Introduction to File I/O

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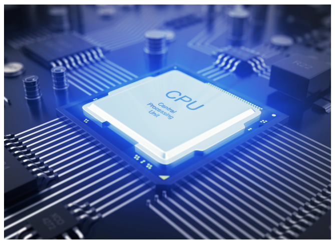
WHAT'S COVERED

In this lesson, we'll be looking at the basic ways to work with files, including opening, reading, writing, and closing files. Specifically, this lesson covers:

1. Opening Files
2. Reading Files
3. Writing to Files
4. Closing Files

1. Opening Files



So far, we have learned how to write programs and communicate our intentions to the **Central Processing Unit** using conditional statements, functions, and iterations. The Central Processing Unit is the brain of any computer. It is what runs the software that we write. It's also called the "CPU" or the "processor". We have learned how to create and use data structures in the Main Memory. The **Main Memory** is used to store information that the CPU needs in a hurry. The main memory is nearly as fast as the CPU. The CPU and Main Memory are where our software works and runs. It is where all of the "thinking" happens.

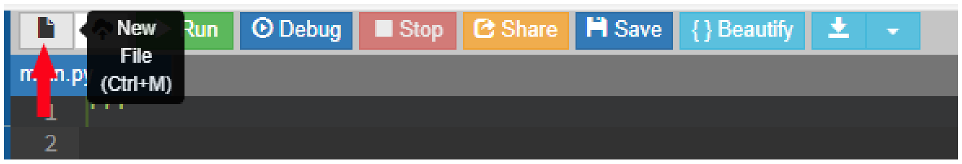
Once the power is turned off, anything stored in either the CPU or Main Memory is erased. Up to now, our programs have just been transient fun exercises to learn Python. Now we will start to work with **Secondary Memory** (or files). Secondary Memory is also used to store information, but it is much slower than Main Memory. The advantage of Secondary Memory is that it can store information even when there is no power to the computer. Examples of Secondary Memory are a USB flash drive or hard drive. If we store our information on a USB flash drive, the information can be removed from the system and transported to another system. We will primarily focus on reading and writing text files such as those we create in a text editor.

When we want to read or write a file (say on your hard drive), we first must open the file. Opening the file communicates with your operating system, which knows where the data for each file is stored. When you open a file, you are asking the operating system to first find the file by name and make sure the file exists, and then make its contents available (open) for reading or writing. When a stored file (data that is stored in Secondary Memory in a file or drive) is initially opened, it is moved from Secondary Memory to Main Memory where the CPU can use it. In the example (below), we open the file `poem.txt`, which should be stored in the same folder as the `main.py` file. In this IDE, we can create a file, name it `poem.txt` and add in the following text:

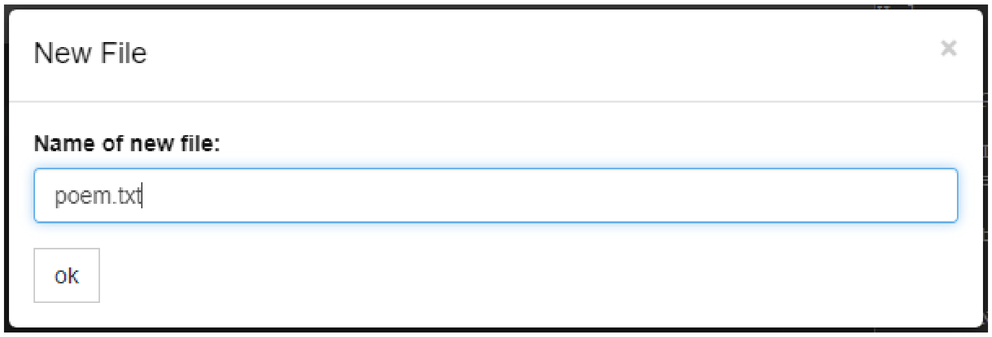
```
Roses Are Red,
Violets are blue,
Sugar is sweet,
And so are you.
```

To do so:

1. Click on the "New File" icon in the top menu.



2. Next, we name the file; in this case, we will call it `poem.txt`. We do not want a `.py` file, so we needed to add the `.txt` to make it a text file.

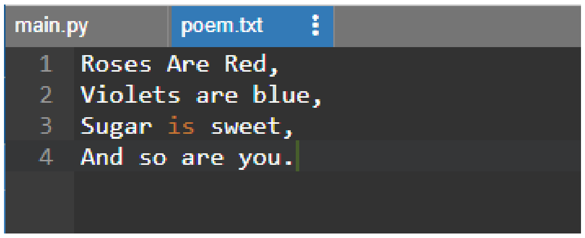

New File

Name of new file:

poem.txt

ok

3. Then we can paste in the code.



```
Roses Are Red,
Violets are blue,
Sugar is sweet,
And so are you.
```

TRY IT

Directions: Try following the steps above to create a new file and add some code.

Now that our `poem.txt` file has information, let’s try to read the file. We need to move back to the `main.py` file to add the following code.

EXAMPLE

```
fhandler = open('poem.txt')
print(fhandler)
```

Here is that output.

```
<_io.TextIOWrapper name='poem.txt' mode='r' encoding='UTF-8'>
```

TRY IT

Directions: Try adding the following code to the `main.py` file and running the program.

Not seeing the poem? That is because at this point we only opened up the file and we haven't read any data from the file. The output we see is just information pointing to the file. We added a variable called `fhandler` (file handler) and used the `open()` function on our `poem.txt` file. The **open() function** returns a file object. The `open()` function contains options for reading the content of the file.

TERMS TO KNOW

Central Processing Unit
The Central Processing Unit is the heart of any computer. It is what runs the software that we write; it is also called the “CPU” or the “processor”.

Main Memory
The Main Memory is used to store information that the CPU needs in a hurry. Main memory is nearly as fast as the CPU. The CPU and memory are where our software works and runs.

Secondary Memory
Secondary Memory is also used to store information, but it is much slower than the Main Memory. The advantage of the Secondary Memory is that it can store information even when there is no power to the computer.

open()
The `open()` function returns a file object. The `open()` function contains options for reading the content of the file.

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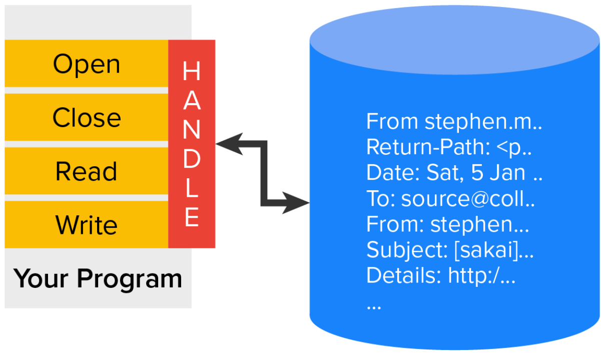
2. Reading Files

If the opening of a file is successful, the operating system returns a file handle. The **file handle** is not the actual data contained in the file, but instead it is a “handle” that we can use to read the data. Think of the file handle as being an address to a house. With the address to a house, you know where the house is but the address itself is just pointing to the house location in the same way that a file handle is pointing to a file. You are given a handle if the requested file exists and you have the proper permissions to read the file. If the file does not exist, open will fail with a traceback error and you will not get a handle to access the contents of the file.



Here is an example of a file that does not exist that we are trying to open.

EXAMPLE

```
fhandler = open('nofile.txt')
print(fhandler)
```

And here is the traceback error.

```
Traceback (most recent call last):
  File "/home/main.py", line 1, in <module>
    fhandler = open('nofile.txt')
FileNotFoundError: [Errno 2] No such file or directory: 'nofile.txt'
```

A text file can be thought of as a sequence of lines, much like a Python string can be thought of as a sequence of characters. The `poem.txt` file simply contains four lines of text for the poem.

While the file handle does not contain the data for the file, it is quite easy to construct a `for` loop to read through and count each of the lines in a file.

EXAMPLE

```
fhandler = open('poem.txt')
count = 0
for line in fhandler:
    count = count + 1
print('Line Count:', count)
```

This simple program gives the following output.

```
Line Count: 4
```

TRY IT

Directions: Try using the `open()` function and `for` loop to count the lines of our `poem.txt` file.

We can use the file handle as the sequence in our `for` loop. Our `for` loop simply counts the number of lines in the file and prints the final total out. The rough translation of the `for` loop into English is, “for each line in the file represented by the file handle, add one to the count variable.” We could call this pseudocode as it helps explain the details. The reason that the `open()` function does not read the entire file is that the file might be quite large with many gigabytes of data. The `for` loop takes the same amount of time to read a line regardless of the size of the file. The `for` loop is actually what causes the data to be read from the file.

When the file is read using a `for` loop in this manner, Python takes care of splitting the data in the file into separate lines using the newline character. Python reads each line through the newline and includes the newline as the last character in the line variable for each iteration of the for loop.

KEY CONCEPT

The newline character is a whitespace character similar to the space and tab character; it is not shown as a '\ ' (space) or a '\t' (tab). Even though the newline character is stored as a '\n' (newline), we do not see that character as a '\n' but rather we see the text moving to the next line.

Because the `for` loop reads the data one line at a time, it can efficiently read and count the lines in very large files without running out of Main Memory to store the data. The above program can count the lines in any size file using very little memory since each line is read, counted, and then discarded.

If you know the file is relatively small compared to the size of your Main Memory, you can read the whole file into one string using the `.read()` method on the file handle. The **.read() method** reads the entire file and returns the entire contents as a string. An example of something that may not fit into memory could be a full 4K movie file.

Here is an example of how to use the `.read()` method to return the full information in a file.

EXAMPLE

```
fhander = open('poem.txt')
text = fhander.read()
print(text)
```

This would be the output.

```
Roses are Red,
Violets are blue,
Sugar is sweet,
And so are you.
```

In this example, the entire contents of the file `poem.txt` are read directly into the variable `text`. When the file is read in this manner, all the characters—including all of the lines and newline characters—are one big string in the variable `text`. Remember that this form of reading the data should only be used if the file data will fit comfortably in the Main Memory of your computer. If the file is too large to fit in Main Memory, you should work with parts of it at a time in your program. This is also where tools like databases become very useful.

TRY IT

Directions: Now try to use the `.read()` method and see if you can output the contents of our `poem.txt` file.

TERMS TO KNOW

File Handle
The file handle is not the actual data contained in the file, but instead, it is a "handle" that we can use to read the data.

.read()
The `.read()` method reads the entire file and returns the entire contents as a string.

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3. Writing to Files

Earlier we mentioned that the `open()` function contains options for reading the content of the file. The `open()` function by default allows us to read the file but we can also pass in 'r' as the second parameter (called mode) to do the same thing.

EXAMPLE

```
fout = open('output.txt', 'r')
```

To write to a file, we use the `open()` function with the mode 'w' as a second parameter of the `open()` function.

EXAMPLE

```
fout = open('output.txt', 'w')
```

KEY CONCEPT

If the file already exists, opening it in write ('w') mode clears out the old data and starts fresh, so be careful!

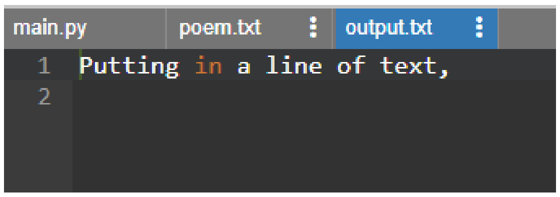
If the file doesn't exist, a new one is created. The **.write() method** of the file handle object writes a specified text to the file, returning the number of characters written. The default write mode is text for writing (and reading) strings.

EXAMPLE

```
fout = open('output.txt', 'w')
line1 = "Putting in a line of text,\n"
fout.write(line1)
```

Here we created a variable called `fout` (file out) that uses the `open()` function with the 'w' (write) in the second parameter. Next, we created variable `line1` and assigned it a string with a newline character at the end. Finally, we are using the `.write()` method to write `line1` to our `output.txt` file.

Notice that the file is created if we run this code.



```
Putting in a line of text,

```

TRY IT

Directions: Go ahead and try to run the code above in the `main.py` file to write to a file called `output.txt`.

Again, the file handle keeps track of where it is, so if you call the `.write()` method again, it adds the new data to the end of the file. We will cover some of the other ways to manipulate files in the next lesson.

DID YOU KNOW

Did you notice nothing has been added to the `output.txt` file? Did you look? That is because when you write to a file, it is similar to writing in Microsoft Word; unless you save it, your work will be lost. Python has a “save” feature—it’s called the `.close()` function, coming up next.

TERM TO KNOW

.write()
The `.write()` method of the file handle object writes a specified text to the file, returning the number of characters written.

4. Closing Files

When you are done writing, you have to close the file to make sure that the last bit of data is saved so it will not be lost if the power goes off.

Here is our last example with a new statement line at the end.

EXAMPLE

```
fout = open('output.txt', 'w')
line1 = "Putting in a line of text,\n"
fout.write(line1)
fout.close()
```

The **.close() method** of the file handle object closes an open file. We could call the `.close()` method after we open a file for reading, but that can add unnecessary lines of code to a program if we are only opening a few files for reading, since Python makes sure that all open files are closed when the program ends. However, when we are writing files, we want to explicitly close the files if we made changes (wrote anything to them); otherwise, the changes will not be saved.

TRY IT

Directions: Now try adding the `.close()` method to your program and running it again. Now that we added the `.close()` method, you should see the string in our `output.txt` file.

TERM TO KNOW

.close()
The `.close()` method of the file handle object closes an open file.

SUMMARY

In this lesson, we learned about the different ways that we can work with files, including creating files, **writing to files** and **reading from files**. We also learned about how to **open a file** and **close a file**. We'll explore and learn more details of these options in upcoming lessons.

Best of luck in your learning!

TERMS TO KNOW

.close()
The `.close()` method of the file handle object closes an open file.

.read()
The `.read()` method reads the entire file and returns the entire contents as a string.

.write()
The `.write()` method of the file handle object writes a specified text to the file, returning the number of characters written.

Central Processing Unit
The Central Processing Unit is the heart of any computer. It is what runs the software that we write; it is also called the "CPU" or the "processor".

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