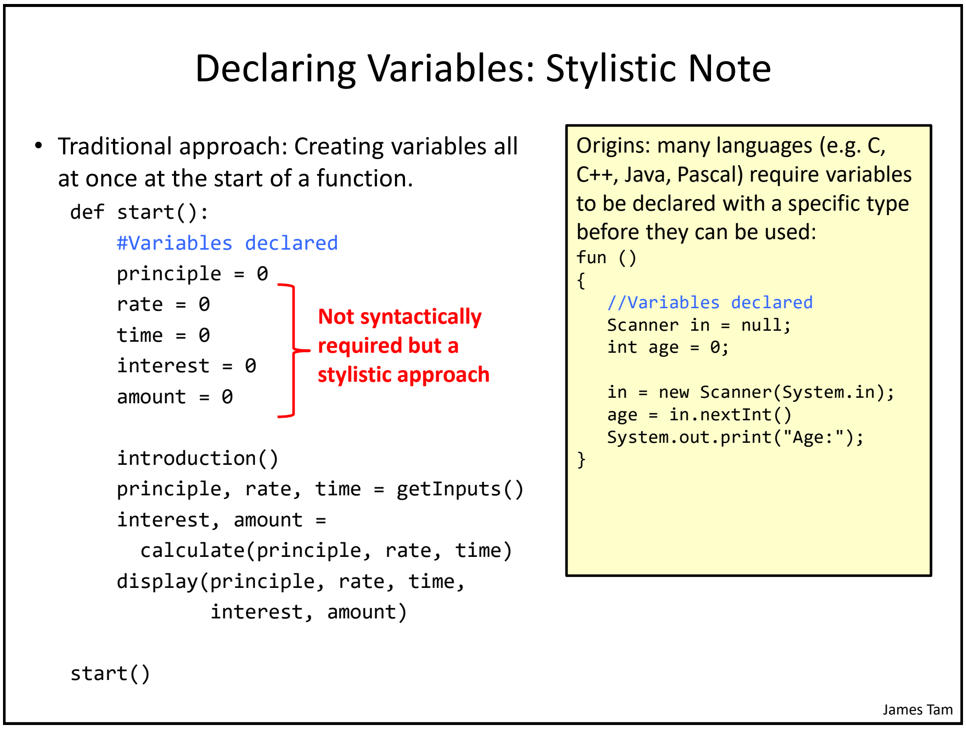
Functions: Decomposition And Code Reuse, Part 3

- Global identifiers, scope and program design
- Declaring variables: where in your function/at what level in your program
- Boolean functions
- Breaking long functions into parts
- Common errors when defining functions
- Program design and defining functions
- Testing functions
- Benefits & drawbacks of defining functions

In Class Exercise, Functions

- Write a function called ‘`emphasize`’ that takes a string as a parameter.
- This function returns a modified version of the string:
  - !!! will be added onto the end (three exclamation marks are added to the end of the existing string).
  - Recall: The concatenation operator is the ‘plus’ operator ‘+’ and it can connect two strings.



Declaring Variables: Stylistic Note

- Traditional approach: Creating variables all at once at the start of a function.

```
def start():
    #Variables declared
    principle = 0
    rate = 0
    time = 0
    interest = 0
    amount = 0

    introduction()
    principle, rate, time = getInputs()
    interest, amount =
      calculate(principle, rate, time)
    display(principle, rate, time,
            interest, amount)

start()
```

Not syntactically required but a stylistic approach

Origins: many languages (e.g. C, C++, Java, Pascal) require variables to be declared with a specific type before they can be used:

```
fun ()
{
   //Variables declared
   Scanner in = null;
   int age = 0;

   in = new Scanner(System.in);
   age = in.nextInt()
   System.out.print("Age:");
}
```

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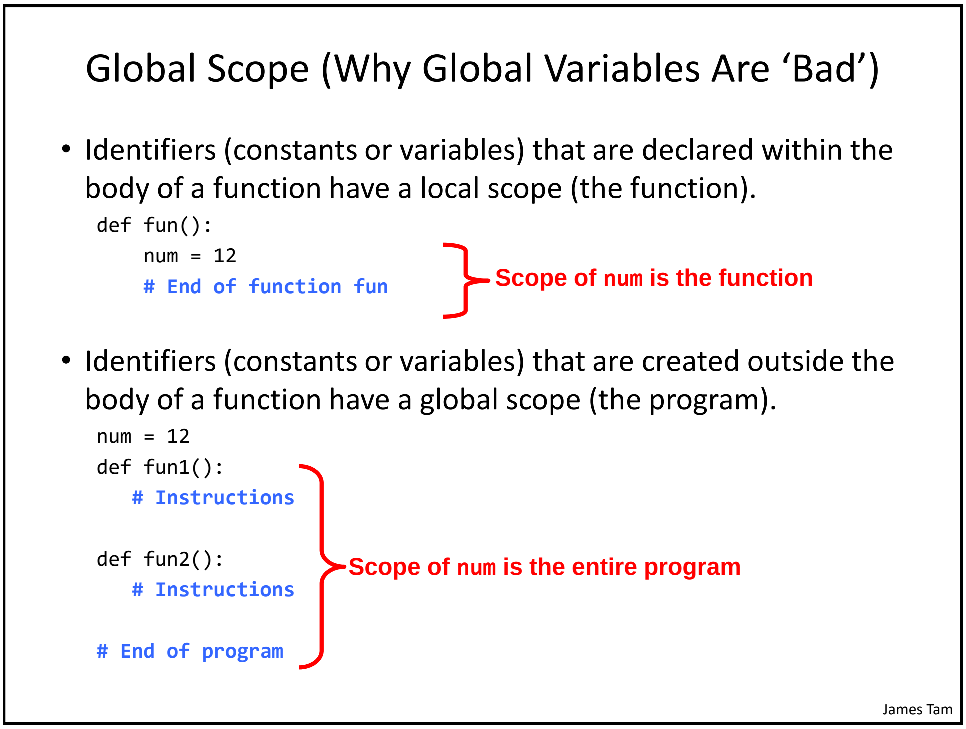

Global Scope (Why Global Variables Are 'Bad')

- Identifiers (constants or variables) that are declared within the body of a function have a local scope (the function).

```
def fun():
    num = 12
    # End of function fun
```

Scope of num is the function

- Identifiers (constants or variables) that are created outside the body of a function have a global scope (the program).

```
num = 12
def fun1():
   # Instructions

def fun2():
   # Instructions

# End of program
```

Scope of num is the entire program

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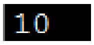
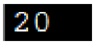
Global Scope: An Example

- **Name of the example program**: `7simple_global_example.py`
  - Learning objective: how global variables are accessible throughout a program.

```
num1 = 10

def fun():
    print(num1)

def start():
    fun()
    print(num2)

num2 = 20

start()
```



```
10
```



```
20
```

Global Variables: General Characteristics

- You can access the contents of global variables anywhere in the program.
  - Python: this can occur even if the ‘`global`’ keyword is not used.
- In most programming languages you can also modify global variables anywhere as well.
  - This is why the **usage of global variables is regarded as bad programming style**, they can be **accidentally modified anywhere** in the program.
  - Changes in one part of the program can introduce **unexpected side effects** in another part of the program.
  - So unless you have a compelling reason you should NOT be using global variables but instead you should pass variables as parameters/returning values.
    - Unless you are told otherwise using global variables can affect the style component of your assignment grade.
    - Global constants are acceptable and are commonly used.
  - Pedagogical (student learning) reasons for the prohibition on using global variables:
    - Important concepts such as: scope, parameter passing and return values may be bypassed.

Global Variables: Python Specific Characteristic

- **Name of the example program**: `8globals_vs_locals.py`
  - Learning objective: Relationship between accessing global variables and creating locals.

```
num = 1
def fun():
    num = 2       2  Local created and displayed
    print(num)
def start():
    print(num)  1   Global
    fun()
    print(num)  1   Global

start()
```

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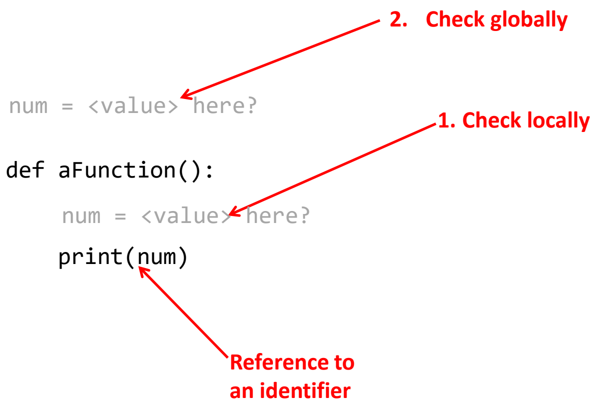
Scoping Rules: Globals

- When an identifier is referenced (variable or constant) then:
  1. First look in the local scope for the creation of the identifier: if found here then stop looking and use this identifier
  2. If nothing exists at the local level then look globally



2. Check globally

```
num = <value> here?

def aFunction():
    num = <value> here?
    print(num)
```

1. Check locally

Reference to an identifier

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Python Globals: 'Read' But Not 'Write' Access

- By default global variables can be accessed globally (read access).
- Attempting to change the value of global variable will only create a new local variable by the same name (no write access to the global, a local is created).

```
num = 1

def fun():
    num = 2
    print(num)
```

Global num

Local num

- Prefacing the name of a variable with the keyword '`global`' in a function will indicate changes in the function will refer to the global variable rather than creating a local one.

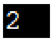
```
global <variable name>
```

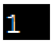
Globals: Another Example ('Write' Access Via The "`Global`" Keyword)

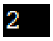
- **Name of the example program**: `9modifying_globals.py`
  - Learning objective: How global variables can be modified inside functions.

```
num = 1

def fun():
    global num
    num = 2
    print(num)

def start():
    print(num)
    fun()
    print(num)

start()
```

References to the name 'num' now affect the global variable, local variable not created inside function 'fun'

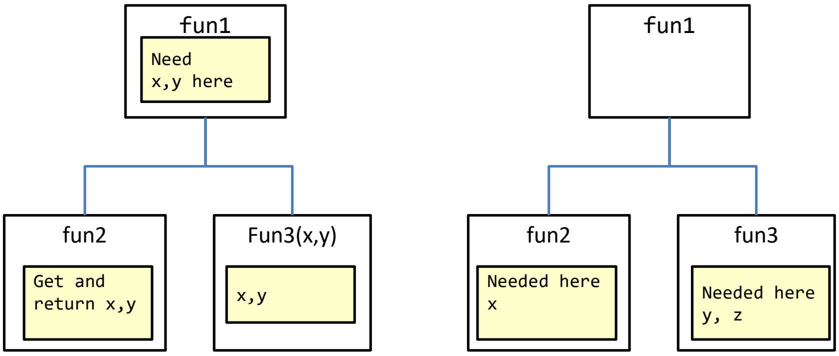

```
2
```
Global changed


```
1
```
Global


```
2
```
Global still changed after '`fun()`' is done

What Level To Declare Variables

- Declare your variables as local to a function.
- When there are multiple levels of functions (a level is formed when one function calls another) then:
  - A variable should be created at the lowest level possible
  - Try the lecture exercise where you work through this process.



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Boolean Functions

- Return a Boolean value (true/false): “Asks a question”
- Typically the Boolean function will ‘ask the question’ about a parameter(s)
- Example:
  - Is it true that the string can be converted to a number?

```
aString = input("Enter age: ")
ageOK = isNum(aString)
if (ageOK != True):
   print("Age must be a numeric value")
else:
   # OK to convert the string to a number
   age = int(aString)
```

```
# Boolean function
def isNum(aString):
   # Returns (True
   # or False)
```

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Example: How To Decompose A Long Function

- To decompose (break into parts) long functions examine the structure for sections e.g. loops (and their bodies), branches (and their bodies).
- Each of these sections may be a candidate to be moved into its own separate function body.
  - Try the lecture exercise where you work through this process.

Before

```
def fun1():
    while(BE1):
        if(BE2):
          #If body #1
        if(BE3):
          #If body #2
```

After

```
def fun3():
    #If body #2

def fun2():
    #If body #1

def fun1():
    while(BE1):
        if(BE2):
            fun2()
        if(BE3):
            fun3()
```

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Functions Should Be Defined Before They Can Be Called!

- **Correct** ☺

```
def fun():
   print("Works")
```

Function definition

```
# Start
fun()
```

Function call

- **Incorrect** ☹

```
# Start
fun()
```

Function call

```
def fun():
   print("Doesn't work")
```

Function definition

Another Common Mistake

- Forgetting the brackets during the function call:

```
def fun():
    print("In fun")

# Start of program
print("Starting the program")
fun
```

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Another Common Mistake

- Forgetting the brackets during the function call:

```
def fun():
    print("In fun")

# Start of program
print("Program started")
fun()
```

With python the missing set of brackets do not produce a syntax/translation error

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Another Common Problem: Indentation

- Recall: In Python indentation indicates that statements are part of the body of a function.
- (In other programming languages the indentation is not a mandatory part of the language but indenting is considered good style because it makes the program easier to read).
- Forgetting to indent:

```
def start():
print("start")

start()
```

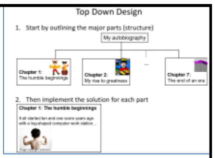
Another Common Problem: Indentation (2)

- Inconsistent indentation:

```
def start():
  print("first")
    # Error: Unless this is the body of branch or loop
    print("second")

start()
```

Creating A Large Document



Top Down Design

1. Start by outlining the major parts (structure)

My autobiography

Chapter 1: The humble beginnings

Chapter 2: My rise to greatness

…

Chapter 7: The end of an era

2. Then implement the solution for each part

Chapter 1: The humble beginnings

It all started ten and one score years ago with a log-shaped computer work station…

- Recall: When creating a large document you should plan out the parts before doing any actual writing.

Step 1: Outline all the parts (no writing)

Chapter 1
- Introduction
- Section 1.1
- Section 1.2
- Section 1.3
- Conclusion

Chapter 2
- Introduction
- Section 2.1
- Section 2.2
- Section 2.3
- Section 2.4
- Conclusion

Chapter 3
- Introduction
- Section 3.1
- Section 3.2
- Conclusion

Step 2: After all parts outlined, now commence writing one part at a time

Section 1.1
It all started seven
and two score
years ago…

Creating A Large Program

- When writing a large program you should plan out the parts before doing any actual writing.

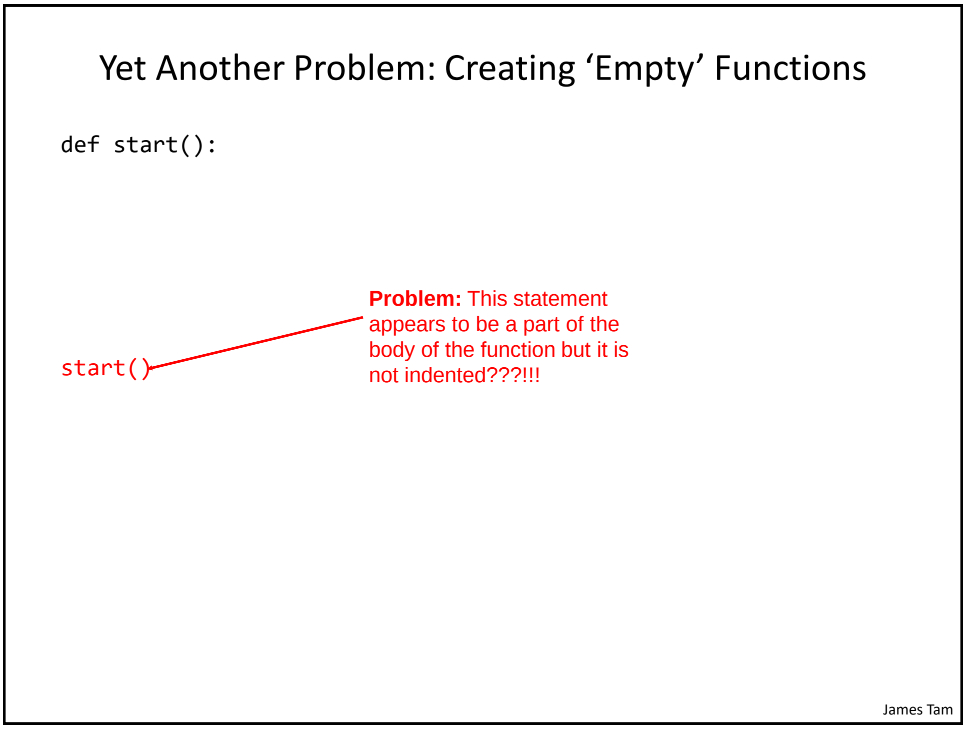
Step 1: Calculate interest (write empty ‘skeleton’ functions)

```
def getInformation():     def doCalculations():     def displayResults():
```

Step 2: All functions outlined, write function bodies one-at-a-time (test before writing next function)

```
def getInformation():
    principle = int(input())
    interest = int(input())
    time = int(input())
    return(principle,interest,time)
```

```
# Simple test: check inputs
# are properly read as input
# and returned to caller
p,r,t = getInformation()
print(p,r,t)
```



Yet Another Problem: Creating ‘Empty’ Functions

```
def start():




start()
```

Problem: This statement appears to be a part of the body of the function but it is not indented???!!!

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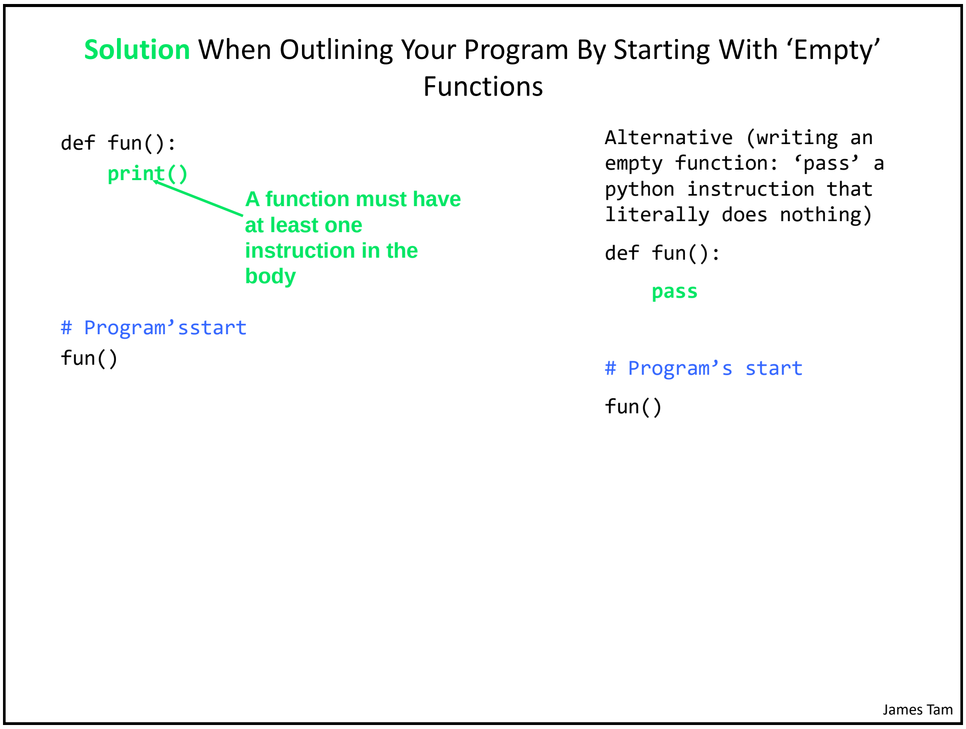

Solution When Outlining Your Program By Starting With ‘Empty’ Functions

```
def fun():
    print()
```

A function must have at least one instruction in the body

```
# Program’sstart
fun()
```

Alternative (writing an empty function: ‘pass’ a python instruction that literally does nothing)

```
def fun():
    pass


# Program’s start
fun()
```

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Testing Functions

- The correctness of a function should be verified. ("Does it do what it is supposed to do?")
- Typically this is done by calling the function, passing in predetermined parameters and checking the result.
- Example: `10absolute_test.py`

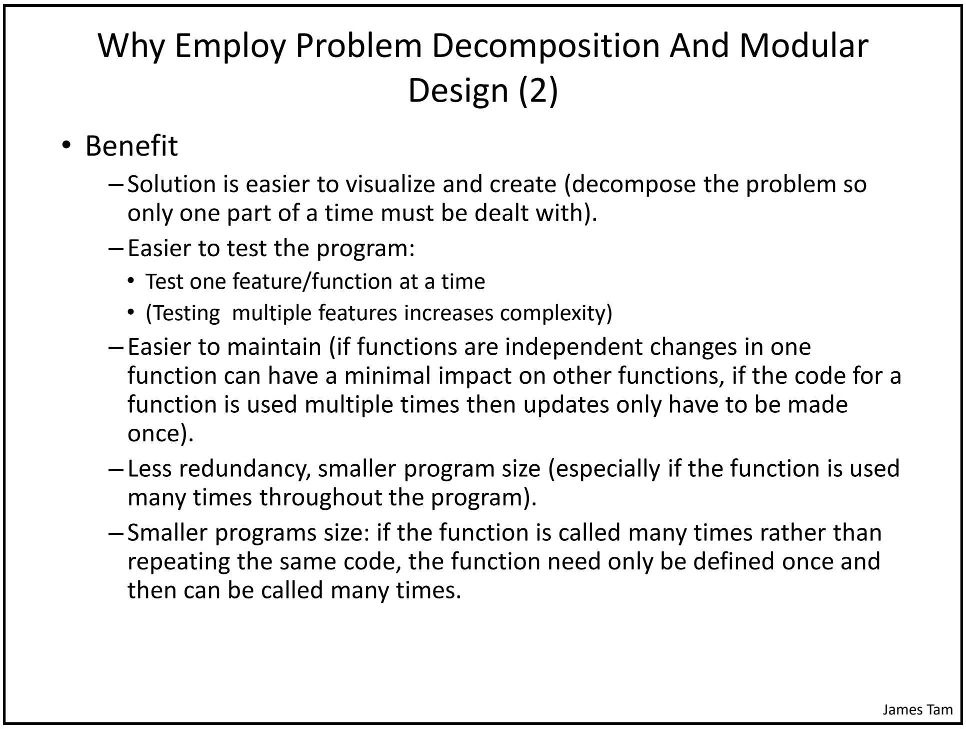
```
def absolute(number):
    if (number < 0):
        result = number * -1
    else:
        result = number
    return(result)

# Test cases
print(absolute(-13))
print(absolute(7))
```

Expected results:
13
7

Why Employ Problem Decomposition And Modular Design (1)

- Drawback
  - Complexity – understanding and setting up inter-function communication may appear daunting at first.
  - Tracing the program may appear harder as execution appears to "jump" around between functions.

  - These are 'one time' costs: once you learn the basic principles of functions with one language then most languages will be similar.



Why Employ Problem Decomposition And Modular Design (2)

- Benefit
  - Solution is easier to visualize and create (decompose the problem so only one part of a time must be dealt with).
  - Easier to test the program:
    - Test one feature/function at a time
    - (Testing multiple features increases complexity)
  - Easier to maintain (if functions are independent changes in one function can have a minimal impact on other functions, if the code for a function is used multiple times then updates only have to be made once).
  - Less redundancy, smaller program size (especially if the function is used many times throughout the program).
  - Smaller programs size: if the function is called many times rather than repeating the same code, the function need only be defined once and then can be called many times.

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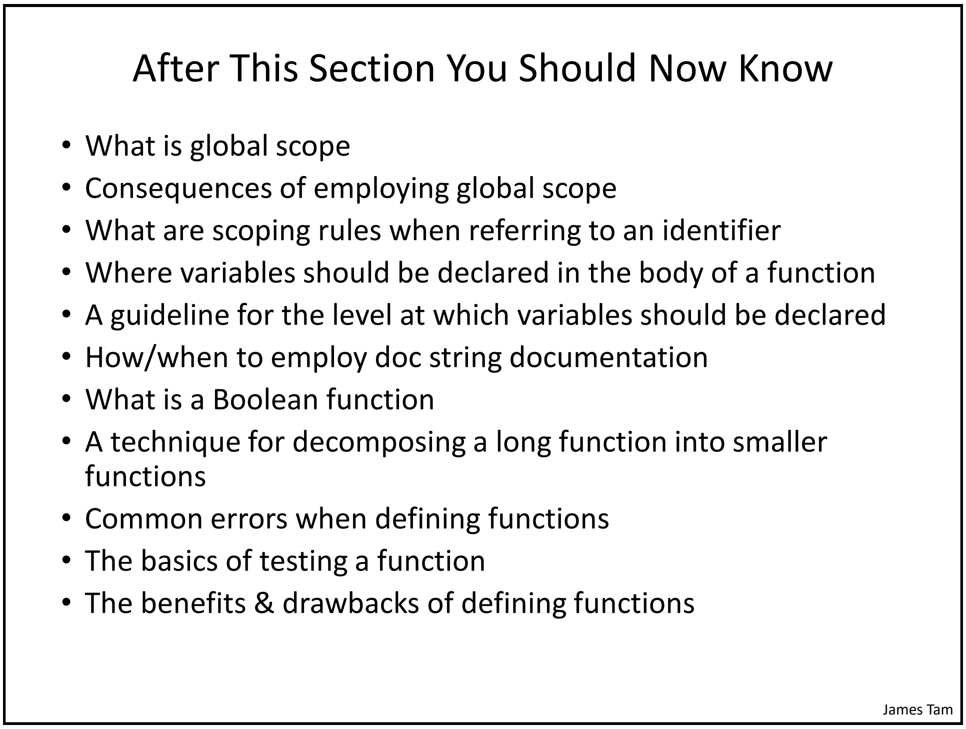

After This Section You Should Now Know

- What is global scope
- Consequences of employing global scope
- What are scoping rules when referring to an identifier
- Where variables should be declared in the body of a function
- A guideline for the level at which variables should be declared
- How/when to employ doc string documentation
- What is a Boolean function
- A technique for decomposing a long function into smaller functions
- Common errors when defining functions
- The basics of testing a function
- The benefits & drawbacks of defining functions

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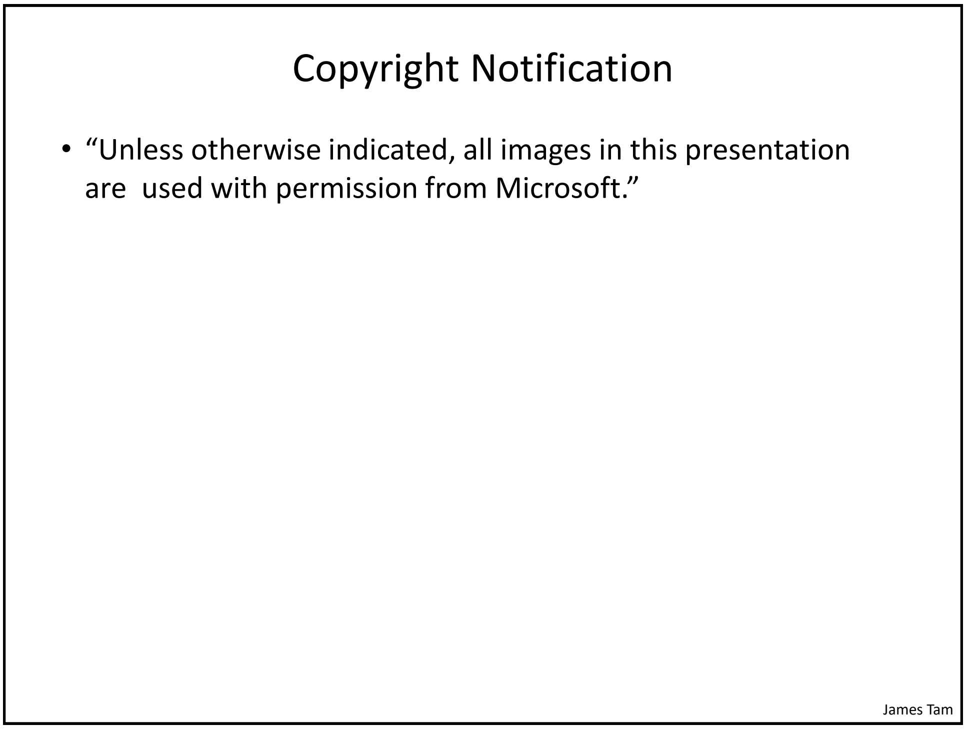

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