CS303E: Elements of Computers and Programming

Files

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Value of Files

Files are a persistent way to store programs, input data, and output data.

Files are stored in the memory of your computer in an area allocated to the *file system*, which is typically arranged into a hierarchy of *directories*.

The *path* to a particular file details where the file is stored within this hierarchy.

Relative Pathnames

A path to a file may be *absolute* or *relative*.

If you just name the file, you're specifying that it is in the current working directory.

```
> pwd
/u/byoung/cs303e/slides
> ls -l MTable
-rw-r----- 1 byoung prof 812 Sep 21 13:11 MTable
> ls -l /u/byoung/cs303e/slides/MTable
-rw-r----- 1 byoung prof 812 Sep 21 13:11 /u/byoung/cs303e/
    slides/MTable
> ls syllabus303e.html
ls: cannot access 'syllabus303e.html': No such file or
    directory
> ls ../syllabus303e.html
../syllabus303e.html
```

File Paths

On Windows, a file path might be:

```
c:\byoung\cs303e\slides\slides11a-files.tex
```

On Linux or MacOS, it might be:

```
/home/byoung/cs303e/slides/slides11a-files.tex
```

Python passes filenames around as strings, which causes some problems for Windows systems, partly because Windows uses the "\" in filepaths. *Recall that backslash is an escape character, and including it in a string may require escaping it.*

Raw Strings

There is a way in Python to treat a string as a **raw string**, meaning that escaped characters are treated just as any other characters.

```
>>> print("abc\ndef")
abc
def
>>> print(r"abc\ndef")
abc\ndef
```

Prefix the string with an "r". You may or may not need to do the for Windows pathnames including "\"

Managing Files in Python

Python provides a simple, elegant interface to storing and retrieving data in files.

open : establish a connection to the file and associate a local file *handle* with a physical file.
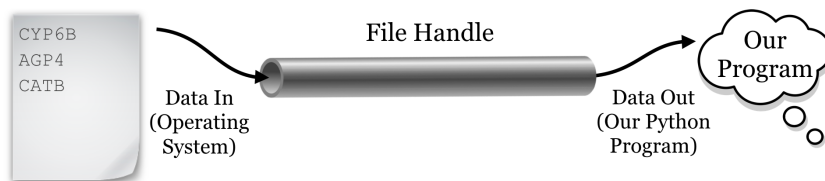
close : terminate the connection to the file.

read : input data from the file into your program.

write : output data from your program to a file.

Opening a File

Before your program can access the data in a file, it is necessary to *open* it. This returns a *file object*, also called a "handle," that you can use within your program to access the file.

It also informs the system how you intend for your program to interact with the file, the "mode."

Example of Opening a File

General Form:

```
fileVariable = open(filename, mode)
```

```
>>> outfile = open("MyNewFile", "w")
>>> outfile.write("My dog has fleas!\n")
18
>>> outfile.close()
>>>    # cntr-D out of interactive mode

> cat MyNewFile
My dog has fleas!
```

Opening a File: Modes

Here are the permissible modes for files:

Mode	Description
"r"	Open for reading.
"w"	Open for writing. If the file already exists the old contents are overwritten.
"a"	Open for appending data to the end of the file.
"rb"	Open for reading binary data.
"wb"	Open for writing binary data.

You also have to have necessary permissions from the operating system to access the files.

This semester we probably won't be using the binary modes.

Closing the File

General form:

```
fileVariable.close()
```

All files are closed by the OS when your program terminates. Still, it is very important to close any file you open in Python.

- the file will be locked from access by any other program while you have it open;
- items you write to the file may be held in internal buffers rather than written to the physical file;
- if you have a file open for writing, you can't read it until you close it, and re-open for reading;
- *it's just good programming practice.*

Reading/Writing a File

There are various Python functions for reading data from or writing data to a file, given the file object in variable `fn`.

Function	Description
fn.read()	Return entire remaining contents of file as a string.
fn.read(k)	Return next k characters from the file as a string.
fn.readline()	Returns the next line as a string.
fn.readlines()	Returns all remaining lines in the file as a list of strings.
fn.write(str)	Writes the string to the file.

These functions advance an internal *file pointer* that indicates where in the file you're reading/writing. open sets it at the beginning of the file.

Testing File Existence

Sometimes you need to know whether a file exists, otherwise you may overwrite an existing file. Use the `isfile` function from the `os.path` module.

```
>>> import os.path
>>> os.path.isfile("slides11a-files.pdf")
True
>>> os.path.isfile("slides11a-files.png")
False
```

Here the filepath given is *relative* to the current directory.

Let's Take a Break

Example: Read Lines from File

```python
import os.path

def main():
    """ Count lines in file. """
    if not os.path.isfile("gettysburg-address"):
        print("File does not exist")
        return

    # Open file for input
    gaFile = open("gettysburg-address", "r")
    line = gaFile.readline()
    lineCount = 0
    while line:                    # line is not empty string
        lineCount += 1
        print(format(lineCount, "3d"), ": ", \
                line.strip(), sep= "" )
        line = gaFile.readline()
    print("\nFound", lineCount, "lines.")
    gaFile.close()

main()
```

Example: Read Lines from File

```
> ls gettysburg-address
gettysburg-address
> wc gettysburg-address
   21  278 1475 gettysburg-address
> python ReadFile.py
  1: Four score and seven years ago our fathers brought
     forth on this
  2: continent, a new nation, conceived in Liberty, and
     dedicated to the
     ...
 21: freedom -- and that government of the people, by the
     people, for the
 22: people, shall not perish from the earth.

Found 22 lines.
```

Example: Write File

Recall our earlier example to generate and print a multiplication up to LIMIT. Below is the code to write the table to a file MTable.

One major difference is that print inserts a newline at the end of each line, unless you ask it not to. write does not do that.

```python
LIMIT = 13

def main():
    """ Print a multiplication table to LIMIT - 1. """
    outfile = open("MTable", "w")
    outfile.write("Multiplication Table".center \
                        ( 6 + 4 * (LIMIT - 1)) + "\n")
    # Display the number title
    outfile.write("    |")
    for j in range(1, LIMIT):
        outfile.write(format(j, "4d"))
    outfile.write("\n")     # jump to a new line
    outfile.write("------" + "----"* (LIMIT - 1) + "\n")
```

Code continues next slide.

Example: Write File

Continued from previous slide.

```
    # Display table body
    for i in range(1, LIMIT):
        outfile.write( format(i, "3d") + " |")
        for j in range(1, LIMIT):
            # Display the product and align properly
            outfile.write( format( i*j, "4d"))
        outfile.write("\n")
    outfile.close()
```

Example: Write File

```
> python MultiplicationTable2.py
> cat MTable
              Multiplication Table
     |   1   2   3   4   5   6   7   8   9  10  11  12
   --------------------------------------------------------
   1 |   1   2   3   4   5   6   7   8   9  10  11  12
   2 |   2   4   6   8  10  12  14  16  18  20  22  24
   3 |   3   6   9  12  15  18  21  24  27  30  33  36
   4 |   4   8  12  16  20  24  28  32  36  40  44  48
   5 |   5  10  15  20  25  30  35  40  45  50  55  60
   6 |   6  12  18  24  30  36  42  48  54  60  66  72
   7 |   7  14  21  28  35  42  49  56  63  70  77  84
   8 |   8  16  24  32  40  48  56  64  72  80  88  96
   9 |   9  18  27  36  45  54  63  72  81  90  99 108
  10 |  10  20  30  40  50  60  70  80  90 100 110 120
  11 |  11  22  33  44  55  66  77  88  99 110 121 132
  12 |  12  24  36  48  60  72  84  96 108 120 132 144
```

Aside: Redirecting Output

There's another way to get the output of a program into a file.

When your file does a print, it sends the output to standard out, which is typically the terminal.

You can *redirect* the output to a file, using > filename. Anything that would have been printed on the screen goes into a file instead.

```
> cat HelloWorld.py
print( "Hello, World!" )
> python HelloWorld.py
Hello, World!
> python HelloWorld.py > HelloOutput
> cat HelloOutput
Hello, World!
```

Notice that this happens at the OS level, not at the Python level.
Good programmers know how to do things multiple ways!

Example: Reading and Writing File

```
import os.path

def CopyFile():
    """ Copy contents from file1 to file2. """
    # Ask user for filenames
    f1 = input("Source filename: ").strip()
    f2 = input("Target filename: ").strip()
    # Check if target file exists.
    if os.path.isfile( f2 ):
        print( f2 + " already exists" )
        return
    # Open files for input and output
    infile = open( f1, "r" )
    outfile = open( f2, "w" )
    # Copy from input to output a line at a time
    for line in infile:
        outfile.write( line )
    # Close both files
    infile.close()
    outfile.close()

CopyFile()
```

Running CopyFile

```
> ls HelloWorld.py
HelloWorld.py
> cat HelloWorld.py
print( "Hello, World!" )
> ls NewHelloWorld.py
ls: cannot access 'NewHelloWorld.py': No
    such file or directory
> python CopyFile.py
Source filename: HelloWorld.py
Target filename: NewHelloWorld.py
> cat NewHelloWorld.py
print( "Hello, World!" )
```

Example: Reading and Writing File

One cannot simultaneously read and write a file in Python. However, you can write a file, close it, and re-open it for reading.

In file WriteReadNumbers.py:

```python
from random import randint

def main():
    """ Write 100 random integers to a file, read them
        back, and print them, 10 per line. """
    # Open file for writing
    outfile = open("RandomNumbers.txt", "w")
    # Write 100 random integers in [0 .. 99] to file
    for i in range(100):
        outfile.write(str(randint(0, 99)) + " ")
    outfile.close()
```

Code continues on next slide.

Example: Reading and Writing File

Continued from previous slide.

```python
    # Re-open the file for reading
    infile = open("RandomNumbers.txt", "r")
    # This will read the entire file into string
    string = infile.read()
    # Split string into numbers.
    numbers = [ int(x) for x in string.split() ]
    onLine = 0
    # Print them 10 per line.
    for num in numbers:
        print( format(num, "2d"), end = " ")
        onLine += 1
        if onLine == 10:
            print()
            onLine = 0
    infile.close()
```

Reading and Writing File

```
> python WriteReadNumbers.py
93  0 48 62 77 84 14 36 99 83
90 46 48 27 27 40 87 87 86 15
72  4 28 48 78 70 90 96 27 97
43 73 40 26 96 93 54 61 13 22
82 66 95 35 56 95 18 54 26 90
63 79  5 26 43 12 49 86 22 90
77 84 66 97 75 35 27 74 75  1
72  2 55 17 12 63 73 89  3 71
81 39 43 46 19 99 45 31 39 35
38 47 56 64 84 31 63 81  4 38
```

Append Mode

Opening a file in append mode "a", means that writing a value to the file appends it at the end of the file.

It *does not* overwrite the previous content of the file.

You might use this to maintain a log file of transactions on an account.

New transactions are added at the end, but all transactions are recorded.