Lecture 23

Advanced Error Handling

Announcements for This Lecture

Prelim 2

- **Prelim, Nov 21st at 7:30**
  - See webpage for rooms
  - Review **Sun Nov. 19 (TBA)**
- **Material up to Today**
  - Recursion + Loops + Classes
  - Study guide is now posted
- **Conflict with Prelim?**
  - Prelim 2 Conflict on CMS
  - SDS students must submit!

Assignments

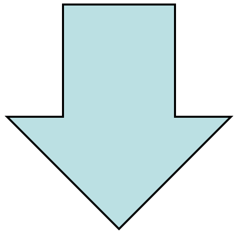
- A4 is now graded
  - **Mean**: 89.1 **Median**: 91
  - **Mean**: 9.3 hrs **SDev**: 5 hrs
- A5 graded by Sunday
- Keep working on A6
  - **MUST** be done with Task 3
  - Should be close with Task 4
  - Start Task 5 by tomorrow

A Problem with Subclasses

```
class Fraction(object):
    """Instances are normal fractions n/d"""
    # INSTANCE ATTRIBUTES
    # _numerator:    int
    # _denominator: int > 0

class FractionalLength(Fraction):
    """Instances are fractions with units """
    # INSTANCE ATTRIBUTES same but
    # _unit: one of 'in', 'ft', 'yd'
    def __init__(self,n,d,unit):
        """Make length of given units"""
        assert unit in ['in', 'ft', 'yd']
        super().__init__(n,d)
        self._unit = unit
```

```
>>> p = Fraction(1,2)
>>> q = FractionalLength(1,2,'ft')
>>> r = p*q
```



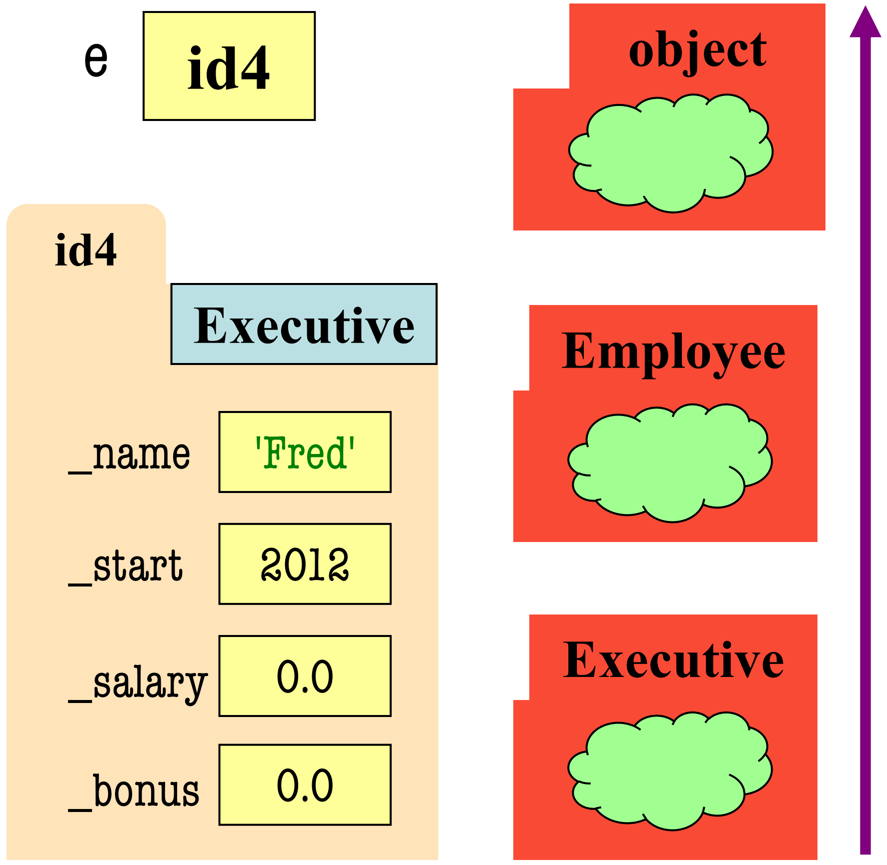
Python converts to

```
>>> r = p.__mul__(q) # ERROR
```

__mul__ has precondition
type(q) == Fraction

The isinstance Function

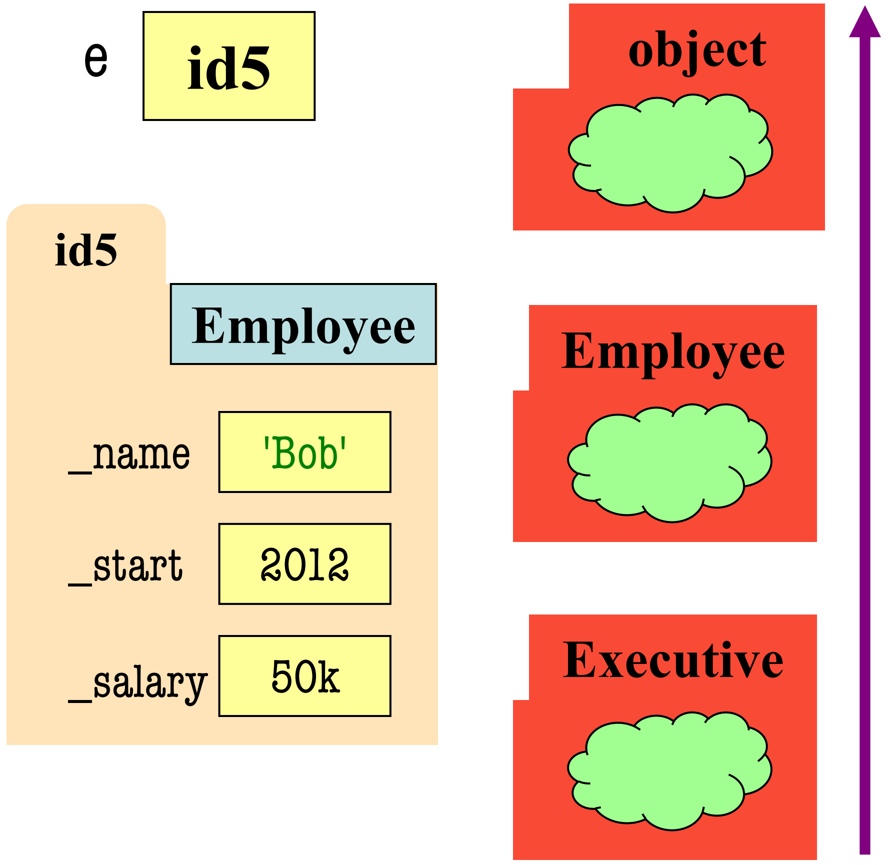
- isinstance(<obj>,<class>)
  - True if <obj>'s class is same as or a subclass of <class>
  - False otherwise
- **Example**:
  - isinstance(e,Executive) is True
  - isinstance(e,Employee) is True
  - isinstance(e,object) is True
  - isinstance(e,str) is False
- Generally preferable to type
  - Works with base types too!



isinstance and Subclasses

```
>>> e = Employee('Bob',2012)
>>> isinstance(e,Executive)
???
```

A: True
B: False
C: Error
D: I don't know



isinstance and Subclasses

```
>>> e = Employee('Bob',2011)
>>> isinstance(e,Executive)
???
```

A: True
B: False   Correct
C: Error
D: I don’t know

$$\begin{tikzcd}
\texttt{object} \\
\texttt{Employee} \arrow[u] \\
\texttt{Executive} \arrow[u]
\end{tikzcd}$$

→ means “extends”
or “is an instance of”

Fixing Multiplication

```
class Fraction(object):
    """Instances are fractions n/d"""
    # _numerator:    int
    # _denominator: int > 0

    def __mul__(self,q):
        """Returns: Product of self, q
        Makes a new Fraction; does not
        modify contents of self or q
        Precondition: q a Fraction"""
        assert isinstance(q, Fraction)
        top = self.numerator*q.numerator
        bot = self.denominator*q.denominator
        return Fraction(top,bot)
```

```
>>> p = Fraction(1,2)
>>> q = FractionalLength(1,2,'ft')
>>> r = p*q
```

Python converts to

```
>>> r = p.__mul__(q) # OKAY
```

Can multiply so long as it has numerator, denominator

Error Types in Python

```
def foo():
    assert 1 == 2, 'My error'
    …
```

```
def foo():
    x = 5 / 0
    …
```

```
>>> foo()
AssertionError: My error
```

```
>>> foo()
ZeroDivisionError: integer
division or modulo by zero
```

Class Names

Error Types in Python

```
def foo():
    assert 1 == 2, 'My error'
    …
```

```
d
```

Information about an error is stored inside an **object**. The error type is the **class** of the error object.

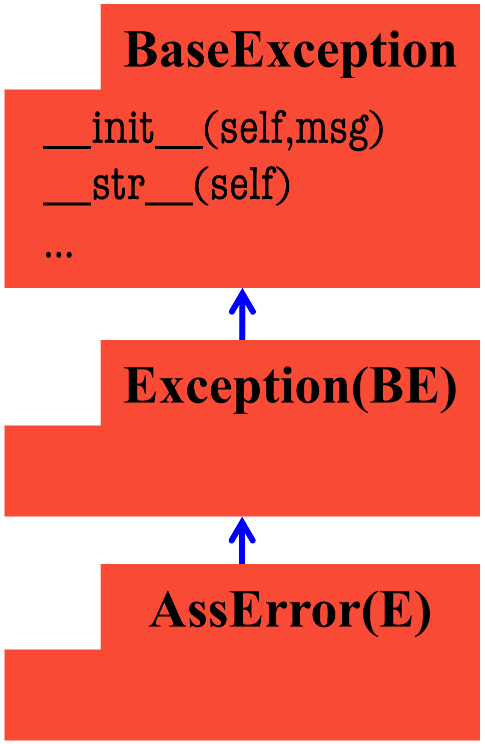
```
>>> foo()
AssertionError: My error
```

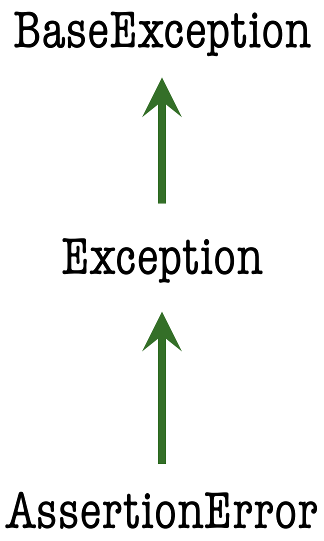
```
>>> foo()
ZeroDivisionError: integer
division or modulo by zero
```

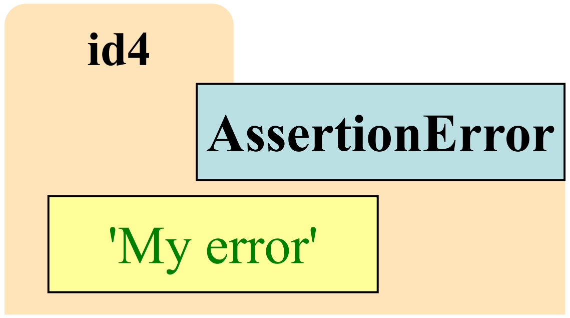
Class Names

Error Types in Python

- All errors are instances of class BaseException
- This allows us to organize them in a hierarchy







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Error Types in Python

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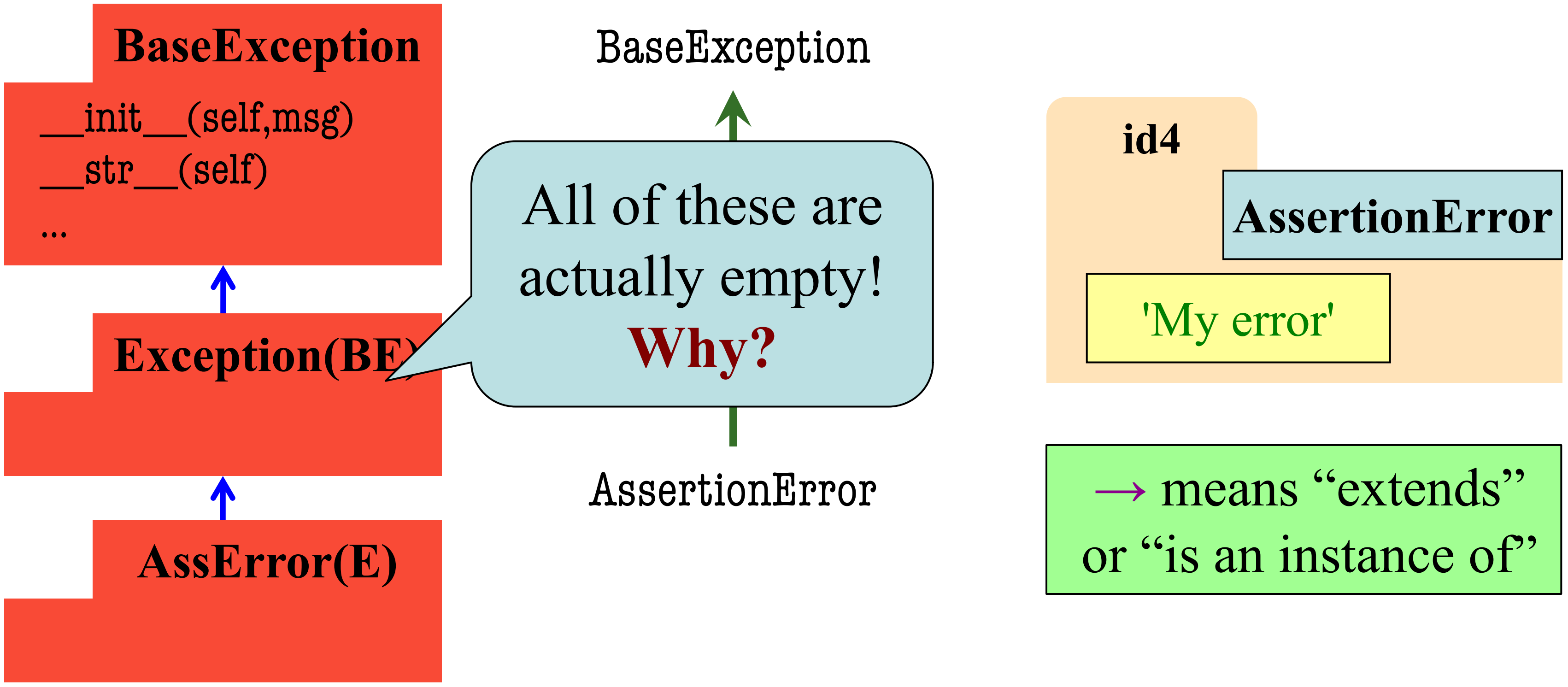
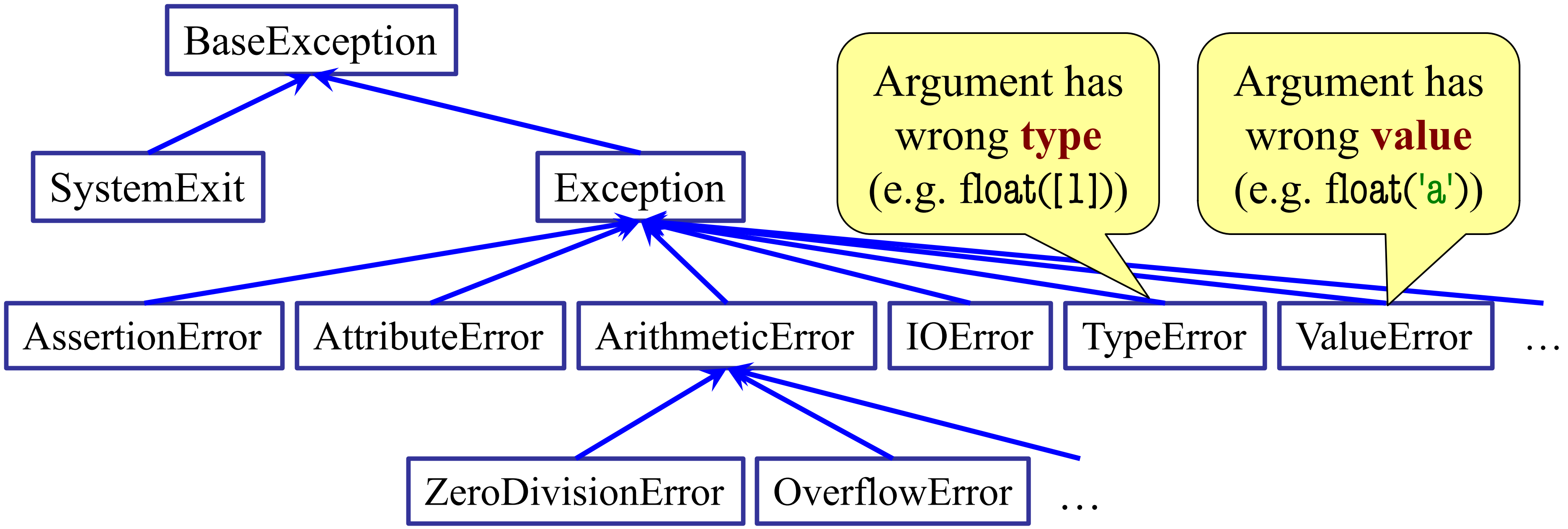


Python Error Type Hierarchy



http://docs.python.org/library/exceptions.html

Why so many error types?

Recall: Recovering from Errors

- try-except blocks allow us to recover from errors
  - Do the code that is in the try-block
  - Once an error occurs, jump to the except
- **Example**:

```
try:
    val = input()         # get number from user
    x = float(val)        # convert string to float
    print('The next number is '+str(x+1))
except:
    print('Hey! That is not a number!')
```

might have an error

executes if have an error

Handling Errors by Type

- try-except blocks can be restricted to **specific** errors
  - Do except if error is **an instance** of that type
  - If error not an instance, do not recover
- **Example**:

```
try:
    val = input()           # get number from user
    x = float(val)          # convert string to float
    print('The next number is '+str(x+1))
except ValueError:
    print('Hey! That is not a number!')
```

May have KeyboardInterrupt

May have ValueError

Only recovers ValueError. Other errors ignored.

Handling Errors by Type

- try-except blocks can be restricted to **specific** errors
  - Doe except if error is **an instance** of that type
  - If error not an instance, do not recover
- **Example**:

```
try:
    val = input()        # get number from user
    x = float(val)       # convert string to float
    print('The next number is '+str(x+1))
except KeyboardInterrupt:
    print('Check your keyboard!')
```

May have KeyboardInterrupt

May have ValueError

Only recovers KeyboardInterrupt. Other errors ignored.

Handling Errors by Type

- try-except can put the error in a variable
- **Example**:

```
try:
    val = input()           # get number from user
    x = float(val)          # convert string to float
    print('The next number is '+str(x+1))
except ValueError as e:
    print(e.args[0])
    print('Hey! That is not a number!')
```

Some Error subclasses have more attributes

Creating Errors in Python

- Create errors with raise
  - **Usage**: raise <exp>
  - exp evaluates to an object
  - An instance of Exception
- Tailor your error types
  - **ValueError**: Bad value
  - **TypeError**: Bad type
- Still prefer **asserts** for preconditions, however
  - Compact and easy to read

```
def foo(x):
    assert x < 2, 'My error'
    ...
```

Identical

```
def foo(x):
    if x >= 2:
        m = 'My error'
        err = AssertionError(m)
        raise err
```

Creating Errors in Python

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def foo(x):
    assert x < 2, 'My error'
    ...
```

Identical

```
def foo(x):
    if x >= 2:
        m = 'My error'
        err = ValueError(m)
        raise err
```

Raising and Try-Except

```
def foo():
    x = 0
    try:
        raise Exception()
        x  = 2
    except Exception:
        x = 3
    return x
```

- The value of foo()?

A: 0
B: 2
C: 3
D: No value. It stops!
E: I don't know

Raising and Try-Except

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def foo():
    x = 0
    try:
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```

- The value of foo()?

A: 0
B: 2
C: 3 **Correct**
D: No value. It stops!
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Raising and Try-Except

```
def foo():
    x = 0
    try:
        raise Exception()
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    except BaseException:
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Raising and Try-Except

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Raising and Try-Except

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def foo():
    x = 0
    try:
        raise Exception()
        x  = 2
    except AssertionError:
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```

- The value of foo()?

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Raising and Try-Except

```
def foo():
    x = 0
    try:
        raise Exception()
        x  = 2
    except AssertionError:
        x = 3
    return x
```

- The value of foo()?

A: 0
B: 2
C: 3
D: No value. **Correct**
E: I don’t know

Python uses isinstance to match Error types

Creating Your Own Exceptions

```
class CustomError(Exception):
    """An instance is a custom exception"""
    pass
```

Only issues is choice of parent error class. Use `Exception` if you are unsure what.

This is all you need!

- No extra attributes
- No extra methods
- No constructors

Inherit everything

Case Study: Files

- Can read the contents of any file with `open()`
  - Returns a file object with method `read()`
  - Method `read()` returns contents as a string
  - Remember to `close()` file when done
- There are **SO** many errors that can happen
  - `FileNotFoundError`: File does not exit
  - `PermissionError`: You are not allowed to read it
  - Other errors possible when processing data

Recall: JSON Files

```
{
  "wind" : {
    "speed" : 13.0,
    "crosswind" : 5.0
    },
  "sky" : [
    {
      "cover" : "clouds",
      "type" : "broken",
      "height" : 1200.0
    },
    {
      "type" : "overcast",
      "height" : 1800.0
    }
  ]
}
```

- Look like a nested `dict`
  - But read in as a string
  - You have to **convert** it
- Python module json
  - Function `loads()`
    Converts str -> dict
  - Function `dumps()`
    Convert dict -> str
- Conversion is sensitive
  - Stray commas crash it

Reading a JSON File

```
def read_json(fname):
    try:
        file = open(fname)
        data = file.read()
        file.close()
        result = json.loads(data)
        return result
    except FileNotFoundError:
        print(fname +' not found')
    except JsonDecodeError:
        print(fname +' is invalid')
    return None
```

Open file with name

Close file when done

Could not find file

JSON contents are not valid

If failed

Note that we can chain excepts like an if-elif statement

Reading a File in General

```
def read_foo(fname):
    try:
        file = open(fname)
        data = file.read()
        file.close()
        result = convert(data)
        return result
    except FileNotFoundError:
        print(fname +' not found')
    except MyConversionError:
        print(fname +' is invalid')
    return None
```

All the work is in conversion step

Custom helper for this file type

Error specific to the file format

Aside: Pathnames

- Files obey the same rule as other modules
  - To read a file, it must be in the same folder
  - Otherwise, you must use a pathname for file
- **Relative path**: directions from current folder
  - **macOS**: `'../../lec22/file.txt'`
  - **Windows**: `'..\..\lec22\file.txt'`

Like navigating command shell

- **Absolute path**: directions that work anywhere
  - **macOS**: `'/Users/white/cs1110/lect22/file.txt'`
  - **Windows**: `'C:\Users\white\cs1110\lect22\file.txt'`

Aside: Pathnames

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  - To read a file, it must be in the same folder
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- **Absolute path**: directions that work anywhere
  - **macOS**: `'/Users/white/cs1110/lect22/file.txt'`
  - **Windows**: `'C:\Users\white\cs1110\lect22\file.txt'`

Note the change in slash direction

Like navigating command shell

Pathnames are OS Specific

- This makes reading files harder
  - May work on Windows but crash on macOS!
  - Yet another error message we need to handle
- **Solution**: Use the module os.path
  - Builds a pathname string for current os
- **Example**: `os.path('..', 'cs1110', 'lec22', 'file.txt')`
  - **macOS**: `'../cs1110/lec22/file.txt'`
  - **Windows**: `'..\cs1110\lec22\file.txt’`
- Absolute paths are a little trickier, but similar

Final Word on Error Handling

- Versions of `try-except` exist in most languages
    - Java, C++, C#, Objective-C all have it
- But those languages try to **minimize** its use
    - Give application a way to crash "nicely"
    - Because processing a try-except it quite slow
- Python has a very **different** philosophy
    - Python is sort-of slow; exceptions are not slower
    - It is okay to use `try-except` all the time
    - Encourages its use as much as `if`-statements

Final Word on Error Handling

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- Python ha hy
  - Python i ot slower
  - It is oka
  - Encoura ents

Developers refer to coding styles unique to python as **pythonic** programming