

Python Lab1: Excel with openpyxl

Visual Programming

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1. Introduction

In this chapter we discuss

The Lab

Python

What's Next?

Are you curious about the Python language and wondering how to read and write Excel files? This manual uses the format of a hands-on Lab, with simple code examples that perform one basic task: compare two Excel files and output differences to a third Excel file. At the end of the Lab, you will know enough about Python to work with your own Excel files, even if you're new to Python or programming.

This manual uses a Python script file. A script is a simple text file with the ".py" extension. I tried to write the manual in such a way that beginners or experienced programmers could quickly find what they're looking for, skipping over details they're not interested in right now. The content is laid out and indexed so you can always come back and review those topics later.

The Lab of step-by-step examples walks through each line of code. There are over 40 illustrations. Since Project1 is only 50 lines of code, I may have gone overboard on the illustrations. I wanted you to visually

Chapter 1

see the code in action with numbered examples, screenshots, and tables. The written explanation and graphics highlight the line numbers in the code, so you can follow along and visualize the code running.

Download the sample Excel files and code from my Github account, as shown in the Appendix. The download includes this manual in PDF form; I'd encourage you to print the PDF and keep it by your side as you work through the Lab. While I can't be there in person to answer your questions, the printed PDF is the next best thing. Please feel free to copy and share the materials with others. If you'd be kind enough to leave a review, it might lead to another \$1 royalty in my future!

1.1 The Lab

The Lab has two parts. Part 1 accomplishes the basic tasks to compare the two Excel files and create the third Excel file. I think of this as the core program that gets the job done. Part 2 adds some nice-to-have features and shows how to customize the code for use with your own Excel files.

Hopefully, a working code example will take all the guesswork out of programming, leaving just the fun of learning something new. With this Lab, you don't have to wonder if you have the correct indentation, your counter is in the right place, or if you forgot the colon at the end of the line when you defined your function.

1.2 Python

Python is an open-source (free) programming language for Web Development, GUI development, Scientific and Numeric data science, Software Development, and System Administration. This Lab uses the open-source Anaconda Data Science Distribution that includes Python version 3.7. Spyder, the Scientific Python Development Environment, comes with Anaconda, and we'll write and run a Python script in Spyder on a Windows machine.

1.3 What's Next?

The next Chapter walks you through installing Anaconda and the basics of running code in Spyder.

Chapter 1

2. Setup & Getting Started

In this Chapter we discuss

Anaconda

Lab Files

Spyder

Run Project1.1.py File

What's Next?

In this Chapter we'll install Anaconda, set up your environment, and run the program Project1.1.

2.1 Anaconda

Download the Anaconda Distribution for Windows that includes Python version 3.7. Other versions will work but may vary slightly

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compared to the examples in this manual. When prompted, update your Path settings. The install will take a while, so you might want to grab a cup of coffee or something.

2.2 Lab Files

Download the files for this Lab and place them in the same folder. See the Appendix for details on the download Github location. It doesn't matter which folder you use because Spyder prompts you for this working directory when you run your program. The next figure displays my working directory and sample project files.

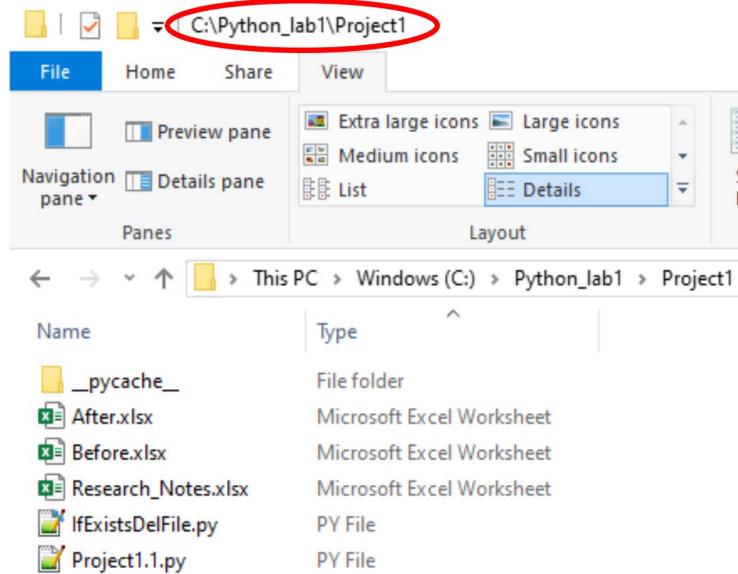


Figure 2.1 Project Files

2.3 Spyder

Launch Spyder from the Start Menu, in the Anaconda folder.

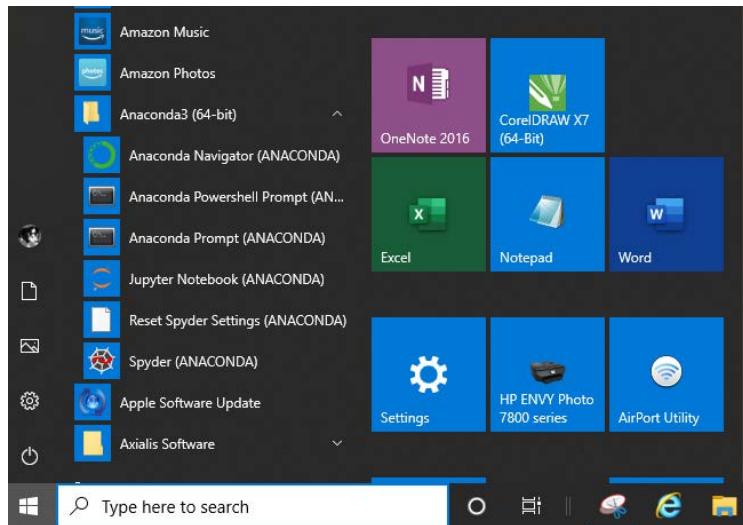


Figure 2.2 Launch Spyder

The Spyder Default Layout has three panes, as shown below. You can return to this layout at any time from the View menu under Windows Layouts. You can close or open other panes to suit your preferences.

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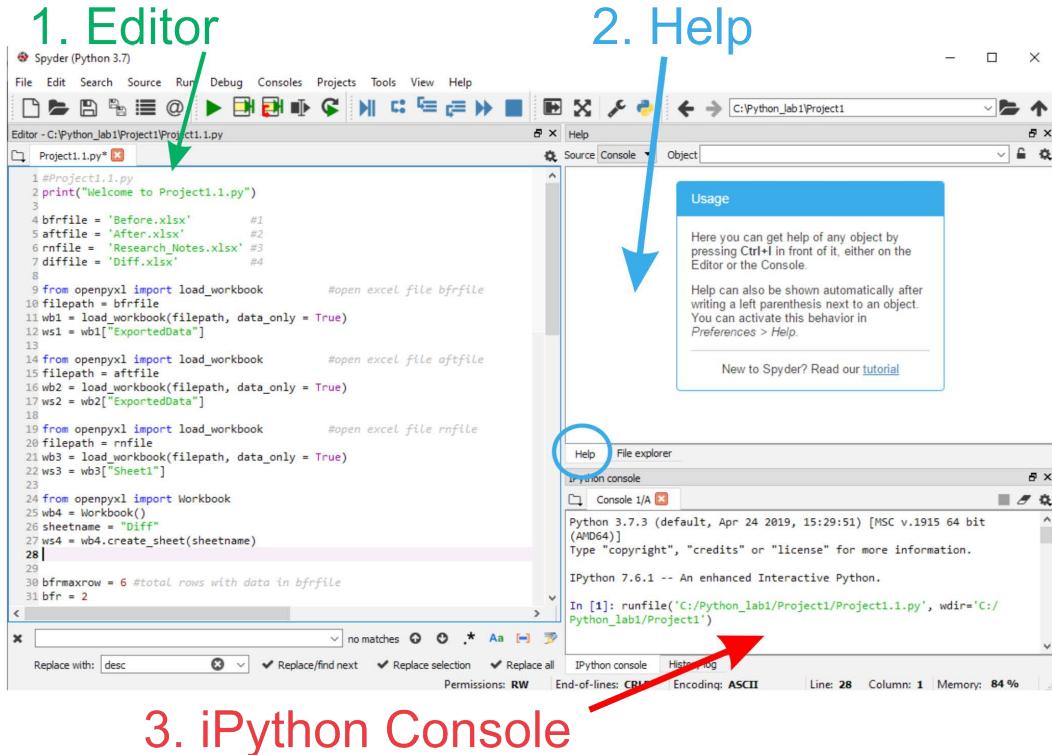


Figure 2.3 Project Files

1. The Editor window is where you type your code.
2. The Help window displays syntax and function help.
3. The iPython Console. When you click "Run," the results are output to the Console. Results include code output and error messages. For example, if you use the `Print` method, the results are output to the Console window. In the example below, the Console displays "**Welcome to Project1.1.py**".

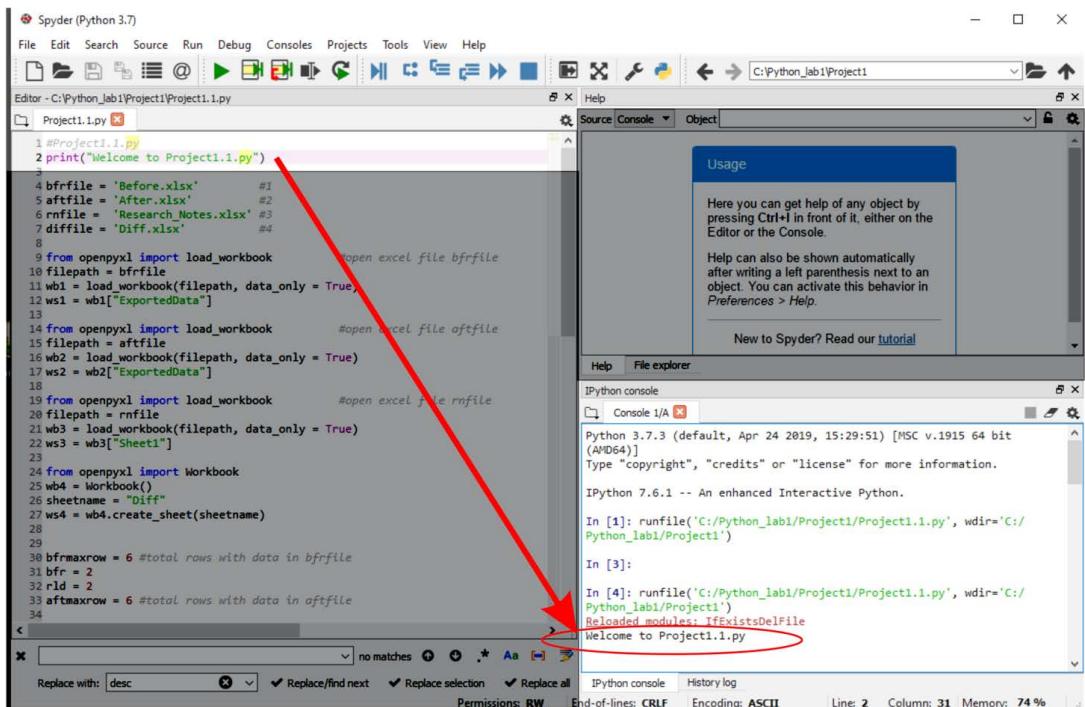


Figure 2.4 The iPython Console

2.4 Run Project1.1.py File

With Spyder open, click on the File menu, and then click on “Open” and browse to the directory with the Lab files. Open the “*Project1.1.py*” file. The Console window To run the code, click on the green arrow or use the Run menu, as shown below.

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Run

The screenshot shows the Spyder Python IDE interface. At the top, there is a menu bar with File, Edit, Search, Source, Run, Debug, Consoles, Projects, Tools, View, and Help. Below the menu bar is a toolbar with various icons for file operations like Open, Save, and Print, as well as run and debug symbols. A green arrow points from the word "Run" to the "Run" button in the toolbar. The main area is an "Editor" window titled "Editor - C:\Python_lab1\Project1\Project1.1.py". It contains Python code for a project named "Project1.1.py". The code uses the openpyxl library to handle Excel files (Before.xlsx, After.xlsx, Research_Notes.xlsx) and create a new file (Diff.xlsx). It also creates a new workbook and sheet named "Diff". The code is numbered from 1 to 31. At the bottom of the editor, there is a search and replace toolbar with fields for "Replace with: desc" and checkboxes for "Replace/find next", "Replace selection", and "Replace all". There is also a "Permissions: RW" button.

```
1 #Project1.1.py
2 print("Welcome to Project1.1.py")
3
4 bfrfile = 'Before.xlsx'          #1
5 aftfile = 'After.xlsx'          #2
6 rnfile = 'Research_Notes.xlsx' #3
7 diffile = 'Diff.xlsx'           #4
8
9 from openpyxl import load_workbook      #open excel file bfrfile
10 filepath = bfrfile
11 wb1 = load_workbook(filepath, data_only = True)
12 ws1 = wb1["ExportedData"]
13
14 from openpyxl import load_workbook      #open excel file aftfile
15 filepath = aftfile
16 wb2 = load_workbook(filepath, data_only = True)
17 ws2 = wb2["ExportedData"]
18
19 from openpyxl import load_workbook      #open excel file rnfile
20 filepath = rnfile
21 wb3 = load_workbook(filepath, data_only = True)
22 ws3 = wb3["Sheet1"]
23
24 from openpyxl import Workbook
25 wb4 = Workbook()
26 sheetname = "Diff"
27 ws4 = wb4.create_sheet(sheetname)
28
29
30 bfrmmaxrow = 6 #total rows with data in bfrfile
31 bfr = 2
```

Figure 2.5 Run the Program

In the next figure, I have two panes open. The Editor is on the left, and the Output window is on the right. Initially, the Console window displays **In [1]:**. After I click “Run,” the Console window changes, as shown below. The first output line displays the name of the program file and the working directory.

In [1]: runfile('C:/Python_lab1/Project1/Project1.1.py', wdir='C:/Python_lab1/Project1')

Welcome to Project1.1.py

In [2]:

The screenshot shows the Spyder Python IDE interface. The top menu bar includes File, Edit, Search, Source, Run, Debug, Consoles, Projects, Tools, View, and Help. The title bar says "Spyder (Python 3.7)". The left pane is the "Editor" containing the code for "Project1.1.py". The right pane is the "IPython console". The console output shows the program running and creating a new file "Diff.xlsx".

```

Spyder (Python 3.7)
File Edit Search Source Run Debug Consoles Projects Tools View Help
Editor - C:\Python_lab1\Project1\Project1.1.py IPython console
In [1]: runfile('C:/Python_lab1/Project1/Project1.1.py', wdir='C:/Python_lab1/Project1')
Welcome to Project1.1.py
In [2]:

```

Figure 2.6 The Console

After running the program, there is a new file “*Diff.xlsx*” in the working directory, **wdir='C:/Python_lab1/Project1'**.

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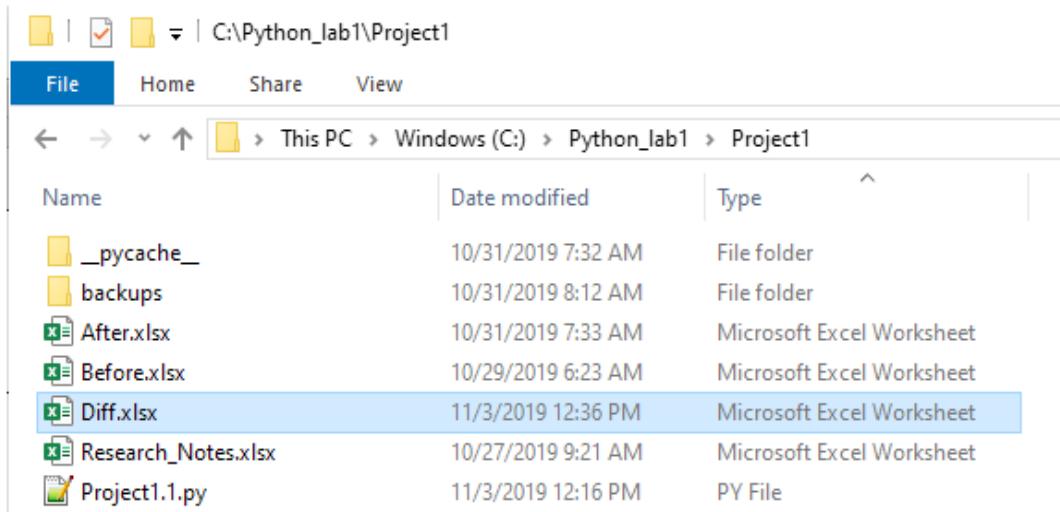


Figure 2.7 The New Diff.xlsx File

2.5 Help

In Spyder, click on the View menu and click “Panes”, and open the “Help” pane. Now, click on the Help menu and click on “Spyder Tutorial.” The tutorial opens in the Help pane. The topic “Recommended first steps for Python beginners” is an excellent resource for new programmers.

The “Debugging” topic demonstrates how to look at your code while it’s running, in effect “debugging.” The Editor pane highlights the line of code that is about to be executed, and the Variable Explorer displays the values in each variable in the current context.

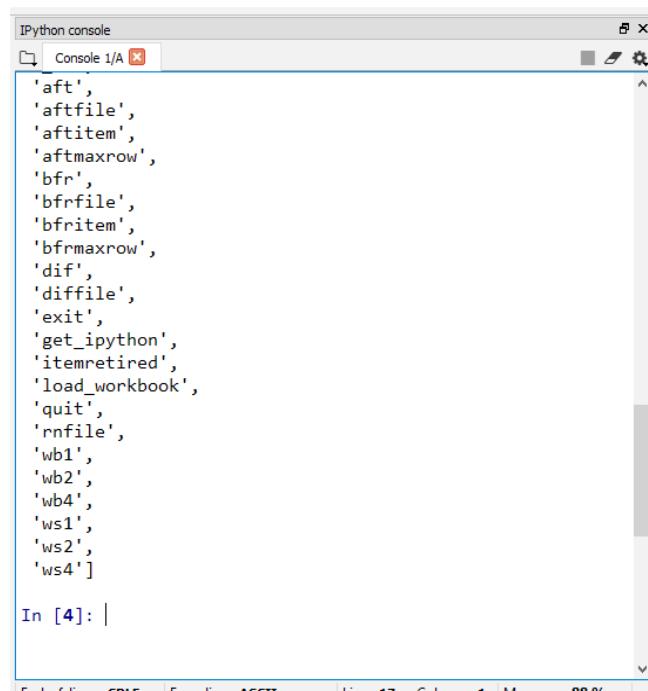
While I’m not going to go into a lot of detail on debugging and help topics, I did want to cover two functions.

`dir()`

`help()`

dir()

The function **dir()** displays a list of names in the current local scope, as shown in the next figure. After running the sample “*Project1.1.py*” script, the local scope of changes. For example, after running the “*Project1.1.py*” script, the **dir()** function displays relevant information about your script. Type the command in the Console window.



A screenshot of the IPython console window titled "Console 1/A". The window shows the output of the `dir()` function, which lists various objects and methods. The list includes: 'aft', 'aftfile', 'aftitem', 'aftmaxrow', 'bfr', 'bfrfile', 'bfritem', 'bfrmaxrow', 'dif', 'diffile', 'exit', 'get_ipython', 'itemretired', 'load_workbook', 'quit', 'rnfile', 'wb1', 'wb2', 'wb4', 'ws1', 'ws2', and 'ws4'. Below the list, the text "In [4]: |" is visible, indicating the current input cell number.

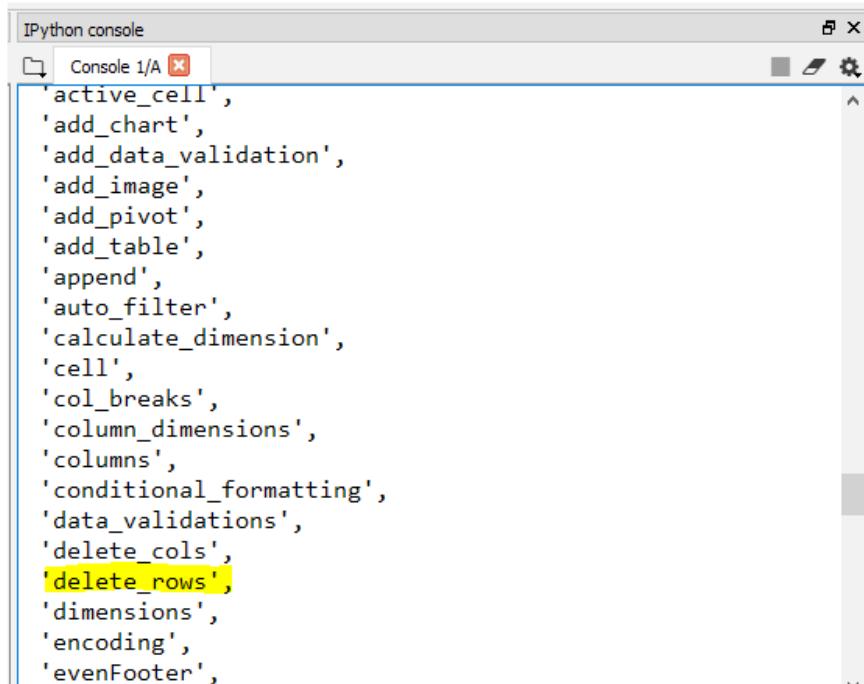
Figure 2.8 Objects in Current Local Scope

At this point, the function results aren't exactly exciting. Type **dir(ws4)** in the Console window display attributes specific to the ws4 object. Attributes vary depending on the type of object.

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There is quite a long list of valid attributes for the `ws4` object, and the next example is only showing a few of the attributes. In particular, I'm interested in what functions I can use with the `ws4` object, and I've highlighted the `"delete_rows"` method.

Note, if you're using an older version of Python, `"delete_rows"` might not be available. The `dir()` function is an easy way to check if a particular function or method should work with your code.



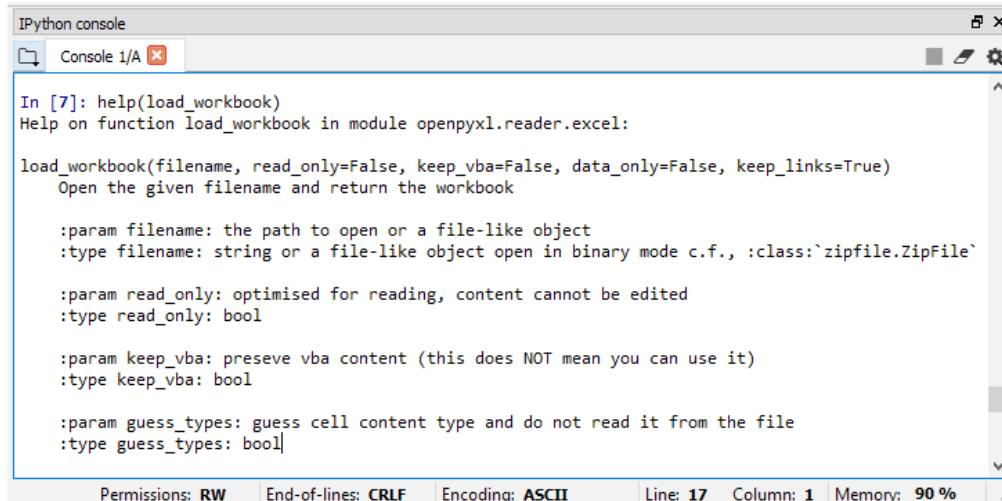
```
IPython console
Console 1/A
['active_cell',
 'add_chart',
 'add_data_validation',
 'add_image',
 'add_pivot',
 'add_table',
 'append',
 'auto_filter',
 'calculate_dimension',
 'cell',
 'col_breaks',
 'column_dimensions',
 'columns',
 'conditional_formatting',
 'data_validations',
 'delete_cols',
 'delete_rows',
 'dimensions',
 'encoding',
 'evenFooter',
```

Figure 2.9 Valid Attributes for the `ws4` Object

help()

The `help()` function invokes the help system for help with a module, function, class, method, keyword, or documentation topic.

For example, when I type `help(load_workbook)` in the Console window, Python displays information specific to that method.



The screenshot shows an IPython console window titled "IPython console". In the top-left corner, it says "Console 1/A". The main area contains the following text:

```
In [7]: help(load_workbook)
Help on function load_workbook in module openpyxl.reader.xlsx:

load_workbook(filename, read_only=False, keep_vba=False, data_only=False, keep_links=True)
    Open the given filename and return the workbook

:param filename: the path to open or a file-like object
:type filename: string or a file-like object open in binary mode c.f., :class:`zipfile.ZipFile`

:param read_only: optimised for reading, content cannot be edited
:type read_only: bool

:param keep_vba: preseve vba content (this does NOT mean you can use it)
:type keep_vba: bool

:param guess_types: guess cell content type and do not read it from the file
:type guess_types: bool
```

At the bottom of the console window, there are status indicators: "Permissions: RW", "End-of-lines: CRLF", "Encoding: ASCII", "Line: 17", "Column: 1", and "Memory: 90 %".

Figure 2.10 Help for `load_workbook` Method

2.6 What's Next?

Your Lab environment is now setup. Let's move on to Chapter 3, where we look at the code line-by-line.

Chapter 2

3. Project 1

In this chapter we discuss

Overview

Structure of the Excel Files

Syntax

Types of Data

Lists vs. Tuples

Immutable Objects

Variables

Objects

Statements

Comparison Operators

The openpyxl Library

Step 1.0: Bfr Loop

Chapter 3

Step 2.0: Aft Loop

Step 2.1: Loop Until Column B Match

Step 2.2: Column B Match is Found

Step 3.0: Compare Column C

Step 3.1: Column C Data Does Not Match

Step 4.0: Write to New Excel File

Step 4.1: Save the New File

Now that your environment is set up, we'll look at Project 1. While walking through the code, I'll introduce the following basic concepts, and explain each as it relates to the sample code. We'll look at chunks of code and focus on one particular concept at a time, so you can quickly skip over familiar concepts.

- Syntax
- Structure of Excel Files
- Variables and Data Types
- Objects
- Statements
- Comparison Operators
- Lists
- The openpyxl Library, Classes, & Objects
- Loop (Bfr counter)
- Read data from a Cell
- Loop (Aft counter)
- Search for a Match
- If ... Else Statements

With a few minor adjustments, you can customize this code to work for your files. I'll show you where to add your Excel filenames and update column numbers in the next Chapter.

3.1 Overview

In Lab 1 - Part 1, the script "*Project1.1.py*" compares data between two Excel files. This Lab is similar to the Excel "vlookup" function. Below I show you the basic steps. I'll refer back to these steps throughout this Chapter.

- Step 1.** To begin, in the "*Before.xlsx*" file, compare the "**Item**" name in Column B for each row in the "*Before.xlsx*" Excel worksheet.
- Step 2.** Next, in the "*After.xlsx*" file in Column B, find the row in the "*After.xlsx*" file with the same "**Item**" name from Step 1.
- Step 3.** Compare Column C "**Description**" in the "*Before.xlsx*" file with Column C "**Description**" in the "*After.xlsx*" file.
- Step 4.** If the data in Step 3 doesn't match, write the information to a new Excel file "*Diff.xlsx*."

3.2 Structure of the Excel Files

- Step 1.** In the "*Before.xlsx*" file, I am using the "**ExportedData**" worksheet.
 - In the code, Column B, "**Item**" is Column "2."
 - In the code, Column C, "**Description**" is Column "3."

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The screenshot shows an Excel spreadsheet window titled "Before.xlsx - Excel". The ribbon menu includes File, Home, Insert, Draw, Page L, Formu, Data, and Revie. The active sheet is labeled "A1" in the top-left corner. Below the ribbon is a toolbar with a delete icon, a checkmark, and a formula icon. The main area contains a table with four columns: Item_Num, Item, Description, and ExpireDate. The table has 6 rows of data. Row 1 is the header. Rows 2 through 6 contain data: Item1, Desc1, 12/31/9999; Item2, Desc2, 12/31/9999; Item3, Desc3, 12/31/9999; Item4, Desc4, 3/3/2019; and Item5, Desc5, 12/31/9999. At the bottom of the table, there is a summary row with "Average: 315.4", "Count: 6", and "Sum: 1577". Below the table, the word "ExportedData" is written in green, followed by a small green plus sign icon. The entire table is highlighted with a green border.

Item_Num	Item	Description	ExpireDate
957	Item1	Desc1	12/31/9999
48	Item2	Desc2	12/31/9999
270	Item3	Desc3	12/31/9999
212	Item4	Desc4	3/3/2019
90	Item5	Desc5	12/31/9999

Figure 3.1 Before.xlsx File

Step 2. In the “After.xlsx” file, I am using the “**ExportedData**” worksheet.

- In the code, Column B, “**Item**” is Column “2.”
- In the code, Column C, “**Description**” is Column “3.”

	A	B	C	D
1	Item	Item	Description	ExpireDate
2	48	Item2	Desc2NoMatch	12/31/9999
3	90	Item5	Desc5	12/31/9999
4	212	Item4	Desc4	3/3/2019
5	270	Item3	Desc3	12/31/9999
6	957	Item1	Desc1	12/31/9999
7				

Figure 3.2 After.xlsx File

Step 4. In the new “Diff.xlsx” Excel workbook, I am writing to the “**Diff**” worksheet.

- In the new “Diff.xlsx” file, cell A2 is “**Item2**.” In the code, this is “**BfrItem**” that represents Column “1” from “Before.xlsx.”
- In the new “Diff.xlsx” file, cell B2 is “**Desc2**.” In the code, this is “**Bfr Description**” or Column “2” in “Before.xlsx.”
- In the new “Diff.xlsx” file, C2 “**Aft Description**” is from Column “C” from “After.xlsx.”

	A	B	C
1			
2	Item2	Desc2	Desc2NoMatch
3			
4			
5			

Figure 3.3 Diff.xlsx File

3.3 Syntax

The Style Guide for Python Source Code is known as “PEP8”. In Spyder on the Tools menu, you can change Preferences for the Editor to check for PEP8 in “Code Introspection/Analysis.” This is a great way to insure your code is in the format expected by all Python developers.

PEP8 recommends the best practice in Python is to use lowercase for variable and function names. Also, when creating variables or defining functions, do not use spaces. Instead, use underscores. Python has reserved keywords like “global” or “try.” When you use a keyword as a variable name it causes a syntax error.

- Variable names begin with a letter.
- Use underscores instead of spaces.

- Use lowercase.
- Do not use keywords.
- Numbers are allowed (except as the first character.)

Indentation in Python scripts defines a code block and must be consistent. Later in this Chapter, you can see an example of the importance of indentation in the topic, "Step 1.1: Bfr Loop."

3.4 Types of Data

Python has several types of data. Text, numeric, and sequence (list/tuple) are some of the built-in data types. A few basic types are shown below. In this lab we will use the **int**, **str**, and **list** types.

Type	Description	Assignment	Value
int	integer	my_var=3	3
str	string of characters	my_var2='Hi'	Hi
float	floating-point number	my_var3=3.85	3.85
bool	boolean (true/false)	my_var4=false	false

Table 3.1 Data Types

Using the examples in the table, the statement **float(my_var+5)** returns **8.0**.

While the statement **print(34/my_var)** returns **11**.

When working with data, you may need to change or convert the data type. For example, during a calculation you may want to convert between a **float** and an **int** to remove decimal places. When

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concatenating numeric values and strings, you would convert the integer value to a string with the statement `str(my_int)`.

```
int(my_var)  
str(my_var)  
float(my_var)  
bool(my_var)
```

If you're unsure of the data type, the `type()` function will display the type of data.

```
print(type(my_var))
```

Integers

When assigning integer values do not use commas. Python interprets 2,000,000 as three integers separated by commas. In the previous example, I assign 2000000 to the integer variable “`mynumber`.”

Strings

To assign a value to a string variable, use single quotes, as shown below.

```
>>>myfilename = 'myExcelfile.xlsx'
```

A **string** is a sequence of characters.

Note: A **list** is a collection of ordered values. A unique index number, or name, refers to each list item. The index is used when updating list items. Lists are discussed later in this Chapter.

3.5 Lists vs. Tuples

A **list** is an ordered collection of values, and is mutable. This means the values can change. A unique index number, or name, refers to each list item. Lists use square brackets [] and usually have similar data types. The index is used when updating list items.

```
ws1 = wb1["ExportedData"]
```

In this example, the workbook object "wb1" is a **list** item. The index "**ExportedData**" refers to one of the worksheets in the **list**.

A **tuple** is similar to a list, and is immutable. Immutable objects can not be changed and are explained in the next section. Tuples use parentheses () and can have heterogeneous data, meaning tuples can have different data types.

3.6 Immutable Objects

Python string and int types are immutable, which means the values can not be changed. You can **not** change an existing string, but you can create a new string with changed data.

If you're new to programming this concept may seem strange. Take the case of a variable of type "**int**" in Python. The code statement **bfr = bfr + 1** seems to change the value of **bfr**. In reality, this statement creates a new variable. The new variable has a new identifier and different location in memory. To see this in action run this code to see the identifiers for the **bfr** objects.

```
print(id(bfr))
bfr = bfr + 1
print(id(bfr))
```

Immutable objects are quicker to access and this improves code performance. Another advantage of immutable objects is understandability, and knowing the object will never change.

3.7 Variables

Think of a variable as a container to store values. When a program runs, the value inside the **variable** may change. A letter or number is a value. An **assignment statement** creates a variable and assigns a value, as shown below. The left side of an assignment statement must be a variable.

```
>>> mynumber = 2000000
```

Lab Variables

When translating the Lab steps into Python code, I've added variables to make it easier to work with the data.

Step 1. In the “*Before.xlsx*” file, compare the “**Item**” name from Column B for each row in that Excel file.

- The “**bfrfile**” variable represents the Excel filename. The type of this variable is a string.
- The “**bfr**” variable represents the current row number in the “*Before.xlsx*” Excel file. The type of this variable is an integer, and I use it to keep track of the row count.
- The “**bfrmamaxrow**” variable represents the total number of rows with data in the “*Before.xlsx*” worksheet. The type of this variable is an integer.

Later in this Chapter, I explain using these integer variables in the topic, “Step 1.0: Bfr Loop.”

The figure below assigns data to the **string** variables in lines 4 to 7. Notice the string data is enclosed in single quotes. The light grey text on the right side of some lines is a **comment**. Anything to the right of a hashtag # is a comment. Programmers may add comments to explain or clarify code.

The screenshot shows the Spyder Python 3.7 IDE interface. The menu bar includes File, Edit, Search, Source, Run, Debug, Consoles, Projects, Tools, View, and Help. Below the menu is a toolbar with various icons. The main area is titled "Editor - C:\Python_Lab1\Project1\Project1.1.py". A file browser window is open, showing a folder icon and the file "Project1.1.py*". The code editor contains the following Python script:

```
1 #Project1.1.py
2 print("Welcome to Project1.1.py")
3
4 bfrfile = 'Before.xlsx'          #1
5 aftfile = 'After.xlsx'          #2
6 rnfile = 'Research_Notes.xlsx' #3 this file will be used in Part 2
7 difffile = 'Diff.xlsx'          #4
8
```

Two lines of code are circled with orange circles: line 4 and line 7. Line 4 is circled once, and line 7 is circled twice.

Figure 3.4 String Variables

- Step 2.** Find the row in the “After.xlsx” file in Column B, with the same **“Item”** name from Step 1. Loop through all rows in the “After.xlsx” file, checking for a match in Column B to Column B in “Before.xlsx.”
- The “**aftfile**” variable represents the filename.
 - The “**aft**” variable represents the current row number in “After.xlsx.”
 - The “**aftmaxrow**” variable represents the number of rows with data in the “After.xlsx” spreadsheet.

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Later in this Chapter, I explain using these integer variables in the topic, “Step 2.0: Aft Loop.”

Step 3. After a match is found in Column B, compare Column C “**Description**” data in the “*Before.xlsx*” file with Column C “**Description**” data in the “*After.xlsx*” file.

Step 4. If the data in Step 3 Column C doesn’t match, write the information to a new Excel file “*Diff.xlsx*.”

- The “**diffile**” variable represents the “*Diff.xlsx*” filename.
- The “**dif**” variable represents the current row number in the “*Diff.xlsx*” file.

The figure below has additional variables on lines 23 to 26, and on line 30. These are all **integer** variables. When assigning integer values, simply type the number. Quotes are not needed.

```
22
23     bfrmaxrow = 6 #total rows with data in bfrfile
24     bfr = 2
25     dif = 2
26     aftmaxrow = 6 #total rows with data in aftfile
27
28     while bfr <= bfrmaxrow:
29         bfritem = wsl.cell(row = bfr, column = 2)
30         aft = 2
31         itemretired = 1
```

Figure 3.5 Integer Variables

3.8 Objects

An object is a collection of data. Objects have an identity, type, and value. With **openpyxl**, you assign **objects** to both the workbook and worksheet, and then you use those **objects** with **methods** to read or update values (the data).

```
from openpyxl import load_workbook
wb2 = load_workbook(aftfile, data_only = True)
ws2 = wb2["ExportedData"]
```

The next section on the **openpyxl** Library looks at objects in detail.

3.9 Statements

The actions that a program takes are called “statements.”

3.10 Comparison Operators

Use Comparison Operators to compare two values.

Operator	Description
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to
==	Equal
!=	Not equal

Table 3.2 Comparison Operators

3.11 The openpyxl Library

The **library** “openpyxl” is used to read and write Excel files. After a brief explanation of how to work with the library, we’ll look at two of the openpyxl classes.

Step 1. Recall that for the “Before.xlsx” file, “**bfrfile**” represents that Excel file. The code below uses the “openpyxl” library to open the workbook for read access using the “load_workbook” method on line 11 in the “Project1.1.py” script file.

```
Line 10: from openpyxl import load_workbook  
Line 11: wb1 = load_workbook(bfrfile, data_only = True)  
Line 12: ws1 = wb1["ExportedData"]
```

In this example, line 12 uses the workbook object “wb1” and references the **list** item “**ExportedData**”. Recall that a **list** is a collection of ordered values. The index “**ExportedData**” refers to one of the worksheets in the **list**.

Description	Before.xlsx	After.xlsx	Diff.xlsx
Workbook	wb1 object	wb2 object	wb4 object
Worksheet	ws1 object	ws2 object	ws4 object
Represents	“ExportedData”	“ExportedData”	“Diff”

Table 3.3 Excel Objects

To access data in an Excel workbook, first you assign **objects** to both the workbook and worksheet, and then you use those **objects** with **methods** to read or update values (the data). In the previous example, the first line of code opens the “openpyxl” library and imports

the “**load_workbook**” **class**. On the second line, the “**load_workbook**” **method** creates a workbook **object** “**wb1**.” The final step is to create a worksheet **object**, “**ws1**.”

- 1.** Import the “openpyxl” class “**load_workbook**.”
- 2.** On the line 11, the method “**load_workbook**” assigns the “**wb1**” object to the “**bfrfile**” file.
- 3.** On the line 12, the object “**ws1**” is assigned to the sheet “**Exported Data**.”

Note: Functions are a sequence of statements. A method is similar, except a **method** is used with objects.

The next section has a topic, “Read Data from a Cell,” that uses the worksheet object “**ws1**” with the “cell” **method** to read the cell data or “values.”

Step 2. For the “*After.xlsx*” file, “**aftfile**” represents the file.

```
Line 14: from openpyxl import load_workbook
Line 15: wb2 = load_workbook(aftfile, data_only = True)
Line 16: ws2 = wb2["ExportedData"]
```

- In Step 2, the workbook **object** is “**wb2**.”
- The worksheet **object** is “**ws2**.”

Step 4. In Step 4, when the data from “*Before.xlsx*” column C does not match the data in “*After.xlsx*” column C, I write data into a new Excel file “*Diff.xlsx*.” The code shown below creates new workbook and worksheet objects.

```
Line 18: from openpyxl import Workbook
```

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```
Line 19: wb4 = Workbook()  
Line 20: ws4 = wb4.create_sheet("Diff")
```

This code is slightly different than Step 2 and uses the “Workbook” **method** on line 19 to create an object to represent the new “*Diff.xlsx*” workbook.

- In Step 4 the workbook **object** is “**wb4**.”
- The worksheet **object** is “**ws4**.”

At this point, we only need the workbook and worksheet **objects** (**wb4** and **ws4**.) Later in this example, we’ll save this new workbook using the filename “**Diff.xlsx**.” In case you’re wondering what it looks like, this is the “save” **function** code.

```
wb4.save(diffile)
```

3.12 Step 1.0: Bfr Loop

This Project example uses two nested code “while statements.” The actions that a program takes are called “statements.” When the “while statement” on the first line is true, it executes statements on the next line, or lines. These lines below the “while statement” are indented, as shown in the next figure.

In this example of a “while loop,” I use two variables as counters for the loop.

- bfr
- bfrmmaxrow

The first “while” statement on line 28 loops through the code while the statement on line 28 is true. Let’s call this first “while loop” that begins on line 28 the “**bfr loop**.”

Line 28: `while bfr <= bfrmaxrow:`

On line 24 I set the variable `bfr = 2`, and on line 23 I set `bfrmaxrow = 6`. The statement above from line 28 evaluates to “`while 2 <= 6`.”

Note: In the next Chapter, I’ll show you a “**function**” to determine the maximum rows with data from your Excel file.

Indented Code Block

In the next figure, there is a red box around the “**bfr loop**” code from line 28 to 48. I added a red vertical dotted line to highlight where the code is indented.

Note the code on lines 29, 30, 31, 32, and 48 is indented to the same vertical level. This block of code is all part of the same “**bfr loop**.”

The shaded block of code is the second “while loop” (lines 34 to 46.) The second loop is “nested” because it is inside the first “**bfr loop**.” Within the “**bfr loop**,” line 38 only runs when the **if statement** on line 37 is true. Later, we’ll look at the nested “if statements” in lines 35 to 46. A nested if statement means there is a second “if statement” within the first.

The “**bfr**” counter on line 48 is the last line in this “**bfr loop**” and in effect moves forward in the loop to the next row in the “*Before.xlsx*” spreadsheet.

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The screenshot shows a code editor window titled "Project1.1.py*". The code is a script for processing two Excel files, "Before.xlsx" and "After.xlsx". It uses pandas to read the files into DataFrames and then iterates through rows to compare specific columns. A red box highlights the main loop structure from line 28 to line 48.

```
22  
23 bfrmaxrow = 6 #total rows with data in bfrfile  
24 bfr = 2  
25 dif = 2  
26 aftmaxrow = 6 #total rows with data in aftfile  
27  
28 while bfr <= bfrmaxrow:  
29     bfritem = ws1.cell(row = bfr, column = 2)  
30     aft = 2  
31     itemretired = 1  
32     while aft <= aftmaxrow:  
33         #%%  
34         aftitem = ws2.cell(row = aft, column = 2)  
35         if bfritem.value == aftitem.value:  
36             itemretired = 0  
37             if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value: #cells match  
38                 aft = aftmaxrow + 1  
39             else:  
40                 ws4.cell(row = dif, column = 1).value = bfritem.value  
41                 ws4.cell(row = dif, column = 2).value = ws1.cell(row = bfr, column = 3).value  
42                 ws4.cell(row = dif, column = 3).value = ws2.cell(row = aft, column = 3).value  
43                 dif = dif + 1  
44                 aft = aftmaxrow + 1  
45             else:  
46                 aft = aft + 1 #move to next row in aftfile  
47         #%%  
48     bfr = bfr + 1 #move to next row in bfrfile  
49
```

Figure 3.6 Bfr Loop

Increment Bfr Counter - Overview

Recall on line 24 I set the “**bfr**” counter = **2**, and **bfr** represents the row in the “*Before.xlsx*” file. The “**bfr loop**” block of code continues running, and the last line 48 increments the **bfr** counter, as shown below. In effect, after this code statement the program moves to the next row in the “*Before.xlsx*” workbook.

Line 48: `bfr = bfr + 1`

After line 48 runs, the code loops from line 48 back up to line 28, and starts the **second bfr loop**. Later in this Chapter, the details of the

code cycling through the **bfr loop** are shown in the topic, "Step 4 Write to New Excel File."

In the next table, the "bfritem.value" column on the right reflects the data in the Excel file while the **bfr loop** is running.

Bfr Loop				
Bfr Loop	Row Variable	Evaluates to:	Row bfr + Col 2 Represents	bfritem.Value
1st time through	bfr	2	Before.xlsx B2	Item1
2nd time through	bfr	3	Before.xlsx B3	Item2

Table 3.4 Bfr Loop with Before.xlsx

Step 1 involves analyzing each item in **Column B** in the "Before.xls" file. The first time the code runs through the "**bfr loop**" and "**bfr**" = 2, cell B2 is "Item1."

Before.xlsx		
	Excel	in Code
Workbook	Before.xlsx	wb1 object
Worksheet	ExportedData	ws1 object
Cell	B2	bfritem
Row	2	bfr

Table 3.5 Before.xlsx Excel Code

While **bfritem.value = Item1**, the nested "**aft loop**" continues cycling, moving through all the rows in the "After.xlsx" file, as shown below.

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	Before.xlsx - Excel		
	B	C	Exp
1	Item	Description	Exp
2	Item1	Desc1	12/
3	Item2	Desc2	12/
4	Item3	Desc3	12/
5	Item4	Desc4	3/3
6	Item5	Desc5	12/
7			

	After.xlsx - Excel		
	B	C	Description
1	Item	Description	
2	Item2	Desc2NoMatch	
3	Item5	Desc5	
4	Item4	Desc4	
5	Item3	Desc3	
6	Item1	Desc1	
7			
8			

Figure 3.7 The first “aft loop”

The **aft loop** continues moving through all rows in the “After.xlsx” file. In this example, there are five rows of data in the “After.xlsx” file, so the program loops through the **aft loop** block of code five times. When the **aft loop** ends, line 48 sets **bfr** = 3, incrementing the **bfr** counter. The program moves from line 48 back up to line 28. The program now runs through the **second loop** of the “**bfr loop**.”

During the **second “bfr loop”** on line 29 the **bfritem.value** represents cell B3 or “Item2” in the “Before.xlsx” file. In effect, the code moves to the next row of data in the “Before.xls” Excel file. The **aft** counter is reset to 2 on line 30, so we can again loop through all the rows in the “After.xlsx” file.

The figure shows two Excel windows side-by-side. The left window is titled 'Before.xlsx - Excel' and contains a table with columns 'Item', 'Item', and 'Description'. The right window is titled 'After.xlsx - Excel' and also contains a table with the same three columns. Red arrows and annotations explain the data movement between these two tables across five rows.

Annotations:

- Row 2: '2nd bfr loop, 1st aft loop' points to the value '48' in cell A2 of the 'After.xlsx' table.
- Row 3: '2nd bfr loop, 2nd aft loop' points to the value '90' in cell A3 of the 'After.xlsx' table.
- Row 4: '2nd bfr loop, 3rd aft loop' points to the value '212' in cell A4 of the 'After.xlsx' table.
- Row 5: '2nd bfr loop, 4th aft loop' points to the value '270' in cell A5 of the 'After.xlsx' table.
- Row 6: '2nd bfr loop, 5th aft loop' points to the value '957' in cell A6 of the 'After.xlsx' table.

	A	B	C
1	Item	Item	Description
2	957	Item1	Desc1
3	48	Item2	Desc2
4	270	Item3	Desc3
5	212	Item4	Desc4
6	90	Item5	Desc5
7			

	A	B	C
1	Item	Item	Description
2	48	Item2	Desc2NoMatch
3	90	Item5	Desc5
4	212	Item4	Desc4
5	270	Item3	Desc3
6	957	Item1	Desc1
7			

Figure 3.8 The second "bfr loop"

Read Data from a Cell

Within the first **While Loop** that we're calling the "**bfr loop**," let's look at line 29. Earlier, I pointed the object "**wb1**" to the workbook "Before.xlsx," and set the "**ws1**" object to the "**Exported Data**" sheet in that workbook "Before.xlsx."

The first time the code runs through the **bfr loop**, **bfr** = 2. The code on line 29, shown below, assigns the "**bfritem**" object to cell B2 in the "Before.xls" Excel file.

Line 29: `bfritem = ws1.cell(row = bfr, column = 2)`

Bfr Loop			
Bfr Loop	Object	Row bfr + Col 2 Represents	bfritem.Value
1st time through	bfritem	Before.xlsx B2	Item1
2nd time through	bfritem	Before.xlsx B3	Item2

Table 3.6 Bfr Loop with bfritem

Line 35 uses the “**.value**” method with the “bfritem” object (from line 34) to compare the value to the **aftitem.value**.

Line 35: **if** bfritem.value == aftitem.value:

Line 37 demonstrates another way to use the “**.cell**” method with the “ws1” worksheet object for a similar comparison. Later, in line 40, I use the **.cell** method to assign a new value to a cell in the new worksheet.

Line 37: **if** ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value:

3.13 Step 2.0 Aft Loop

Earlier, I mentioned there are nested **loops** and **if statements** in this code. In the earlier code example, the shaded area represents a second nested while loop. Let’s call this second loop that begins on line 33 the “**aft loop**.” The “**aft loop**” begins on line 33 and goes through line 46.

Line 33: **while** aft <= aftmaxrow:

```

32
33     while aft <= aftmaxrow:
34         aftitem = ws2.cell(row = aft, column = 2)
35         if bfritem.value == aftitem.value:
36             itemretired = 0
37             if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value:
38                 aft = aftmaxrow + 1
39             else:
40                 ws4.cell(dif, 1).value = bfritem.value
41                 ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value
42                 ws4.cell(dif, 3).value = ws2.cell(aft, 3).value
43                 dif = dif + 1
44                 aft = aftmaxrow + 1
45         else:
46             aft = aft + 1 #move to next row in aftfile
47

```

Figure 3.9 The “Aft Loop” from line 33 to 46

Aft Loop				
Bfr Loop	Row Variable	aft counter	Row aft + Col 2 Represents	Aftitem.Value
1st time through	aft	2	After.xlsx B2	Item2
2nd time through	aft	3	After.xlsx B3	Item5

Table 3.7 Aft Loop with After.xlsx

In the same way we set a counter **bfr = 2** on line 24, I am setting the counter **aft = 2** on line 30, as shown below. Since this is a nested loop, it’s important to set this counter **aft = 2** **within** the indented code block of the second “**bfr loop**.” Because line 30 is indented, it’s “within” the while “**bfr loop**” code block I started on line 28.

aft = 2

```
27  
28 while bfr <= bfrmmaxrow:  
29     bfritem = ws1.cell(row = bfr, column = 2)  
30     aft = 2  
31     itemretired = 1  
32
```

Figure 3.10 Aft Counter Line 30

3.14 Step 2.1 Loop Until Column B Match

Within the “**aft loop**” that starts on **line 33**, I compare Column B values on Line 35, as shown below. Recall Step 2 involves searching for the “**bfritem**” in the “*After.xls*” file.

Line 35: **if** bfritem.value == aftitem.value:

Line 34 sets the “**aftitem**” object to cell B2 in the “*After.xls*” file when the code loops through the “**aft loop**” the first time, as shown below.

```

28 while bfr <= bfrmaxrow:
29     bfritem = ws1.cell(row = bfr, column = 2)
30     aft = 2
31     itemretired = 1
32
33     while aft <= aftmaxrow:
34         aftitem = ws2.cell(row = aft, column = 2)
35         if bfritem.value == aftitem.value:
36             itemretired = 0
37             if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value
38                 aft = aftmaxrow + 1
39             else:
40                 ws4.cell(dif, 1).value = bfritem.value
41                 ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value
42                 ws4.cell(dif, 3).value = ws2.cell(aft, 3).value
43                 dif = dif + 1
44                 aft = aftmaxrow + 1
45         else:
46             aft = aft + 1 #move to next row in aftfile
47
48     bfr = bfr + 1      #move to next row in bfrfile

```

Figure 3.11 Lines 33 to 46

As shown in the next table, the first time Python loops through the “**aft loop**” code, the “**bfritem**” has a value of “**Item1**” from cell B2 of the “*Before.xlsx*” file. Line 34 sets the **aftitem** to ws2.cell(aft, 2).

Line 34: aftitem = ws2.cell(row = aft, column = 2)

The first row in the next table represents the values when the program moves through the “aft loop” the first time. Line 35 compares the **bfritem** value of “**Item1**” to the “**aftitem**” value “**Item2**.” The statement on line 35 evaluates to “false,” because the values do not match. Now, the program moves to line 45.

Line 35: if bfritem.value == aftitem.value:

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The Aft Loop						
Aft Loop	Before.xlsx cell	After.xlsx cell	bfr counter	aft counter	bfritem.value	aftitem.value
1st loop	B2	B2	2	2	Item1	Item2
2nd loop	B2	B3	2	3	Item1	Item5
3rd loop	B2	B4	2	4	Item1	Item4
4th loop	B2	B5	2	5	Item1	Item3
5th loop	B2	B6	2	6	Item1	Item1

Table 3.8 Inside the Aft Loop

Because the two values in **Column B** do not match the first time through the loop, the “**aft loop**” increments the aft counter in line 46 of the code, as shown below. In effect, this code moves the aft counter to the next row of data in the “*After.xlsx*” file.

Line 46: `aft = aft + 1`

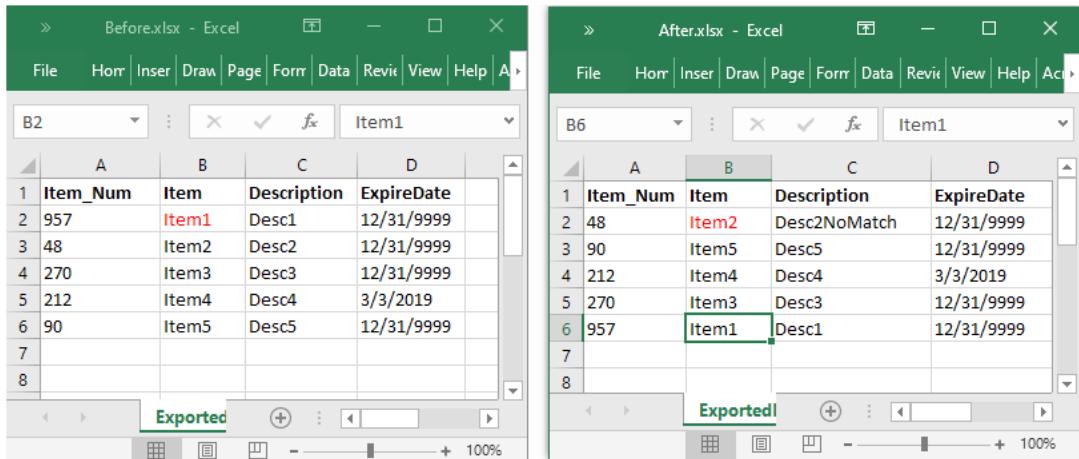


Figure 3.12 Compare B2 Cells

The program continues to run and on line 46 the “`aft`” counter is incremented to 3. The program then loops back to line 33. At this point, the “`aft`” variable represents row 3 in the “`After.xlsx`” file. The code on line 33 evaluates to `3 <= 6`, and the loop continues.

Line 33: `while aft <= aftmaxrow:`

The program continues looping from line 46 back up to line 33, incriminating the `aft` counter each time it loops through the “`aft loop`”.

The Code Cycles and Loops Through the Lines

The following chart is a visual representation of how the program loops back and forth as it runs, branching to different lines of code. Follow along as the code steps into while loops and if statements. The second column “Line” shows the movement of the program. The first column

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represents the **Loop** or **if statement**, and you can see the code moves back and forth.

bfrmaxrow =6, aftmaxrow = 6			
	Line	evaluates to	Notes
1st bfr loop	28	$2 \leq 6$	bfr=2, aft =2, true go to line 29
1st bfr loop	33	$2 \leq 6$	bfr=2, aft =2, true go to line 34
1st bfr loop, 1st aft loop	35	item1==item2	Not true, go to line 45
1st bfr loop, 1st aft loop	45	else	
1st bfr loop, 1st aft loop	46	aft = aft + 1	bfr = 2, aft is now 3, go back to line 33

<pre> 28 while bfr <= bfrmaxrow: 29 bfritem = ws1.cell(row = bfr, column = 2) 30 aft = 2 31 itemretired = 1 32 33 while aft <= aftmaxrow: 34 aftitem = ws2.cell(row = aft, column = 2) 35 if bfritem.value == aftitem.value: 36 itemretired = 0 37 if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value: 38 aft = aftmaxrow + 1 39 else: 40 ws4.cell(dif, 1).value = bfritem.value 41 ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value 42 ws4.cell(dif, 3).value = ws2.cell(aft, 3).value 43 dif = dif + 1 44 aft = aftmaxrow + 1 45 else: 46 aft = aft + 1 #move to next row in aftfile 47 48 bfr = bfr + 1 #move to next row in bfrfile </pre> 																
<table border="1"> <thead> <tr> <th></th> <th>Line</th> <th>evaluates to</th> <th>Notes</th> </tr> </thead> <tbody> <tr> <td>1st bfr loop, 2nd aft loop</td> <td>33</td> <td>$3 \leq 6$</td> <td>bfr=2, aft =3, true go to line 34</td></tr> <tr> <td>1st bfr loop, 2nd aft loop</td> <td>35</td> <td>item1==item5</td> <td>Not true, go to line 45</td></tr> <tr> <td>1st bfr loop, 2nd aft loop</td> <td>45</td> <td>else</td> <td>...</td></tr> </tbody> </table>		Line	evaluates to	Notes	1st bfr loop, 2nd aft loop	33	$3 \leq 6$	bfr=2, aft =3, true go to line 34	1st bfr loop, 2nd aft loop	35	item1==item5	Not true, go to line 45	1st bfr loop, 2nd aft loop	45	else	...
	Line	evaluates to	Notes													
1st bfr loop, 2nd aft loop	33	$3 \leq 6$	bfr=2, aft =3, true go to line 34													
1st bfr loop, 2nd aft loop	35	item1==item5	Not true, go to line 45													
1st bfr loop, 2nd aft loop	45	else	...													

bfrmaxrow =6, aftmaxrow = 6			
	Line	evaluates to	Notes
1st bfr loop, 2nd aft loop	46	aft = aft +1	bfr = 2, aft is now 4, go back to line 33
1st bfr loop, 3rd aft loop	33	4 <=6	bfr=2, aft =4, true go to line 34
1st bfr loop, 3rd aft loop	35	item1==item4	Not true, go to line 45
1st bfr loop, 3rd aft loop	45	else	...
1st bfr loop, 3rd aft loop	46	aft = aft +1	bfr = 2, aft is now 5, go back to line 33
1st bfr loop, 4th aft loop	33	5 <=6	bfr = 2, aft =5, true go to line 34
1st bfr loop, 4th aft loop	35	item1==item3	Not true, go to line 45
1st bfr loop, 4th aft loop	45	else	
1st bfr loop, 4th aft loop	46	aft = aft +1	bfr = 2, aft is now 6, go back to line 33
1st bfr loop, 5th aft loop	33	5 <=6	bfr=2, aft =6
1st bfr loop, 5th aft loop	35	item1 ==item1	true, go to line 38
1st bfr loop, 5th aft loop	38	6 = 6 +1	bfr =2, aftmaxrow = 7, go back to line 33
<pre> 32 33 33 while aft <= aftmaxrow: 34 aftitem = ws2.cell(row = aft, column = 2) 35 if bfritem.value == aftitem.value: 36 itemretired = 0 37 if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value: 38 aft = aftmaxrow + 1 39 else: </pre>			
1st bfr loop, 5th aft loop	33	7<=6	Not true, go down to line 48

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bfrmaxrow = 6, aftmaxrow = 6			
	Line	evaluates to	Notes
	<pre> 32 33 while aft <= aftmaxrow: 34 aftitem = ws2.cell(row = aft, column = 2) 35 if bfritem.value == aftitem.value: 36 itemretired = 0 37 if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value: 38 aft = aftmaxrow + 1 39 else: 40 ws4.cell(dif, 1).value = bfritem.value 41 ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value 42 ws4.cell(dif, 3).value = ws2.cell(aft, 3).value 43 dif = dif + 1 44 aft = aftmaxrow + 1 45 else: 46 aft = aft + 1 #move to next row in aftfile 47 48 bfr = bfr + 1 #move to next row in bfrfile </pre>		
1st bfr loop, 5th aft loop	48	2 = 2 +1	bfr = 3, go back to line 28
	<pre> 28 while bfr <= bfrmaxrow: 29 bfritem = ws1.cell(row = bfr, column = 2) 30 aft = 2 31 itemretired = 1 32 33 while aft <= aftmaxrow: 34 aftitem = ws2.cell(row = aft, column = 2) 35 if bfritem.value == aftitem.value: 36 itemretired = 0 37 if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value: 38 aft = aftmaxrow + 1 39 else: 40 ws4.cell(dif, 1).value = bfritem.value 41 ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value 42 ws4.cell(dif, 3).value = ws2.cell(aft, 3).value 43 dif = dif + 1 44 aft = aftmaxrow + 1 45 46 aft = aft + 1 #move to next row in aftfile 47 48 bfr = bfr + 1 #move to next row in bfrfile </pre>		

bfrmaxrow =6, aftmaxrow = 6			
	Line	evaluates to	Notes
2nd bfr loop	28	3 <= 6	bfr = 3, aft = 6, true go to line 29
2nd bfr loop	30	aft = 2	reset aft counter to begin a new "aft loop"
2nd bfr loop, 1st aft loop	33	2 <= 6	bfr = 3, aft = 2, true go to line 34

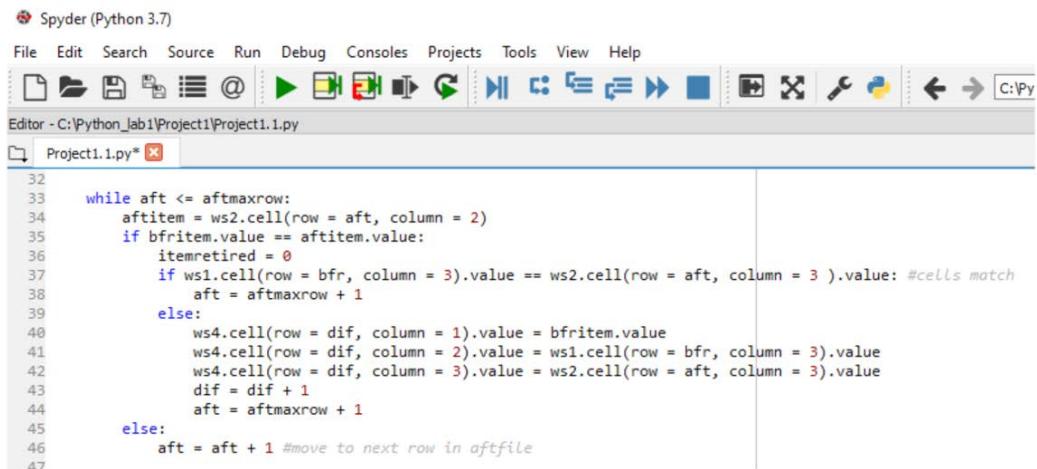
Table 3.9 Looping Through Code

3.15 Step 2.2: Column B Match is Found

The fifth time the loop runs **aft = 6** and the “After.xlsx” B6 cell on row 6 is “Item1.” At this point, a match is found on line 35, which compares the two cells in Column B, as shown below.

Line 35: **if** bfritem.value == aftitem.value

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The screenshot shows the Spyder Python 3.7 IDE interface. The menu bar includes File, Edit, Search, Source, Run, Debug, Consoles, Projects, Tools, View, and Help. Below the menu is a toolbar with various icons. The main area is titled "Editor - C:\Python_Lab1\Project1\Project1.1.py". A file named "Project1.1.py" is open. The code is as follows:

```
32
33     while aft <= aftmaxrow:
34         aftitem = ws2.cell(row = aft, column = 2)
35         if bfritem.value == aftitem.value:
36             itemretired = 0
37             if ws1.cell(row = bfr, column = 3).value == ws2.cell(row = aft, column = 3).value: #cells match
38                 aft = aftmaxrow + 1
39             else:
40                 ws4.cell(row = dif, column = 1).value = bfritem.value
41                 ws4.cell(row = dif, column = 2).value = ws1.cell(row = bfr, column = 3).value
42                 ws4.cell(row = dif, column = 3).value = ws2.cell(row = aft, column = 3).value
43                 dif = dif + 1
44                 aft = aftmaxrow + 1
45         else:
46             aft = aft + 1 #move to next row in aftfile
47
```

A red circle highlights the number 35, indicating the current line of execution.

Figure 3.13 Compare on Line 35

Move to Next Item in the Bfr Loop

In line 37 the “**aft loop**” compares Column C values. If the statement on line 37 is true, the program runs line 38. When the statement on line 37 is false, the program skips to line 39. In either case, the code on line 38 or 44 increments the **aft** counter.

When the statement on line 37 is true, the program moves to line 38. When the statement on line 37 is false, the program moves to line 44. Both line 38 and 44 set the **aft** counter to a value greater than **aftmaxrow**, as shown below.

Line 38 or line 44: **aft = aftmaxrow + 1**

The “**aft loop**” continues and moves from line 46 back to line 33. On line 33 **aft** has a value of 7, and the statement on line 33 evaluates to **7 > aftmaxrow**. Because the statement on line 33 is false, the program moves from line 33 down to line 48, as shown below.



```

32
33 33 while aft <= aftmaxrow:
34     aftitem = ws2.cell(row = aft, column = 2)
35     if bfritem.value == aftitem.value:
36         itemretired = 0
37         if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value:
38             aft = aftmaxrow + 1
39         else:
40             ws4.cell(dif, 1).value = bfritem.value
41             ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value
42             ws4.cell(dif, 3).value = ws2.cell(aft, 3).value
43             dif = dif + 1
44             aft = aftmaxrow + 1
45         else:
46             aft = aft + 1 #move to next row in aftfile
47
48 48 bfr = bfr + 1      #move to next row in bfrfile

```

Figure 3.14 Line 33 moves to Line 48

When the statement on line 33 evaluates to “false”, the program exits the “**aft loop**.” In effect the program is moving to the next item in the “**bfr loop**.”

Incrementing the Bfr Counter

The “**bfr loop**” continues until the last line of code in the “**bfr loop**” on line 48. Recall on line 24 I set the “**bfr**” counter = **2**. **Bfr** represents the row in the Excel “*Before.xlsx*” file.

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The last line of the “**bfr loop**” is line 48. Line 48 increments the “**bfr**” counter, in effect moving to the next row in the “*Before.xlsx*” workbook.

Line 48: `bfr = bfr + 1`

The program loops from line 48 back to line 28, to begin the **second bfr loop**. In effect, this represents the next row in the “*Before.xlsx*” workbook. The details are shown in the topic “Step 4 Write to New Excel File.”

In the next table, the “`bfritem.value`” column on the right reflects the data in the Excel file.

Bfr Loop				
Bfr Loop	Row Variable	Evaluates to:	Row bfr + Col 2 Represents	<code>bfritem.Value</code>
1st time through	bfr	2	Before.xlsx B2	Item1
2nd time through	bfr	3	Before.xlsx B3	Item2

Table 3.10 Bfr Loop with Before.xlsx

This figure below shows the program looping from line 48 back to line 28, effectively moving to the next row in the “*Before.xlsx*” spreadsheet.



```

28 while bfr <= bfrmaxrow:
29     bfritem = ws1.cell(row = bfr, column = 2)
30     aft = 2
31     itemretired = 1
32
33     while aft <= aftmaxrow:
34         aftitem = ws2.cell(row = aft, column = 2)
35         if bfritem.value == aftitem.value:
36             itemretired = 0
37             if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value:
38                 aft = aftmaxrow + 1
39             else:
40                 ws4.cell(dif, 1).value = bfritem.value
41                 ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value
42                 ws4.cell(dif, 3).value = ws2.cell(aft, 3).value
43                 dif = dif + 1
44                 aft = aftmaxrow + 1
45             else:
46                 aft = aft + 1 #move to next row in aftfile
47
48     bfr = bfr + 1      #move to next row in bfrfile

```

Figure 3.15 Line 48 moves to Line 28

3.16 Step 3.0 Compare Column C

The program eventually finds a match for Item 2 in Column B. At that point, Python compares the “Description” column C values.

Diff.xlsx			
	ws4.cell(diff,1) or Column 1	ws4.cell(diff,2) or Column 2	ws4.cell(diff,3) or Column 3
Code	bfritem.value	ws1.cell(bfr, 3).value	ws2.cell(aft, 3).value
Evaluates to:	Item2	Desc2	Desc2NoMatch

Table 3.11 The Diff.xlsx File

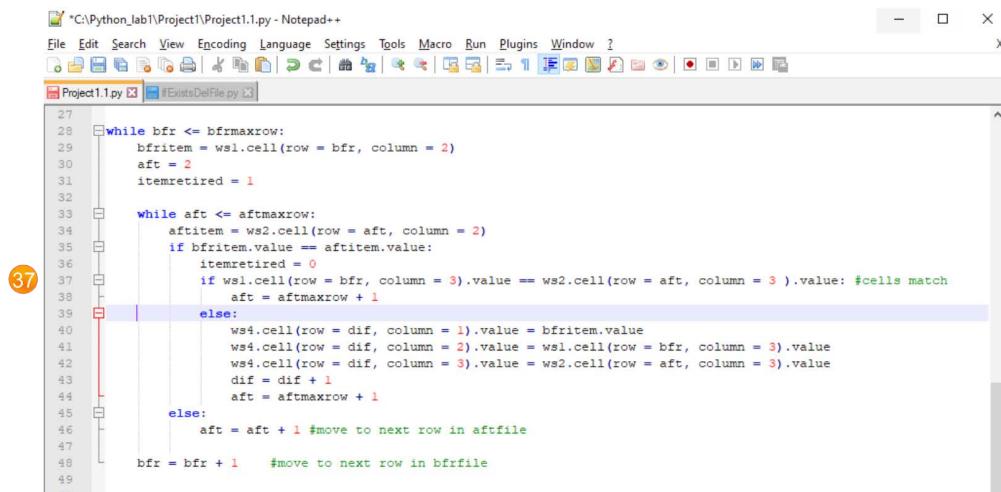
3.17 Step 3.1 Column C Data Does Not Match

When Line 35 is true (a match is found for column B), line 37 compares the values in **Column C**, as shown below. Notice I shortened the syntax from **cell(row=bfr, column =3)** to **cell(bfr, 3)**.

Line 37: **if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value:**

The program evaluates the “**if statement**” on line 37, and the Column C data does **NOT** match. Now the program jumps to the “else” statement on line 39, which writes data to the output “*Diff.xlsx*” file.

Note: Another way to write this part of the code would be to use the comparison operator **not equal to !=**.



```

 27
 28 while bfr <= bfrmaxrow:
 29     bfritem = ws1.cell(row = bfr, column = 2)
 30     aft = 2
 31     itemretired = 1
 32
 33     while aft <= aftmaxrow:
 34         aftitem = ws2.cell(row = aft, column = 2)
 35         if bfritem.value == aftitem.value:
 36             itemretired = 0
 37             if ws1.cell(row = bfr, column = 3).value == ws2.cell(row = aft, column = 3 ).value: #cells match
 38                 aft = aftmaxrow + 1
 39             else:
 40                 ws4.cell(row = dif, column = 1).value = bfritem.value
 41                 ws4.cell(row = dif, column = 2).value = ws1.cell(row = bfr, column = 3).value
 42                 ws4.cell(row = dif, column = 3).value = ws2.cell(row = aft, column = 3).value
 43                 dif = dif + 1
 44                 aft = aftmaxrow + 1
 45             else:
 46                 aft = aft + 1 #move to next row in aftfile
 47
 48     bfr = bfr + 1    #move to next row in bfrfile
 49

```

Figure 3.16 Column C Data does NOT Match

3.18 Step 4.0: Write to New Excel File

Let's take a moment to look at the code and output. The table below shows the actual code, as well as what it will evaluate to. When I say "evaluate to," this is what will be written into the "*Diff.xlsx*" file.

Code	Excel File	Excel Column	Column Counter	Row Counter	Value
ws4.cell(diff,1).value	Diff.xlsx	A2	1	2	Item2
bfritem.value	Before.xlsx	B3	2	3	Item2
ws4.cell(diff,2).value	Diff.xlsx	B2	2	2	Desc2
ws1.cell(bfr,3).value	Before.xlsx	C3	3	3	Desc2
ws4.cell(diff,3).value	Diff.xlsx	C2	3	2	Desc2NoMatch
ws2.cell(diff,3).value	After.xlsx	C2	3	2	Desc2NoMatch

Table 3.12 Data for the *Diff.xlsx* Output File

A quick look at the Excel files shows how the data flows from the Excel files into the new "*Diff.xlsx*" file.

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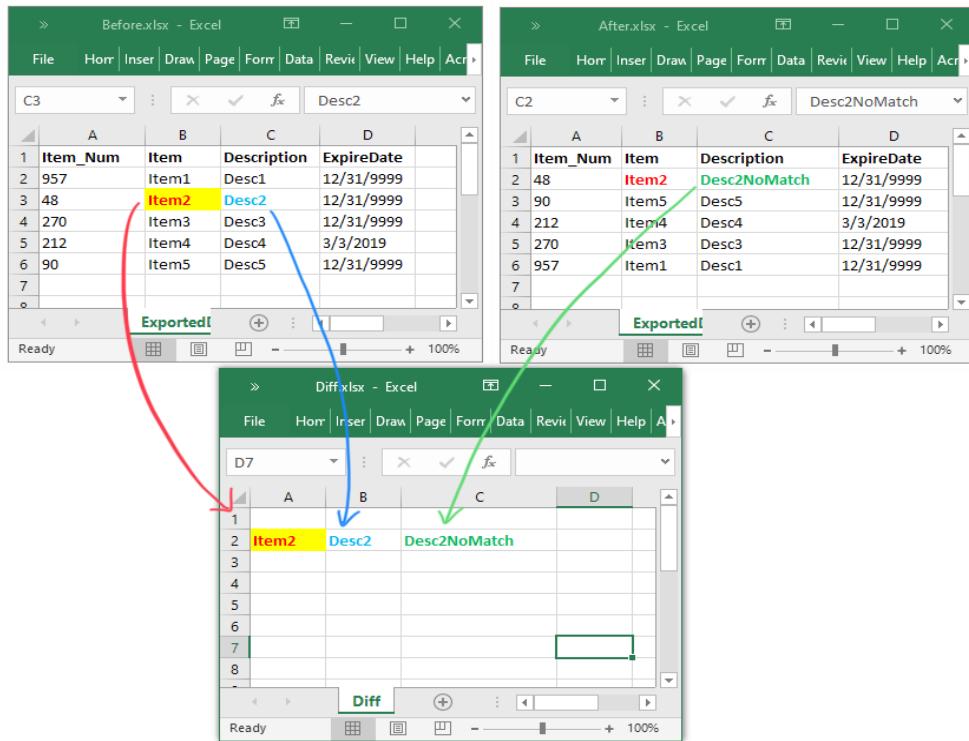


Figure 3.17 Data Flows to Diff.xlsx Output File

The “else:” code on line 39 creates the output data in lines 40 to 42 for the “Diff.xlsx” file, using the **ws4.cell** object reference.

```
Line 37: if ws1.cell(bfr, 3).value == ws2.cell(aft, 3).value:  
Line 38:     aft = aftmaxrow + 1  
Line 39: else:  
Line 40:     ws4.cell(dif, 1).value = bfritem.value  
Line 41:     ws4.cell(dif, 2).value = ws1.cell(bfr, 3).value  
Line 42:     ws4.cell(dif, 3).value = ws2.cell(aft, 3).value
```

Next, line 43 increments the **dif** counter to move to the next row in the “*Diff.xlsx*” output file, as shown below.

Line 43: **dif = dif + 1**

1	A	C
2	Item2	Desc2
3		
4		
5		

Figure 3.18 Next Row in Diff.xlsx Spreadsheet

3.19 Step 4.1 Save the New File

Eventually, the program ends. The last line uses the `.save` method to save the new Excel file.

```
wb4.save(diffile)
```

Chapter 3

Customize Project 1

In this chapter we discuss

[**Delete Worksheets**](#)

[**Count Rows With Data**](#)

[**Search for Strings & Substrings**](#)

[**Delete Rows**](#)

[**Headings and Formatting**](#)

[**Delete Existing File**](#)

[**Adding Your Filename, Worksheet, & Column**](#)

[**Item Retired**](#)

[**New Items**](#)

[**Compare Dates**](#)

Now that the basic Project 1 program is working, I want to revisit the script to simplify and improve the code. Did you notice the output

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Excel file is a little drab? It would definitely benefit from headings and formating.

So far the Excel sample data files were relatively simple without a lot of extraneous data. Unfortunately, this rarely seems to be the case with a new project. The files always need some type of data scrubbing. Part of this lab will search for data to delete rows I don't want in my data set. We'll also look at adding methods to automate basic tasks.

- Delete worksheets
- Count rows with data in the Excel file
- Search strings
- Delete rows

Finally, I'll show you how to customize the code to make it your own. This involves using your Excel filenames, and the particular columns you want to compare.

4.1 Delete Worksheets

When I created a new workbook, the worksheet "Sheet" was created by default. On line 23, I delete that worksheet using the method "**remove**" with the function "**get_sheet_by_name**."

```
wb4.remove(wb4.get_sheet_by_name(name = 'Sheet'))
```

```
19
20 from openpyxl import Workbook
21 wb4 = Workbook()
22 ws4 = wb4.create_sheet("Diff")
23 wb4.remove(wb4.get_sheet_by_name(name = 'Sheet'))
24
```

Figure 4.1 Delete Worksheet

The function “**get_sheet_by_name**” returns an object to the method “**remove**.”

Note: Functions are a sequence of statements. A method is similar, except a **method** is used with objects.

4.2 Count Rows With Data

In the original version of the program, I provided a value for the total rows in the Excel spreadsheet. A better way to set the value is to use the function “**max_row**.” Max_row returns the maximum row index containing data.

```
bfrmaxrow = ws1.max_row
```

```

24
25 bfrmaxrow = ws1.max_row
26 bfr = 2
27 dif = 2
28 aftmaxrow = 6 #total rows with data in aftfile
29
30 while bfr <= bfrmaxrow:
31     bfritem = ws1.cell(row = bfr, column = 2)
32     aft = 2
33     itemretired = 1

```

Figure 4.2 max_row Function

4.3 Search for Strings & Substrings

This section contains two methods for searching for a string or substring.

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- .search
- .find

Search

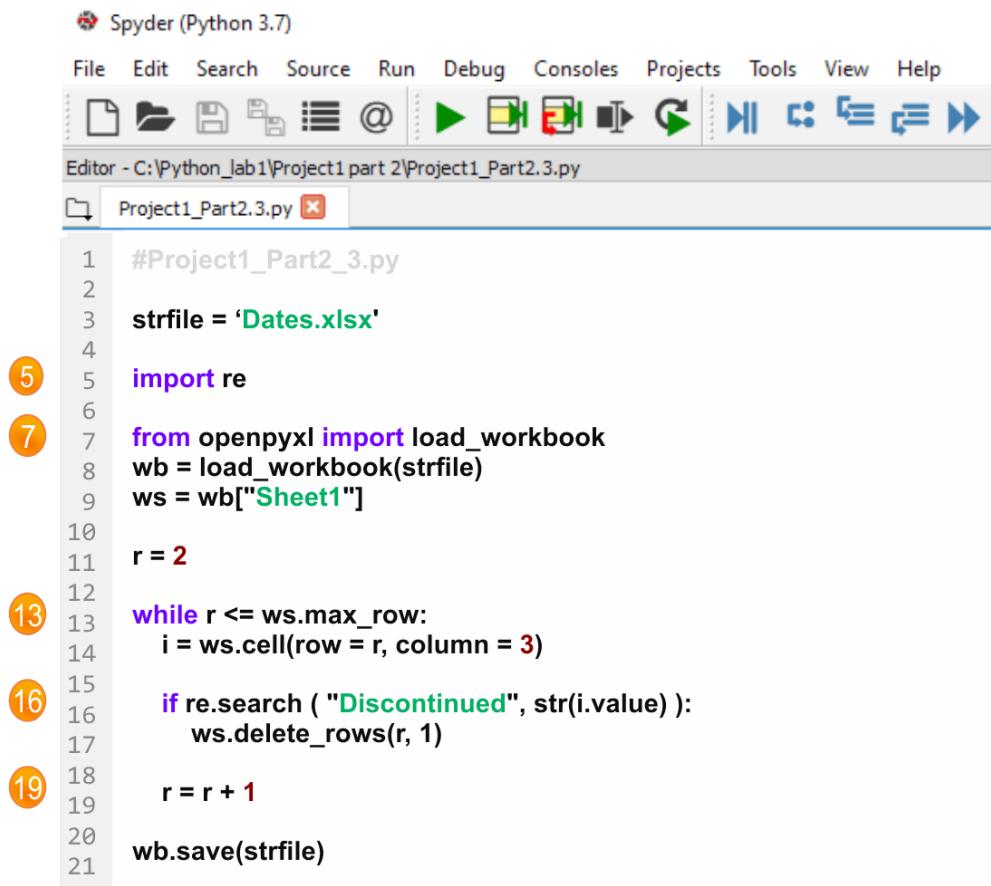
In the script **Project1_Part2_3.py**, I search for the phrase “Discontinued” in column “C” of the Excel file “Dates.xlsx.” When I create a workbook object for the Excel file “Dates.xlsx” on line 8, I do not use “`data_only = true`,” because I want to change the file.

	A	B	C	D
1	Item_Num	Item	Status	ChangeDate
2	957	Item1		11/11/2030
3	48	Item2		03/05/2025
4	270	Item3		01/30/2021
5	212	Item4	Discontinued	01/01/1995
6	90	Item5		04/08/2026
7				

Figure 4.3 The Excel File “Dates.xlsx”

In the script **Project1_Part2_3.py**, line 5 imports the module “`re`.” The “`re.search`” method looks for the string “Discontinued” in line 16. When line 16 is true, the program moves to line 17.

In row 11, I set a counter “r” to 2, because I want to skip the headings in row 1. The “while” loop from lines 13 to 19 moves through each row in the “Dates.xlsx” file.



The screenshot shows the Spyder Python 3.7 IDE interface. The title bar says "Spyder (Python 3.7)". The menu bar includes File, Edit, Search, Source, Run, Debug, Consoles, Projects, Tools, View, and Help. Below the menu is a toolbar with various icons. The main area is the "Editor - C:\Python_lab1\Project1 part 2\Project1_Part2.3.py" window, which contains the following Python code:

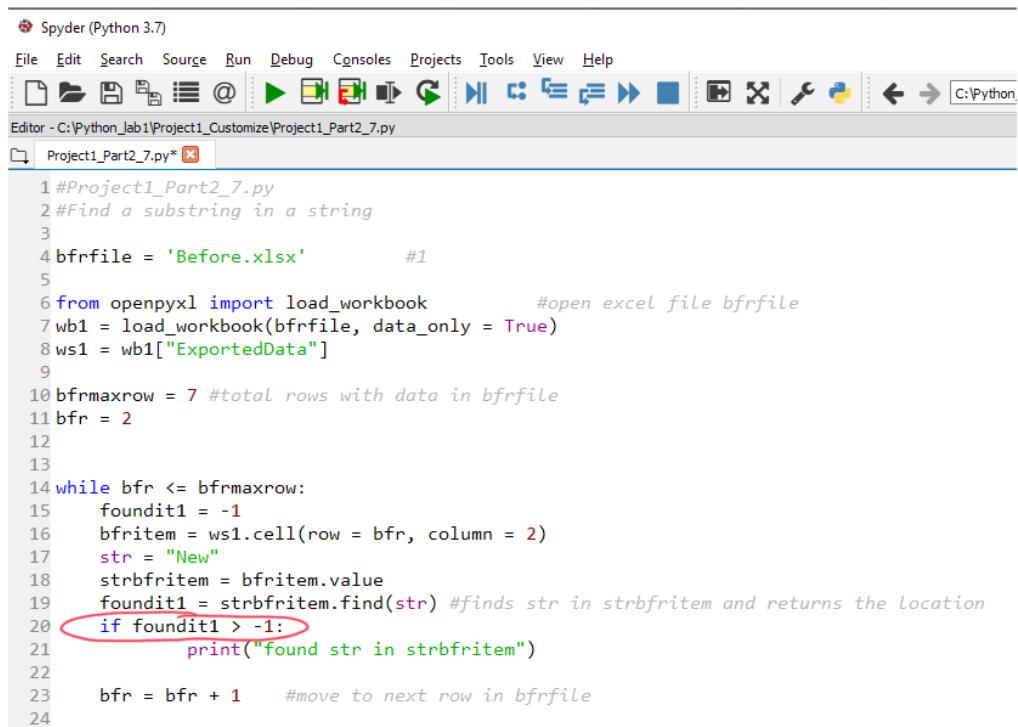
```
1 #Project1_Part2_3.py
2
3 strfile = 'Dates.xlsx'
4
5 import re
6
7 from openpyxl import load_workbook
8 wb = load_workbook(strfile)
9 ws = wb["Sheet1"]
10
11 r = 2
12
13 while r <= ws.max_row:
14     i = ws.cell(row = r, column = 3)
15
16     if re.search ( "Discontinued", str(i.value) ):
17         ws.delete_rows(r, 1)
18
19     r = r + 1
20
21 wb.save(strfile)
```

Several lines of code are highlighted with orange circles containing numbers: line 5 (import re), line 7 (from openpyxl import load_workbook), line 13 (while r <= ws.max_row), line 16 (if re.search ("Discontinued", str(i.value))), and line 19 (r = r + 1). The code is written in Python, using the openpyxl library to interact with an Excel file named 'Dates.xlsx'.

Figure 4.4 Search and Delete Row

Find

In the script **Project1_Part2_7.py**, I search for a substring within a string on line 19, using the “**find**” method. The “**find**” method returns **-1** if the substring is not found. If the substring is found, the “**find**” method returns the location within the string. In line 19 in the next figure, the variable “**foundit**” is set to the location within the string.



```
Spyder (Python 3.7)
File Edit Search Source Run Debug Consoles Projects Tools View Help
Editor - C:\Python\lab1\Project1_Customize\Project1_Part2_7.py*
Project1_Part2_7.py* [x]

1 #Project1_Part2_7.py
2 #Find a substring in a string
3
4 bfrfile = 'Before.xlsx'           #1
5
6 from openpyxl import load_workbook      #open excel file bfrfile
7 wb1 = load_workbook(bfrfile, data_only = True)
8 ws1 = wb1["ExportedData"]
9
10 bfrmaxrow = 7 #total rows with data in bfrfile
11 bfr = 2
12
13
14 while bfr <= bfrmaxrow:
15     foundit1 = -1
16     bfritem = ws1.cell(row = bfr, column = 2)
17     str = "New"
18     strbfritem = bfritem.value
19     foundit1 = strbfritem.find(str) #finds str in strbfritem and returns the location
20     if foundit1 > -1:
21         print("found str in strbfritem")
22
23     bfr = bfr + 1      #move to next row in bfrfile
24
```

Figure 4.5 Search for Substring

In this example, I search for the substring “**New**” within Column 2 of the “*Before.xlsx*” file. The “**find**” method returns the location or position within the string or “**2**,” as shown in the next diagram.

A	B	C	D
1	Item_Num	Item	Description
2	957	Item1	Desc1
3	48	Item2	Desc2
4	270	Item3	Desc3
5	212	Item4	Desc4
6	90	Item5	Desc5
7	123	A New Item	The New Item 12/31/9999

A New Item

0 1 2 3 4 5 6 7 8 9

Figure 4.6 Substring Location

The “find” method also takes parameters for the beginning index (the starting location), and the ending index. Often this method is combined with the length method. For example, `len(str)` would determine the length of the string `str`.

```
str.find(str, beg=0, end=len(str))
```

4.4 Delete Rows

As part of my data scrubbing, I delete rows that have the phrase “Discontinued” in column C. In the previous script **Project1_Part2_3.py**, the method “`delete_rows`” is available in the latest version of `openpyxl`. When the “if” statement on line 16 is true, the code moves to line 17 and deletes the row.

4.5 Headings and Formatting

In the same way I used the “openpyxl” library, I imported my own module called “**FormatHeadings.py**.” First, let’s look at the code in “**FormatHeadings.py**.” Line 1 defines the “**fh**” method. Notice line 1 begins with “**def**” and ends in a colon **:**. The method “**fh**” takes five arguments, as shown below.

```
def fh(ws4, str1, str2, str3, colwidth):
```

The next step would be to add the code below to the script file, for example **Project1.1.py**. This script imports my module, and then calls my method “**fh**.” .

```
from FormatHeadings import fh
fh(ws4, "Item", "Description", "Comments", 20)
```

Argument	Value	Description
1	ws4	worksheet object for Diff worksheet
2	Item	Heading Column A
3	Description	Heading Column B
4	Comments	Heading Column C
5	20	Width of Column

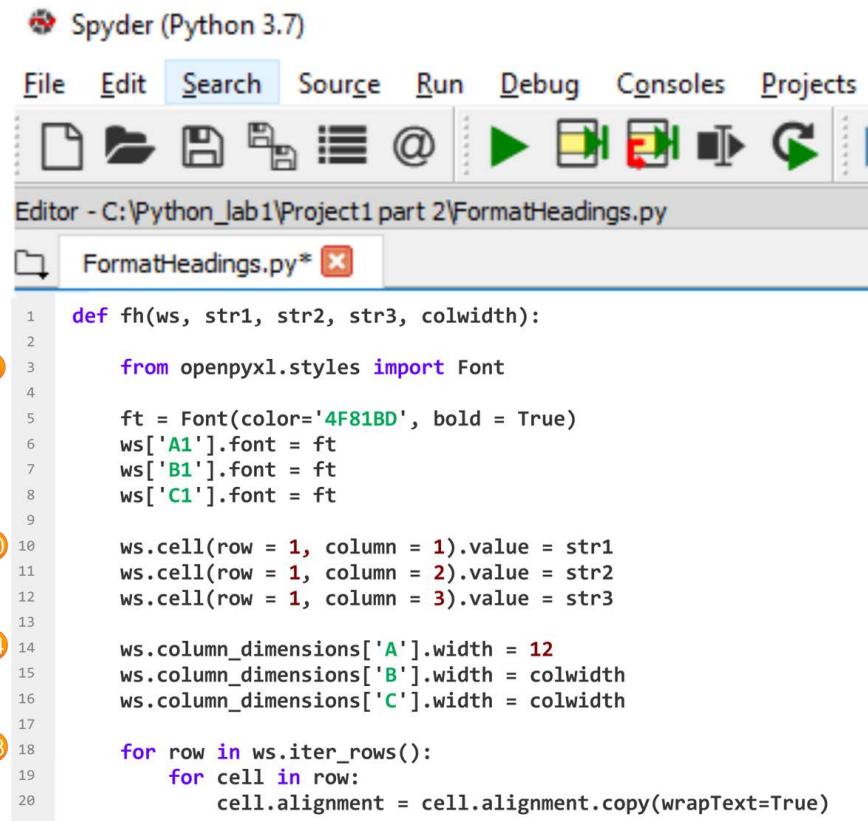
Table 4.1 Five Arguments

Line 3 of “**FormatHeadings.py**” imports the **styles** module to work with the **Font** function.

Lines 5 to 8 set the bold font and blue color for the heading cells. After the program runs, the “Diff.xlsx” file has color headings and the format shown in the figure below.

Lines 10 to 12 set the heading name to the values passed in the arguments **str1**, **str2**, and **str3**. Lines 15 and 16 set the column width

to the fifth argument **colwidth**. Lines 18 to 20 set cell alignment to wrap text.



```
def fh(ws, str1, str2, str3, colwidth):
    from openpyxl.styles import Font
    ft = Font(color='4F81BD', bold = True)
    ws['A1'].font = ft
    ws['B1'].font = ft
    ws['C1'].font = ft
    ws.cell(row = 1, column = 1).value = str1
    ws.cell(row = 1, column = 2).value = str2
    ws.cell(row = 1, column = 3).value = str3
    ws.column_dimensions['A'].width = 12
    ws.column_dimensions['B'].width = colwidth
    ws.column_dimensions['C'].width = colwidth
    for row in ws.iter_rows():
        for cell in row:
            cell.alignment = cell.alignment.copy(wrapText=True)
```

Figure 4.7 FormatHeadings.py

The screenshot shows a Microsoft Excel spreadsheet titled "Diff.xlsx - Excel". The table has columns labeled B, C, D, and E. Row 1 contains "Description" in column B and "Comments" in column C. Row 2 contains "Desc2" in column B and "Desc2NoMatch" in column C. Row 3 is empty. Row 4 is empty. The "Diff" tab is selected at the bottom of the ribbon.

	B	C	D	E
1	Description	Comments		
2	Desc2	Desc2NoMatch		
3				
4				

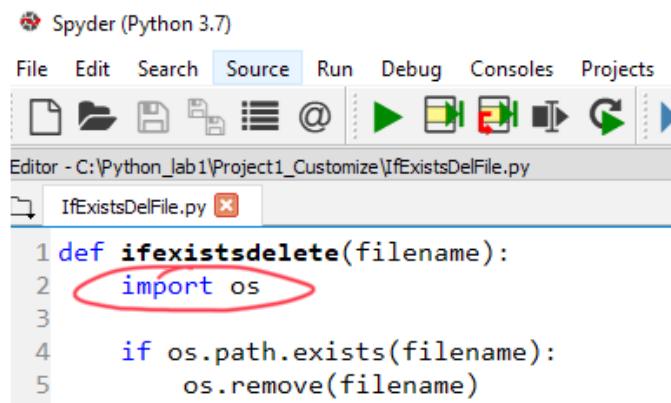
Figure 4.8 Diff.xlsx with Headings

4.6 Delete Existing File

If the output file "Diff.xlsx" already exists, I want to delete it before creating a new file. In "**Project1.1.py**" on line 62 to 64, I import my own "**IfExistsDelFile.py**" module with a function "**ifexistsdelete**."

```
Line 62: from IfExistsDelFile import ifexistsdelete
Line 63: filepath = diffile
Line 64: ifexistsdelete(filepath)
```

In this example using "**IfExistsDelFile.py**," I import the "**os**" library to work with the Windows file system. The "**os.remove**" method deletes the file if it exists.



```
1 def ifexistsdelete(filename):
2     import os
3
4     if os.path.exists(filename):
5         os.remove(filename)
```

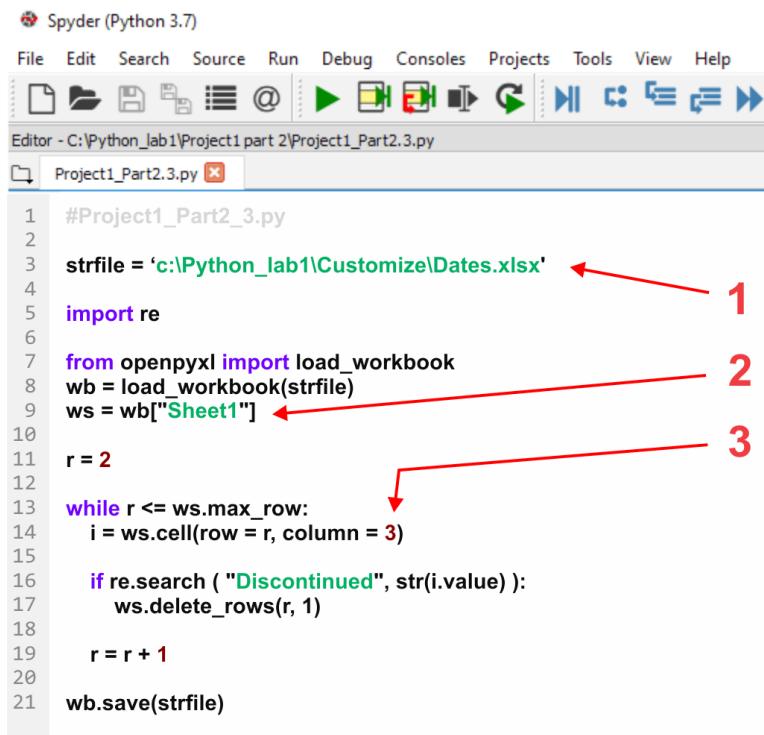
Figure 4.9 *IfExistsDelFile.py*

4.7 Add Your Filename, Worksheet & Column

In the example below, the red arrows highlight lines in the **Project1_Part2_3.py** file. To customize the code to work with your file, worksheet, or column, update the lines shown below.

1. Replace the filename in green on line 3 with your filename.
2. Update line 9 with your worksheet name.
3. Change the column number as appropriate. For example, to use Column B, change the column number in line 14 to “2.”

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```
#Project1_Part2_3.py
1
2
3 strfile = 'c:\Python_lab1\Customize\Dates.xlsx'    1
4
5 import re
6
7 from openpyxl import load_workbook
8 wb = load_workbook(strfile)
9 ws = wb['Sheet1']    2
10
11 r = 2
12
13 while r <= ws.max_row:
14     i = ws.cell(row = r, column = 3)
15
16     if re.search ( "Discontinued", str(i.value) ):
17         ws.delete_rows(r, 1)
18
19     r = r + 1
20
21 wb.save(strfile)
```

The screenshot shows the Spyder Python 3.7 IDE interface. The menu bar includes File, Edit, Search, Source, Run, Debug, Consoles, Projects, Tools, View, and Help. Below the menu is a toolbar with various icons. The main area is titled 'Editor - C:\Python_lab1\Project1 part 2\Project1_Part2.3.py'. The code itself is labeled 'Project1_Part2.3.py'. Red annotations with numbers 1, 2, and 3 point to specific lines of code: 1 points to the file path assignment, 2 points to the worksheet selection, and 3 points to the row iteration loop.

Figure 4.10 Your Filename, Worksheet, and Column

4.8 Item Retired

Did you wonder about the variable “**itemretired**” on line 33? In the **Project1_Part2.6.py** file, on lines 53 to 58, I use “**itemretired**” to mark items in “*Before.xlsx*” that were not found in “*After.xlsx*.”

```

29
30 while bfr <= bfrmaxrow:
31     bfritem = ws1.cell(row = bfr, column = 2)
32     aft = 2
33     itemretired = 1
34
35     while aft <= aftmaxrow:
36         aftitem = ws2.cell(row = aft, column = 2)
37         if bfritem.value == aftitem.value:
38             itemretired = 0
39             if ws1.cell(row=bfr, column = 3).value == ws2.cell(row=aft, column = 3).value:
40                 aft = aftmaxrow + 1
41             else: #Column 3 of data is different so write to Diff.xlsx file
42                 ws4.cell(row=dif, column = 1).value = bfritem.value
43                 ws4.cell(row=dif, column = 2).value = ws1.cell(row=bfr, column = 3).value
44                 ws4.cell(row=dif, column = 3).value = ws2.cell(row=aft, column = 3).value
45                 dif = dif + 1
46                 aft = aftmaxrow + 1
47         else:
48             aft = aft + 1 #move to next row in aftfile
49
50     bfr = bfr + 1      #move to next row in bfrfile
51
52 #%%
53     if itemretired == 1: #the item was removed (not found in the after file)
54         ws5.cell(row = 1, column = 1).value = "Item Name"
55         ws5.cell(row = 1, column = 2).value = "Comments"
56         ws5.cell(row = dif, column = 1).value = bfritem.value
57         ws5.cell(row = dif, column = 2).value = "Item not in After File"
58         dif = dif + 1
59 #%%

```

Figure 4.11 Item Retired

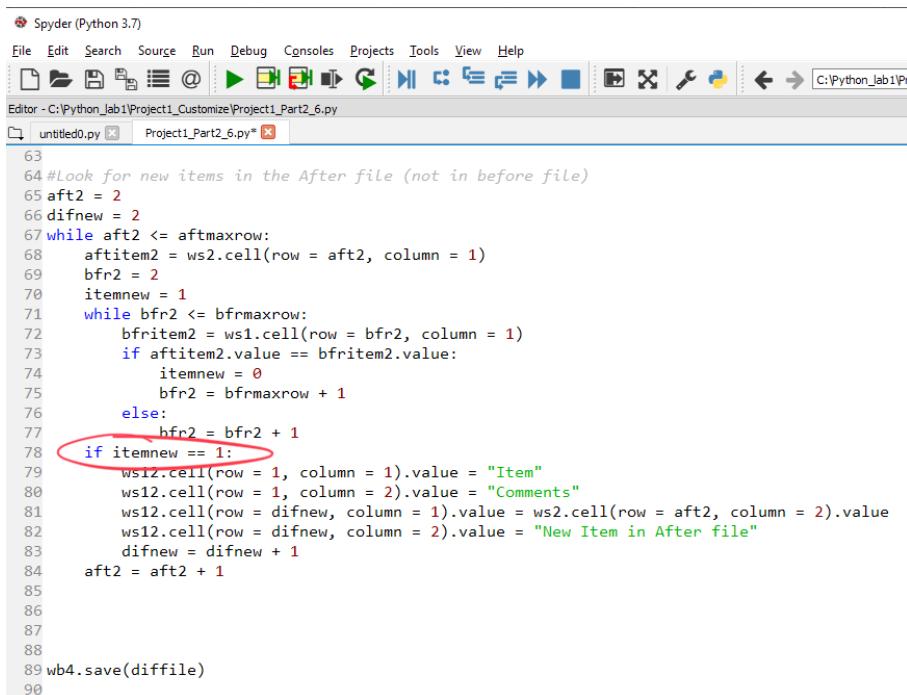
4.9 New Items

In the **Project1_Part2.6.py** file, I added lines 64 to 84 to find new items in “After.xlsx” that were not in “Before.xlsx.” Notice this code is at the left margin and is **not** part of the previous block of code, or loop. I also create a new spreadsheet object “ws12” on line 21.

On line 70 I assign 1 to **itemnew**. When an item in the “After.xlsx” is not in “Before.xlsx,” line 74 does not run. When the items match on line 73, line 74 changes **itemnew** to 0.

Chapter 4

Line 78 runs after the code loops through all rows in the "After.xlsx" file. If **itemnew** still has a value of 1, I update ws12 objects in lines 79 to 82.



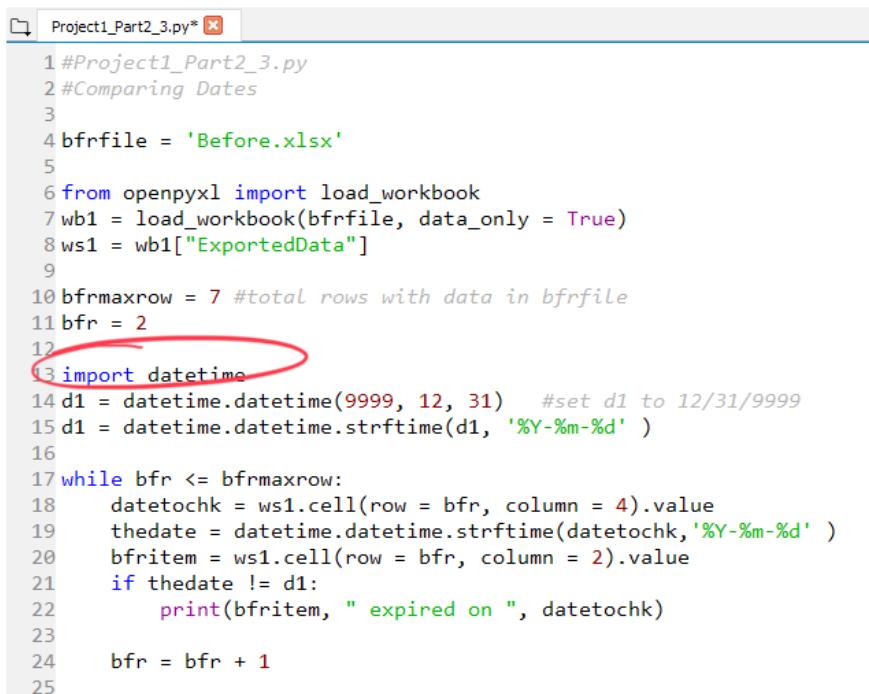
```
Spyder (Python 3.7)
File Edit Search Source Run Debug Consoles Projects Tools View Help
Editor - C:\Python_Lab1\Project1_Customize\Project1_Part2_6.py
untitled0.py  Project1_Part2_6.py*
63
64 #Look for new items in the After file (not in before file)
65 aft2 = 2
66 difnew = 2
67 while aft2 <= aftmaxrow:
68     aftitem2 = ws2.cell(row = aft2, column = 1)
69     bfr2 = 2
70     itemnew = 1
71     while bfr2 <= bfrmaxrow:
72         bfitem2 = ws1.cell(row = bfr2, column = 1)
73         if aftitem2.value == bfitem2.value:
74             itemnew = 0
75             bfr2 = bfrmaxrow + 1
76         else:
77             bfr2 = bfr2 + 1
78     if itemnew == 1:
79         ws12.cell(row = 1, column = 1).value = "Item"
80         ws12.cell(row = 1, column = 2).value = "Comments"
81         ws12.cell(row = difnew, column = 1).value = ws2.cell(row = aft2, column = 2).value
82         ws12.cell(row = difnew, column = 2).value = "New Item in After file"
83         difnew = difnew + 1
84     aft2 = aft2 + 1
85
86
87
88
89 wb4.save(diffile)
90
```

Figure 4.12 New Items

4.10 Compare Dates

The program **Project1_Part2_3.py** uses the "datetime" library to work with dates. This example uses two methods: **datetime** and **strftime**. The **strftime** method converts datetime objects to strings. Line 21 compares the two strings.

- The **datetime** method creates a datetime object in line 14. Line 15 converts the new datetime object to a string.
- The **strftime** takes a datetime object and returns a formatted string representing the date.
- The **strptime** takes a string and returns a datetime object.



```

1 #Project1_Part2_3.py
2 #Comparing Dates
3
4 bfrfile = 'Before.xlsx'
5
6 from openpyxl import load_workbook
7 wb1 = load_workbook(bfrfile, data_only = True)
8 ws1 = wb1['ExportedData']
9
10 bfrmaxrow = 7 #total rows with data in bfrfile
11 bfr = 2
12
13 import datetime
14 d1 = datetime.datetime(9999, 12, 31) #set d1 to 12/31/9999
15 d1 = datetime.datetime.strftime(d1, '%Y-%m-%d' )
16
17 while bfr <= bfrmaxrow:
18     datetochk = ws1.cell(row = bfr, column = 4).value
19     thedate = datetime.datetime.strptime(datetochk, '%Y-%m-%d' )
20     bfritem = ws1.cell(row = bfr, column = 2).value
21     if thedate != d1:
22         print(bfritem, " expired on ", datetochk)
23
24     bfr = bfr + 1
25

```

Figure 4.13 Compare Dates

Another useful datetime function returns today's date.

```
>>> strtoday = date.today()
```

Chapter 4

Conclusion

Einstein said, “If you can’t explain it simply, you don’t understand it well enough.” Learning new things is a passion of mine, and I’ve found the process of organizing notes, creating illustrations, and pondering how to craft clear examples helps me grasp concepts. Then too, it’s nice to go back in a year when I’ve forgotten something and refer to a solid example.

Thank you for reading along with me through the interesting topics and less than thrilling subjects. If the result is you have mastered new features, it was worth it! I’d love to hear the cool things you’re doing with Python, so please don’t hesitate to leave comments in a review.

Appendix

Download the sample Excel files and code from Github. The download includes this manual in PDF form.

<https://github.com/cryoung6/Lab1>

Please feel free to copy and share any and all materials with others. If you'd be kind enough to leave a review, it might lead to another \$1 royalty in my future!

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