

Recall: Overloading Multiplication

```

class Fraction(object):
    """Instance attributes:
        numerator: top [int]
        denominator: bottom [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 type(q) == Fraction
        top = self.numerator*q.numerator
        bot = self.denominator*q.denominator
        return Fraction(top,bot)
    
```

```

>>> p = Fraction(1,2)
>>> q = 2 # an int
>>> r = p*q
    
```

↓ Python converts to

```

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

Can only multiply fractions.
But ints "make sense" too.

Dispatch on Type

- Types determine behavior
 - Diff types = diff behavior
 - Example:** + (plus)
 - Addition for numbers
 - Concatenation for strings
- Can implement with ifs
 - Main method checks type
 - "Dispatches" to right helper
- How all operators work**
 - Checks (class) type on left
 - Dispatches to that method

```

class Fraction(object):
    ...
    def __mul__(self,q):
        """Returns: Product of self, q
        Precondition: q a Fraction or int"""
        if type(q) == Fraction:
            return self._mulFrac(q)
        elif type(q) == int:
            return self._mulInt(q)
    ...
    def _mulInt(self,q): # Hidden method
        return Fraction(self.numerator*q,
                        self.denominator)
    
```

Another Problem: Subclasses

```

class Fraction(object):
    """Instances are normal fractions n/d
    Instance attributes:
        numerator: top [int]
        denominator: bottom [int > 0]"""
    class BinaryFraction(Fraction):
        """Instances are fractions k/2^n
        Instance attributes are same, BUT:
        numerator: top [int]
        denominator: bottom [= 2^n, n ≥ 0]"""
        def __init__(self,k,n):
            """Make fraction k/2^n """
            assert type(n) == int and n >= 0
            Fraction.__init__(k,2**n)
    
```

```

>>> p = Fraction(1,2)
>>> q = BinaryFraction(1,2) # 1/4
>>> 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!

Fixing Multiplication

```

class Fraction(object):
    """Instance attributes:
        numerator: top [int]
        denominator: bottom [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 = BinaryFraction(1,2) # 1/4
>>> 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
    ...
    
```

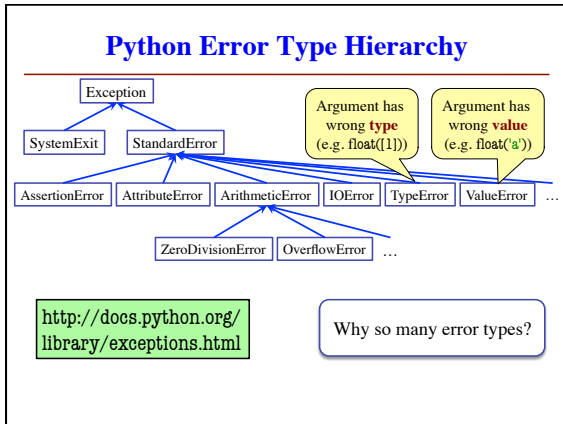
```

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

```

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

Class Names



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

Annotations:

- input = raw_input() # get number from user: May have IOError
- x = float(input) # convert string to float: May have ValueError
- except ValueError: Only recovers ValueError. Other errors ignored.

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'
        raise AssertionError(m)
    ...
  
```

Identical

Creating Your Own Exceptions

```

class CustomError(StandardError):
    """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 Exception class. Use StandardError if you are unsure what.

Errors and Dispatch on Type

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

```

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

Some Error subclasses have more attributes

Typing Philosophy in Python

- Duck Typing:**
 - "Type" object is determined by its methods and properties
 - Not the same as type() value
 - Preferred by Python experts
- Implement with hasattr()
 - hasattr(<object>, <string>)
 - Returns true if object has an attribute/method of that name
- This has many problems
 - The name tells you nothing about its specification

```

class Fraction(object):
    """Instance attributes:
    numerator: top [int]
    denominator: bottom [int > 0]"""
    ...
    def __eq__(self,q):
        """Returns: True if self, q equal,
        False if not, or q not a Fraction"""
        if (not (hasattr(other,'numerator') and
        hasattr(other,'denominator'))):
            return False
        left = self.numerator*q.denominator
        right = self.denominator*q.numerator
        return left == right
  
```