3. Control Statements and Program Development

Objectives ¶

- Decide whether to execute actions with the statements `if` , `if` … `else` and if…elif…else.
- Execute statements repeatedly with `while` and `for` .
- Shorten assignment expressions with augmented assignments.
- Use the `for` statement and the built-in `range` function to repeat actions for a sequence of values.
- Perform sentinel-controlled iteration with `while` .

Objectives (cont.)

- Learn problem-solving skills: understanding problem requirements, dividing problems into smaller pieces, developing algorithms to solve problems and implementing those algorithms in code.
- Develop algorithms through the process of top-down, stepwise refinement.
- Create compound conditions with the Boolean operators `and` , `or` and `not` .

Objectives (cont.)

- Stop looping with `break` .
- Force the next iteration of a loop with `continue` .
- Use some functional-style programming features to write scripts that are more concise, clearer, easier to debug and easier to parallelize.

Outline

Outline

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3.5 `if` Statement

- Pseudocode: Suppose that a passing grade on an examination is 60. The pseudocode

```
If student’s grade is greater than or equal to 60
    Display 'Passed'
```

- If the condition is true, 'Passed' is displayed. Then, the next pseudocode statement in order is “performed.”
- If the condition is false, nothing is displayed, and the next pseudocode statement is “performed.”
- Indentation emphasizes that 'Passed' is displayed only if the condition is true.

Corresponding `if` Statement

In [1]:

```
grade = 85
```

In [2]:

```
if grade >= 60:
    print('Passed')
```

```
Passed
```

Suite Indentation

- Indenting a suite is required.

In [3]:

```
if grade >= 60:
print('Passed')  # statement is not indented properly
```

```
  File "<ipython-input-3-eb5359d7857b>", line 2
    print('Passed')  # statement is not indented properly
        ^
IndentationError: expected an indented block
```

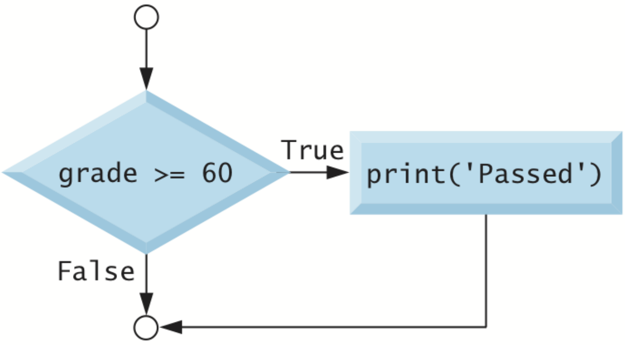
- Statements in a suite must have the same indentation.

In [5]:

```
if grade >= 60:
    print('Passed')
  print('Good job!)
```

```
  File "<tokenize>", line 3
    print('Good job!)
    ^
IndentationError: unindent does not match any outer indentation leve
l
```

`if` Statement Flowchart



- The decision (diamond) symbol contains a condition that can be either `True` or `False`.
- Two flowlines emerging from it:
  - One indicates the direction to follow when the condition in the symbol is `True`.
  - The other indicates the direction to follow when the condition is `False`.

Every Expression Can Be Treated as `True` or `False`

In [6]:

```
if 1:
    print('Nonzero values are true, so this will print')
```

```
Nonzero values are true, so this will print
```

In [7]:

```
if 0:
    print('Zero is false, so this will not print')
```

An Additional Note on Confusing `==` and `=`

- Using `==` instead of `=` in an assignment statement can lead to subtle problems.
- Writing `grade == 85` when we intend to define a variable with `grade = 85` would cause a `NameError`.
- Logic error: If `grade` had been defined **before** the preceding statement, then `grade == 85` would evaluate to `True` or `False`, depending on `grade`'s value, and not perform the intended assignment.

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3.6 `if…else` and `if…elif…else` Statements

- Performs different suites, based on whether a condition is `True` or `False`.
- Pseudocode:

```
If student’s grade is greater than or equal to 60
    Display 'Passed'
Else
    Display 'Failed'
```

- Correspondong Python code with variable `grade` initalized to `85`

In [1]:

```
grade = 85
```

In [2]:

```
if grade >= 60:
    print('Passed')
else:
    print('Failed')
```

```
Passed
```

- Assign `57` to `grade`, then shows the `if`…`else` statement again to demonstrate that only the `else` suite executes

In [3]:

```
grade = 57
```

In [4]:

```
if grade >= 60:
    print('Passed')
else:
    print('Failed')
```

```
Failed
```

In IPython:

- The up and down arrow keys navigate backwards and forwards through the current interactive session’s snippets.
- Pressing *Enter* re-executes the snippet that’s displayed.
- In JupyterLab, you can select a cell in its left margin, press *C* to copy it and *V* to paste it below the currently selected cell.

In [5]:

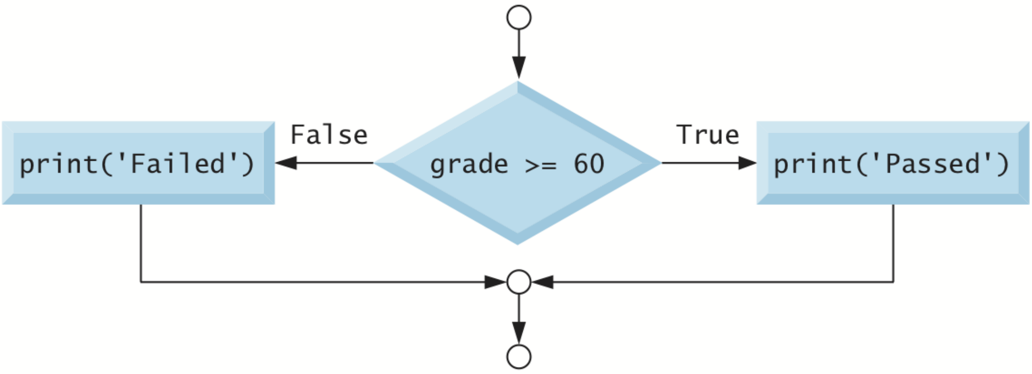
```
grade = 99
```

In [6]:

```
if grade >= 60:
    print('Passed')
else:
    print('Failed')
```

```
Passed
```

`if`…`else` Statement Flowchart



Conditional Expressions

- Sometimes the suites in an `if`…`else` statement assign different values to a variable, based on a condition

In [7]:

```
grade = 87
```

In [8]:

```
if grade >= 60:
    result = 'Passed'
else:
    result = 'Failed'
```

In [9]:

```
result
```

Out[9]:

```
'Passed'
```

- Can write statements like this using a concise conditional expression.
- The parentheses are not required, but they make it clear that the statement assigns the conditional expression's value to `result`.

In [10]:

```
result = ('Passed' if grade >= 60 else 'Failed')
```

In [11]:

```
result
```

Out[11]:

```
'Passed'
```

- In interactive mode, you also can evaluate the conditional expression directly.

In [12]:

```
'Passed' if grade >= 60 else 'Failed'
```

Out[12]:

```
'Passed'
```

Multiple Statements in a Suite

In [13]:

```
grade = 49
```

In [14]:

```
if grade >= 60:
    print('Passed')
else:
    print('Failed')
    print('You must take this course again')
```

```
Failed
You must take this course again
```

- If you do not indent the second `print` , then it’s not in the `else` ’s suite.
- In that case the statement always executes, creating strange incorrect output.

In [15]:

```
grade = 100
```

In [16]:

```
if grade >= 60:
    print('Passed')
else:
    print('Failed')
print('You must take this course again')
```

```
Passed
You must take this course again
```

`if`…`elif`…`else` Statement

- Can test for many cases.
- Only the action for the first `True` condition executes.

In [17]:

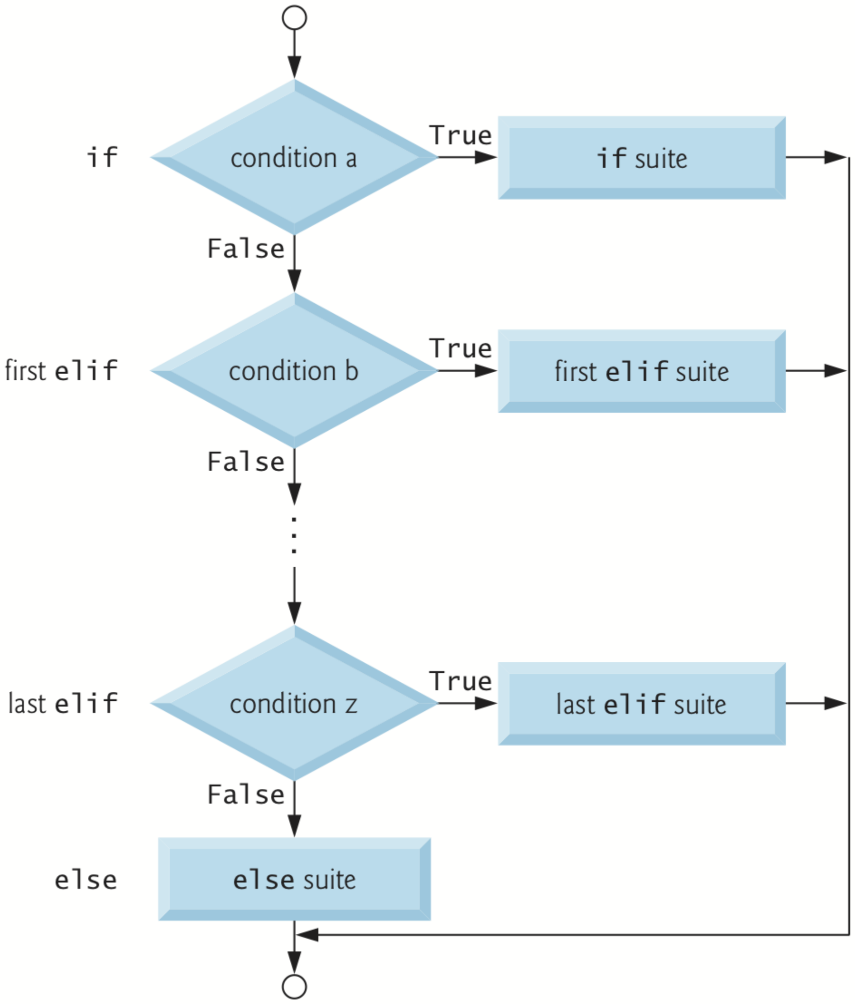
```
grade = 77
```

In [18]:

```
if grade >= 90:
    print('A')
elif grade >= 80:
    print('B')
elif grade >= 70:
    print('C')
elif grade >= 60:
    print('D')
else:
    print('F')
```

```
C
```

`if`…`elif`…`else` Statement Flowchart



`else` Is Optional

- Handle values that do not satisfy any of the conditions.
- Without an `else` , if no conditions are `True` , the program does not execute any of the statement's suites.

Logic Errors

- For a nonfatal logic error, code executes, but produces incorrect results.
- For a fatal logic error in a script, an exception occurs, Python displays a traceback, then the script terminates.
- A fatal error in interactive mode terminates the current snippet, then IPython waits for your next input.

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3.7 `while` Statement

- Repeats one or more actions while a condition remains `True`.

In [1]:

```
product = 3
```

In [2]:

```
while product <= 50:
    product = product * 3
```

In [3]:

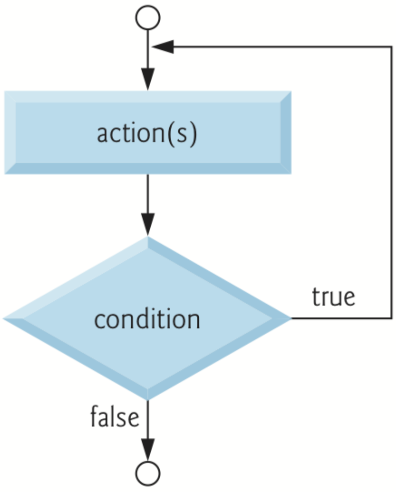
```
product
```

Out[3]:

```
81
```

- To prevent an infinite loop, something in the `while` suite must change `product`'s value, so the condition eventually becomes `False`.

`while` Statement Flowchart



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3.8 `for` Statement

- Repeat an action or several actions for each item in a sequence of items.
- A string is a sequence of individual characters.

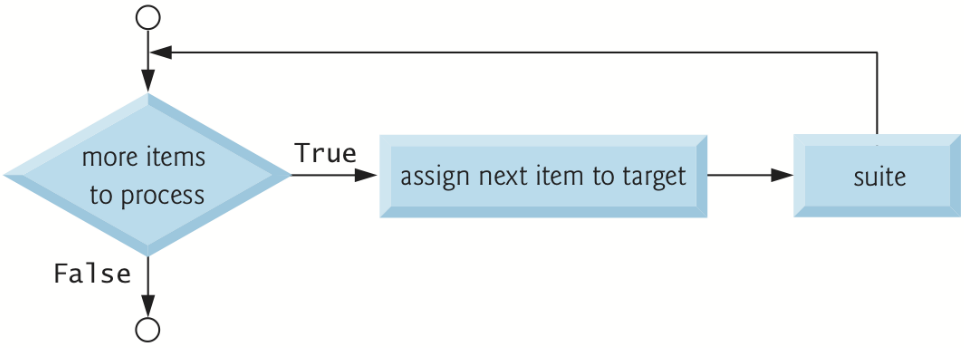
In [1]:

```
for character in 'Programming':
    print(character, end='  ')
```

```
P  r  o  g  r  a  m  m  i  n  g
```

- Upon entering the `for` loop, Python assigns the 'P' in 'Programming' to the **target variable** between keywords `for` and `in`.
- After executing the suite, Python assigns to character the next item in the sequence (that is, the `'r'` in `'Programming'`), then executes the suite again.
- Continues while there are more items in the sequence.
- Using the target variable in the suite is common but not required.

`for` Statement Flowchart



Function `print`'s `end` Keyword Argument

- `print` displays its argument(s), then moves the cursor to the next line.
- Can change this behavior with the argument `end`:

```
print(character, end='  ')
```

- `end` is a **keyword argument**, but it's not a Python keyword.
- The *Style Guide for Python Code* recommends placing no spaces around a keyword argument's =.
- Keyword arguments are sometimes called named arguments.

Function `print` ’s `sep` Keyword Argument

- Keyword argument `sep` (short for separator) specifies the string that appears between the items that print displays.
- A space character by default.
- To remove the spaces, use an empty string with no characters between its quotes.

In [2]:

```
print(10, 20, 30, sep=', ')
```

```
10, 20, 30
```

3.8.1 Iterables, Lists and Iterators

- The sequence to the right of the `for` statement’s in keyword must be an iterable.
  - An object from which the `for` statement can take one item at a time.
- One of the most common iterables is a list, which is a comma-separated collection of items enclosed in square brackets (`[` and `]`).

In [3]:

```
total = 0
```

In [4]:

```
for number in [2, -3, 0, 17, 9]:
    total = total + number
```

In [5]:

```
total
```

Out[5]:

```
25
```

- Each sequence has an iterator.
- The for statement uses the iterator “behind the scenes” to get each consecutive item until there are no more to process.

3.8.2 Built-In `range` Function and Generators

- Creates an iterable object that represents a sequence of consecutive integer values starting from 0 and continuing up to, but not including, the argument value.

In [6]:

```
for counter in range(10):
    print(counter, end=' ')
```

```
0 1 2 3 4 5 6 7 8 9
```

Off-By-One Errors

A logic error known as an off-by-one error occurs when you assume that `range`'s argument value is included in the generated sequence.

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3.10 Program Development: Sequence-Controlled Iteration

- Most challenging part of solving a problem on a computer is developing an algorithm for the solution.
- Once a correct algorithm has been specified, creating a working Python program from the algorithm is typically straightforward.

3.10.1 Requirements Statement

- A **requirements statement** describes what a program is supposed to do, but not how the program should do it.
- Consider the following simple requirements statement:

> A class of ten students took a quiz. Their grades (integers in the range 0 – 100) are 98, 76, 71, 87, 83, 90, 57, 79, 82, 94. Determine the class average on the quiz.

- Once you know the problem's requirements, you can begin creating an algorithm to solve it. Then, you can implement that solution as a program.
- The algorithm for solving this problem must:
  - Keep a running total of the grades.
  - Calculate the average—the total of the grades divided by the number of grades.
  - Display the result.

3.10.2 Pseudocode for the Algorithm

```
Set total to zero
Set grade counter to zero
Set grades to a list of the ten grades

For each grade in the grades list:
    Add the grade to the total
    Add one to the grade counter

Set the class average to the total divided by the number of grades
Display the class average
```

- Note the mentions of **total** and **grade counter**.
- We'll use these in the script to calculate the average.
- Variables for totaling and counting normally are initialized to zero.

3.10.3 Coding the Algorithm in Python

```python
# fig03_01.py
"""Class average program with sequence-controlled iteration."""

# initialization phase
total = 0  # sum of grades
grade_counter = 0
grades = [98, 76, 71, 87, 83, 90, 57, 79, 82, 94]  # list of 10 grades

# processing phase
for grade in grades:
    total += grade  # add current grade to the running total
    grade_counter += 1  # indicate that one more grade was processed

# termination phase
average = total / grade_counter
print(f'Class average is {average}')
```

In [1]:

```
run fig03_01.py
```

```
Class average is 81.7
```

Execution Phases

- Initialization phase creates the variables needed to process the grades and set these variables to appropriate initial values.
- Processing phase processes the grades, calculating the running total and counting the number of grades processed so far.
- Termination phase calculates and displays the class average.
- Many scripts can be decomposed into these three phases.

3.10.4 Introduction to Formatted Strings

- An **f-string** (short for formatted string) allows inserting values into a string.
- The letter f before the string's opening quote indicates it's an f-string.
- You specify where to insert values by using placeholders delimited by curly braces ({ and }).
- `{average}` converts the variable average's value to a string representation, then replaces `{average}` with that *&replacement text**.
- Replacement-text expressions may contain values, variables or other expressions.

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3.13 Built-In Function `range`: A Deeper Look

- Function `range`'s two-argument version produces a sequence of consecutive integers from its first argument's value up to, but not including, the second argument's value

In [1]:

```
for number in range(5, 10):
    print(number, end=' ')
```

```
5 6 7 8 9
```

- Function `range`'s three-argument version produces a sequence of integers from its first argument's value up to, but not including, the second argument's value, incrementing by the third argument's value (the step)

In [2]:

```
for number in range(0, 10, 2):
    print(number, end=' ')
```

```
0 2 4 6 8
```

- If the third argument is negative, the sequence progresses from the first argument's value down to, but not including the second argument's value, decrementing by the third argument's value

In [3]:

```
for number in range(10, 0, -2):
    print(number, end=' ')
```

```
10 8 6 4 2
```

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3.15 `break` and `continue` Statements

- Executing a `break` statement in a `while` or `for` immediately exits that statement.

In [1]:

```
for number in range(100):
    if number == 10:
        break
    print(number, end=' ')
```

```
0 1 2 3 4 5 6 7 8 9
```

- Executing a `continue` statement in a `while` or `for` loop skips the remainder of the loop's suite.
    - In a `while`, the condition is then tested to determine whether the loop should continue executing.
    - In a `for`, the loop processes the next item in the sequence (if any)

In [2]:

```
for number in range(10):
    if number == 5:
        continue
    print(number, end=' ')
```

```
0 1 2 3 4 6 7 8 9
```

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3.16 Boolean Operators `and`, `or` and `not`

Boolean Operator `and`

- Ensure that two conditions are both `True` with the **Boolean `and` operator**.

In [1]:

```
gender = 'Female'
```

In [2]:

```
age = 70
```

In [3]:

```
if gender == 'Female' and age >= 65:
    print('Senior female')
```

```
Senior female
```

- *Truth table* for the `and` operator:

expression1	expression2	expression1 `and` expression2
`False`	`False`	`False`
`False`	`True`	`False`
`True`	`False`	`False`
`True`	`True`	`True`

Boolean Operator `or`

- Ensure that one *or* both of two conditions are `True` with the **Boolean `or` operator**.

In [4]:

```
semester_average = 83
```

In [5]:

```
final_exam = 95
```

In [6]:

```
if semester_average >= 90 or final_exam >= 90:
    print('Student gets an A')
```

```
Student gets an A
```

- *Truth table* for the `or` operator:

expression1	expression2	expression1 or expression2
`False`	`False`	`False`
`False`	`True`	`True`
`True`	`False`	`True`
`True`	`True`	`True`

Improving Performance with Short-Circuit Evaluation

- Python stops evaluating an `and` expression as soon as it knows whether the entire condition is `False`.
- Python stops evaluating an `or` expression as soon as it knows whether the entire condition is `True`.
- In expressions that use `and`, make the condition that's more likely to be `False` the leftmost condition.
- In `or` operator expressions, make the condition that's more likely to be `True` the leftmost condition.

Boolean Operator `not`

- "Reverse" the meaning of a condition.
- **Unary operator**—it has only *one* operand.

In [7]:

```
grade = 87
```

In [8]:

```
if not grade == -1:
    print('The next grade is', grade)
```

```
The next grade is 87
```

In [9]:

```
if grade != -1:
    print('The next grade is', grade)
```

```
The next grade is 87
```

- Truth table for the `not` operator.

expression	not expression
`False`	`True`
`True`	`False`

- Precedence and grouping of the operators introduced so far—shown in decreasing order of precedence.

Operators	Grouping
`()`	left to right
`**`	right to left
`*` `/` `//` `%`	left to right
`+` `-`	left to right
`<` `<=` `>` `>=` `==` `!=`	left to right
`not`	left to right
`and`	left to right
`or`	left to right

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3.17 Intro to Data Science: Measures of Central Tendency—Mean, Median and Mode

- **Measures of central tendency**:
    - **mean**—the *average value* in a set of values.
    - **median**—the *middle value* when all the values are arranged in sorted order.
    - **mode**—the *most frequently occurring value*.
- Each represents a “central” value in a set of values.
    - A value which is in some sense typical of the others.

In [1]:

```
grades = [85, 93, 45, 89, 85]
```

In [2]:

```
sum(grades) / len(grades)
```

Out[2]:

```
79.4
```

- `sum` and `len` are both examples of functional-style programming reductions
- The Python Standard Library’s **`statistics`** module provides functions for calculating the **reductions** mean, median and mode.

In [3]:

```
import statistics
```

In [4]:

```
statistics.mean(grades)
```

Out[4]:

```
79.4
```

In [5]:

```
statistics.median(grades)
```

Out[5]:

```
85
```

In [6]:

```
statistics.mode(grades)
```

Out[6]:

```
85
```

- Sorting `grades` helps you see the median and mode.

In [7]:

```
sorted(grades)
```

Out[7]:

```
[45, 85, 85, 89, 93]
```

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