# File I/O

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## Objectives

- See how to read and write multiple file types
- Use deterministic cleanup for files correctly
- Work with in-memory streaming APIs
- Work with paths and directories cross-platform

## File I/O in Python

- There are five common types of file operations
  - **Text**
    - Read / write text of any format
    - String-based IO
  - **Binary**
    - Read / write binary of any format
    - Stream bytes and bytearray in and out
  - **XML**
    - Load XML documents
    - Parse / query documents using XPath
  - **JSON**
    - Convert JSON to / from dictionaries
    - Convert JSON to / from custom classes
  - **Pickling**
    - Serialize object graphs to proprietary binary formats

## Text I/O [modes]

- Opening and creating text files
  - Uses `open(filename, mode)` built-in

| Mode | Meaning |
|---|---|
| r | Open text file for **reading**.<br>Stream is positioned at the **beginning** of the file. |
| r+ | Open for **reading** and **writing**.<br>The stream is positioned at the **beginning** of the file. |
| w | **Truncate** file to zero length or create text file for writing.<br>The stream is positioned at the **beginning** of the file. |
| w+ | Open for **reading** and **writing**.<br>The file is **created** if it does not exist, otherwise it is **truncated**. The stream is positioned at the **beginning** of the file. |
| a | Open for **writing**.<br>The file is **created** if it does not exist.<br>The stream is positioned at the **end** of the file. |
| a+ | Open for **reading** and **writing**.<br>The file is **created** if it does not exist.<br>The stream is positioned at the **end** of the file. |

## Text I/O [reading examples]

Open file with built-in open method.

Utility methods make text files easy.

```
csvFileName = "SomeData.csv"

fin = open(csvFileName, 'r', encoding="utf-8")
lines = fin.readlines()
```

Loads all data at once

Text file handles are iterable (line by line)

```
csvFileName = "SomeData.csv"

fin = open(csvFileName, 'r', encoding="utf-8")
for line in fin:
    print(line, end='')
```

Uses deferred iteration

## Text I/O [cleaning up]

Files should be closed ASAP.

```
csvFileName = "SomeData.csv"

fin = open(csvFileName, 'r', encoding="utf-8")
lines = fin.readlines()
fin.close()
```

```
csvFileName = "SomeData.csv"

with open(csvFileName, 'r', encoding="utf-8") as fin:
    for line in fin:
        print(line, end='')
```

The **with** statement makes this trivial, even in the case of exceptions or early returns.

## Text I/O [writing text files]

Create or open text file for appending with **a+** mode

```
with open("app.log", 'a+', encoding="utf-8") as fout:
    fout.write("The application is starting up...\n")
    fout.write("Everything looks good.\n")
```

Write method takes a string, appends it to the file

There is no 'writeline' but you can make one.

## Text I/O [in-memory stream - reading]

The **io** package has helpful utility classes

We can treat this string as an incoming text-based file stream

```
import io

txt = """\
This is my text.
There are many words like it
But this one is my own\
"""
fin = io.StringIO(txt)

for l in fin:
    print(l, end='')

# prints
# This is my text.
# There are many words like it
# But this one is my own
```

## Text I/O [in-memory stream - writing]

The **io** package has helpful utility classes

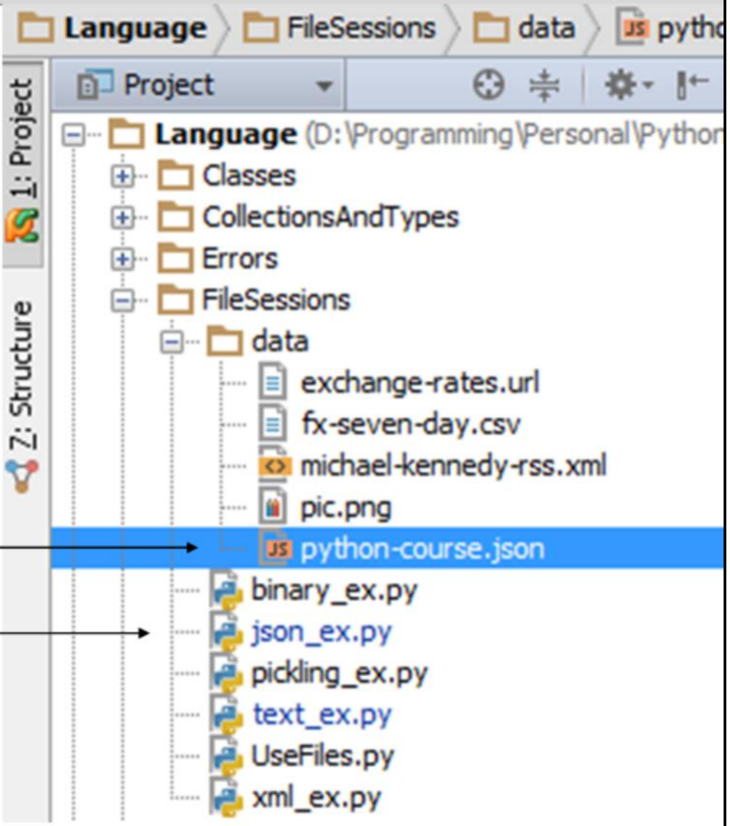
We can treat this in-memory stream as a text file handle, mode w+.

```
import io

fout = io.StringIO()

fout.write("This is line one!\n")
fout.write("This is line two!\n")

fout.seek(0)
print(fout.read())

# prints
# This is line one!
# This is line two!
```

## Working with file paths (cross-platform)

How do I locate this file

From this file?



Note: this must be cross-platform safe.

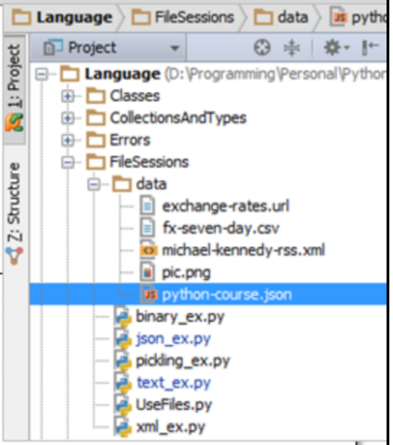
## Working with file paths (cross-platform)

OS module has path and file tools

os.path.dirname() gets the folder

__file__ is the script

os.path.join() creates the new file path



```
Language > FileSessions > data > pytho
Project
Language (D:\Programming\Personal\Pythor
  Classes
  CollectionsAndTypes
  Errors
  FileSessions
    data
      exchange-rates.url
      fx-seven-day.csv
      michael-kennedy-rss.xml
      pic.png
      python-course.json
    binary_ex.py
    json_ex.py
    pickling_ex.py
    text_ex.py
    UseFiles.py
    xml_ex.py
```

```python
import os

srcFile = __file__
srcDir = os.path.dirname(srcFile)
file = 'python-course.json'

targetFile = os.path.join(srcDir, 'data', file)

print(targetFile)

# prints this on OS X
#/Users/mkennedy/epython/Language/FileSessions/data/python-course.json

# prints this on Windows
#D:\Python_Course\Language\FileSessions\data\python-course.json
```

From Python 3.4 changes: Module __file__ attributes (and related values) should now always contain absolute paths by default, with the sole exception of __main__.__file__ when a script has been executed directly using a relative path. (Contributed by Brett Cannon in issue 18416.)

## Binary I/O [reading files]

Incoming data can be stored in **bytearray** or directly processed.

**Must** specify **binary mode** (rb)

```
bytes = bytearray()

with open(srcFile, 'rb') as fin:
    chunkSize = 1024
    buffer = fin.read(chunkSize)
    while buffer:
        bytes.extend(buffer)
        buffer = fin.read(chunkSize)
```

Read buffer sized chunks and store or process them.

## Binary I/O [writing files]

Use mode 'wb'

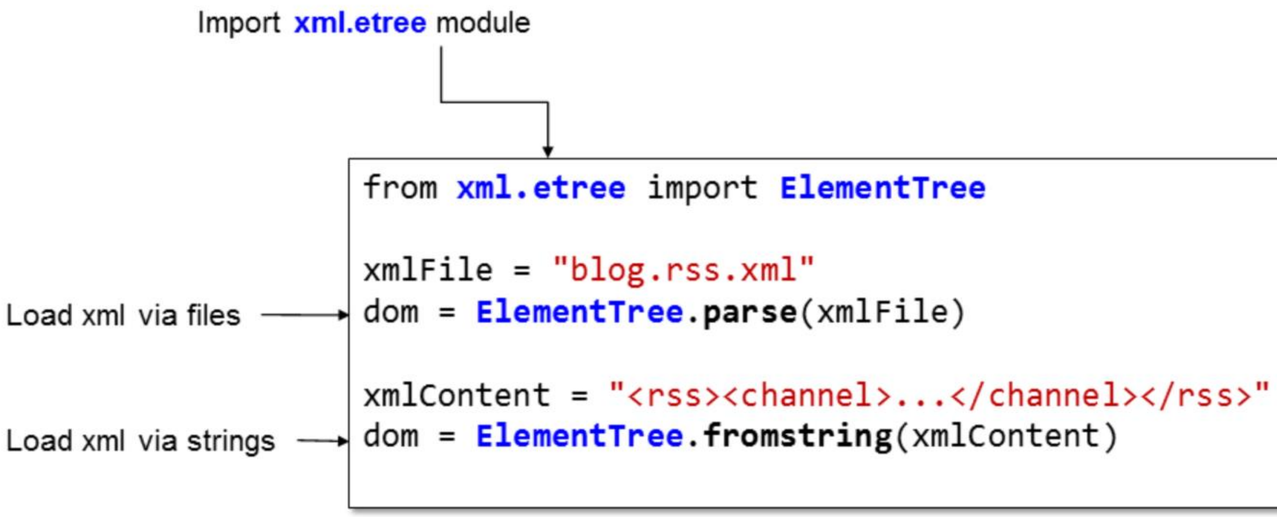
Write byte by byte

Memory streams have a simpler method

```
memStream = getBinaryDataToSave()

# iteratively write (buffered)
with open(destFile, 'wb') as fout:
    for b in memStream:
        fout.write(b)

# write all in one shot
with open(destFile, 'wb') as fout:
    allBytes = memStream.getbuffer()
    fout.write(allBytes)
```

## XML Files

- XML file support is built-in to Python
  - Import the **`xml.etree`** module
  - The **ElementTree** XML API provides simple DOM-based API



```
from xml.etree import ElementTree

xmlFile = "blog.rss.xml"
dom = ElementTree.parse(xmlFile)

xmlContent = "<rss><channel>...</channel></rss>"
dom = ElementTree.fromstring(xmlContent)
```

## XML Files [querying data]

- Given this RSS data, find all titles and related links.

```
<?xml version="1.0" encoding="UTF-8"?>
<rss version="2.0">
    <channel>
        <title>Michael Kennedy on Technology</title>
        <link>http://blog.michaelckennedy.net</link>
        <item>
            <title>Watch Building beautiful web...</title>
            <link>http://blog.michaelckennedy.net/...</link>
        </item>
        <item>
            <title>MongoDB for .NET developers</title>
            <link>http://blog.michaelckennedy.net/...</link>
        </item>
        <item>...</item>
     </channel>
</rss>
```

## XML Files [querying data]

Search for elements using dom.**findall**()

```
from xml.etree import ElementTree
dom = ElementTree.parse("blog.rss.xml")

items = dom.findall('channel/item')
print("Found {0} blog entries.".format(len(items)))

entries = []
for item in items:
    title = item.find('title').text
    link  = item.find('link').text
    entries.append( (title, link) )
```

Extract the data from each item

```
Found 50 blog entries.
entries[:3] =>
[
   ('title1', 'link1'),
   ('title2', 'link2'),
   ('title3', 'link3),
]
```

## JSON data

- JSON support comes built-in to Python
  - import the **`json`** module
  - serialize dictionaries
  - serialize custom objects
    - that have been built to support JSON
    - that do not intentionally support JSON

## JSON data [parsing JSON]

- Python dictionaries' and JSON string representations are extremely similar.
  - Converting between them should be easy

**Python dictionary**

```
{
   'hobbies': [
      'biking',
      'motocross',
      'hiking'],
    'name': 'Michael',
    'email': '...'
}
```

**JSON string**

```
{
  "hobbies": [
       "biking",
       "motocross",
       "hiking"],
   "email": "...",
   "name": "Michael"
}
```

## JSON data [JSON to dictionaries]

Access JSON classes by importing **json**

Start with JSON text as a string

**json.loads** converts a string to a dictionary

```python
import json

jsonTxt = '{"name": "Jeff", "age": 24}'

d = json.loads(jsonTxt)
print( type(d) )
print( d )

# prints:
# <class 'dict'>
# {'age': 24, 'name': 'Jeff'}
```

Note: **json.load** converts a file to a dictionary (pass a file **stream** as the parameter).

## JSON data [dictionaries to JSON]

Access JSON classes by importing **json**

Start with a dictionary

```
import json

d = dict(name="Jeff", age=24)

jsonTxt = json.dumps(d)
print( jsonTxt )

# prints: '{"age": 24, "name": "Jeff"}'
```

**json.dumps** converts a dictionary to a string

Note: **json.dump** converts a dictionary to a file.

## JSON data [objects to JSON]

- Classes cannot be directly converted to JSON

```
class Person(object):
    def __init__(self, name, hobbies, email):
        self.name = name
        self.email = email
        self.hobbies = hobbies
```

Not supported

```
import json

jeff = Person('Jeff', [], 'j@develop.com')
jsonTxt = json.dumps(jeff)

# TypeError:
<Person object at 0x000000000250CEF0> is not JSON serializable
```

## JSON data [objects to JSON]

- Classes cannot be directly converted to JSON
  - But their dictionaries can be
  - Converting back is harder

```
class Person(object):
    def __init__(self, name, hobbies, email):
        self.name = name
        self.email = email
        self.hobbies = hobbies
```

```
import json

jeff = Person('Jeff', [], 'j@develop.com')
jsonTxt = json.dumps(jeff.__dict__)
print(jsonTxt)

# prints:
# {"hobbies": [], "email": "j@develop.com", "name": "Jeff"}
```

## JSON data [objects to JSON]

- Adding JSON support to our class

```
import json

class Person(object):
    def toJSON(self):
        return json.dumps(self.__dict__)

```

↓

```
jeff = Person('Jeff', [], 'j@develop.com')
jsonTxt = jeff.toJSON()
print(jsonTxt)

# prints:
# {"hobbies": [], "email": "j@develop.com", "name": "Jeff"}
```

## JSON data [JSON to objects]

- Adding JSON **parsing** support to our class

```
import json

class Person(object):
    def toJSON(self): ...

    @staticmethod
    def fromJSON(jsonText):
        d = json.loads(jsonText)
       return Person(**d) # requires arg names to match
```

↓

```
jsonTxt = '{"hobbies": [], "email": "j@develop.com", "name": "Jeff"}'

jeff = Person.fromJSON(jsonTxt)
type(jeff) # <class Person>
```

## JSON data [for humans]

- For nested data, indentation can be a big help

```
import json

d = dict(name="Jeff", age=24, hobbies=['skiing', 'hiking'])

jsonTxt = json.dumps(d, indent=4)
print( jsonTxt )

# prints:
{
    "age": 24,
    "hobbies": [
        "skiing",
        "hiking"
    ],
    "name": "Jeff"
}
```

## Binary object serialization

- Python supports a proprietary binary serialization format
  - Called Pickle
  - Good for short-term storage

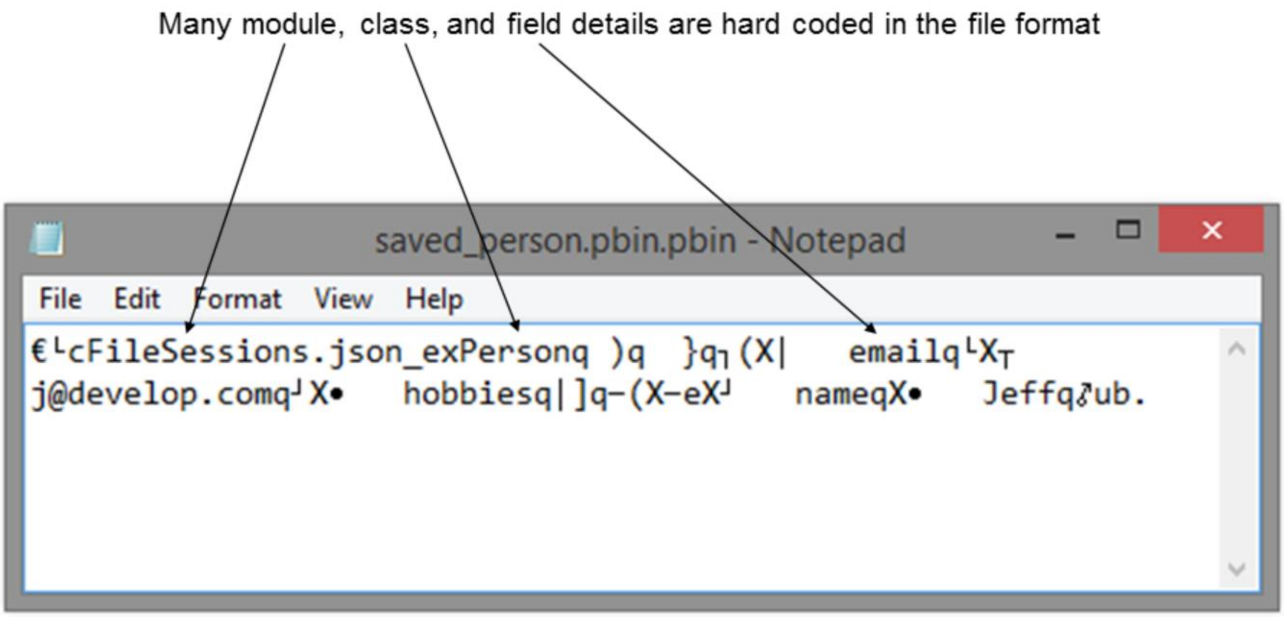
**dump** writes object to binary file

**load** reads object from binary file

```
import pickle

jeff = Person('Jeff', [], 'j@develop.com')
pFile = 'saved_person.pbin'

with open(pFile, 'wb+') as fout:
    pickle.dump(jeff, fout)

with open(pFile, 'rb') as fin:
    newJeff = pickle.load(fin)
```

## Binary object serialization [limitations]

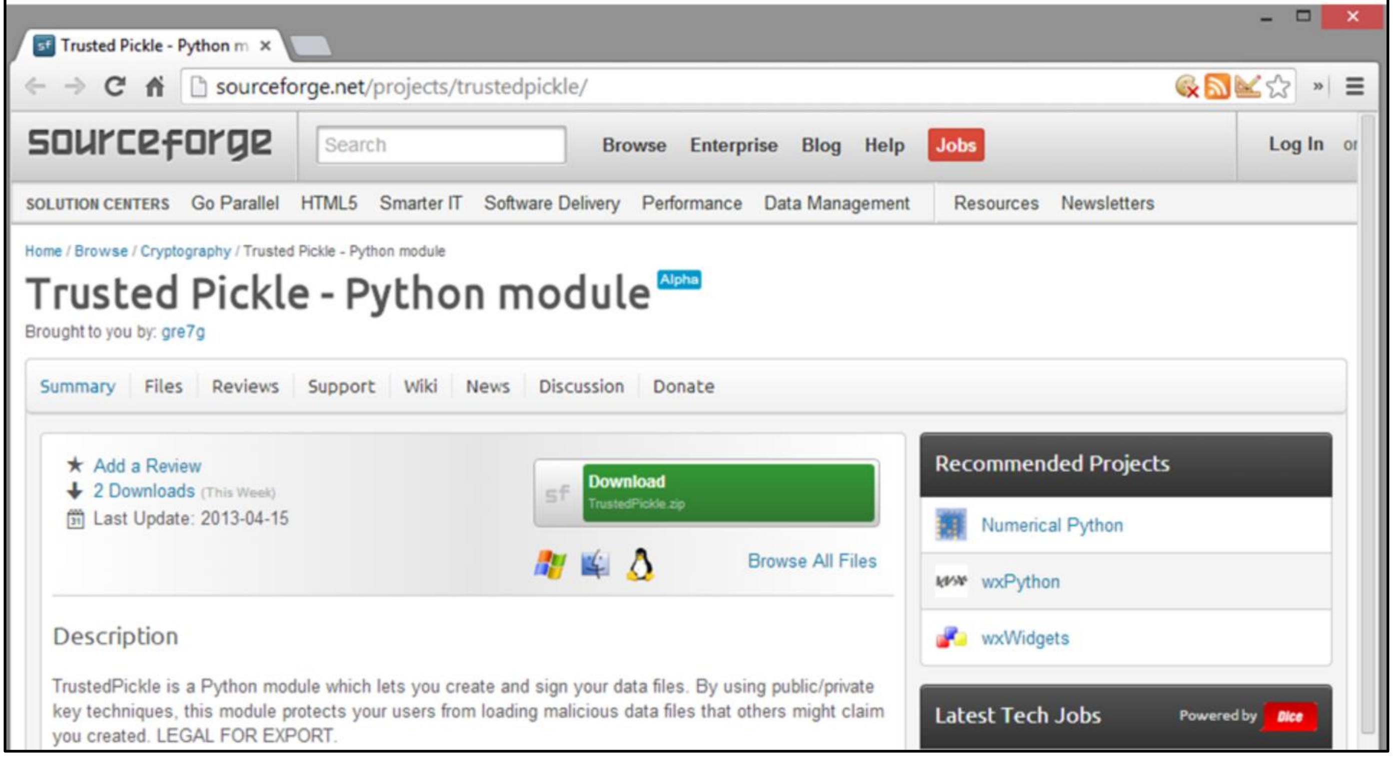
- Picking is not good for
  - Code that may change (fields, module names, class names)


Many module, class, and field details are hard coded in the file format
saved_person.pbin.pbin - Notepad
File Edit Format View Help

```
€└cFileSessions.json_exPersonq )q  }q┐(X|   emailq└X┬
j@develop.comq┘X•   hobbiesq|]q-(X-eX┘   nameqX•   Jeffq♪ub.
```

## Binary object serialization [security]

- Unpickling can result in arbitrary code execution
  - Do not use pickle files for IPC with untrusted clients / services
  - Trusted pickle is a secure version [1]



Trusted Pickle - Python module Alpha

Brought to you by: gre7g

2 Downloads (This Week)

Last Update: 2013-04-15

Description

TrustedPickle is a Python module which lets you create and sign your data files. By using public/private key techniques, this module protects your users from loading malicious data files that others might claim you created. LEGAL FOR EXPORT.

## Summary

- Python has built-in support for text, binary, JSON, XML, and serialization files
- File handles should generally be used within `with` blocks
- The io module gives a file API to in-memory objects
- The os module enables cross-platform file operations