

## Objectives

- More on Functions
  - Scope, variable lifetime
- Modules

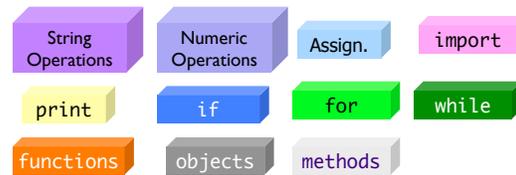
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## Lab Review

- Combinations of building blocks
- Faster recognition of how to solve
  - String without spaces → accumulate string!
- Iterative problem solving



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## Review: Functions

- What is the keyword to create a new function?
- What is the keyword to give output from a function?
- How do we give input to a function?
- Why write functions?

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## Review: Functions

- In general, a function can have
  - 0 or more inputs (the parameters)
  - 0 or 1 outputs (what is returned)
- When we define a function, we know its inputs and if it has output

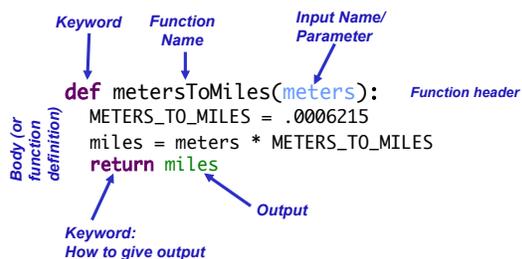


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## Review: Syntax of Function Definition



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## Review: Parameters

- **Formal Parameters** are the variables named in the function definition
- **Actual Parameters** or **Arguments** are variables or literals that really get used when the function is called.

Defined: `def round(x, n):`  
Use: `roundCelc = round(celc, 2)`

Formal & actual parameters must match in **order**, **number**, and **type**!

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## Review: Function Output

- When the code reaches a statement like `return x` the function stops executing and `x` is the **output returned** to the place where function was called
- For functions that don't have explicit output, `return` does not have a value with it, e.g.,
  - `return`
  - Optional: don't need to have `return`

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## Function Input and Output

- What is the input and output to this function?

```
def metersToMiles(meters) :  
    METERS_TO_MILES = .0006215  
    miles = meters * METERS_TO_MILES  
    return miles
```

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## Function Input and Output

- 1 **input**: `meters`
- 1 **output**: the converted miles

```
def metersToMiles(meters) :  
    METERS_TO_MILES = .0006215  
    miles = meters * METERS_TO_MILES  
    return miles
```

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## Function Input and Output

- Identify input and output

```
def printVerse(animal, sound):  
    print BEGIN_END + EIEIO  
    print "And on that farm he had a " + animal + EIEIO  
    print "With a " + sound + ", " + sound + " here"  
    print "And a " + sound + ", " + sound + " there"  
    print "Here a", sound  
    print "There a", sound  
    print "Everywhere a " + sound + ", " + sound  
    print BEGIN_END + EIEIO  
    print
```

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## Function Input and Output

- 2 **inputs**: `animal` and `sound`
- 0 **outputs**
  - *Displays* something but does not **return** anything

```
def printVerse(animal, sound):  
    print BEGIN_END + EIEIO  
    print "And on that farm he had a " + animal + EIEIO  
    print "With a " + sound + ", " + sound + " here"  
    print "And a " + sound + ", " + sound + " there"  
    print "Here a", sound  
    print "There a", sound  
    print "Everywhere a " + sound + ", " + sound  
    print BEGIN_END + EIEIO  
    print
```

## Function Input and Output

- Input? Output?

```
def printMenu():  
    print "You have some options for what to do: "  
    print "Enter an 'F' to find a song"  
    print "Enter an 'S' to sort by Song title"  
    print "Enter an 'A' to sort by Album"  
    print "Enter an 'R' to sort by aRtist name"  
    print "Enter an 'H' to list your options again"  
    print "Enter a 'Q' to quit"
```

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## Function Input and Output

- 0 inputs and 0 outputs
  - Again, it *displays* something but does not **return** anything

```
def printMenu():
    print "You have some options for what to do: "
    print "Enter an 'F' to find a song"
    print "Enter an 'S' to sort by Song title"
    print "Enter an 'A' to sort by Album"
    print "Enter an 'R' to sort by aRtist name"
    print "Enter an 'H' to list your options again"
    print "Enter a 'Q' to quit"
```

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## Alternative Approach to Development

- Create overview, define functions later
  - Top-down approach

```
def main():
    # get the binary number from the user, as a string
    binNum = raw_input("Please enter a binary number: ")
    isBinary = checkBinary(binNum)
    while not isBinary : # equivalent to isBinary == False
        print binNum, "is not a binary number."
        binNum = raw_input("Please enter a binary number: ")
        isBinary = checkBinary(binNum)

    decVal = binaryToDecimal(binNum)
    print binNum, "is", decVal
```

- More later...

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## Review: Why write functions?

- Allows you to break up a hard problem into *smaller*, more *manageable* parts
- Makes your code easier to *understand*
- Hides implementation details (*abstraction*)
  - Provides interface (input, output)
- Makes part of the code reusable so that you:
  - Only have to write function code once
  - Can debug it all at once
    - Isolates errors
  - Can make changes in one function (maintainability)

Similar to benefits of OO Programming

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## VARIABLE LIFETIMES AND SCOPE

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## What does this program output?

```
def main():
    x = 10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit):
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total

main()
```

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mystery.py

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## Function Variables

```
def main():
    x = 10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit):
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total

main()
```

Why can we name two different variables x?

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## Tracing through Execution

```

def main():
    x = 10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit):
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
    
```

When you call main(), that means you want to execute this function

Defines functions

main()

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## Function Variables

```

def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
    
```

The stack

Variable names are like first names

Function names are like last names

main()	main	x	10
--------	------	---	----

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## Function Variables

```

def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
    
```

Called the function sumEvens  
Add its parameters to the stack

sumEvens	limit	10
main	x	10

main()

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## Function Variables

```

def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
    
```

sumEvens	total	0
limit	10	
main	x	10

main()

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## Function Variables

```

def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
    
```

sumEvens	x	0
total	0	
limit	10	
main	x	10

main()

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## Function Variables

```

def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
    
```

sumEvens	x	8
total	20	
limit	10	
main	x	10

main()

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## Function Variables

```
def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
```

Function `sumEvens` returned

- no longer have to keep track of its variables on stack
- lifetime of those variables is over

```
main()
main()
sum 20
x 10
```

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## Function Variables

```
def main() :
    x=10
    sum = sumEvens( x )
    print "The sum of even #s up to", x, "is", sum

def sumEvens(limit) :
    total = 0
    for x in xrange(0, limit, 2):
        total += x
    return total
```

```
main()
main()
x 10
sum 20
```

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## Variable Scope

- Functions can have the same parameter and variable names as other functions
  - Need to look at the variable's **scope** to determine which one you're looking at
  - Use the **stack** to figure out which variable you're using
- Scope levels
  - **Local scope** (also called **function scope**)
    - Can only be seen within the function
  - **Global scope** (also called **file scope**)
    - Whole program can access
    - More on these later

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## Function Scope

- What variables can we "see" (i.e., use)?

```
def main():
    binary_string = raw_input("Enter a binary #: ")
    if not isBinary(binary_string):
        print "That is not a binary string"
        sys.exit()
    decVal = binaryToDecimal(binary_string)
    print "The decimal value is", decVal
```

```
def isBinary(string):
    for bit in string:
        if bit != "0" and bit != "1":
            return False
    return True
```

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## Variable Scope

- Practice: `scope.py`
  - Trace through program--what does it do?
- Answer questions in program...

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## Practice

- What is the output of this program?
  - Example: user enters 4

```
def main():
    num = input("Enter a number to be squared: ")
    square = square(num)
    print "The square is:", square

def square(n):
    return n * n

main()
```

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practice1.py

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## Practice

- What is the output of this program?

➤ Example: user enters 4

```
def main():
    num = input("Enter a number to be squared: ")
    squared = square(num)
    print "The square is:", squared
    print "The original num was:", n
```

```
def square(n):
    return n * n
```

```
main()
```

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practice2.py

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## Practice

- What is the output of this program?

➤ Example: user enters 4

```
def main():
    num = input("Enter a number to be squared: ")
    squared = square(num)
    print "The square is:", squared
    print "The original num was:", n
```

```
def square(n):
    return n * n
```

```
main()
```

Error! **n** does not  
have a value in  
function **main()**

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## Variable Scope

- Know “lifetime” of variable
  - Only during execution of function
  - Related to idea of “scope”
- What about variables outside of functions?
  - Example: `non_function_vars.py`

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## Passing Parameters

- Only **copies** of the actual parameters are given to the function
  - For **immutable** data types (which are what we’ve talked about so far)
- The *actual* parameters in the calling code do not change
- **Swap example:**
  - Swap two values in script
  - Then, put into a function

```
x = 5   x = 7
y = 7   y = 5
```

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swap.py

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## Swapping Characters

- Had this team:



- Wanted this team (temporarily):



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## WHAT MAKES A FUNCTION GOOD?

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## Writing a “Good” Function

- Should be an “intuitive chunk”
  - Doesn't do too much or too little
- Should be reusable
- Always have comment that tells what the function does

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## Good vs. Bad Functions

- Bad: Does too little

```
def getUserInput():  
    input = input("Enter a number")  
    return input
```

- Good: Validates the input

```
def getUserInput():  
    input = input("Enter a number")  
    while input <= 0:  
        print "Number must be positive"  
        input = input("Enter a number")  
    return input
```

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## Debugging Advice

- Build up your program in steps
  - Always write only small pieces of code
  - Test, debug. **Repeat**
- Write function body as part of **main**, test
  - Then, separate out into its own function
  - Similar to process using in lab probs
- Test function separately from other code
  - Comment out irrelevant code to make sure that the function behaves as expected

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## CREATING MODULES

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## Where are Functions Defined?

- Functions can go inside of program script
  - Defined before use/called (if no **main()** function)
  - Or, below the **main()** function
- Functions can go inside a separate **module**

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## Benefits of Defining Functions in Separate Module

- Reduces code in primary driver script
- Easier to reuse by importing from a module
- Maintains the “black box”
  - **Abstraction**
- Isolates testing of function
- Write “test driver” scripts to test functions separately from use in script

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menu.py

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## Creating Modules

- Modules group together related functions and constants
- Unlike functions, no special keyword to define a module
  - A module is named by its filename
- Example, `oldmac.py`
  - In Python shell: `import oldmac`
  - Explain what happened

Just a Python file!

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## Creating Modules

- So that our program doesn't execute when it is **imported** in a program, at bottom, add

```
if __name__ == '__main__':  
    main()
```

Not important how this works; just know when to use

- Then, to call **main** function
  - `oldmac.main()`
- Note the files now listed in the directory

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## Creating Modules

- Then, to call **main** function
  - `oldmac.main()`
- Why would you want to call a module's **main** function?
  - Automation
  - Use **main** function as driver to test functions in module
- To access one of the defined constants
  - `oldmac.EIEIO`

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## Defining Constants in Modules

- Constant in `menu.py`
  - `STOP_OPTION`
- Show use in `menu_withfunctions.py`

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## Summary: Program Organization

- Larger programs require **functions** to maintain readability
  - Use **main()** and other functions to break up program into *smaller, more manageable* chunks
  - “**Abstract away**” the details
- As before, can still write smaller scripts without any functions
  - Can try out functions using smaller scripts
- Need the **main()** function when using other functions to keep “driver” at top
  - Otherwise, functions need to be defined **before use**

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## This Week

- Lab 6 due Friday
- SSA – Friday
  - Opportunities for Extra Credit
  - *Truth Values* play requires tickets—Free!

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## Writing Comments for Functions

- Good style: Each function **must** have a comment
  - Describes functionality at a high-level
  - Include the *precondition*, *postcondition*
  - Describe the parameters (their types) and the result of calling the function (precondition and postcondition may cover this)

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## Writing Comments for Functions

- Include the function's pre- and post-conditions
- **Precondition:** Things that must be true for function to work correctly
  - E.g., num must be even
- **Postcondition:** Things that will be true when function finishes (if precondition is true)
  - E.g., the returned value is the max

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## Example Comment

- Describes at high-level
- Describes parameters

```
# prints a verse of Old MacDonald, plugging in the
# animal and sound parameters (which are strings),
# as appropriate
def printVerse(animal, sound):
    print BEGIN_END + EIEIO
    print "And on that farm he had a " + animal + EIEIO
    ...
```

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## Writing a Function

- Write a function that determines if a string is a binary string
- Write comments for that function

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## Pre/Post Conditions

```
# pre: binary_string is a string that contains only
# 0s and 1s
# post: returns the decimal value for the binary
# string
def binaryToDecimal( binary_string ):
    exponent = len(binary_string)-1
    dec_value = 0

    for bit in binary_string:
        bit = int(bit)
        # print bit, " 2^%d" % exponent
        dec_value += bit * (2 ** exponent)
        exponent -= 1

    return dec_value
```

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