num1 += 2
        num2 += 5
        return num1 + num2
        num1 += 10
value = mySum (10, 2)
```

Unreachable code

Ans: It is OK – runs without error

Why: After **return**, the function terminates

Do not write any code after **return**

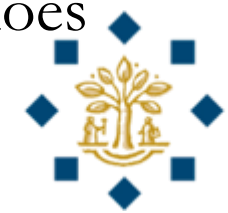
Review Exercise 11 – Is this OK ?

Is the following code OK – runs without error?

```
def mySum (num1, num2) :
        num1 += 2
        num2 += 5
        return num1 + num2
        num1 += 10
        return num1 + num2
value = mySum (10, 2)
```

Ans: Yes, it is OK – runs without error

Why: A second **return** is not executed, but Python does not show any error



Review Exercise 12 – Is this OK?

Is the following code OK – runs without error?

```
value = mySum (10, 2)
def mySum (num1, num2) :
        num1 += 2
        num2 += 5
        return num1 + num2
        num1 += 10
        return num1 + num2
```

Ans: No, there is an error

Why: Always define the function before invoking it

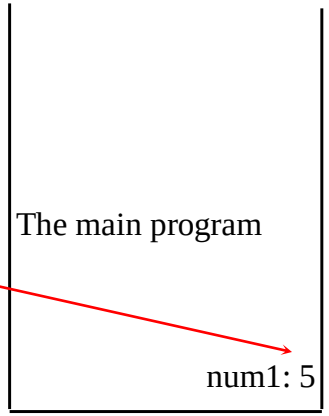
Call Stack

- Each time a function is invoked
  - The system creates an **activation record**
- **Activation record**
  - Stores parameters and variables for the function
  - Places the activation record in an area of memory
  - This memory area is known as a **call stack**
- **A local variable**
  - Variable defined inside a function

Trace Call Stack

num1 is declared and initialized

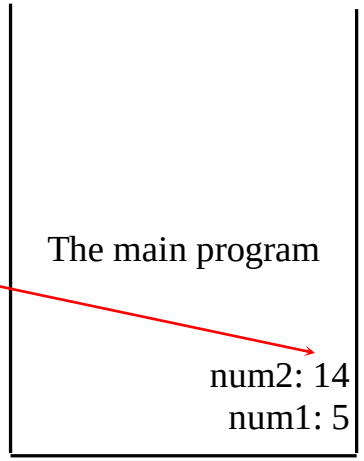
```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```



Trace Call Stack

```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

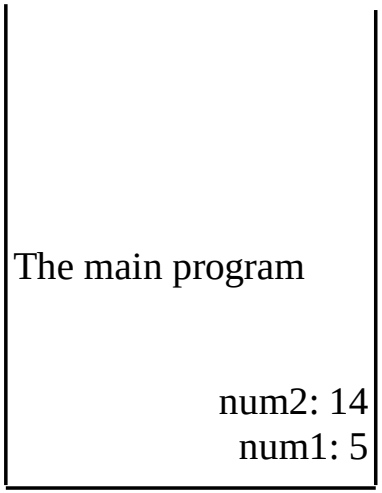
num2 is declared and initialized



Trace Call Stack

```
def myInteger (num1, num2) :
          num1 += 1
          print ( num1 )
          return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

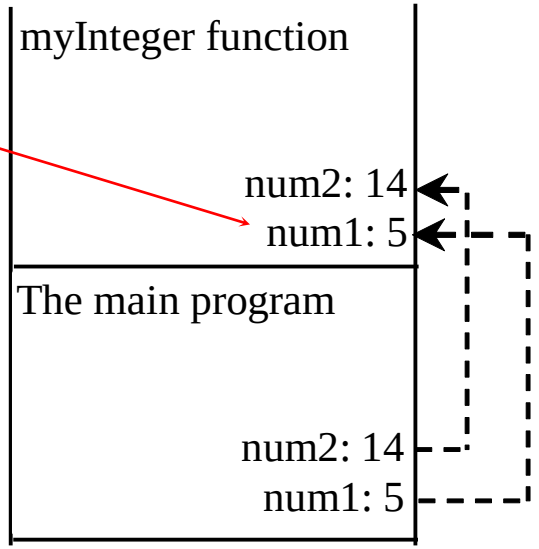
Invoke myInteger (5, 14)



Trace Call Stack

pass the values of 5 and 14 to num1 and num2

```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

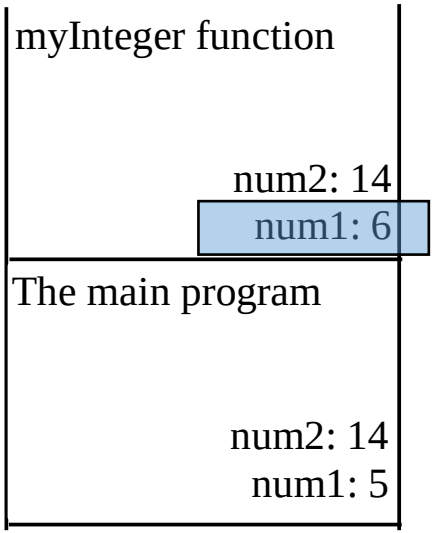


myInteger method is invoked.

Trace Call Stack

num1 in myInteger function is increased by 1

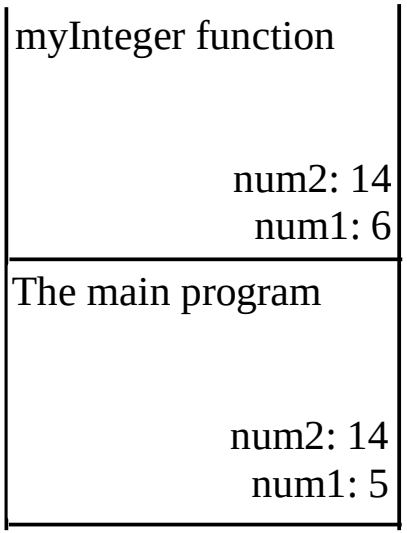
```
def myInteger (num1, num2) :
        num1 += 1
        print ( num1 )
        return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```



Trace Call Stack

```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

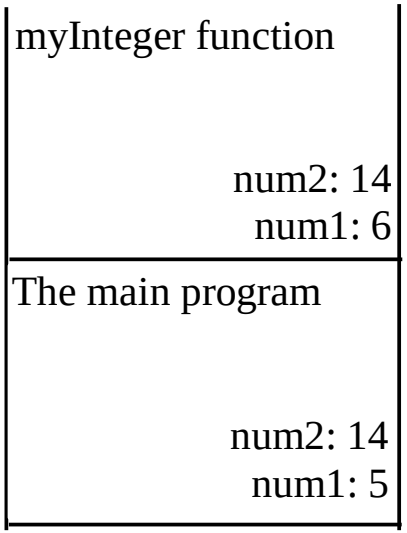
Print num1 in myInteger function, which is 6



Trace Call Stack

```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

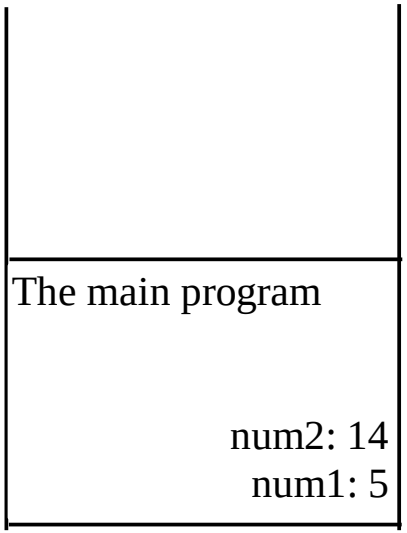
Return 14 % 6, the remainder is 2



Trace Call Stack

```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

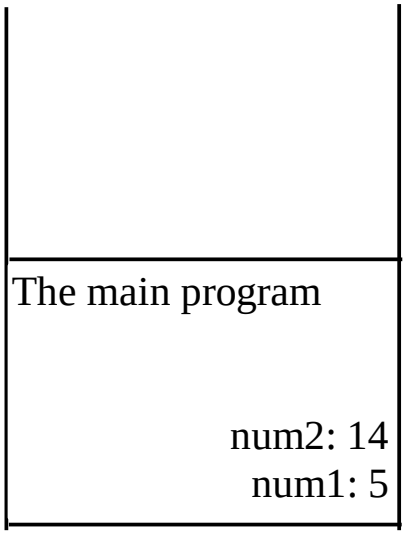
2 is printed



Trace Call Stack

```
def myInteger (num1, num2) :
            num1 += 1
            print ( num1 )
            return num2 % num1
num1 = 5
num2 = 14
print ( myInteger (num1, num2) )
print ( num1 )
```

5 is printed



Review Exercise 13

What does the following code print ?

```
def myInteger (num1, num2) :
        num1 //= 5
        print ( num1 )
        return num2 % num1
num1 = 15
num2 = myInteger(33, num1)
print ( myInteger (num1*num2, num2) )
print ( num2 )
```

Ans: First prints **6**, then **9**, then **3**, and finally **3**

```
def myInteger (num1, num2) :
        num1 //= 5
        print ( num1 )
        return num2 % num1
num1 = 15
num2 = myInteger(33, num1)
print ( myInteger (num1*num2, num2) )
print ( num2 )
```

Ans: First prints **6**, then **9**, then **3**, and finally **3**

Why: **myInteger** is invoked with actual parameters of 33 and 15

num1 in **myInteger** becomes **6** when num1 //= 5, **print(6)**

myInteger returns a value of 15 % 6 = 3

num2 in the main program becomes **3**

myInteger is invoked with actual parameters of 3*15 and 3

num1 in **myInteger** becomes **9** when 45 //= 5, **print(9)**

myInteger returns a value of 3 % 9 = 3, **print(3)**

num2 in the main program is still **3**, **print(3)**

Benefits of Functions

- Write a function **once** and **reuse** it anywhere
- Information hiding. Hide the implementation from the user
- Reduce complexity