INT3075 Programming and Problem Solving for Mathematics

Functions

What is a function?

Functions

- From Mathematics we know that functions perform some operation and return one value.
- They "encapsulate" the performance of some particular operation, so it can be used by others (for example, the `sqrt()` function)

Why have them?

- Support divide-and-conquer strategy
- Abstraction of an operation
- Reuse. Once written, use again
- Sharing. If tested, others can use
- Security. Well tested, then secure for reuse
- Simplify code. More readable.

Mathematical Notation

- Consider a function which converts temperatures in Celsius to temperatures in Fahrenheit.
  - Formula: $F = C * 1.8 + 32.0$
  - Functional notation:

    $F \sim$ celsius_to_Fahrenheit(C) where

    celsius_to_Fahrenheit(C) = $C * 1.8 + 32.0$

Python Invocation

- Math: F = celsius_to_Fahrenheit(C)
- Python, the invocation is much the same

```
F = celsius_to_Fahrenheit(cel_float)
```

Terminology: `cel_float` is the ***argument***

Function defintion

- Math: g(C) = C*1.8 + 32.0
- Python

```
def celsius_to_Fahrenheit(param_float):
    return param_float * 1.8 + 32.0
```

- Terminology: `param_float` is the ***parameter***

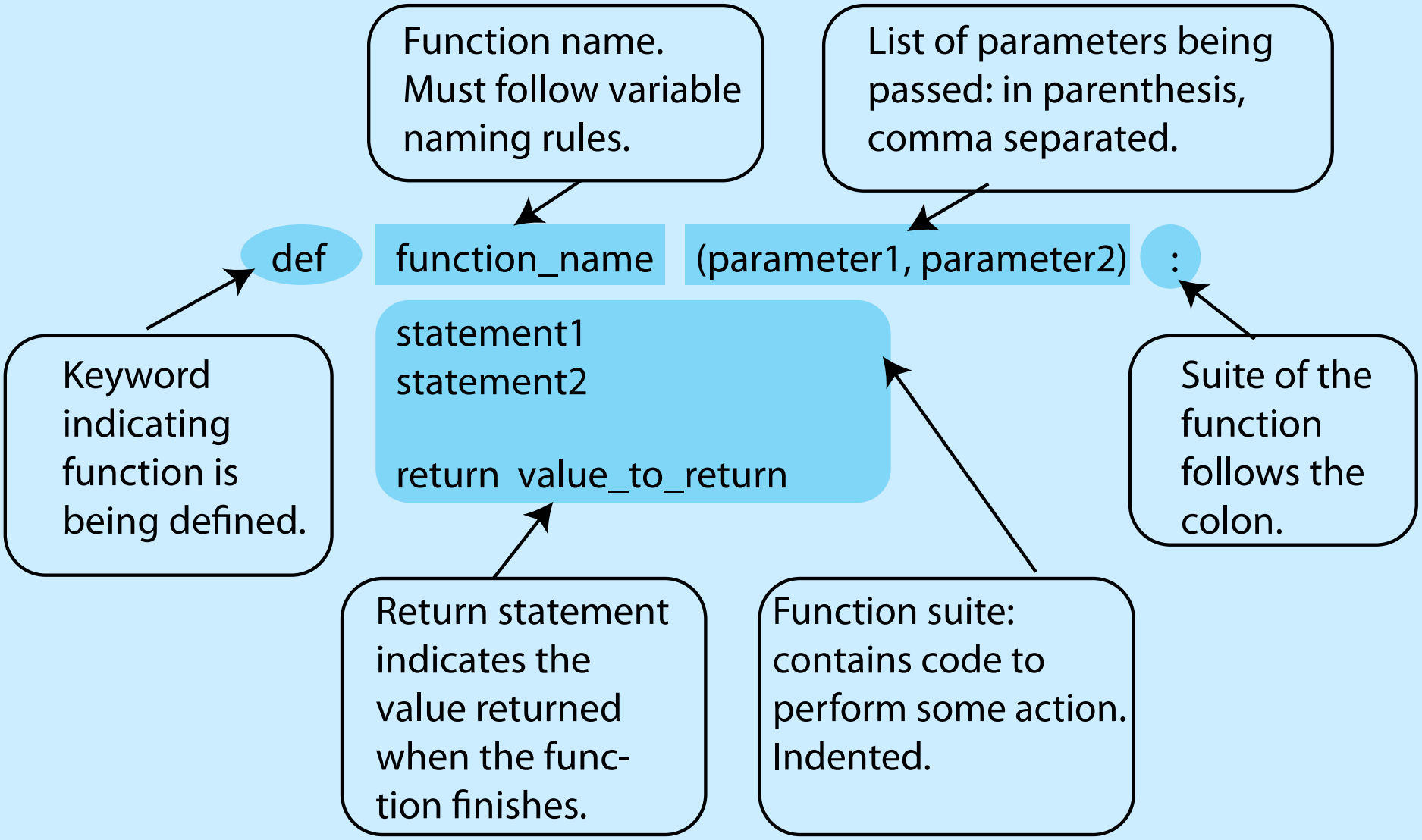
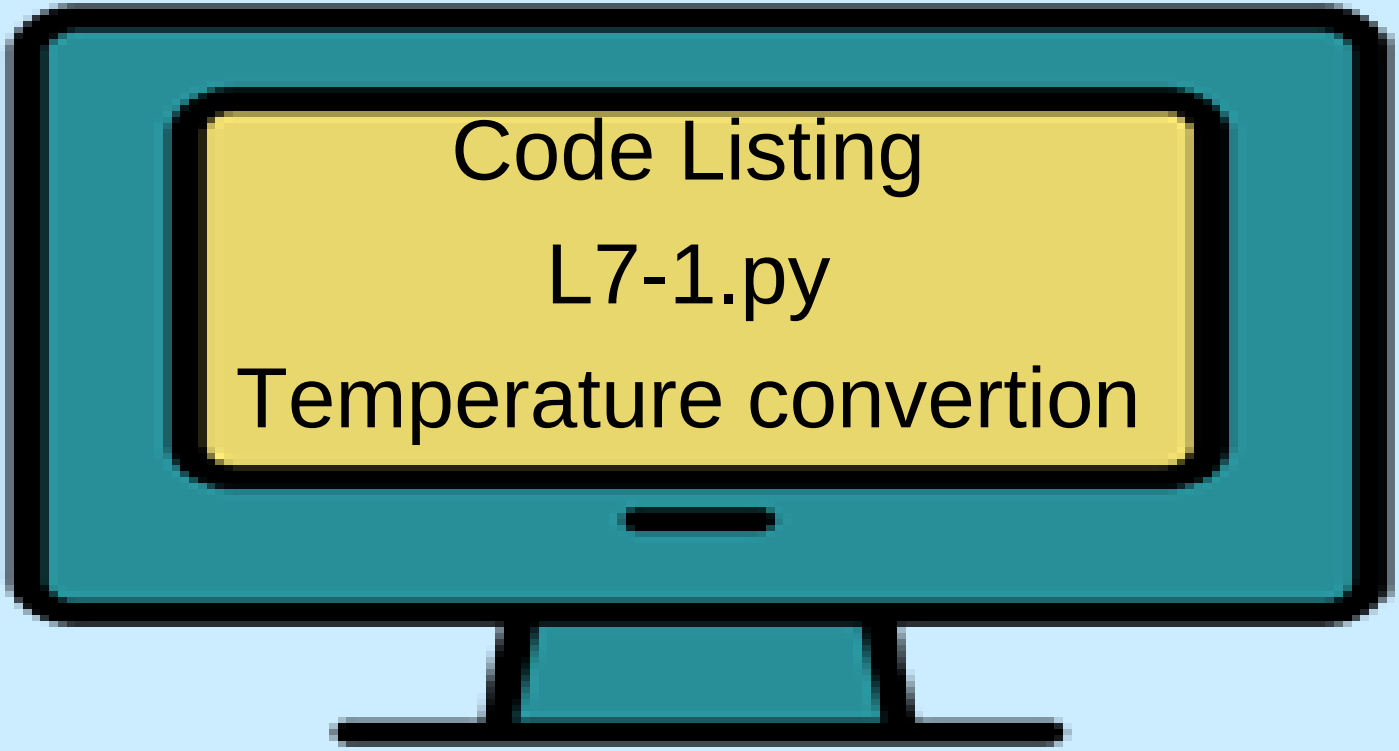


FIGURE 6.1 Function parts.

return statement

- The `return` statement indicates the value that is returned by the function
- The statement is optional (the function can return nothing). If no `return`, function is often called a procedure.

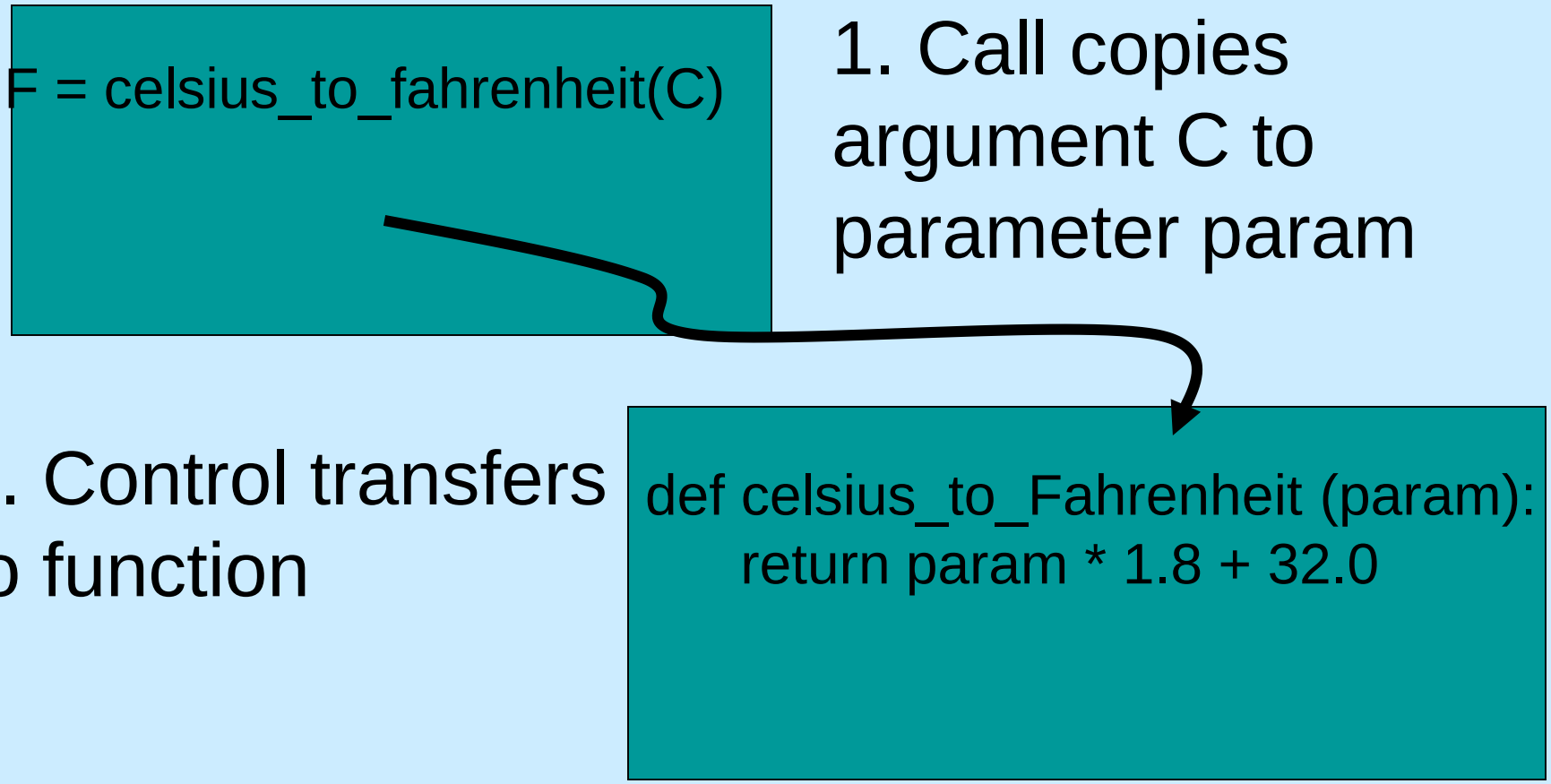

Code Listing
L7-1.py
Temperature convertion

```
1 # Temperature conversion
2
3 def celsius_to_fahrenheit(celsius_float):
4     """ Convert Celsius to Fahrenheit."""
5     return celsius_float * 1.8 + 32
```

Triple quoted string in function

- A triple quoted string just after the def is called a ***docstring***
- docstring is documentation of the function's purpose, to be used by other tools to tell the user what the function is used for.

Operation


F = celsius_to_fahrenheit(C)
1. Call copies argument C to parameter param
2. Control transfers to function
def celsius_to_Fahrenheit (param):
return param * 1.8 + 32.0

Operation (con't)

F = celsius_to_fahrenheit(C)

3. Expression in function is evaluated

4. Value of expression is returned to the invoker

```
def celsius_to_Fahrenheit (param):
    return param * 1.8 + 32.0
```

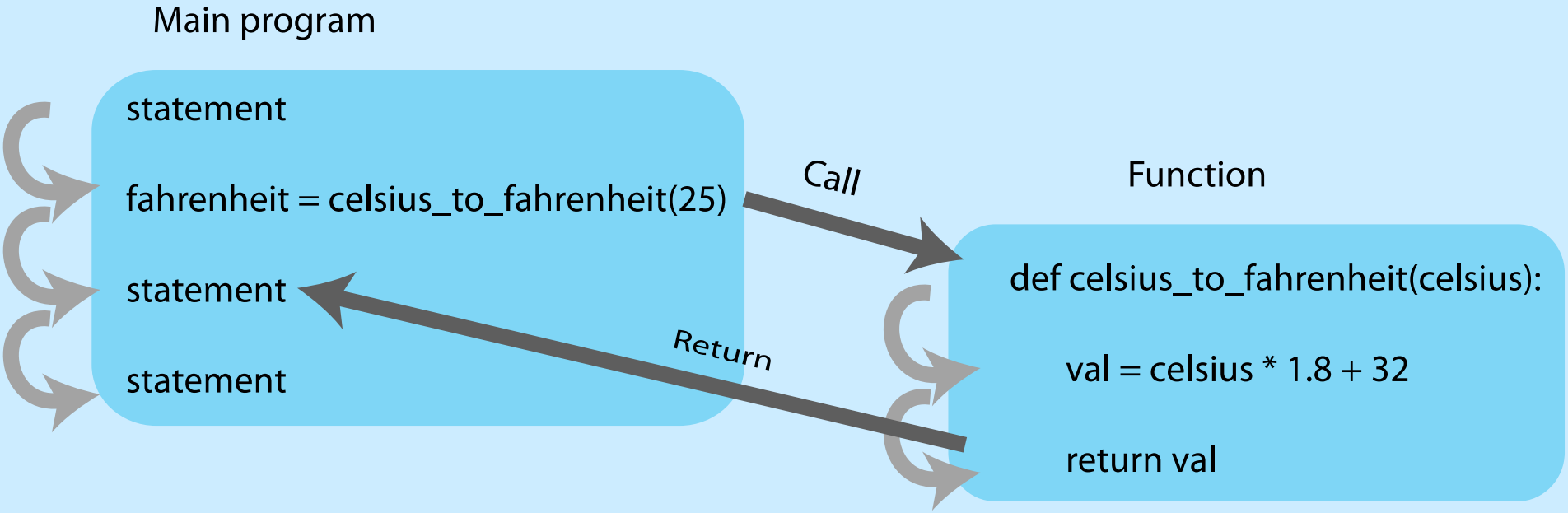
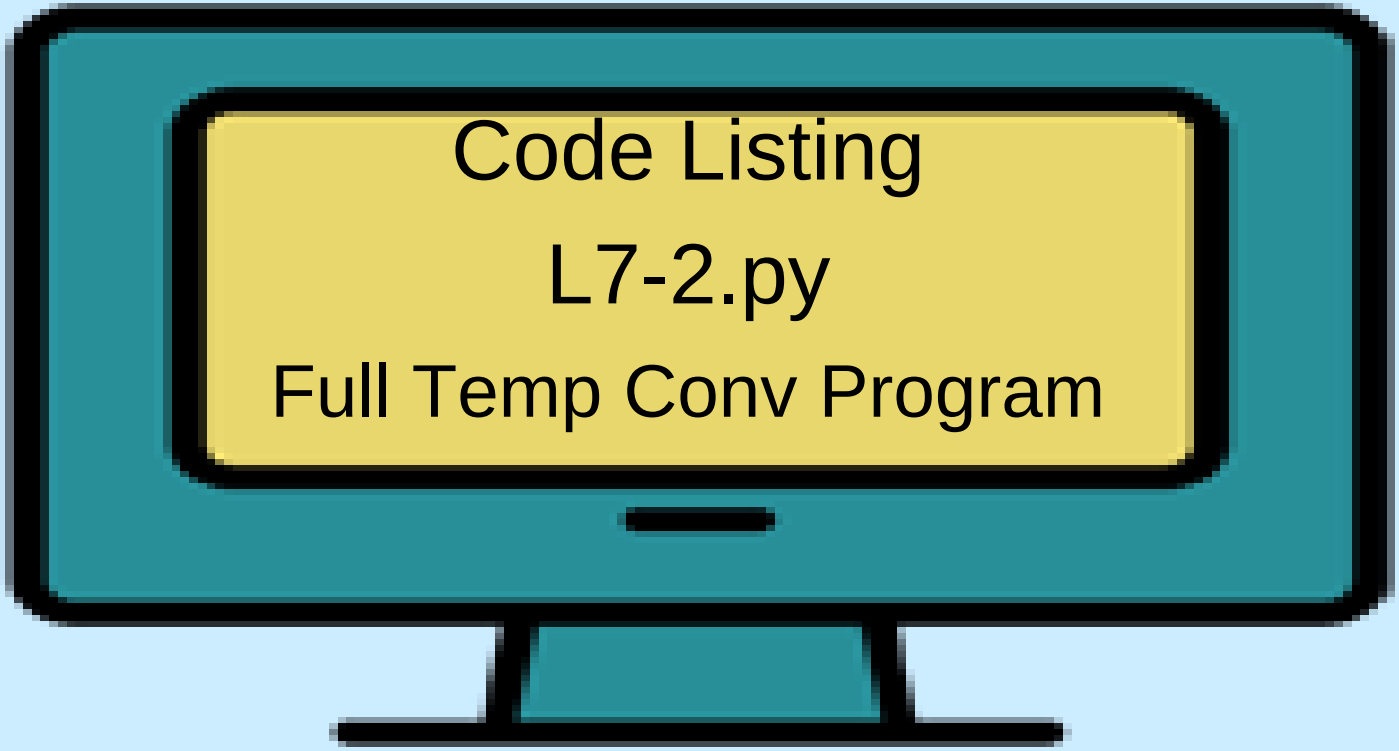
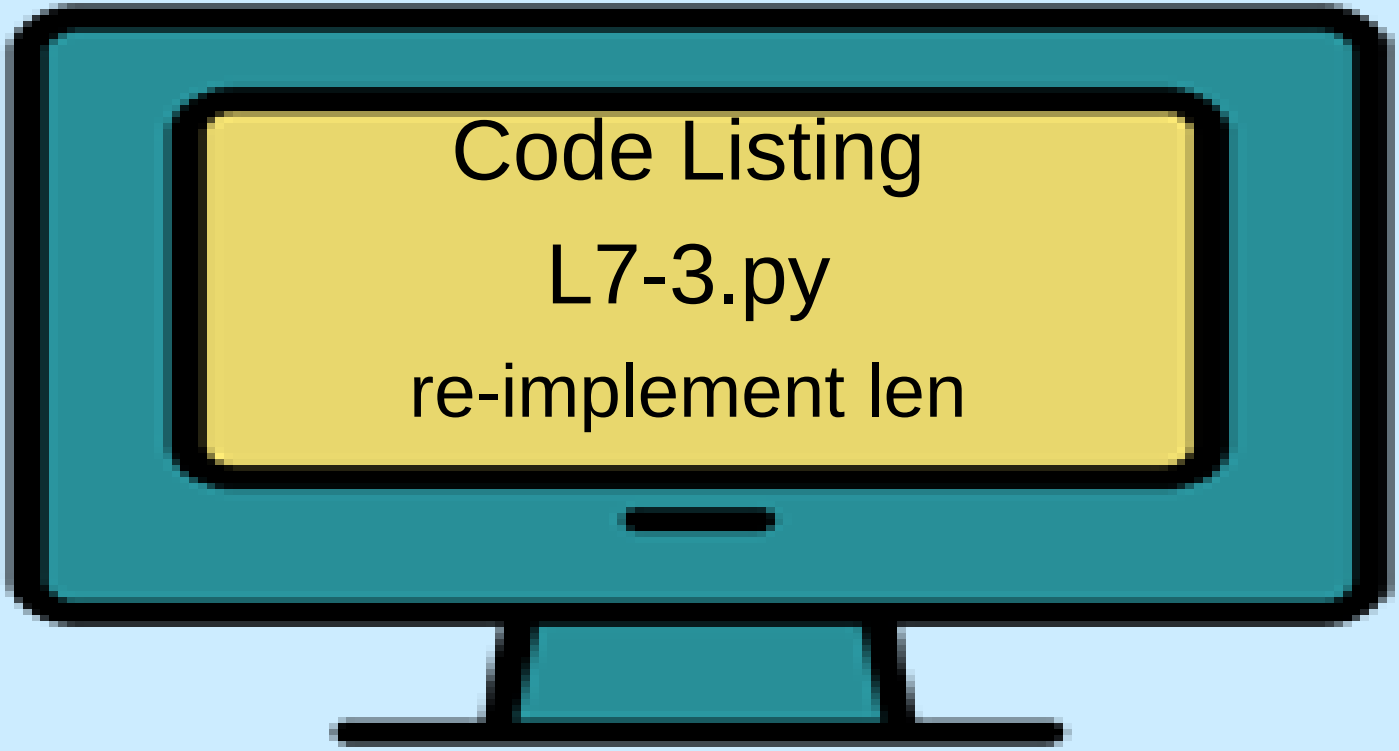


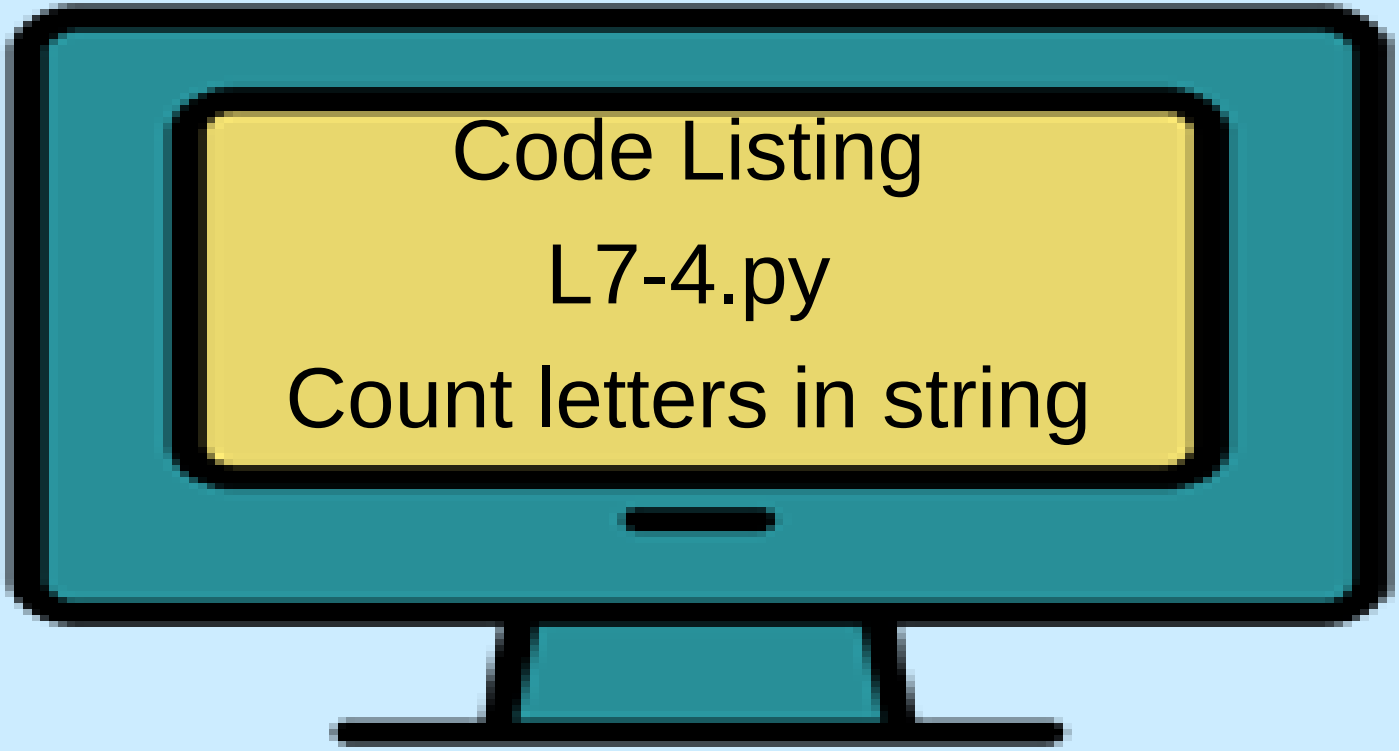
FIGURE 6.2 Function flow of control.


Code Listing
L7-2.py
Full Temp Conv Program

```
# Conversion program

def celsius_to_fahrenheit(celsius_float):
    """ Convert Celsius to Fahrenheit."""
    return celsius_float * 1.8 + 32

# main part of the program
print("Convert Celsius to Fahrenheit.")
celsius_float = float(input("Enter a Celsius temp: "))
# call the conversion function
fahrenheit_float = celsius_to_fahrenheit(celsius_float)
# print the returned value
print(celsius_float," converts to ",fahrenheit_float," Fahrenheit")
```


Code Listing
L7-3.py
re-implement len

```
1 def length(a_str):
2     """Return the length of a_str"""
3     count = 0
4     for char in a_str:
5         count += 1
6     return count
```


Code Listing
L7-4.py
Count letters in string

check membership in lowercase

- `import string`
- use `string.ascii_lowercase`, string of lowercase english letters
  - 'abcdefghijklmnopqrstuvwxyz'
- check if each char is a member (using in operator) of `string.ascii_lowercase`
- `char.lower()` before membership (catch Capital Letters that way)

```
1 import string
2
3 def letter_count(a_str):
4     """Return the count of letters in a_str."""
5     count = 0
6     for char in a_str:
7         if char.lower() in string.ascii_lowercase:
8             count += 1
9     return count
```

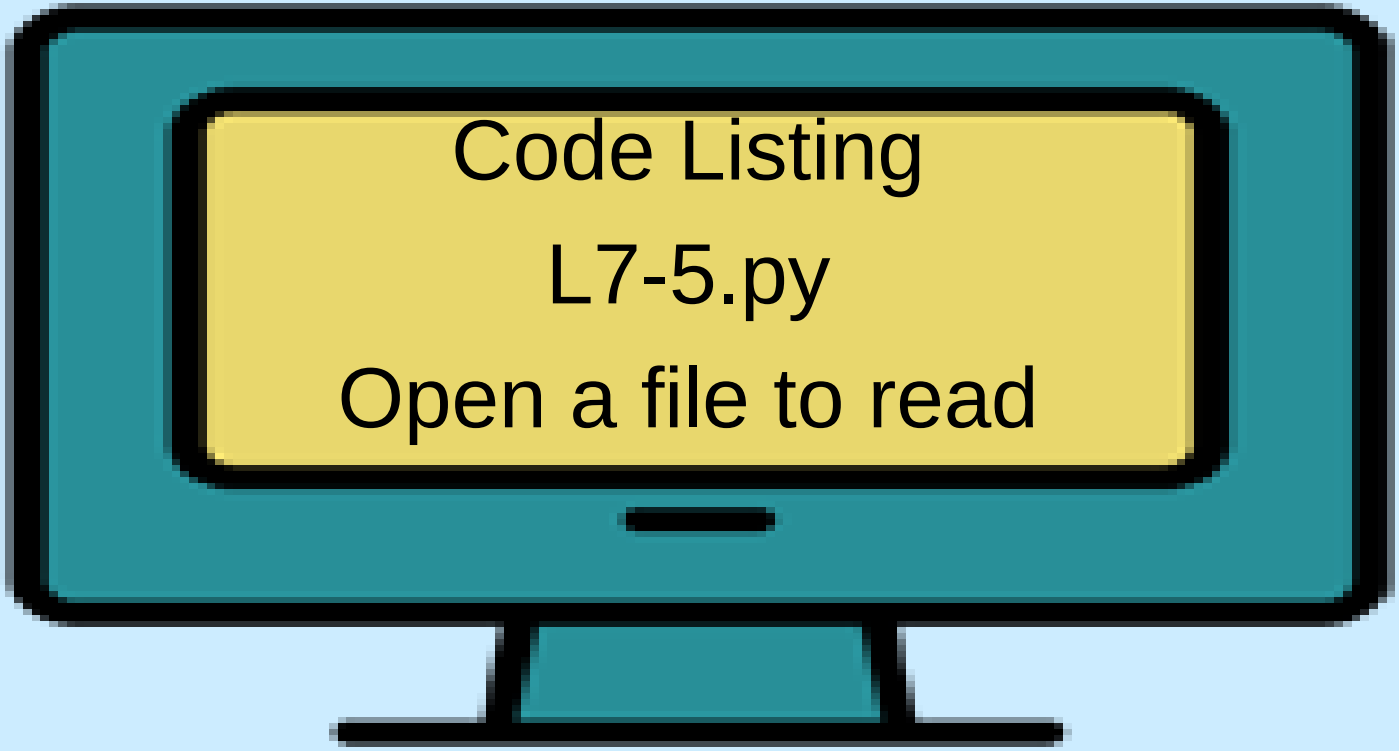
Word Puzzle

- Find an English language word that has the vowels 'a', 'e', 'i', 'o', and 'u' in sequence

Reading a file of Text

Remember how to work with text files

- The open function takes a string (a file name) and a mode ('r' for reading) and returns a file object.
- You can use a for loop on the file object to fetch one line of text at a time (a line ends with a carriage return)

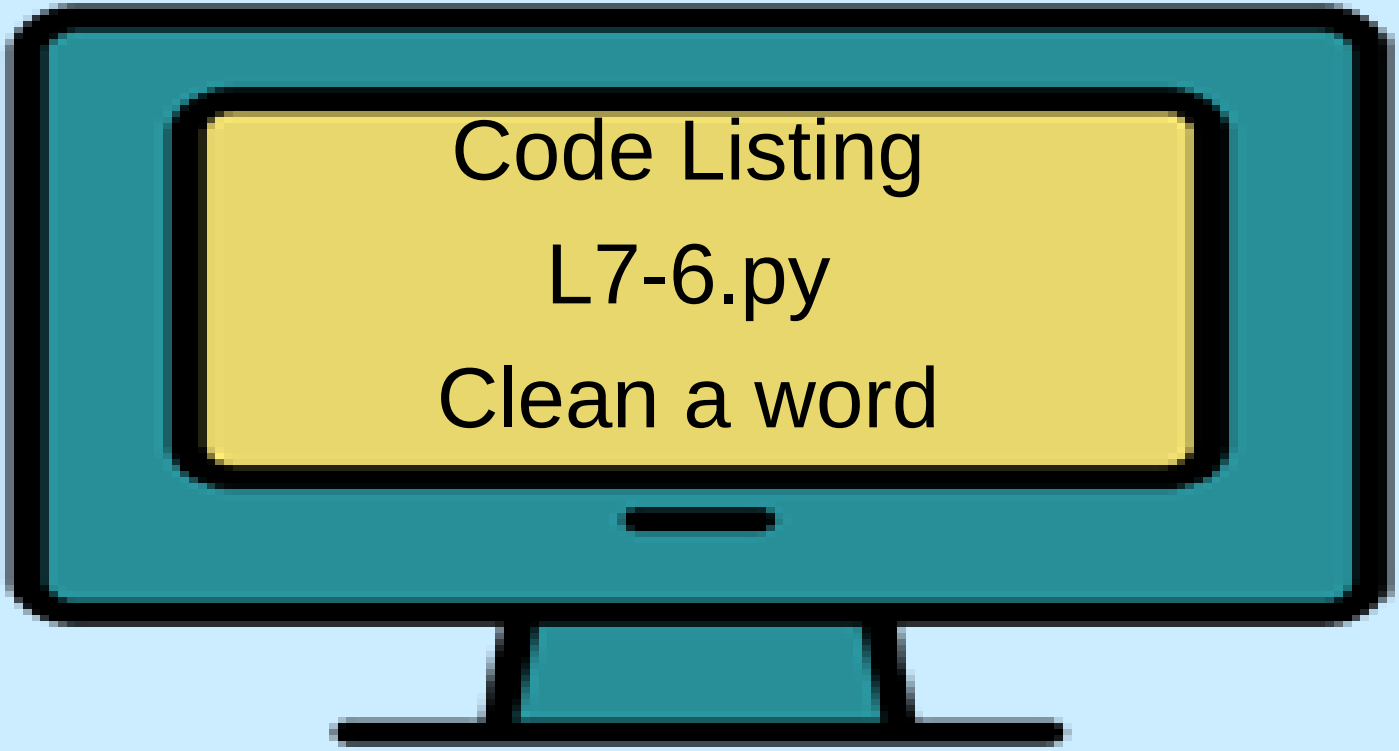

Code Listing
L7-5.py
Open a file to read

Need a list of words

We use a dictionary file (easily found on the web) of english words, one word per line

- open the file
- process each line (a single word)
- this example just prints them all

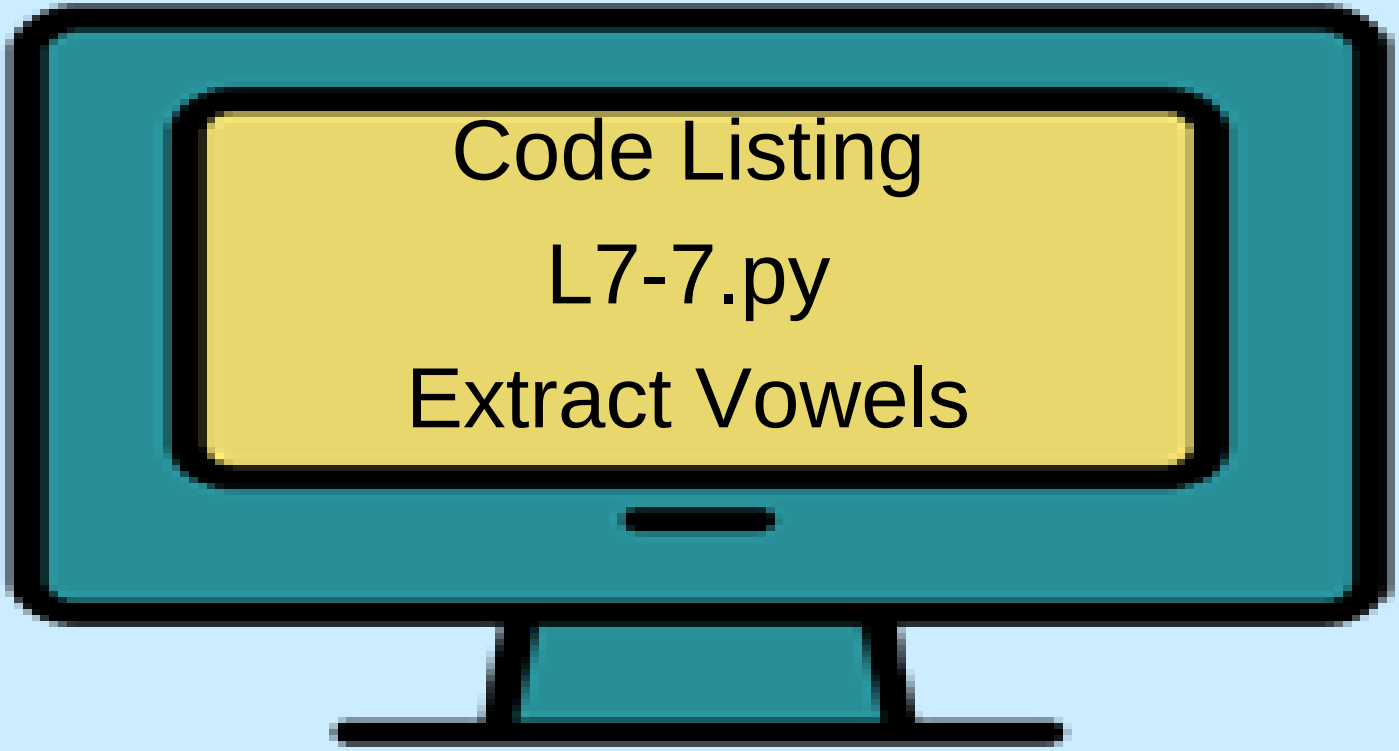
```
# Print all words in a dictionary file that has one word per line

# open file named "dictionary.txt" for reading ('r')
data_file = open("dictionary.txt", 'r')

# iterate through the file one line at a time
for line_str in data_file:
    print(line_str)
```


Code Listing
L7-6.py
Clean a word

clean the word

- `strip` method removes white space characters from the beginning and end of a string (can remove other chars as well)
  - beginning and end only, not the middle
  - all such characters from either end
  - file line likely has returns or tabs of spaces which might hurt compares
- `lower` method so case won't matter

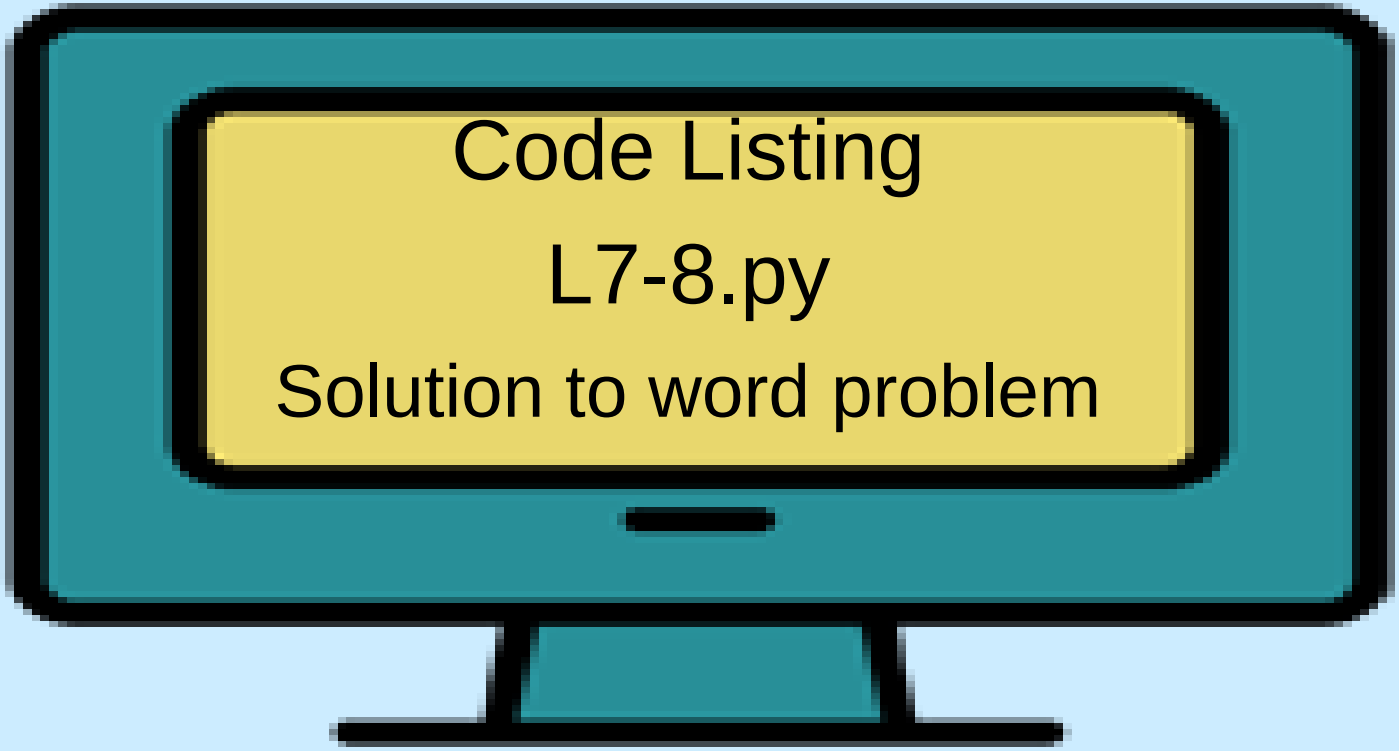
```
def clean_word(word):
    """Return word in lowercase stripped of whitespace."""
    return word.strip().lower()
```


Code Listing
L7-7.py
Extract Vowels

collect vowels

- collect only vowels as a string, in order from the word, and compare against the reference "aeiou"
  - use `in` operator for membership
  - use `+` operator to concat vowels together

```
def get_vowels_in_word(word):
    """Return vowels in string word—include repeats."""
    vowel_str = "aeiou"
    vowels_in_word = ""
    for char in word:
        if char in vowel_str:
            vowels_in_word += char
    return vowels_in_word
```


Code Listing
L7-8.py
Solution to word problem

```
3  data_file = open("dictionary.txt", "r")
4
5  def clean_word(word):
6      """Return word in lowercase stripped of whitespace."""
7      return word.strip().lower()
8
9  def get_vowels_in_word(word):
10     """Return vowels in string word—include repeats."""
11     vowel_str = "aeiou"
12     vowels_in_word = ""
13     for char in word:
14         if char in vowel_str:
15             vowels_in_word += char
16     return vowels_in_word
17
18 # main program
19 print("Find words containing vowels 'aeiou' in that order:")
20 for word in data_file:        # for each word in the file
21     word = clean_word(word) # clean the word
22     if len(word) <= 6:        # if word is too small, skip it
23         continue
24     vowel_str = get_vowels_in_word(word)  # get vowels in word
25     if vowel_str == 'aeiou':              # check if you have exactly all
   vowels in order
26         print(word)
```

Did functions help?

- Made our problem solving easier (solved smaller problems as functions)
- main program very readable (details hid in the functions)

How to write a function

- ***Does one thing***. If it does too many things, it should be broken down into multiple functions (refactored)
- ***Readable.*** How often should we say this? If you write it, it should be readable
- ***Reusable***. If it does one thing well, then when a similar situation (in another program) occurs, use it there as well.

More on functions

- ***Complete***. A function should check for all the cases where it might be invoked. Check for potential errors.
- ***Not too long***. Kind of synonymous with do one thing. Use it as a measure of doing too much.

Procedures

- Functions that have no return statements are often called *procedures*.
- Procedures are used to perform some duty (print output, store a file, etc.)
- Remember, return is not required in procedures.

Multiple returns in a function

- A function can have multiple `return` statements.
- Remember, the first `return` statement executed ends the function.
- Multiple returns can be confusing to the reader and should be used carefully.