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

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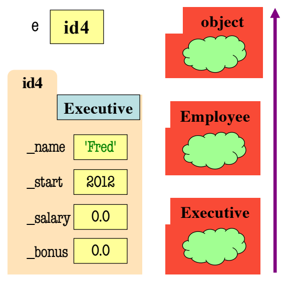
The isinstance Function

- 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!



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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

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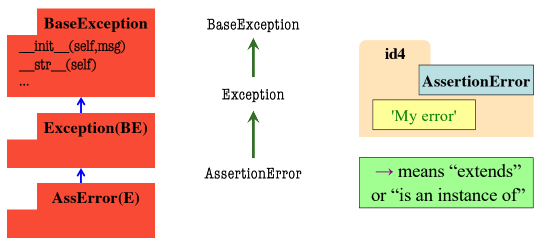
Error Types in Python

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



→ means "extends" or "is an instance of"

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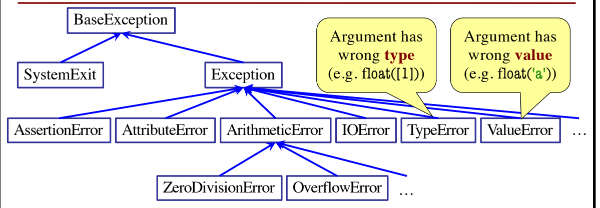
Python Error Type Hierarchy



Argument has wrong **type** (e.g. float([1]))

Argument has wrong **value** (e.g. float('a'))

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

Why so many error types?

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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 ValueError:
    print('Hey! That is not a number!')
```

May have IOError

May have ValueError

Only recovers ValueError. Other errors ignored.

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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'
    ...

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

Identical

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Creating Your Own Exceptions

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

This is all you need
- No extra fields
- No extra methods
- No constructors

Inherit everything

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

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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

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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

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

Like navigating command shell

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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

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