24.1 User-defined function basics

Functions (general)

A program may perform the same operation repeatedly, causing a large and confusing program due to redundancy. Program redundancy can be reduced by creating a grouping of predefined statements for repeatedly used operations, known as a ***function***. Even without redundancy, functions can prevent a main program from becoming large and confusing.

PARTICIPATION ACTIVITY 24.1.1: Functions can reduce redundancy and keep the main program simple.

Animation content:

`undefined`

Animation captions:

1. Commonly, a program performs the same operation, such as a calculation, in multiple places. Here, the Fahrenheit to Celsius calculation is done in three places.
2. Repeated operations clutter the main program. And such repeated operations are more prone to errors.
3. A better approach defines the Fahrenheit to Celsius calculation once, named F2C here. Then, F2C can be "called" three times, yielding a simpler main program.
4. The impact is even greater when the operation has multiple statements -- here 3 statements, but commonly tens of statements. The main program is much simpler.
5. Even without repeated operations, calling predefined operations keeps the main program simple and intuitive.

PARTICIPATION ACTIVITY 24.1.2: Reasons for functions.

Consider the animation above.

1) In the original main program, the Fahrenheit to Celsius calculation appeared how many times?

2) Along with yielding a simpler main program, using the predefined Fahrenheit to Celsius calculation prevented what error in the original program?
   - 1
   - 3
   - Adding rather than subtracting 32.0
   - Multiplying by 9.0 / 5.0 rather than by 5.0 / 9.0

3) In the last example above, the main program was simplified by _____.
   - eliminating redundant code for operation XYZ
   - predefining operations for XYZ and CalcPQR

Function basics

A ***function*** is a named series of statements.

- A ***function definition*** consists of the new function's name and a block of statements. Ex: `def calc_pizza_area():`. An indented block of statements follows the definition.
- A ***function call*** is an invocation of the function's name, causing the function's statements to execute.

Python comes with a number of built-in functions, such as `input()`, `int()`, `len()`, etc. The ***def*** keyword is used to create new functions.

The function call calc_pizza_area() in the animation below causes execution to jump to the function's statements. Execution returns to the original location after executing the function's last statement.

Good practice is to follow the convention of naming functions with lowercase letters and underscores, such as get_name or calc_area.

Other aspects of the function definition, like the (), are discussed later.

PARTICIPATION ACTIVITY 24.1.3: Function example: Printing a pizza area.

Animation content:

```
undefined
```

Animation captions:

1. The function call to calc_pizza_area() jumps execution to the function's statements.
2. After the last statement of the calc_pizza_area() function, execution returns to the original location and the area of the pizza is returned and printed.

PARTICIPATION ACTIVITY 24.1.4: Function basics.

Given the following program and the `calc_pizza_area()` function defined above:

```
print(f'{12:.1f} inch pizza is {calc_pizza_area():.3f} square inches')
print(f'{12:.1f} inch pizza is {calc_pizza_area():.3f} square inches')
```

1) How many function calls to calc_pizza_area() exist?

Check Show answer

2) How many function definitions of calc_pizza_area() exist?

Check Show answer

3) How many output statements would execute in total?

Check Show answer

4) How many print statements exist in calc_pizza_area()?

Check Show answer

PARTICIPATION ACTIVITY 24.1.5: Calling a function.

CHALLENGE ACTIVITY 24.1.1: Basic function call

get_pattern() returns 5 characters. Call get_pattern() twice in print() statements to return and print 10 characters. Example output:

```
*****
*****
```


422102.2723990.qx3zqy7

```
1 def get_pattern():
2    return '*****'
3
4 ''' Your solution goes here '''
5
```

Run

Return statements

A function may return one value using a ***return statement***. Below, the compute_square() function returns the square of its argument.

PARTICIPATION ACTIVITY 24.1.6: Function example: Returning a value.

Animation content:

`undefined`

Animation captions:

1. Call compute_square and pass in the value 7.
2. Compute the square of num_to_square and return the result.
3. num_squared is assigned the return value of compute_square(7).

A function can only return one item, not two or more (though a list or a tuple with multiple elements could be returned). A function with no return statement, or a return statement with no following expression, returns the value `None`. ***None*** is a special keyword that indicates no value.

A return statement may appear at any point in a function, not just as the last statement. A function may also contain multiple return statements in different locations.

PARTICIPATION ACTIVITY 24.1.7: Return basics.

1) Add a return statement to the function that returns the result of adding `num1` and `num2`.

```
def compute_sum(num1,
num2):
      return
```

2) Add a return statement to the function that returns the cube of the argument, i.e. (num*num*num).

```
def compute_cube(num):
```

Check Show answer

Check Show answer

Parameters

A programmer can influence a function's behavior via an input.

- A ***parameter*** is a function input specified in a function definition. Ex: A pizza area function might have diameter as an input.
- An ***argument*** is a value provided to a function's parameter during a function call. Ex: A pizza area function might be called as `calc_pizza_area(12.0)` or as `calc_pizza_area(16.0)`.

A parameter is like a variable definition. Upon entering the function, the parameter is bound to the argument object provided by the call, creating a shared reference to the object. Upon return, the parameter can no longer be used.

An argument may be an expression, like `12.0`, `x`, or `x * 1.5`.

PARTICIPATION ACTIVITY 24.1.8: Function parameters.

PARTICIPATION ACTIVITY 24.1.9: Parameters.

1) Complete the function definition to have a parameter named num_grade.

```
def get_letter_grade(
                    ):
```

Check Show answer

2) Call a function named calc_calories(), passing the value 21 as an argument.

Check Show answer

3) Is the following a valid function

definition beginning? Type yes or no.

```
def my_fct(userNum +
5):
```

Check Show answer

4) Assume a function def get_birthday_age(user_age): simply returns the value of user_age + 1. What will the following code output?

```
print(get_birthday_age(42),
get_birthday_age(20))
```

Check Show answer

Multiple or no parameters

A function may have multiple parameters, which are separated by commas. Parameters are assigned with argument values: First parameter with the first argument, second with the second, etc.

A function definition with no parameters must still have the parentheses, as in: `def calc_something():`. The call to such a function must include parentheses, and they must be empty, as in: `calc_something()`.

Figure 24.1.1: Function with multiple parameters.

```
def calc_pizza_volume(pizza_diameter, pizza_height):
    pi_val = 3.14159265

    pizza_radius = pizza_diameter / 2.0
    pizza_area = pi_val * pizza_radius * pizza_radius
    pizza_volume = pizza_area * pizza_height
    return pizza_volume

print(f'12.0 x 0.3 inch pizza is {calc_pizza_volume(12.0, 0.3):.3f} cubic
inches.')

print(f'12.0 x 0.8 inch pizza is {calc_pizza_volume(12.0, 0.8):.3f} cubic
inches.')

print(f'16.0 x 0.8 inch pizza is {calc_pizza_volume(16.0, 0.8):.3f} cubic
inches.')
```

```
12.0 x 0.3 inch pizza is 33.929 cubic inches.
12.0 x 0.8 inch pizza is 90.478 cubic inches.
16.0 x 0.8 inch pizza is 160.850 cubic inches.
```


PARTICIPATION ACTIVITY 24.1.10: Multiple parameters.

1) Which correctly defines two parameters `x` and `y` for a function definition: `def calc_val(...):`?

   - (x; y)
   - (x y)
   - (x, y)

2) Which correctly passes two integer arguments for the function call `calc_val(...)`?

   - (99, 44 + 5)
   - (99 + 44)
   - (99 44)

3) Given a function definition: `def calc_val(a, b, c):`, b is assigned with what value during

this function call:
`calc_val(42, 55, 77)`?

- Unknown
- 42
- 55

4) Given a function definition:
`def calc_val(a, b, c):`
and given variables i, j, and k, which are valid arguments in the call
`calc_val(...)`?

- (i, j)
- (k, i + j, 99)
- (i + j + k)

PARTICIPATION ACTIVITY 24.1.11: Calls with multiple parameters.

Given:

```
def compute_sum(num1, num2):
    return num1 + num2
```

1) What will be returned for the following function call?
`compute_sum(1, 2)`

Check Show answer

2) Write a function call using compute_sum() to return the sum of x and 400 (providing the arguments in that order).

Check Show answer

Hierarchical function calls

A function's statements may include function calls, known as ***hierarchical function calls*** or ***nested function calls***. Code such as `user_input = int(input())` consists of such a hierarchical function call, wherein the input() function is called and evaluates to a value that is then passed as an argument to the int() function.

PARTICIPATION ACTIVITY 24.1.12: Hierarchical function calls

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PARTICIPATION ACTIVITY 24.1.13: Hierarchical function calls.

Complete the calc_pizza_calories_per_slice() function to calculate the calories for a single slice of pizza.
A calc_pizza_calories() function returns a pizza's total calories given the pizza diameter

passed as an argument.
A calc_num_pizza_slices() function returns the number of slices in a pizza given the pizza diameter passed as an argument.

```
def calc_pizza_calories_per_slice(pizza_diameter):
    total_calories = <placeholder_A>
    calories_per_slice = <placeholder_B>
    return calories_per_slice
```


1) Type the expression for `placeholder_A` to calculate the total calories for a pizza with diameter `pizza_diameter`.

`total_calories =`

Check Show answer

2) Type the expression for `placeholder_B` to calculate the calories per slice.

`calories_per_slice =`

Check Show answer

CHALLENGE ACTIVITY 24.1.2: Basic function call.

Complete the function definition to return the hours given minutes.

Sample output with input: 210.0

```
3.5
```


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```
1 def get_minutes_as_hours(orig_minutes):
2
3     ''' Your solution goes here '''
4
5 minutes = float(input())
6 print(get_minutes_as_hours(minutes))
```

Run

CHALLENGE ACTIVITY 24.1.3: Function call with parameters: Converting measurements.

Define a function `calc_total_inches`, with parameters num_feet and num_inches, that returns the total number of inches. Note: There are 12 inches in a foot.

Sample output with inputs: 5 8

```
Total inches: 68
```

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```
1
2 ''' Your solution goes here '''
3
4 feet = int(input())
5 inches = int(input())
6 print('Total inches:', calc_total_inches(feet, inches))
```


Run

CHALLENGE ACTIVITY 24.1.4: Enter the output of the returned value.

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Start

Type the program's output


```
def change_value(x):
    return x + 4

print(change_value(2))
```

6

1 2

Check Next

CHALLENGE ACTIVITY 24.1.5: Function definition: Volume of a pyramid.

Define a function `calc_pyramid_volume` with parameters `base_length`, `base_width`, and `pyramid_height`, that returns as a number the volume of a pyramid with a rectangular base.

Sample output with inputs: 4.5 2.1 3.0

```
Volume for 4.5 2.1 3.0 is: 9.45
```

Relevant geometry equations:
Volume = base area x height x 1/3
Base area = base length x base width

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```
1
2 ''' Your solution goes here '''
3
4 length = float(input())
5 width = float(input())
6 height = float(input())
7 print(f'Volume for {length} {width} {height} is: {calc_pyramid_volume(length, width, heigh
```

Run

24.2 Print functions

Printing from a function

A common operation for a function is to print text. Large text outputs can clutter the main program, especially if the text needs to be output multiple times. A function that only prints typically does not return a value. A function with no return statement is called a ***void function***, and such a function returns the value `None`.

PARTICIPATION ACTIVITY 24.2.1: Printing with a void function.

Animation content:

`undefined`

Animation captions:

1. Printing instructions can clutter a program.
2. A print function can handle output and reduce clutter in the main program.
3. The main program calls function print_summary(), which prints the parameters as formatted output.
4. print_summary() completes execution and returns back to the caller, the main program.

PARTICIPATION ACTIVITY 24.2.2: Print functions.

1) Print operations must be performed in the main program.

2) A void function can have any number of parameters.
   - True
   - False

3) A print function must return the value that was output.
   - True
   - False

A function that produces output can also return a value, but this material separates these operations for clarity. A function that both outputs and returns a value is not void.

Calling a print function multiple times

One benefit of a print function is that complex output statements can be written in code once. Then the print function can be called multiple times to produce the output instead of rewriting complex statements for every necessary instance. Changes to output and formatting are made easier and are less prone to error.

PARTICIPATION ACTIVITY 24.2.3: Calling a print function repeatedly.

Animation content:

Animation captions:

1. A print function can improve the organization of a program.
2. The benefit of a print function increases with repeated calls. Both Program A and B output the formatted text twice, but the output code for Program B is only written once in the print_greatest() function.
3. In Program B, any changes to the output, e.g. adding '!', only have to be made in the print_greatest() function.

4. Without a function, like in Program A, output must be changed in multiple instances, which can be time-consuming and lead to errors.

PARTICIPATION ACTIVITY 24.2.4: Calling a print function multiple times.

Refer to the example programs above.

1) To output the phrase, "The Greatest [word] on Earth", with ten different words, what is the minimum number of times the main program would need to call print_greatest() in Program B?
   - 1
   - 10
   - 30

2) To output "in the Galaxy" instead of "on Earth" in the phrase (Ex: "--The Greatest *Cafe* in the Galaxy!-- "), how many statements need to be changed in Program A and Program B?
   - Program A: 1
     Program B: 1
   - Program A: 2
     Program B: 1
   - Program A: 2
     Program B: 2

Example: Menu system

Figure 24.2.1: Example: Menu System.

```
def print_menu():
    print("Today's Menu:")
    print('   1) Gumbo')
    print('   2) Jambalaya')
    print('   3) Quit\n')

quit_program = False

while not quit_program :
    print_menu()
    choice = int(input('Enter choice:
'))
    if choice == 3 :
        print('Goodbye')
        quit_program = True
    else :
        print('Order: ', end='')
        if choice == 1 :
            print('Gumbo')
        elif choice == 2 :
            print('Jambalaya')
        print()
```

```
Today's Menu:
   1) Gumbo
   2) Jambalaya
   3) Quit

Enter choice: 2
Order:
Jambalaya

Today's Menu:
   1) Gumbo
   2) Jambalaya
   3) Quit

Enter choice: 1
Order: Gumbo

Today's Menu:
   1) Gumbo
   2) Jambalaya
   3) Quit

Enter choice: 3
Goodbye
```


PARTICIPATION ACTIVITY 24.2.5: Example: Menu System.

Consider the example above.

1) How many times is print_menu() called?

- 1
- 2
- 3

2) Which of the following code statements if added to print_menu() would make the function no longer void?

- num_options = 3
- return 0
- return

CHALLENGE ACTIVITY 24.2.1: Print functions.

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Start

Type the program's output


```
def print_age(user_age):
    print(f'You are {user_age}')

age_to_print = 21
print_age(age_to_print)
```

```
You are 21
```

1 2 3 4

Check Next

CHALLENGE ACTIVITY 24.2.2: Function call with parameter: Printing formatted measurement.

Define a function print_feet_inch_short(), with parameters num_feet and num_inches, that prints using ' and " shorthand. End with a newline. Remember that print() outputs a newline by default. Ex: print_feet_inch_short(5, 8) prints:

```
5' 8"
```

Hint: Use \" to print a double quote.

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```
1
2 ''' Your solution goes here '''
3
4 user_feet = int(input())
5 user_inches = int(input())
6
7 print_feet_inch_short(user_feet, user_inches) # Will be run with (5, 8), then (4, 11)
```

Run

24.3 Reasons for defining functions

Improving program readability

Programs can become hard for humans to read and understand. Decomposing a program into functions can greatly aid program readability, helping yield an initially correct program, and easing future maintenance. The following program contains two user-defined functions, making the main program (after the function definitions) easier to read and understand. For larger programs, the effect is even greater.

Figure 24.3.1: With user-defined functions, the main program is easy to understand.

```
def steps_to_feet(num_steps):
    feet_per_step = 3
    feet = num_steps * feet_per_step
    return feet

def steps_to_calories(num_steps):
    steps_per_minute = 70.0
    calories_per_minute_walking = 3.5

    minutes = num_steps / steps_per_minute
    calories = minutes *
calories_per_minute_walking
    return calories

steps = int(input('Enter number of steps
walked: '))

feet = steps_to_feet(steps)
print('Feet:', feet)

calories = steps_to_calories(steps)
print('Calories:', calories)
```

```
Enter number of steps
walked: 1000
Feet: 3000
Calories: 50
```

Figure 24.3.2: Without user-defined functions, the main program is harder to read and understand.

```
feet_per_step = 3
steps_per_minute = 70.0
calories_per_minute_walking = 3.5

steps = int(input('Enter number of steps
walked: '))

feet = steps * feet_per_step
print('Feet:', feet)

minutes = steps / steps_per_minute
calories = minutes *
calories_per_minute_walking
print('Calories:', calories)
```



```
Enter number of steps
walked: 1000
Feet: 3000
Calories: 50
```

PARTICIPATION ACTIVITY 24.3.1: Improved readability.

Consider the above examples.

1) In the example *without* functions, how many statements are in the main program?
   - 5
   - 9

2) In the example *with* functions, how many statements are in the main program?
   - 5
   - 9

3) Which has fewer *total* lines of code (including blank lines), the program with or without functions?

With

Modular program development

Programmers commonly use functions to write programs modularly. ***Modular development*** is the process of dividing a program into separate modules that can be developed and tested separately and then integrated into a single program.

A programmer can use function stubs (described in depth elsewhere) to capture the high-level behavior of the required functions (or modules) before diving into details of each function, like planning a route for a road trip before starting to drive.

Avoid writing redundant code

A function can be defined once, then called from multiple places in a program, thus avoiding redundant code. Examples of such functions are math module functions like sqrt() that relieve a programmer from having to write several lines of code each time a square root needs to be computed.

The skill of decomposing a program's behavior into a good set of functions is a fundamental part of programming that helps characterize a good programmer. Each function should have easily-recognizable behavior, and the behavior of the main program (and any function that calls other functions) should be easily understandable via the sequence of function calls.

A general guideline (especially for beginner programmers) is that a function's definition usually shouldn't have more than about 30 lines of code, although this guideline is not a strict rule.

PARTICIPATION ACTIVITY 24.3.2: Redundant code can be replaced by multiple calls to one function.

Animation content:

`undefined`

Animation captions:

1. Circle area is calculated twice, leading to redundant code.
2. The redundant code can be replaced by defining a calc_circle_area() function.
3. Then main program is simplified by calling the calc_circle_area() function from multiple places in the program.

PARTICIPATION ACTIVITY 24.3.3: Reasons for defining functions.

1) A key reason for creating functions is to help the program run faster.
   - True
   - False

2) Avoiding redundancy means to avoid calling a function from multiple places in a program.
   - True
   - False

3) If a function's internal statements are revised, all function calls will have to be modified too.
   - True
   - False

4) A benefit of functions is to increase redundant code.
   - True
   - False

CHALLENGE ACTIVITY 24.3.1: Functions: Factoring out a unit-conversion calculation.

Write a function so that the main program below can be replaced by the simpler code that calls function mph_and_minutes_to_miles(). Original main program:

```
miles_per_hour = float(input())
minutes_traveled = float(input())
hours_traveled = minutes_traveled / 60.0
miles_traveled = hours_traveled * miles_per_hour

print(f'Miles: {miles_traveled:f}')
```


Sample output with inputs: 70.0 100.0

```
Miles: 116.666667
```

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Run

24.4 Writing mathematical functions

Mathematical functions

A function is commonly defined to compute a mathematical calculation involving several numerical parameters and returning a numerical result. Ex: The following program uses a function to convert a person's height in U.S. units (feet and inches) into total centimeters.

PARTICIPATION ACTIVITY 24.4.1: Program with a function to convert height in feet/inches to centimeters.

Most Americans only know their height in feet/inches, not in total inches. Human average height is increasing, attributed largely to better nutrition. (Source: Our World in Data: Human height.)

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PARTICIPATION ACTIVITY 24.4.2: Mathematical functions.

Indicate which is a valid use of the height_US_to_cm() function above.

1) x = height_US_to_cm(5, 0)

- Valid
- Not valid

2) x = 2 * (height_US_to_cm(5, 0) + 1.0)

- Valid
- Not valid

3) x = (height_US_to_cm(5, 0) + height_US_to_cm(6, 1)) / 2.0

- Valid
- Not valid

4) Suppose pow(y, z) returns y to the power of z. Is the following valid?
x = pow(2, pow(3, 2))

- Valid
- Not valid

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zyDE 24.4.1: Temperature conversion.

Complete the program by writing and calling a function that converts a temperature f
Celsius into Fahrenheit. Use the formula `F = C x 9/5 + 32`. Test your program kr
that 50 Celsius is 122 Fahrenheit.

Load default ter

```
def c_to_f():
    # FIXME
    return  # FIXME: Finish

temp_c = float(input('Enter temperature in Celsius: '))
temp_f = None

# FIXME: Call conversion function
# temp_f = ??

# FIXME: Print result
# print('Fahrenheit:' , temp_f)
```

50

Run

Calling functions in expressions

A function call evaluates to its returned value. Thus, a function call often appears within an expression. Ex: `5 + compute_square(4)` would become `5 + 16`, or `21`. A function that returns `None` cannot be used as such within an expression.

PARTICIPATION ACTIVITY 24.4.3: Function called twice in an expression.

Animation content:

undefined

Animation captions:

1. compute_square() is called within an expression two times, first with the argument 7. 7 is passed to compute_square() the value 49 is returned.
2. compute_square() is called a second time with the argument 9 and the value 81 is returned to the expression.
3. The expression then evaluates to c2 = 49 + 81, which assigns variable c2 with 130. Lastly, the print statement executes.

PARTICIPATION ACTIVITY 24.4.4: Function calls in an expression.

Given the following functions, determine which statements are valid.

```
def square_root(x):
    return math.sqrt(x)

def print_val(x):
    print(x)
```

1) y = square_root(49.0)

- Valid
- Invalid

2) square_root(49.0) = z

- Valid
- Invalid

3) y = 1.0 + square_root(144.0)

- Valid
- Invalid

4) y = square_root(square_root(16.0))

- Valid
- Invalid

5) y = square_root()

- Valid
- Invalid

6) square_root(9.0)

- Valid
- Invalid

7) y = print_val(9.0)

- Valid
- Invalid

8) y = 1 + print_val(9.0)

- Valid
- Invalid

9) print_val(9.0)

- Valid
- Invalid

CHALLENGE ACTIVITY 24.4.1: Function call in expression.

Assign `max_sum` with the greater of `num_a` and `num_b`, PLUS the greater of `num_y` and `num_z`. Use just one statement. Hint: Call `find_max()` twice in an expression.

Sample output with inputs: 5.0 10.0 3.0 7.0

```
max_sum is: 17.0
```

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```
1  def find_max(num_1, num_2):
2     max_val = 0.0
3
4     if (num_1 > num_2):  # if num1 is greater than num2,
5        max_val = num_1   # then num1 is the maxVal.
6     else:                # Otherwise,
7        max_val = num_2   # num2 is the maxVal
8     return max_val
9
10 max_sum = 0.0
11
12 num_a = float(input())
13 num_b = float(input())
14 num_y = float(input())
```

Run

Modular functions for mathematical expressions

Modularity allows more complex functions to incorporate simpler functions. Complex mathematical functions often call other mathematical functions. Ex: A function that calculates the volume or surface area of a cylinder calls a function that returns the area of the cylinder's base, which is needed for both calculations.

Figure 24.4.1: Program that calculates cylinder volume and surface area by calling a modular function for the cylinder's base.

```
import math

def calc_circular_base_area(radius):
   return math.pi * radius * radius

def calc_cylinder_volume(baseRadius, height):
   return calc_circular_base_area(baseRadius) * height

def calc_cylinder_surface_area(baseRadius, height):
   return (2 * math.pi * baseRadius * height) + (2 *
calc_circular_base_area(baseRadius))

radius = float(input('Enter base radius: '))
height = float(input('Enter height: '))

print('Cylinder volume: ' +
f'{calc_cylinder_volume(radius, height):.3f}')
print('Cylinder surface area: ' +
f'{calc_cylinder_surface_area(radius, height):.3f}')
```

```
Enter base
radius: 10
Enter height: 5
Cylinder volume:
1570.796
Cylinder surface
area: 942.478
```


CHALLENGE ACTIVITY 24.4.2: Function definition: Volume of a pyramid with modular functions.

Define a function calc_pyramid_volume() with parameters base_length, base_width, and pyramid_height, that returns the volume of a pyramid with a rectangular base. calc_pyramid_volume() calls the given calc_base_area() function in the calculation.

Relevant geometry equations:

Volume = base area x height x 1/3
(Watch out for integer division).

Sample output with inputs: 4.5 2.1 3.0

```
Volume for 4.5 2.1 3.0 is: 9.45
```


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```
1 def calc_base_area(base_length, base_width):
2    return base_length * base_width
3
4 ''' Your solution goes here '''
5
6 length = float(input())
7 width = float(input())
8 height = float(input())
9 print(f'Volume for {length} {width} {height} is: {calc_pyramid_volume(length, width, heigh
```

Run

24.5 Functions with branches/loops

Example: Auction website fee calculator

Note: This section requires knowledge of if-else and loop statements.

A function's block of statements may include branches, loops, and other statements. The following example uses a function to compute the fee charged by eBay when a customer sells an item online.

Figure 24.5.1: Function example: Determining fees given an item selling price for an auction website.

```
def calc_ebay_fee(sell_price):
    """Returns the fees charged by ebay.com
given the selling
    price of fixed-price books, movies,
music, or video games.
    fee is $0.50 to list plus 13% of selling
price up to $50.00,
    5% of amount from $50.01 to $1000.00,
and
    2% for amount $1000.01 or more."""

    p50 = 0.13  # for amount $50 and lower
    p50_to_1000 = 0.05  # for $50.01-$1000
    p1000 = 0.02  # for $1000.01 and higher
    fee = 0.50  # fee to list item

    if sell_price <= 50:
        fee  = fee + (sell_price*p50)
    elif sell_price <= 1000:
        fee = fee + (50*p50) + ((sell_price-
50)*p50_to_1000)
    else:
        fee = fee + (50*p50) +
((1000-50)*p50_to_1000) \
                  + ((sell_price-
1000)*p1000)

    return fee

selling_price = float(input('Enter item
selling price (ex: 65.00): '))
print('eBay fee: $',
calc_ebay_fee(selling_price))
```



```
Enter item selling price
(ex: 65.00): 9.95
eBay fee: $
1.7934999999999999
...
Enter item selling price
(ex: 65.00): 40
eBay fee: $ 5.7
...
Enter item selling price
(ex: 65.00): 100
eBay fee: $ 9.5
...
Enter item selling price
(ex: 65.00): 500
eBay fee: $ 29.5
...
Enter item selling price
(ex: 65.00): 2000
eBay fee: $ 74.5
```

PARTICIPATION ACTIVITY 24.5.1: Analyzing the ebay fee function.

1) For any call to calc_ebay_fee(), how many assignment statements will execute?

Check Show answer

2) What does calc_ebay_fee() return if the sell_price argument is 0.0 (show your answer in the form #.#)?

Check Show answer

3) What does calc_ebay_fee() return if the sell_price argument is 100.0 (show your answer in the form #.#)?

Check Show answer

4) Write a function call using the calc_ebay_fee() function to determine the fee for a selling price of 15.23, storing the result in a variable named my_fee.

Check Show answer

Example: Numbers program with multiple functions

The following is a more complex example with user-defined functions. Notice that functions keep the program's behavior readable and understandable.

zyDE 24.5.1: User-defined functions make a program easier to understand.

The problem below uses the function get_numbers() to read a number of integers frc user. Three unfinished functions are defined, which should print only certain types of that the user entered. Complete the unfinished functions, adding loops and branches necessary. Match the output with the below sample:


```
Enter 5 integers:
0 5
1 99
2 -44
3 0
4 12
Numbers: 5 99 -44 0 12
Odd numbers: 5 99
Negative numbers: -44
```

Load default template...

```
1  size = 5
2
3  def get_numbers(num):
4      numbers = []
5      user_input = input(f'Enter {num} intege
6
7      i = 0
8      for token in user_input.split():
9          number = int(token)      # Convert
10         numbers.append(number)   # Add to n
11
12         print(i, number)
13         i += 1
14
15     return numbers
16
17 def print_all_numbers(numbers):
```

5 99 -44 0 12

Run

PARTICIPATION ACTIVITY 24.5.2: Analyzing the numbers program.

1) For a single execution of the program, how many calls to user-defined functions are made?

Check **Show answer**

CHALLENGE ACTIVITY 24.5.1: Output of functions with branches/loops.

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Start

Type the program's output

```
def print_message(message):
    if len(message) > 6:
        print('too long')
    else:
        print(message)

print_message('Hi!')
print_message('Where are you?')
```

```
Hi!
too long
```

1 2

Check Next

CHALLENGE ACTIVITY 24.5.2: Function with branch: Popcorn.

Define function print_popcorn_time() with parameter bag_ounces. If bag_ounces is less than 3, print "Too small". If greater than 10, print "Too large". Otherwise, compute and print 6 * bag_ounces followed by "seconds". End with a newline. Remember that print() automatically adds a newline.

Sample output with input: 7

```
42 seconds
```

422102.2723990.qx3zqy7


```
1
2 ''' Your solution goes here '''
3
4 user_ounces = int(input())
5 print_popcorn_time(user_ounces)
```

Run

CHALLENGE ACTIVITY 24.5.3: Function with loop: Shampoo.

Write a function print_shampoo_instructions() with parameter num_cycles. If num_cycles is less than 1, print "Too few.". If more than 4, print "Too many.". Else, print "N : Lather and rinse." num_cycles times, where N is the cycle number, followed by "Done.".

Sample output with input: 2

```
1 : Lather and rinse.
2 : Lather and rinse.
Done.
```

Hint: Define and use a loop variable.

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```
1
2 ''' Your solution goes here '''
3
4 user_cycles = int(input())
5 print_shampoo_instructions(user_cycles)
```


Run

24.6 Function stubs

Incremental development and function stubs

Programs are typically written using ***incremental development***, meaning a small amount of code is written and tested, then a small amount more (an incremental amount) is written and tested, and so on.

To assist with the incremental development process, programmers commonly introduce ***function stubs***, which are function definitions whose statements haven't been written yet. The benefit of a function stub is that the high-level behavior of the program can be captured before diving into details of each function, akin to planning the route of a road trip before starting to drive. Capturing high-level behavior first may lead to better-organized code, reduced development time, and even to code with fewer bugs.

A programmer writing a function stub should consider whether or not calling the unwritten function is a valid operation. Simply doing nothing and returning nothing may be acceptable early in the development of a larger program. One approach is to use the ***pass*** keyword, which performs no operation except to act as a placeholder for a required statement.

Figure 24.6.1: Using the pass statement in a function stub performs no operation.

```
def steps_to_feet(num_steps):
    feet_per_step = 3
    feet = num_steps * feet_per_step
    return feet

def steps_to_calories(num_steps):
    pass

steps = int(input('Enter number of steps
walked: '))

feet = steps_to_feet(steps)
print('Feet:', feet)

calories = steps_to_calories(steps)
print('Calories:', calories)
```

```
Enter number of steps
walked: 1000
Feet: 3000
Calories: None
...
Enter number of steps
walked: 0
Feet: 0
Calories: None
...
Enter number of steps
walked: 99999
Feet: 299997
Calories: None
```


The program above has a function stub in place of the steps_to_calories() function. The function

contains a single pass statement because at least one statement is required in any user-defined function.

Another useful approach is to print a message when a function stub is called, thus alerting the user to the missing function statements. Good practice is for a stub to return -1 for a function that will have a return value. The following function stub could be used to replace the steps_to_calories() stub in the program above:

Figure 24.6.2: A function stub using a print statement.

```
def steps_to_calories(steps):
    print('FIXME: finish
steps_to_calories')
    return -1
```

In some cases, a programmer may want a program to stop executing if an unfinished function is called. Ex: A program that requires user input should not execute if the user-defined function that gets input is not completed. In such cases, a ***NotImplementedError*** can be generated with the statement `raise NotImplementedError`. The NotImplementedError indicates that the function is not implemented and causes the program to stop execution. NotImplementedError and the "raise" keyword are explored elsewhere in material focusing on *exceptions*. The following demonstrates an error being generated by a function stub:

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Figure 24.6.3: Stopping the program using NotImplementedError in a function stub.

```
import math

def get_points(num_points):
    """Get num_points from the user. Return a
list of (x,y) tuples."""
    raise NotImplementedError

def side_length(p1, p2):
    return math.sqrt((p2[0] - p1[0])**2 +
(p2[1] - p1[1])**2)

def get_perimeter_length(points):
    perimeter = side_length(points[0],
points[1])
    perimeter += side_length(points[0],
points[2])
    perimeter += side_length(points[1],
points[2])
    return perimeter

coordinates = get_points(3)
print('Perimeter of triangle:',
get_perimeter_length(coordinates))
```



```
Traceback (most recent
call last):
 File "<stdin>", line 10,
in glt;module<
 File "<stdin>", line 2,
in get_points
NotImplementedError
```

PARTICIPATION ACTIVITY 24.6.1: Incremental development and function stubs.

1) Incremental development may involve more frequent testing, but ultimately leads to faster development of a program.
   - True
   - False

2) The main advantage of function stubs is that they ultimately lead to faster-running programs.
   - True
   - False

3) A pass statement should be used in a function stub when the programmer wants the stub to stop program execution when called.

- True
- False

CHALLENGE ACTIVITY 24.6.1: Function stubs: Statistics.

Define stubs for the functions get_user_num() and compute_avg(). Each stub should print "FIXME: Finish function_name()" followed by a newline, and should return -1. Each stub must also contain the function's parameters.

Sample output with two calls to get_user_num() and one call to compute_avg():

```
FIXME: Finish get_user_num()
FIXME: Finish get_user_num()
FIXME: Finish compute_avg()
Avg: -1
```

422102.2723990.qx3zqy7

```
1
2 ''' Your solution goes here '''
3
4 user_num1 = 0
5 user_num2 = 0
6 avg_result = 0
7
8 user_num1 = get_user_num()
9 user_num2 = get_user_num()
10 avg_result = compute_avg(user_num1, user_num2)
11
12 print('Avg:', avg_result)
```


Run

24.7 Functions are objects

Functions as objects

A function is also an object in Python, having a type, identity, and value. A function definition like `def print_face():` creates a new function object with the name print_face bound to that object.

A part of the value of a function object is compiled ***bytecode*** that represents the statements to be executed by the function. A bytecode is a low-level operation, such as adding, subtracting, or loading from memory. One Python statement might require multiple bytecode operations. Ex: The function below adds 1 to an argument and returns the result. The corresponding bytecode for the function requires 4 bytecode operations to perform the addition, and 2 to return the result.

Figure 24.7.1: Python bytecode.

Program	Bytecode

`def add_one(x):`
`  y = x + 1`
`  return y`
	`0 LOAD_FAST 0 (x)`
	`3 LOAD_CONST 1 (1)`
	`6 BINARY_ADD`
	`7 STORE_FAST 1 (y)`
	
	`10 LOAD_FAST 1 (y)`
	`13 RETURN_VALUE`

All Python code is compiled before being executed by the interpreter. Statements entered in an interactive interpreter are compiled immediately, then executed. Modules are compiled when imported, and functions are compiled when the interpreter evaluates the function definition.

A statement like `print_face()` causes the function object to execute a call operation, which in turn executes the function's bytecode. A programmer never has to deal with bytecode – bytecode is used internally by the interpreter.

Because a function is an object, a function can be used in an assignment statement just like other objects. This is illustrated in the following animation.

PARTICIPATION ACTIVITY 24.7.1: Functions are objects.

Animation content:

undefined

Animation captions:

1. def print_face() creates a new function object.
2. The compiled bytecode of print_face function is stored in the function object.
3. When print_face() is called, the print_face() function runs.
4. Calling func() is the same as calling print_face().

The interpreter creates a new function object when the definition `def print_face()` is evaluated. The function object contains as part of its value the function's bytecode. Since a function is just an object, assignment operations work the same: `func = print_face` binds the name func to the same object as print_face, thus creating multiple names for a single function. Both `func()` and `print_face()` perform the same call operation and jump execution to print_face.

Functions can be passed like any other object as an argument to another function. Consider the following example, which defines two different functions print_human_head() and print_monkey_head(). A third function print_figure() accepts a function as an argument, calling that function to print a head, and then printing a body.

Figure 24.7.2: Functions can be passed as arguments.

```
def print_human_head():
    print('   ||||| ')
    print('   o   o')
    print('     >' )
    print('   ooooo')
    return

def print_monkey_head():
    print('   .-"-.')
    print(' _/.-.-.\\_')
    print('( ( o o ) )')
    print(' |/  "  \\|')
    print('  \\ .-. /')
    print('  /`"""`\\')
    return

def print_figure(face):
    face()  # Print the face
    print('     |')
    print('   --|--')
    print('  /  |  \\')
    print('@    |    @')
    print('     |')
    print('    /|\\')
    print('   @   @')
    return

choice = int(input('Enter "1" to draw monkey,
"2" for human: '))

if choice == 1:
    print_figure(print_monkey_head)
elif choice == 2:
    print_figure(print_human_head)
```

```
Enter "1" to draw
monkey, "2" for human: 1
   .-"-.
 _/.-.-.\_
( ( o o ) )
 |/  "  \|
  \ .-. /
  /`"""`\
     |
   --|--
  /  |  \
@    |    @
     |
    /|\
   @   @

...

Enter "1" to draw
monkey, "2" for human: 2
   |||||
   o   o
     >
   ooooo
     |
   --|--
  /  |  \
@    |    @
     |
    /|\
   @   @
```

Passing functions as arguments can sometimes improve the readability of code. The above example could have been implemented using an if statement to call either print_human_head() or print_monkey_head() followed by a call to a print_body() function. However, the code is simplified by reducing the required number of function calls in the first code block to the more simple print_figure(face).

Whereas objects like integers support many operations (adding, subtracting, etc.), functions really only support the call operation.[1]

PARTICIPATION ACTIVITY 24.7.2: Function objects.

1) Functions are compiled into bytecode when the function definition is evaluated by the interpreter.

   - True
   - False

2) The output of the following program is 'meow':

```
def print_cat():
    print('meow')

def print_pig():
    print('oink')

print_cat = print_pig
print_cat()
```

   - True
   - False

3) If my_func1() and my_func2() are defined functions, then the expression `my_func1 + my_func2` returns a valid value.

   - True
   - False

4) The expression `my_func1(my_func2())` passes the my_func2 function object as an argument to my_func1.

   - True
   - False

(*1) Functions also support adding attributes with the attribute reference "." operator, but that concept is out of scope for the discussion here.

24.8 Scope of variables and functions

Variable and function scope

A variable or function object is only visible to part of a program, known as the object's ***scope***. When a variable is created inside a function, the variable's scope is limited to *inside* that function. In fact, because a variable's name does not exist until bound to an object, the variable's scope is actually limited to *after* the first assignment of the variable until the end of the function. The following program highlights the scope of variable `total_inches`.

Figure 24.8.1: Variable scope.


```
centimeters_per_inch = 2.54
inches_per_foot = 12

def height_US_to_centimeters(feet, inches):
    """ Converts a height in feet/inches to centimeters."""
    total_inches = (feet * inches_per_foot) + inches  # Total inches
    centimeters = total_inches * centimeters_per_inch
    return centimeters

feet = int(input('Enter feet: '))
inches = int(input('Enter inches: '))

print('Centimeters:', height_US_to_centimeters(feet, inches))
```

Local variable scope extends from assignment to end of function. Global variable scope extends to end of file.

The function's variables `total_inches` and `centimeters` are invisible to the code outside of the function and cannot be used. Such variables defined inside a function are called ***local variables***.

Global variables

In contrast, a variable defined outside of a function is called a ***global variable***. A global variable's scope extends from assignment to the end of the file and can be accessed inside of functions.

A ***global*** statement must be used to *change* the value of a global variable inside of a function. The following shows two programs: the right uses a global statement to allow the modification of global variable `employee_name` inside of the `get_name` function.

Figure 24.8.2: The global statement (right) allows modifying a global variable.

```
employee_name = 'N/A'

def get_name():

    name = input('Enter
employee name:')
    employee_name = name

get_name()
print('Employee name:',
employee_name)
```

```
Enter employee name: Romeo Montague
Employee name: N/A
```

```
employee_name = 'N/A'

def get_name():
    global employee_name
    name = input('Enter
employee name:')
    employee_name = name

get_name()
print('Employee name:',
employee_name)
```

```
Enter employee name: Juliet Capulet
Employee name: Juliet Capulet
```


The global statement must be applied to any global variable that is to be assigned in a function. Modification of mutable global variables, such as list or dict containers, does not require a global statement if a programmer is adding or removing elements from the container. The reasons for requiring a global statement are discussed in more detail later.

Assignment of global variables in functions should be used sparingly. If a local variable (including a parameter) has the same name as a global variable, then the naming can be very confusing to a reader. Furthermore, if a function updates the global variable, then that function's behavior is no longer limited to its parameters and return value; the function may have *side effects* that are hard for a programmer to recognize. Good practice is to limit the use of global variables to defining constants that are independent of any function. Global variables should generally be avoided (with a few exceptions), especially by beginner programmers.

A function also has scope, which extends from the function's definition to the end of the file. To be able to call a function, the interpreter must have already evaluated the function definition (thus binding the function name to a function object). An attempt to call a function before a function has been defined results in an error.

Figure 24.8.3: Function definitions must be evaluated before that function is called.

```
employee_name = 'N/A'

get_name()
print('Employee name:',
employee_name)

def get_name():
    global employee_name
    name = input('Enter employee
name:')
    employee_name = name
```



```
NameError: name 'get_name' is not
defined
```

PARTICIPATION ACTIVITY 24.8.1: Variable/ function scope.

1) A local variable is defined inside a function, while a global variable is defined outside any function.
   - ○ True
   - ○ False

2) A local variable's scope extends from a function definition's ending colon ":" to the end of the function.
   - ○ True
   - ○ False

3) A global statement must be used to assign a global variable inside a function.
   - ○ True
   - ○ False

4) A function definition must be evaluated by the interpreter before the function can be called.
   - ○ True

False

24.9 Namespaces and scope resolution

Namespace

A ***namespace*** maps names to objects. The Python interpreter uses namespaces to track all of the objects in a program. For example, when executing `z = x + y`, the interpreter looks in a namespace to find the value of the objects referenced by `x` and `y`, evaluates the expression, and then updates `z` in the namespace with the expression's result.

PARTICIPATION ACTIVITY 24.9.1: Namespaces.

Animation content:

`undefined`

Animation captions:

1. Global variables are tracked in the global namespace.
2. The value of variables is found by looking in the namespace.

In fact, a namespace is actually just a normal Python dictionary whose keys are the names and whose values are the objects. A programmer can examine the names in the current local and global namespace by using the `locals()` and `globals()` built-in functions.

Figure 24.9.1: Using the globals() to get namespace names.

```
print('Initial global
namespace: ')
print(globals())

my_var = "This is a
variable"
print('\nCreated new
variable')
print(globals())

def my_func():
    pass

print('\nCreated new
function')
print(globals())
```

```
Initial global namespace:
{}

Created new variable
{'my_var': 'This is a variable'}

Created new function
{'my_func': <function my_func at 0x2349d4>,
'my_var': 'This is a variable'}
```


By default, a few names already exist in the global namespace – those names have been omitted in the output for brevity. Notice that `my_var` and `my_func` are added into the namespace once assigned.

Scope and scope resolution

Scope is the area of code where a name is visible. Namespaces are used to make scope work. Each scope, such as global scope or a local function scope, has its own namespace. If a namespace contains a name at a specific location in the code, then that name is visible and a programmer can use it in an expression.

There are at least three nested scopes that are active at any point in a program's execution: [1]

1. Built-in scope – Contains all of the built-in names of Python, such as `int()`, `str()`, `list()`, `range()`, etc.
2. Global scope – Contains all globally defined names outside of any functions.
3. Local scope – Usually refers to scope within the currently executing function, but is the same as global scope if no function is executing.

When a name is referenced in code, the local scope's namespace is the first checked, followed by the global scope, and finally the built-in scope. If the name cannot be found in any namespace, the interpreter generates a `NameError`. The process of searching for a name in the available namespaces is called ***scope resolution***.

PARTICIPATION ACTIVITY 24.9.2: Scope resolution.

Animation content:

undefined

Animation captions:

1. Global variables are added to the global namespace.
2. Calling a function creates a new local namespace for local variables.
3. Variables are resolved by looking in the local namespace first, then global, then built-in.
4. The local namespace is removed when the function returns.

As the code executes, the global scope namespace is filled with names as they are defined. The function call creates a new namespace to track the variables in the function's local scope. The new local namespace automatically contains the parameter value `cals_left`. When the expression `cals_left - soda_cals` is evaluated, the interpreter finds `cals_left` in the local namespace, then finds `soda_cals` in the global namespace after unsuccessfully searching the local namespace.

PARTICIPATION ACTIVITY 24.9.3: Namespaces and scopes.

If unable to drag and drop, refresh the page.

Scope **Namespace** **locals()** **Scope resolution**

Maps the visible names in a scope to objects.

The area of code where a name is visible.

Returns a dictionary of the names found in the local namespace.

The process of searching namespaces for a name.

Reset

PARTICIPATION ACTIVITY 24.9.4: Namespaces.

Given the following program, select the namespace that each name would belong to.

```
import random

player_name = 'Gandalf'
player_type = 'Wizard'

def roll():
    """Returns a roll of a 20-sided die"""
    number = random.randint(1, 20)
    return number

print('A troll attacks!')
troll_roll = roll()
player_roll = roll()


print(f'Player: {str(player_roll)}    Troll: {str(troll_roll)}')
```


1) player_name
   - local
   - global
   - built-in

2) roll
   - local
   - global
   - built-in

3) number
   - local
   - global
   - built-in

4) str
   - local
   - global
   - built-in

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More scoping and namespaces

The concept of scopes and namespaces helps to explain how multiple variables can share the same name, yet have different values. Consider the following program that first creates a variable `tmp` in the global namespace, then creates another variable named `tmp` in a local function. The assignment statement in the `avg()` function creates a new variable within the function's local namespace. When the function returns, the namespace is deleted as well (since the local variables are now out of scope). The later statement `print f'Sum: {tmp:f}'` looks up the name `tmp` in the global scope, finding the `tmp` previously created with the statement `tmp = a + b`.

Note that the Python Tutor tool below uses the term "frame" in place of "namespace".

PARTICIPATION ACTIVITY 24.9.5: Function scope.

By default, any assignment statement automatically creates (or modifies) a name in the local namespace only, even if the same name exists in a higher global or built-in scope. A global statement such as `global tmp` forces the interpreter to consider the variable in the global scope, thus allowing modification of existing global variables instead of creating local variables.

PARTICIPATION ACTIVITY 24.9.6: Namespace and scope.

1) A namespace is how the Python interpreter restricts variables to a specific scope.
   - True
   - False

2) Whenever a function is called, a local namespace is created for that function.
   - True
   - False

3) The same name cannot be in multiple namespaces.
   - True
   - False

4) If a programmer defines a function called `list()`, the program will crash because there is already a built-in function with the same name.
   - True
   - False

(*1) Actually, there are four levels of scopes. We have omitted a level between the local function scope and global scope for clarity. It is possible to define a function within another function – in such a case the scope of the outer function is checked before the global scope is checked.

24.10 Keyword arguments and default parameter values

Keyword arguments

Sometimes a function requires many arguments. In such cases, a function call can become very long and difficult to read. Furthermore, a programmer might easily make a mistake when calling such a function if the ordering of the arguments is given incorrectly. Consider the following program:

Figure 24.10.1: A function with many arguments.

```
def print_book_description(title, author, publisher, year, version,
num_chapters, num_pages):
    # Format and print description of a book...

print_book_description('The Lord of the Rings', 'J. R. R. Tolkien',
'George Allen & Unwin',
                       1954, 1.0, 22, 456)
```


In the example above, a programmer might very easily swap the positions of some of the arguments in the function call, potentially introducing a bug into the program. Python provides for ***keyword arguments*** that allow arguments to map to parameters by name, instead of implicitly by position in the argument list. When using keyword arguments, the argument list does not need to follow a specific ordering.

Figure 24.10.2: Using keyword arguments.

```
def print_book_description(title, author, publisher, year, version,
num_chapters, num_pages):
    # Format and print description of a book...

print_book_description(title='The Lord of the Rings', publisher='George
Allen & Unwin',
                       year=1954, author='J. R. R. Tolkien', version=1.0,
                       num_pages=456, num_chapters=22)
```

Keyword arguments provide a bit of clarity to potentially confusing function calls. Good practice is to use keyword arguments for any function containing more than approximately 4 arguments.

Keyword arguments can be mixed with positional arguments, provided that the keyword arguments come last. A common error is to place keyword arguments before all position arguments, which generates an exception.

Figure 24.10.3: All keyword arguments must follow positional arguments.

```
def split_check(amount, num_people, tax_percentage, tip_percentage):
    # ...

split_check(125.00, tip_percentage=0.15, num_people=2,
tax_percentage=0.095)
```


PARTICIPATION ACTIVITY 24.10.1: Keyword arguments.

Assume the function below is defined:

```
def split_check(amount, num_people, tax_percentage, tip_percentage):
    # ...
```

1) What value is passed as the `tax_percentage` argument in the function call `split_check(60.52, 5, .07, tip_percentage=0.18)`? Answer ERROR if an error occurs.

Check Show answer

2) What value is passed as the `num_people` argument in the function call `split_check(tax_percentage=.07, 60.52, 2, tip_percentage=0.18)`? Answer ERROR if an error occurs.

Check Show answer

Default parameter values

Sometimes a function has parameters that are optional. A function can have a ***default parameter value*** for one or more parameters, meaning that a function call can optionally omit an argument, and the default parameter value will be substituted for the corresponding omitted argument.

The following function prints a date in a particular style, given parameters for day, month, and year. The fourth parameter indicates the desired style, with 0 meaning American style, and 1 meaning European style. For July 30, 2012, the American style is 7/30/2012 and the European style is 30/7/2012.

Figure 24.10.4: Parameter with a default value.

```
def print_date(day, month, year, style=0):
    if style == 0:  # American
        print(month, '/', day, '/', year)
    elif style == 1:  # European
        print(day, '/', month, '/', year)
    else:
        print('Invalid Style')

print_date(30, 7, 2012, 0)
print_date(30, 7, 2012, 1)
print_date(30, 7, 2012)  # style argument not provided!
Default value of 0 used.
```

```
7 / 30 / 2012
30 / 7 / 2012
7 / 30 / 2012
```

The fourth (and last) parameter is defined with a default value: `style=0`. If the function call does not provide a fourth argument, then `style` has value 0. A parameter's ***default value*** is the value used in the absence of an argument in the function call.

The same can be done for other parameters, as in: `def print_date(day=1, month=1, year=2000, style=0)`. If positional arguments are passed (i.e., not keyword-arguments), then only the last arguments can be omitted. The following are valid calls to this `print_date()` function:

Figure 24.10.5: Valid function calls with default parameter values.

```
print_date(30, 7, 2012, 0)   # Defaults: none
print_date(30, 7, 2012)      # Defaults:
style=0
print_date(30, 7)            # Defaults:                year=2000,
style=0
print_date(30)               # Defaults:       month=1, year=2000,
style=0
print_date()                 # Defaults: day=1, month=1, year=2000,
style=0
```


If a parameter does not have a default value, then failing to provide an argument (either keyword or positional) generates an error.

A common error is to provide a mutable object, like a list, as a default parameter. Such a definition can be problematic because the default argument object is created only once, at the time the function is defined (when the script is loaded), and not every time the function is called. Modification of the default parameter object will persist across function calls, which is likely not what a programmer intended. The below program demonstrates the problem with mutable default objects and illustrates a solution that creates a new empty list each time the function is called.

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Figure 24.10.6: Mutable default objects remain changed over multiple function calls.

Default object modification

```
def append_to_list(value,
my_list=[]):
    my_list.append(value)
    return my_list

numbers = append_to_list(50)
# default list appended with
50
print(numbers)
numbers = append_to_list(100)
# default list appended with
100
print(numbers)
```

```
[50]
[50, 100]
```

Solution: Make new list


```
def append_to_list(value,
my_list=None):  # Use default
parameter value of None
    if my_list == None:  # Create
a new list if a list was not
provided
        my_list = []

    my_list.append(value)
    return my_list

numbers = append_to_list(50)  #
default list appended with 50
print(numbers)
numbers = append_to_list(100)  #
default list appended with 100
print(numbers)
```

```
[50]
[100]
```

The left program shows a function `append_to_list()` that has an empty list as default value of `my_list`. A programmer might expect that each time the function is called without specifying `my_list`, a new empty list will be created and the result of the function will be `[value]`. However, the default object persists across function calls. The solution replaces the default list with `None`, checking for that value, and then creating a new empty list in the local scope if necessary.

PARTICIPATION ACTIVITY 24.10.2: Default parameter values.

The following function is defined:

```
def split_check(amount, num_people, tax_percentage=0.095,
tip_percentage=0.15)
    # ...
```

1) What will the parameter tax_percentage be assigned for

the following call? Type ERROR if the call is invalid.

```
split_check(65.50, 3)
```

Check Show answer

2) What will the parameter `tax_percentage` be assigned for the following call? Type ERROR if the call is invalid.

```
split_check(65.50, 3, 0.125)
```

Check Show answer

3) What will the parameter `num_people` be assigned for the following call? Type ERROR if the call is invalid.

```
split_check(12.50, tip_percentage=0.18)
```

Check Show answer

4) What will the parameter `num_people` be assigned for the following call? Type ERROR if the call is invalid.

```
split_check(tip_percentage=0.18, 12.50, 4)
```

Check Show answer

Mixing keyword arguments and default parameter values

Mixing keyword arguments and default parameter values allows a programmer to omit arbitrary arguments from a function call. Because keyword arguments use names instead of position to match arguments to parameters, any argument can be omitted as long as that argument has a default value.

Consider the `print_date` function from above. If every parameter has a default value, then the user can use keyword arguments to pass specific arguments anywhere in the argument list. Below are some sample function calls:

Figure 24.10.7: Mixing keyword arguments and default parameter values allows omitting arbitrary arguments.

```
def print_date(day=1, month=1, year=2000, style=0):
    # ...


print_date(day=30, year=2012)   # Defaults:        month=1,
style=0
print_date(style=1)             # Defaults: day=1, month=1, year=2000
print_date(year=2012, month=4)  # Defaults: day=1,
style=0
```

PARTICIPATION ACTIVITY 24.10.3: Mixing keyword and default arguments.

Assume the function below is defined:

```
def split_check(amount=10, num_people=2, tax_percentage=0.095,
tip_percentage=0.18):
    # ...
```

When entering answers, use the same number of significant digits as the default parameter values in the `split_check()` definition.

1) What will the parameter `tax_percentage` be assigned for the following call? Type ERROR if the call is invalid.
`split_check(amount=49.50, num_people=3)`

Check Show answer

2) Write a statement that splits a $50 check among 4 people. Use the default tax percentage and tip amount.

Check Show answer

3) Write a statement that splits a $25 check among 3 people and leaves a 25% tip. Use the default tax rate.

Check Show answer

CHALLENGE ACTIVITY 24.10.1: Keyword arguments and default parameters.

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Start

Type the program's output

```
def show(a, b, c):
    print(f'{a}/{b}/{c}')

show(c=5, b=9, a=1)
```

1/9/5

1 2 3

Check Next

CHALLENGE ACTIVITY 24.10.2: Return number of pennies in total.

Write a function number_of_pennies() that returns the total number of pennies given a number of dollars and (optionally) a number of pennies. Ex: If you have $5.06 then the input is 5 6, and if you have $4.00 then the input is 4.

Sample output with inputs: 5 6 4

```
506
400
```

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```
1
2 ''' Your solution goes here '''
3
4 print(number_of_pennies(int(input()), int(input()))) # Both dollars and pennies
5 print(number_of_pennies(int(input())))               # Dollars only
```

Run

CHALLENGE ACTIVITY 24.10.3: Default parameters: Calculate splitting a check between diners.

Write a `split_check` function that returns the amount that each diner must pay to cover the cost of the meal.

The function has four parameters:

- `bill`: The amount of the bill.
- `people`: The number of diners to split the bill between.
- `tax_percentage`: The extra tax percentage to add to the bill.
- `tip_percentage`: The extra tip percentage to add to the bill.

The tax or tip percentages are optional and may not be given when calling `split_check`. Use default parameter values of 0.15 (15%) for `tip_percentage`, and 0.09 (9%) for `tax_percentage`. Assume that the tip is calculated from the amount of the bill before tax.

Sample output with inputs: 25 2

```
Cost per diner: $15.50
```

Sample output with inputs: 100 2 0.075 0.21

```
Cost per diner: $64.25
```

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```
# FIXME: Write the split_check function. HINT: Calculate the amount of tip and tax,
# add to the bill total, then divide by the number of diners.

''' Your solution goes here '''

bill = float(input())
people = int(input())

# Cost per diner at the default tax and tip percentages
print(f'Cost per diner: ${split_check(bill, people):.2f}')

bill = float(input())
people = int(input())
new_tax_percentage = float(input())
new_tip_percentage = float(input())

# Cost per diner at different tax and tip percentages
```

Run

24.11 Arbitrary argument lists

Arbitrary arguments

Sometimes a programmer doesn't know how many arguments a function requires. A function definition can include a ****args*** parameter that collects optional positional parameters into an ***arbitrary argument list*** tuple.

Figure 24.11.1: Arbitrary numbers of position arguments using *args.

```
def print_sandwich(bread, meat, *args):
    print(f'{meat} on {bread}', end=' ')
    if len(args) > 0:
        print('with', end=' ')
    for extra in args:
        print(extra, end=' ')
    print('')

print_sandwich('sourdough', 'turkey', 'mayo')
print_sandwich('wheat', 'ham', 'mustard',
'tomato', 'lettuce')
```

```
turkey on sourdough with
mayo
ham on wheat with mustard
tomato lettuce
```


Adding a final function parameter of ****kwargs*** creates a dictionary containing "extra" arguments not defined in the function definition; kwargs is short for ***keyword arguments***. The keys of the dictionary are the parameter names specified in the function call.

Figure 24.11.2: Arbitrary numbers of keyword arguments using **kwargs.

```
def print_sandwich(meat, bread, **kwargs):
    print(f'{meat} on {bread}')
    for category, extra in kwargs.items():
        print(f'   {category}: {extra}')
    print()

print_sandwich('turkey', 'sourdough', sauce='mayo')
print_sandwich('ham', 'wheat', sauce1='mustard',
veggie1='tomato', veggie2='lettuce')
```

```
turkey on
sourdough
   sauce: mayo

ham on wheat
   sauce1:
mustard
   veggie1:
tomato
   veggie2:
lettuce
```


The * and ** characters in `*args` and `**kwargs` are the important symbols. Using "args" and "kwargs" is standard practice, but any valid identifier is acceptable (like perhaps using `*condiments` in the sandwich example).

One or both of `*args` or `**kwargs` can be used. They must come last (and in that order if both are used) in the parameter list, otherwise an error occurs.

Below is a practical example showing how to combine normal parameters and the `**kwargs` parameter. Operating systems like Windows or MacOS have a command line that can be used

instead of clicking icons on a desktop. To start an application using the command line, a user types in the application name followed by some options (usually denoted with a double dash `--`), as in `notepad.exe` or `firefox.exe --new-window=http://google.com --private-toggle=True`. The example below uses a function call's arguments to generate a new command.

PARTICIPATION ACTIVITY 24.11.1: Arbitrary numbers of arguments using *args and **kwargs.

PARTICIPATION ACTIVITY 24.11.2: Arbitrary arguments.

1) Complete the first line of the function definition for `f()` requiring two arguments `arg1` and `arg2`, and an arbitrary argument list `*args`.

```
def f(
                    ):
    # ...
```

Check Show answer

2) Complete the function call so that the output of the program is

```
John is:
age: 10
gender: m
```

```
def print_stats(name, **info):
    print(name, 'is:')
    for key, value in
info.items():
        print(f'{key}:
{value}')

print_stats(
)
```

Check Show answer

24.12 Multiple function outputs

Multiple function outputs

Occasionally a function should produce multiple output values. However, function return statements are limited to returning only one value. A workaround is to package the multiple outputs into a single container, commonly a tuple, and to then return that container.

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Figure 24.12.1: Multiple outputs can be returned in a container.

```
student_scores = [75, 84, 66, 99, 51, 65]

def get_grade_stats(scores):
    # Calculate the arithmetic mean
    mean = sum(scores)/len(scores)

    # Calculate the standard deviation
    tmp = 0
    for score in scores:
        tmp += (score - mean )**2
    std_dev = (tmp/len(scores))**0.5

    # Package and return average, standard
deviation in a tuple
    return mean, std_dev

# Unpack tuple
average, standard_deviation =
get_grade_stats(student_scores)

print('Average score:', average)
print('Standard deviation:',
standard_deviation)
```



```
Average score:
73.33333333333333
Standard deviation:
15.260697523012796
```

The above example calculates the mean and standard deviation of a set of student test scores. The statement `return mean, std_dev` creates and returns a tuple container. Recall that a tuple doesn't require parentheses around the contents, as the comma indicates a tuple should be created. An equivalent statement would have been `return (mean, std_dev)`. The outputs could also have been returned in a list, as in `return [mean, std_dev]`.

The statement `average, standard_deviation = get_grade_stats(student_scores)` utilizes ***unpacking*** to perform multiple assignments at once, so that `average` and `standard_deviation` are assigned the first and second elements from the returned tuple.

PARTICIPATION ACTIVITY 24.12.1: Multiple function outputs.

1) The statement `return a, b, [c, d]` is valid.
   - True
   - False

2) A function may return multiple objects.

- True
- False

24.13 Help! Using docstrings to document functions

Docstrings

A large program can contain many functions with a wide variety of uses. A programmer should document each function, giving a high-level description of the purpose of the function, so that later readers of the code can more easily understand. A ***docstring*** is a string literal placed in the first line of a function body.

A docstring starts and ends with three consecutive quotation marks. Good practice is to keep the docstring of a simple function as a single line, including the quotes. Furthermore, there should be no blank lines before or after the docstring.

Multi-line docstrings can be used for more complicated functions to describe the function arguments. Multi-line docstrings should use consistent indentation for each line, separating the ending triple-quotes by a blank line.

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Figure 24.13.1: A single and a multi-line docstring.

```
def num_seats(airliner_type):
    """Determines number of seats on a plane"""
    #Function body statements ...

def ticket_price(origin, destination, coach=True, first_class=False):
    """Calculates the price of a ticket between two airports.
    Only one of coach or first_class must be True.

    Arguments:
    origin -- string representing code of origin airport
    destination -- string representing code of destination airport

    Optional keyword arguments:
    coach -- Boolean. True if ticket cost priced for a coach class ticket
(default True)
    first_class -- Boolean. True if ticket cost priced for a first class
ticket (default False)

    """
    #Function body statements ...
```


The help() function

The ***help()*** function can aid a programmer by providing them with all the documentation associated with an object. A statement such as `help(ticket_price)` would print out the docstring for the `ticket_price()` function, providing the programmer with information about how to call that function.

zyDE 24.13.1: Using the help() function.

Run the following program that prints out the response of help(ticket_price). Add an a parameter "vegetarian=False" to ticket_price, augment the docstring appropriately, an program again.

Load default template... Run


```
1  def ticket_price(origin, destination, coacl
2      """Calculates the price of a ticket be
3      Only one of coach or first_class must l
4
5      Arguments:
6      origin -- string representing code of
7      destination -- string representing code
8
9      Optional keyword arguments:
10     coach -- Boolean. True if ticket cost
11     first_class -- Boolean. True if ticket
12
13     """
14     #Function body statements ...
15
16 help(ticket_price)
17
```

The `help()` function actually works with most of the built-in Python names, since the language creators were nice enough to provide docstrings for many items. Notice that the output of help depends on the object passed as an argument. If the argument is a function, then the docstring is printed. If you have studied classes or modules, note how `help(str)` prints out a description of the string str class methods, and how `help(math)` prints out all the contents of the math module.

zyDE 24.13.2: Use the help() function on built-in names.

Use the following interpreter to play with the help() function. Try the following: help(st
help(range), and help(max). Try defining a function or two of your own. The statemen
help(__name__) runs the help function on the global scope of the editor, printing infor
about all items defined there.

Load default template... Run

```
1 def my_function(arg):
2     pass
3
4 help(__name__)
5
```

24.14 Engineering examples

This section contains some examples of functions used to carry out engineering-type calculations.

Example: Gas equation

An equation used in physics and chemistry that relates pressure, volume, and temperature of a gas is PV = nRT. P is the pressure, V the volume, T the temperature, n the number of moles, and R a constant. The function below outputs the temperature of a gas given the other values.

Figure 24.14.1: PV = nRT. Compute the temperature of a gas.

```
gas_constant = 8.3144621  # Joules / (mol*Kelvin)

def convert_to_temp(pressure, volume, mols):
    """Convert pressure, volume, and moles to a temperature"""
    return (pressure * volume) / (mols * gas_constant)

press = float(input('Enter pressure (in Pascals): '))
vol = float(input('Enter volume (in cubic meters): '))
mols = float(input('Enter number of moles: '))


print(f'Temperature = {convert_to_temp(press, vol, mols):.2f} K')
```



```
Enter pressure (in Pascals): 2500
Enter volume (in cubic meters): 35.5
Enter number of moles: 18
Temperature = 593.01 K
```

PARTICIPATION ACTIVITY 24.14.1: PV = nRT calculation.

Questions refer to convert_to_temp function above.

1) Function convert_to_temp uses a rewritten form of PV = nRT to solve for T, namely T = PV/nR.
   - True
   - False

2) Function convert_to_temp uses a global variable for the gas constant R.
   - True
   - False

3) Function convert_to_pres() would likely return (temp * volume) / (mols * gas_constant).
   - True
   - False

Example: Trajectory of object on Earth

Common physics equations determine the x and y coordinates of a projectile object at any time, given the object's initial velocity and angle at time 0 with initial position x = 0 and y = 0. The equation for x is v * t * cos(a). The equation for y is v * t * sin(a) - 0.5 * g * t * t.

The program's code asks the user for the object's initial velocity, angle, and height (y position), and then prints the object's position for every second until the object's y position is no longer greater than 0 (meaning the object fell back to Earth).

zyDE 24.14.1: Trajectory of object on Earth.

Load default template...

```
1
2  import math
3
4  def trajectory(t, a, v, g, h):
5      """Calculates new x,y position"""
6      x = v * t * math.cos(a)
7      y = h + v * t * math.sin(a) - 0.5 * g *
8      return (x,y)
9
10 def degree_to_radians(degrees):
11     """Converts degrees to radians"""
12     return ((degrees * math.pi) / 180.0)
13
14 gravity = 9.81 # Earth gravity (m/s^2)
15 time = 1.0 # time (s)
16 x_loc = 0
17 h = 0
```

```
45
100
3
```

Run

PARTICIPATION ACTIVITY 24.14.2: Projective location.

Questions refer to function trajectory above.

1) trajectory() cannot return two values (for x and y), so instead returns a single tuple containing both x and y.

   - True
   - False

2) The program could replace float() by int() without causing much change in

computed values.

- ○ True
- ○ False

3) Each iteration of the loop will see y_loc increase.

- ○ True
- ○ False

4) Assuming the launch angle is less than 90 degrees, each iteration of the loop will see x_loc increase.

- ○ True
- ○ False

CHALLENGE ACTIVITY 24.14.1: Function to compute gas volume.

Define a function compute_gas_volume that returns the volume of a gas given parameters pressure, temperature, and moles. Use the gas equation PV = nRT, where P is pressure in Pascals, V is volume in cubic meters, n is number of moles, R is the gas constant 8.3144621 (J / (mol*K)), and T is temperature in Kelvin.

Sample output with inputs: 100.0 1.0 273.0

```
Gas volume: 22.698481533 m^3
```

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```
1  gas_const = 8.3144621
2
3  ''' Your solution goes here '''
4
5  gas_pressure = float(input())
6  gas_moles = float(input())
7  gas_temperature = float(input())
8  gas_volume = 0.0
9
10 gas_volume = compute_gas_volume(gas_pressure, gas_temperature, gas_moles)
11 print('Gas volume:', gas_volume, 'm^3')
```

Run

24.15 LAB: Track laps to miles

One lap around a standard high-school running track is exactly 0.25 miles. Define a function named laps_to_miles that takes a number of laps as a parameter, and returns the number of miles. Then, write a main program that takes a number of laps as an input, calls function laps_to_miles() to calculate the number of miles, and outputs the number of miles.

Output each floating-point value with two digits after the decimal point, which can be achieved as follows:
`print(f'{your_value:.2f}')`

Ex: If the input is:

```
7.6
```

the output is:

```
1.90
```

Ex: If the input is:

```
2.2
```

the output is:

```
0.55
```

The program must define and call the following function:
`def laps_to_miles(user_laps)`

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LAB ACTIVITY 24.15.1: LAB: Track laps to miles 0 / 10

main.py Load default template...

```
1 # Define your function here
2
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

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24.16 LAB: Max magnitude

Write a function max_magnitude() with three integer parameters that returns the largest magnitude value. Use the function in the main program that takes three integer inputs and outputs the largest magnitude value.

Ex: If the inputs are:

```
5
7
9
```

function max_magnitude() returns and the main program outputs:


```
9
```

Ex: If the inputs are:

```
-17
-8
-2
```

function max_magnitude() returns and the main program outputs:

```
-17
```

Note: The function does not just return the largest value, which for -17 -8 -2 would be -2. Though not necessary, you may use the built-in absolute value function to determine the max magnitude, but you must still output the input number (Ex: Output -17, not 17).

Your program must define and call the following function:
`def max_magnitude(user_val1, user_val2, user_val3)`

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.16.1: LAB: Max magnitude | 0 / 10

main.py — Load default template...

```
1 # Define your function here.
2
3 if __name__ == '__main__':
4     # Type your code here.
5
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.17 LAB: Driving costs - functions

Write a function driving_cost() with input parameters miles_per_gallon, dollars_per_gallon, and miles_driven, that returns the dollar cost to drive those miles. All items are of type float. The function called with arguments (20.0, 3.1599, 50.0) returns 7.89975.

Define that function in a program whose inputs are the car's miles per gallon and the price of gas in dollars per gallon (both float). Output the gas cost for 10 miles, 50 miles, and 400 miles, by calling your driving_cost() function three times.

Output each floating-point value with two digits after the decimal point, which can be achieved as follows:

```
print(f'{your_value:.2f}')
```

Ex: If the input is:

```
20.0
3.1599
```

the output is:

```
1.58
7.90
63.20
```


Your program must define and call a function:
`def driving_cost(miles_per_gallon, dollars_per_gallon, miles_driven)`

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.17.1: LAB: Driving costs - functions | 0 / 10

main.py — Load default template...

```
1 # Define your function here.
2
3 if __name__ == '__main__':
4     # Type your code here.
5
6
7
```

Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → main.py (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.18 LAB: Step counter

A pedometer treats walking 1 step as walking 2.5 feet. Define a function named feet_to_steps that takes a float as a parameter, representing the number of feet walked, and returns an integer that represents the number of steps walked. Then, write a main program that reads the number of feet walked as an input, calls function feet_to_steps() with the input as an argument, and outputs the number of steps as an integer.

Use floating-point arithmetic to perform the conversion.

Ex: If the input is:

```
150.5
```

the output is:

```
60
```

The program must define and call the following function:
`def feet_to_steps(user_feet)`

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.18.1: LAB: Step counter 0 / 10

main.py Load default template...

```
1 # Define your function here
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Input (from above) → main.py (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```


24.19 LAB: A jiffy

A "jiffy" is the scientific name for 1/100th of a second. Define a function named jiffies_to_seconds that takes the number of "jiffies" as a parameter, and returns the number of seconds. Then, write a main program that reads the number of jiffies (float) as an input, calls function jiffies_to_seconds()

with the input as argument, and outputs the number of seconds.

Output each floating-point value with ***three*** digits after the decimal point, which can be achieved as follows:
`print(f'{your_value:.3f}')`

Ex: If the input is:

```
15.25
```


the output is:

```
0.152
```

The program must define and call the following function:
`def jiffies_to_seconds(user_jiffies)`

422102.2723990.qx3zqy7

LAB ACTIVITY 24.19.1: LAB: A jiffy 0 / 10

main.py Load default template...

```
1 # Define your function here
2
3 if __name__ == '__main__':
4     # Type your code here. Your code must call the function.
5
```

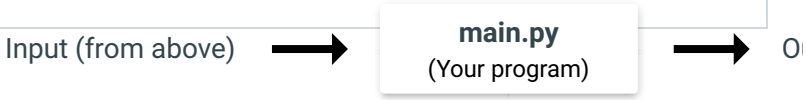

Develop mode **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program



Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.20 LAB: Leap year - functions

A common year in the modern Gregorian Calendar consists of 365 days. In reality, Earth takes longer to rotate around the sun. To account for the difference in time, every 4 years, a leap year takes place. A leap year is when a year has 366 days: An extra day, February 29th. The requirements for a given year to be a leap year are:

1) The year must be divisible by 4

2) If the year is a century year (1700, 1800, etc.), the year must be evenly divisible by 400; therefore, both 1700 and 1800 are not leap years

Some example leap years are 1600, 1712, and 2016.

Write a program that takes in a year and determines the number of days in February for that year.

Ex: If the input is:

```
1712
```

the output is:


```
1712 has 29 days in February.
```

Ex: If the input is:

```
1913
```

the output is:

```
1913 has 28 days in February.
```

Your program must define and call the following function. The function should return the number of days in February for the input year.

```
def days_in_feb(user_year)
```

422102.2723990.qx3zqy7

LAB ACTIVITY 24.20.1: LAB: Leap year - functions 0 / 10

main.py Load default template...

```
1 # Define your function here.
2
3 if __name__ == '__main__':
4     # Type your code here. Your code must call the function.
```

Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```


24.21 LAB: Convert to binary - functions

Write a program that takes in a positive integer as input, and outputs a string of 1's and 0's representing the integer in binary. For an integer x, the algorithm is:

```
As long as x is greater than 0
   Output x % 2 (remainder is either 0 or 1)
   x = x // 2
```

Note: The above algorithm outputs the 0's and 1's in reverse order. You will need to write a second function to reverse the string.

Ex: If the input is:

```
6
```

the output is:

```
110
```

The program must define and call the following two functions. Define a function named int_to_reverse_binary() that takes an integer as a parameter and returns a string of 1's and 0's representing the integer in binary (in reverse). Define a function named string_reverse() that takes an input string as a parameter and returns a string representing the input string in reverse.

```
def int_to_reverse_binary(integer_value)
def string_reverse(input_string)
```

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.21.1: LAB: Convert to binary - functions | 0 / 10

main.py Load default template...

```
1 # Define your functions here.
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

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24.22 LAB: Swapping variables

Define a function named swap_values that takes four integers as parameters and swaps the first with the second, and the third with the fourth values. Then write a main program that reads four integers from input, calls function swap_values() to swap the values, and prints the swapped values

on a single line separated with spaces.

Ex: If the input is:

```
3
8
2
4
```


function swap_values() returns and the main program outputs:

```
8 3 4 2
```

The program must define and call the following function.
`def swap_values(user_val1, user_val2, user_val3, user_val4)`

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.22.1: LAB: Swapping variables | 0 / 10

main.py Load default template...

```
1 # Define your function here.
2
3 if __name__ == '__main__':
4     # Type your code here. Your code must call the function.
```


Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.23 LAB: Exact change - functions

Define a function called exact_change that takes the total change amount in cents and calculates the change using the fewest coins. The coin types are pennies, nickels, dimes, and quarters. Then write a main program that reads the total change amount as an integer input, calls exact_change(), and outputs the change, one coin type per line. Use singular and plural coin names as appropriate, like 1 penny vs. 2 pennies. Output "no change" if the input is 0 or less.

Ex: If the input is:

```
0
```

(or less), the output is:

```
no change
```

Ex: If the input is:

```
45
```


the output is:

```
2 dimes
1 quarter
```

Your program must define and call the following function. The function exact_change() should

return num_pennies, num_nickels, num_dimes, and num_quarters.

`def exact_change(user_total)`

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.23.1: LAB: Exact change - functions | 0 / 10

main.py Load default template...

```
1 # Define your function here
2
3 if __name__ == '__main__':
4     input_val = int(input())
5     num_pennies, num_nickels, num_dimes, num_quarters = exact_change(input_val)
6
7     # Type your code here.
8
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.24 LAB: Multiples of ten in a list

Write a program that reads a list of integers, and outputs whether the list contains all multiples of 10, no multiples of 10, or mixed values. Define a function named is_list_mult10 that takes a list as a parameter, and returns a boolean that represents whether the list contains all multiples of ten. Define a function named is_list_no_mult10 that takes a list as a parameter and returns a boolean that represents whether the list contains no multiples of ten.

Then, write a main program that takes an integer, representing the size of the list, followed by the list values. The first integer is not in the list.

Ex: If the input is:

```
5
20
40
60
80
100
```

the output is:

```
all multiples of 10
```

Ex: If the input is:

```
5
11
-32
53
-74
95
```


the output is:

```
no multiples of 10
```

Ex: If the input is:

```
5
10
25
30
40
55
```


the output is:

```
mixed values
```

The program must define and call the following two functions. is_list_mult10() returns true if all integers in the list are multiples of 10 and false otherwise. is_list_no_mult10() returns true if no integers in the list are multiples of 10 and false otherwise.

```
def is_list_mult10(my_list)
def is_list_no_mult10(my_list)
```

422102.2723990.qx3zqy7

LAB ACTIVITY 24.24.1: LAB: Multiples of ten in a list 0 / 10

main.py Load default template...

```
1 # Define your functions here
2
3 if __name__ == '__main__':
4     # Type your code here.
5
```


Develop mode **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and

Enter program input (optional) observe the program's output in the second box.

If your code requires input values, provide them here.

Run program Input (from above) → main.py (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.25 LAB: Output values in a list below a user defined amount - functions

Write a program that first gets a list of integers from input. The input begins with an integer indicating the number of integers that follows. Then, get the last value from the input, and output all integers less than or equal to that value.

Ex: If the input is:

```
5
50
60
140
200
75
100
```


the output is:

```
50
60
75
```

The 5 indicates that five integers are in the list, namely 50, 60, 140, 200, and 75. The 100 indicates that the program should output all integers less than or equal to 100, so the program outputs 50, 60, and 75.

Such functionality is common on sites like Amazon, where a user can filter results. Utilizing functions will help to make your main very clean and intuitive.

The program must define the following two functions:
`def get_user_values()` - read from input the size of the list, the integers in the list, and the threshold value. Return the list of integers and the threshold value.

`def ints_less_than_or_equal_to_threshold(user_values, upper_threshold)` - create a new list that contains values in `user_values` that are less than or equal to `upper_threshold`. Return the newly created list.

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.25.1: LAB: Output values in a list below a user defined amount - functions | 0 / 10

main.py — Load default template...

```
1 # Define your functions here
2
3 if __name__ == '__main__':
4     user_values, upper_threshold = get_user_values()
5     res_values = ints_less_than_or_equal_to_threshold(user_values, upper_threshold)
6
7     for value in res_values:
8         print(value)
9
```


Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and

observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.26 LAB: Warm up: Text analyzer & modifier

(1) Prompt the user to enter a string of their choosing. Output the string. (1 pt)

Ex:

```
Enter a sentence or phrase:
The only thing we have to fear is fear itself.

You entered: The only thing we have to fear is fear itself.
```

(2) Complete the get_num_of_characters() function, which returns the number of characters in the user's string. *We encourage you to use a for loop in this function.* (2 pts)

(3) Extend the program by calling the get_num_of_characters() function and then output the returned result. (1 pt)

(4) Extend the program further by implementing the output_without_whitespace() function. output_without_whitespace() outputs the string's characters except for whitespace (spaces, tabs). Note: A tab is '\t'. Call the output_without_whitespace() function in main(). (2 pts)

Ex:

```
Enter a sentence or phrase:
The only thing we have to fear is fear itself.

You entered: The only thing we have to fear is fear itself.

Number of characters: 46
String with no whitespace: Theonlythingwehavetofearisfearitself.
```


422102.2723990.qx3zqy7

LAB ACTIVITY 24.26.1: LAB: Warm up: Text analyzer & modifier 0 / 6

main.py Load default template...

```
1 def get_num_of_characters(input_str):
2     # Type your code here
3     return
4
5
6 if __name__ == '__main__':
7     # Type your code here
```

Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```


24.27 LAB*: Program: Authoring assistant

(1) Prompt the user to enter a string of their choosing. Store the text in a string. Output the string. (1 pt)

Ex:

```
Enter a sample text:
we'll continue our quest in space.  there will be more shuttle
flights and more shuttle crews and,  yes;  more volunteers, more
civilians,  more teachers in space.  nothing ends here;  our hopes
and our journeys continue!

You entered: we'll continue our quest in space.  there will be more
shuttle flights and more shuttle crews and,  yes;  more volunteers,
more civilians,  more teachers in space.  nothing ends here;  our
hopes and our journeys continue!
```

(2) Implement the print_menu() function to print the following command menu. (1 pt)

Ex:

```
MENU
c - Number of non-whitespace characters
w - Number of words
f - Fix capitalization
r - Replace punctuation
s - Shorten spaces
q - Quit
```

(3) Implement the execute_menu() function that takes 2 parameters: a character representing the user's choice and the user provided sample text. execute_menu() performs the menu options, according to the user's choice, by calling the appropriate functions described below. (1 pt)

(4) In the main program, call print_menu() and prompt for the user's choice of menu options for analyzing/editing the string. Each option is represented by a single character.

If an invalid character is entered, continue to prompt for a valid choice. When a valid option is entered, execute the option by calling execute_menu(). Then, print the menu and prompt for a new option. Continue until the user enters 'q'. *Hint: Implement Quit before implementing other options.* (1 pt)

Ex:

```
MENU
c - Number of non-whitespace characters
w - Number of words
f - Fix capitalization
r - Replace punctuation
s - Shorten spaces
q - Quit

Choose an option:
```

(5) Implement the get_num_of_non_WS_characters() function. get_num_of_non_WS_characters() has a string parameter and returns the number of characters in the string, excluding all whitespace. Call get_num_of_non_WS_characters() in the execute_menu() function, and then output the returned value. (4 pts)

Ex:

```
Enter a sample text:
we'll continue our quest in space.  there will be more shuttle
flights and more shuttle crews and,  yes;  more volunteers, more
civilians,  more teachers in space.  nothing ends here;  our hopes
and our journeys continue!

You entered: we'll continue our quest in space.  there will be more
shuttle flights and more shuttle crews and,  yes;  more volunteers,
more civilians,  more teachers in space.  nothing ends here;  our
hopes and our journeys continue!
```

```
MENU
c - Number of non-whitespace characters
w - Number of words
f - Fix capitalization
r - Replace punctuation
s - Shorten spaces
q - Quit

Choose an option:
c
Number of non-whitespace characters: 181
```


(6) Implement the get_num_of_words() function. get_num_of_words() has a string parameter and returns the number of words in the string. *Hint: Words end when a space is reached except for the last word in a sentence.* Call get_num_of_words() in the execute_menu() function, and then output the returned value. (3 pts)

Ex:

```
Number of words: 35
```

(7) Implement the fix_capitalization() function. fix_capitalization() has a string parameter and returns an updated string, where lowercase letters at the beginning of sentences are replaced with uppercase letters. fix_capitalization() also returns the number of letters that have been capitalized. Call fix_capitalization() in the execute_menu() function, and then output the number of letters capitalized followed by the edited string. *Hint 1: Look up and use Python functions .islower() and .upper() to complete this task. Hint 2: Create an empty string and use string concatenation to make edits to the string.* (3 pts)

Ex:

```
Number of letters capitalized: 3
Edited text: We'll continue our quest in space.  There will be more
shuttle flights and more shuttle crews and,  yes;  more volunteers,
more civilians,  more teachers in space.  Nothing ends here;  our
hopes and our journeys continue!
```


(8) Implement the replace_punctuation() function. replace_punctuation() has a string parameter and two keyword argument parameters **exclamation_count** and **semicolon_count**. replace_punctuation() updates the string by replacing each exclamation point (!) character with a

period (.) and each semicolon (;) character with a comma (,). replace_punctuation() also counts the number of times each character is replaced and outputs those counts. Lastly, replace_punctuation() returns the updated string. Call replace_punctuation() in the execute_menu() function, and then output the edited string. (3 pts)

Ex:

```
Punctuation replaced
exclamation_count: 1
semicolon_count: 2
Edited text: we'll continue our quest in space.  there will be more
shuttle flights and more shuttle crews and,  yes,  more volunteers,
more civilians,  more teachers in space.  nothing ends here,  our
hopes and our journeys continue.
```


(9) Implement the shorten_space() function. shorten_space() has a string parameter and updates the string by replacing all sequences of 2 or more spaces with a single space. shorten_space() returns the string. Call shorten_space() in the execute_menu() function, and then output the edited string. *Hint: Look up and use Python function .isspace().* (3 pt)

Ex:

```
Edited text: we'll continue our quest in space. there will be more
shuttle flights and more shuttle crews and, yes; more volunteers,
more civilians, more teachers in space. nothing ends here; our hopes
and our journeys continue!
```

422102.2723990.qx3zqy7

LAB ACTIVITY 24.27.1: LAB*: Program: Authoring assistant 0 / 20

main.py Load default template...

```
1 # Define your functions here.
2
3 if __name__ == '__main__':
4     # Complete the main program here.
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin
working on this zyLab.
```

24.28 Lab training: Unit tests to evaluate your program

Auto-graded programming assignments may use a *Unit test* to test small parts of a program. Unlike a *Compare output test*, which evaluates your program's output for specific input values, a *Unit test* evaluates individual functions to determines if each function:

- is named correctly and has the correct parameters and return type
- calculates and returns the correct value (or prints the correct output)

The zyLabs auto-grader runs **main.py** as a script. In **main.py**, the line `if __name__ == '__main__':` is used to separate the main code from the functions' code so that each function

can be unit tested. Enter statements to be run as the main code under `if __name__ == '__main__':`. Indent the statements so the statements belong to the if block. Refer to the subsection *Importing modules and executing scripts* under section *Module basics* for more information about running a program as a script.

Note: Do not remove `if __name__ == '__main__':` from the code. Otherwise, the unit tests will fail even though the program produces the correct output.

This example lab uses multiple unit tests to test the kilo_to_pounds() function.

Complete a program that takes a weight in kilograms as input, converts the weight to pounds, and then outputs the weight in pounds. 1 kilogram = 2.204 pounds (lbs).

The program must define the following function:
`def kilo_to_pounds(kilos)` - take `kilos` as a parameter, convert `kilos` from kilograms to pounds, and return the weight in pounds.

Ex: If the input of the program is:

```
10
```

10 is passed to kilo_to_pounds() and the output of the program is:

```
22.040 lbs
```

The program below has an error in the kilo_to_pounds() function.

1. Try submitting the program for grading (click "Submit mode", then "Submit for grading"). Notice that the first two test cases fail, but the third test case passes. The first test case fails because the program outputs the result from the kilo_to_pounds() function, which has an error. The second test case uses a *Unit test* to test the kilo_to_pounds() function, which fails.
2. Change the kilo_to_pounds() function to multiply the variable kilos by 2.204, instead of dividing. The return statement should be: `return (kilos * 2.204)`. Submit again. Now the test cases should all pass.

Note: A common error is to mistype a function name with the incorrect capitalization. Function names are case sensitive, so if a lab program asks for a kilo_to_pounds() function, a kilo_To_Pounds() function that works for you in "Develop mode" will result in a failed unit test. The unit test will not be able to find kilo_to_pounds().

422102.2723990.qx3zqy7

LAB ACTIVITY | 24.28.1: Lab training: Unit tests to evaluate your program | 0 / 3

main.py Load default template...

```
1  def kilo_to_pounds(kilos):
2      # This statement intentionally has an error.
3      return (kilos / 2.204)
4
5
6  # Main part of the program starts here. Do not remove the line below.
7  if __name__ == '__main__':
8      kilos = float(input())
9
10     pounds = kilo_to_pounds(kilos)
11     print(f'{pounds:.3f} lbs')
```


Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.py** (Your program) → O

Program output displayed here

Coding trail of your work What is this?

History of your effort will appear here once you begin working on this zyLab.

24.29 LAB: Fibonacci sequence

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