COMS 3101-3 Programming Languages – Python: Lecture 3

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Homework 2

1000778,
Zimmerman Farmers Market,
http://www.pzfarmersmarket.org,
"Lions Park, Main Street",
Zimmerman,
Sherburne,
Minnesota,
55398,
-93.5868786,
45.4407107

```
fields = line.split(‘,’)
for field in fields:
    if field.startswith(‘”’):
        ...
    elif fields.endswith(‘”’):
        ...
    else:
        ...
```

Review

- Advanced data types
  - Dictionary
  - String
  - Sets
- Function
  - Function basics
  - Positional parameters, named parameters
  - Default parameters
  - Scoping issues
  - Closures

Agenda

- Advanced Functions
  - Functional programming with Map, Reduce, and Filter
- Objected Oriented Programming
- Modules and Packages
- If time permits
  - Basic modules os, sys

map, reduce, and filter

ADVANCED FUNCTIONS

Map, Reduce, and Filter

- Functional programming elements in action
  - Core constructs in parallel programming paradigm
  - We're not covering `lambda` from this lecture
- Function is a first-class citizen in Python
  - Provided as a first parameter
- Smart way to iterate over sequence data structure
  - More readable and concise syntax
    - at least for some

Map

- We want to apply a function for all elements of sequence data type

```
map(func, seq1, [seq2, ... seqN])
```

- `func` need to be a callable object (i.e., function)
- `func` take *N* arguments where *N* is number sequence data types
- seq1, seq2 ... seq*N* need to be in the same length

```
def to_str(lst):
  ret = []
  for i in lst:
    ret.append(str(i)
  return ret
```

- List comprehension

```
[str(i) for i in lst]
```

- Map

```
map(str, lst)
```

Map: Adding One for All Elements

```
map(func, seq1, [seq2, ...])
```

- Applying add_one() to all elements

```
def inc_one(x):
  return x + 1
```

```
map(inc_one, range(10))
[1,2,3,4,5,6,7,8,9,10]
```

```
def inc_one_list(lst):
    ret = []
    for i in lst:
        ret.append(inc_one(i))
    return ret

inc_one_list(range(10))
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

Map: Adding *X* for All Elements

```
map(func, seq1, [seq2, ...])
```

- Closure: `inc_x()` preserved <u>state</u> defined from `inc_some()`

```
def inc_some(x):
  def inc_x(y):
    return x + y
  return add_x
```

```
>>> map(inc_some(2), range(10))
[2,3,4,5,6,7,8,9,10,11]
```

```
def inc_some_list(lst):
    ret = []
    inc_two = inc_some(2)
    for i in lst:
        ret.append(inc_two(i))
    return ret

inc_some_list(range(10))
[2, 3, 4, 5, 6, 7, 8, 9, 10, 11]
```

Map: Combining Two (or more) Sequence

```
map(func, seq1, [seq2, ...])
```

- `add_two()` takes two parameters
- if `func` is `None`, the identity function is assumed

```
def add_two(x, y):
  return x + y
```

```
>>> map(add_two, range(5), \
                  range(5))
[0, 2, 4, 6, 8]
```

```
def add_two_lists(lst0, lst1):
    ret = []
    add_two = add_some(2)
    for i, j in zip(lst0, lst1):
        ret.append(i + j)
    return ret

add_two_list(range(5), range(5))
[0, 2, 4, 6, 8]
```

filter

```
filter(func, seq)
```

- Extracts each element x for which `func(x)` returns True
- `func` takes a single parameter and returns `boolean` type (`True, False`)

```
def is_neg(x):
  return x < 0
```

```
>>>filter(is_neg, range(-5, 5))
[-5, -4, -3, -2, -1]
```

```
def filter_neg(lst):
    ret = []
    for i in lst:
        if is_neg(i):
            ret.append(i)
    return ret

filter_neg(range(-5, 5))
[-5, -4, -3, -2, -1]
```

reduce

```
reduce(func, seq)
```

- Reduce a sequence data type(`seq`) to a single value by combining elements via `func`
- `func` takes two parameter and returns a single value

```
add(x, y):
  return x + y
```

```
>>>reduce(add, range(-4, 5))
0
```

```
def sum(lst):
    ret = None
    for i in lst:
        if ret:
            ret = add(ret, i)
        else:
            ret = i
    return ret

sum(range(-4, 5))
0
```

OBJECT ORIENTED PYTHON

Object Oriented Programming in Python

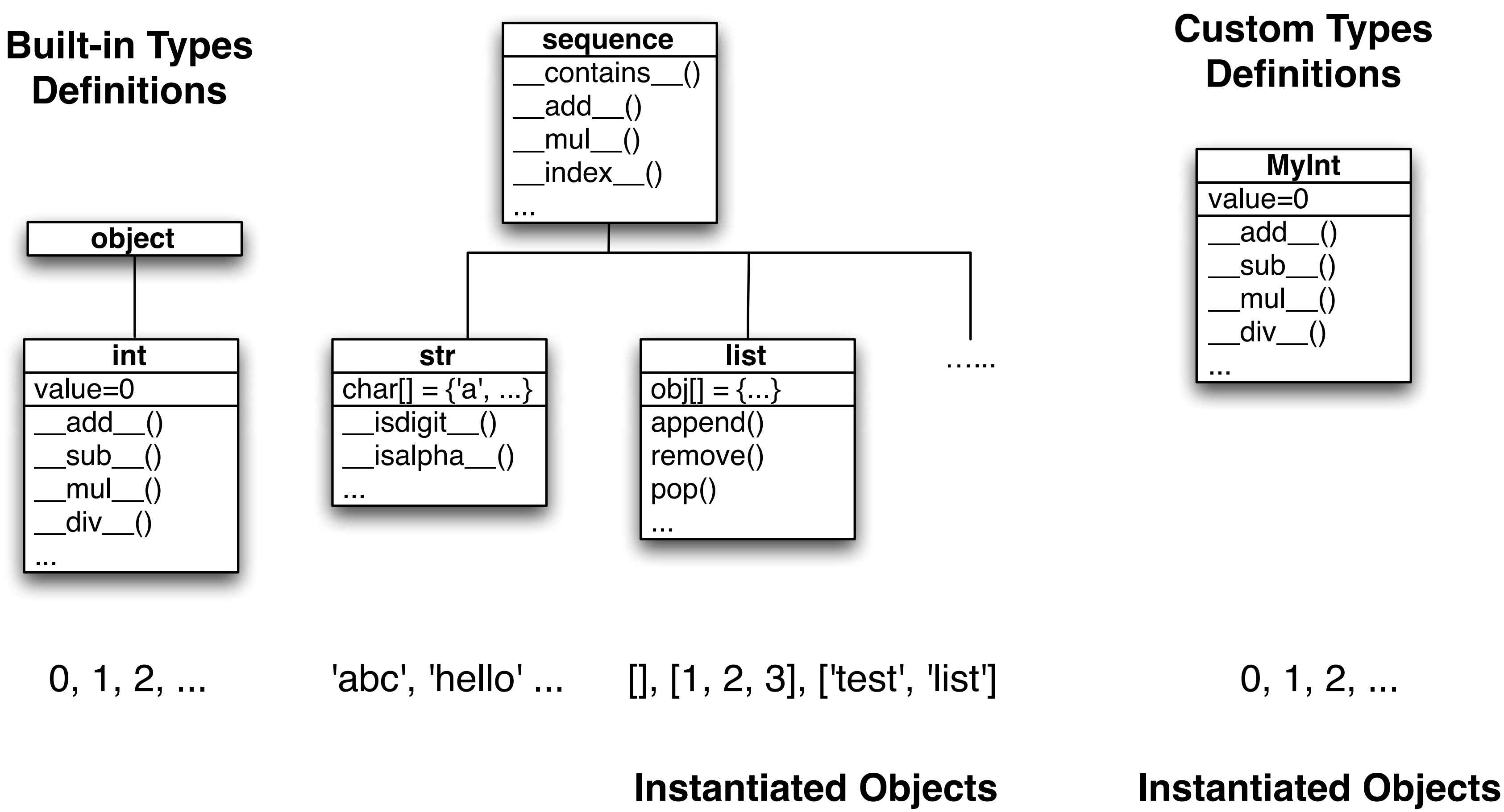
- Object Oriented Programming(OOP) is at the core of Python
  - Everything is an object!
  - Operations are methods on objects
  - Modularizations
- We have seen examples of objects already
  - Objects of built-in data types (int, str, list, dict …)
  - Functions
- Class allow us to create our own type

int() class

```
>>> a = int(1)
>>> type(a)
<type 'int'>
>>> a
1
>>> dir(a)
['__abs__', '__add__', '__and__', '__class__', '__cmp__',
...
'denominator', 'imag', 'numerator', 'real’]
>>> a.__add__(1)
2
>>> b = myint(2)
>>> b + a
additon: 2 + 1
3
```

http://www.cs.columbia.edu/~jikk/teaching/3101-3/files/myint.py

Class: A Custom Type



Objects, Attributes, Methods, Classes

- Classes
  - User-defined types of objects (including their methods, attributes, relations to other objects)
  - Can be instantiated into an object / is a ‘blueprint’ that describes how to build an object

```
Knights can eat sleep, have a favorite color, and a title.
```

- Object: Grouping of state(attributes) and behavior (methods) into a functional ‘package’

```
l = Knight()
```

- Attributes: data fields of the object for state maintenace

```
l.name = “Launcelot, l.title = “The brave” ...
```

- Methods: functions that belong to the object and can access and manipulate the object’s data. All methods are attribute

```
l.eat(food), l.sleep() ...
```

Class Definition with class

- Class definitions contains
  - *methods*: functions defined in the class' scope
  - *class attributes*: variables defined in the class's scope
  - *docstring*: documentation that explains the class

```
class Knight(object):
    """A knight with two legs,
       who can eat food.
    """
    legs = 2  # class attribute

    def __init__(self):
        self.stomach = []

    def eat(self, food):
        self.stomach.append(food)
        print('Yummy!')
```

class definition with inheritance and docstring

class attribute 'leg'

constructor method '__init__()' defines instance attribute 'self.stomach'

instance method 'eat()'

Class Definition with class

- Class definitions contains
  - *methods*: functions defined in the class' scope
  - *class attributes*: variables defined in the class's scope
  - *docstring*: documentation that explains the class

```
class Knight(object):
    """A knight with two legs,
       who can eat food.
    """
    legs = 2  # class attribute

    def __init__(self):
        self.stomach = []

    def eat(self, food):
        self.stomach.append(food)
        print('Yummy!')
```

- Classes are objects too.
  - Methods and attributes are attributes of the class object

```
>>> Knight.legs
2
>>> Knight.eat
<unbound method Knight.eat>
```

Instantiating a Class to an Instance Object

```
class Knight(object):
    """A knight with two legs,
       who can eat food.
    """
    legs = 2  # class attribute

    def __init__(self):
        print "init. Knight"
        self.stomach = []

    def eat(self, food):
        self.stomach.append(food)
        print('Yummy!')
```

- Functions are instantiated into instance objects by calling a class object

```
>>> k = Knight()  # invoke Knight.__init__(self)
init. Knight
>>> k
<__main__.Knight object at 0x107709f90>
>>> type(k)
<class '__main__.Knight'>
```

Calling Bound Methods on Instance Objects

```
class Knight(object):
    “””A knight with two legs,
       who can eat food.
    ”””
    legs = 2  # class attribute

    def __init__(self):
    print “init. Knight”
        self.stomach = []

    def eat(self, food):
        self.stomach.append(food)
        print(‘Yummy!’)
```

- Functions are instantiated into instance objects by calling a class object
- The first parameter in a method definition (‘*self*’) is bound to the instance object when a bound method is called

```
>>> k = Knight() # invoke Knight.__init__(self)
>>> k.eat("cheese")
Yummy!
>>> k.stomach
['cheese']
```

Constructor Method: __init__

```
class Knight(object):
    """A knight with two legs,
       who can eat food.
    """
    legs = 2  # class attribute

    def __init__(self, name):
        self.stomach = []
        self.name = name

    def eat(self, food):
        self.stomach.append(food)
        print('Yummy!')
```

- The special method __init__() is called when an instance is created
  - ClassName(x, y) corresponds to ClassName.__init__(*self*, x, y)
- Main purpose:
  - Initialize instance object referred by *self*
  - sets up attributes of the instance

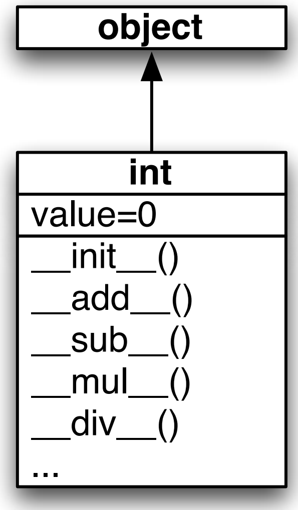
```
>>> k = Knight('kangkook')
>>> k.name
"kangkook"
```

self

- *self* represents instantiated object
  - Become a reference point to runtime instances
  - Created as we call constructor method *__init__()*
- *self* is an *automatically* passed as a first argument when *instances* call methods
- Instance methods must specify *self* as their first parameter

```
>>> k.eat('bacon')
Yummy!
>>> Knight.eat(k, 'toast')
Yummy!
>>> k.stomach
['bacon', 'toast']
```

‘int’ Type

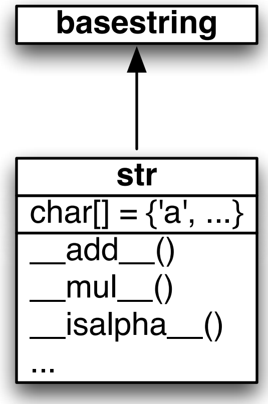



```
class int(object)
    def __init__(self, x=0):
        ...
    def __init__(self, x, base=10):
        ...
    def __add__(self, other):
        ...
    def __sub__(self, other):
        ...
```

```
>>> x = int()
>>> x
0
>>> y = int('10', base=16)
>>> x.__add__(y)
16
```

- Two constructors for ‘int’ and ‘str’ respectively
- int.__add__() methods overrides ‘+’ operator
  - x.__add__(y) <==> x + y

‘str’ Type




```
class str(basestring)
    def __init__(obj=''):
        ...
    def __add__(self, other):
        ...
    def __contains__(self, other):
        ...
    def __format__(format_spec)
        ...
```

```
>>> s = str(12345)
>>> s
'12345'
>>> s.__contains__('1')
True
```

- A constructors: a parameter ‘obj’ can be any type that implements __str__()
- int.__contains__() methods overrides ‘in’ operator
  - s.__contains__(x) <==> x in s

Class vs. Instance Attributes

```
class Knight0(object):

    # class attribute
    inst_count = 0

    def __init__(self):
        Knight0.inst_count += 1
```

```
>>> c1 = Knight0()
>>> c2 = Knight0()
>>> c2.inst_count
2
>>> Knight0.inst_count
2
```

```
class Knight1(object):

    # class attribute
    inst_count = 0

    def __init__(self):
        self.inst_count += 1
```

```
>>> c1 = Knight1()
>>> c2 = Knight1()
>>> c2.inst_count
1
>>> Knight1.inst_count
0
```

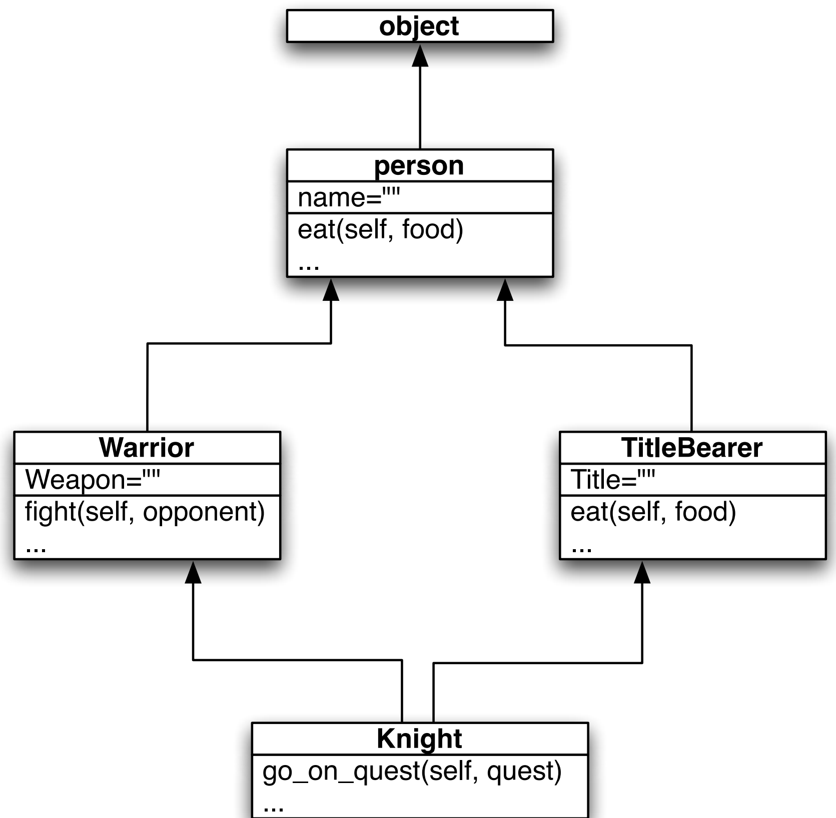
- Class variables are access with class name (not with self)
- Class attributes are visible from instances
- Re-binding attribute names in an instance creates a new instance attribute that hides the class attribute

Inheritance

- Classes inherits from one or more base classes
  - Multiple inheritance allowed
- Look up methods and class attributes in base classes if not found in class

```
class Knight(Warrior, TitleBearer):

    def __init__(self, name):
        ...

    def go_on_quest(self, quest):
        ...
```

```
>>> k1 = Knight("Galahad")
>>> k2 = Knight("Robin")
>>> k1.fight(k2)
>>> k2.eat("bacon")
```

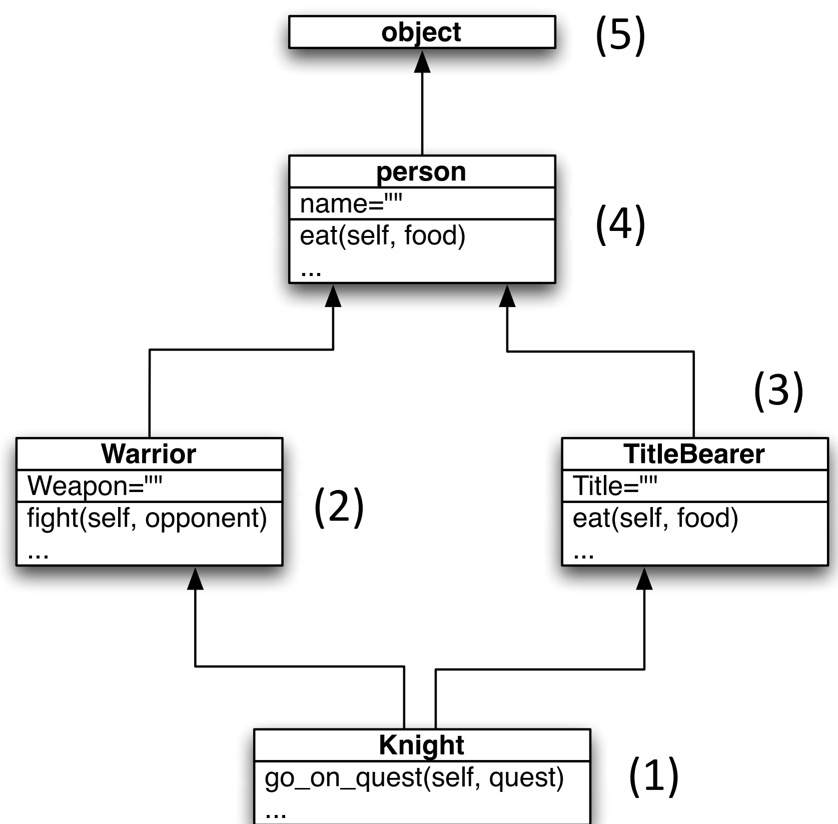


Multiple Inheritance – Method Resolution Order

- Problem: Which `eat` method to use?
- User first found according to method resolution order

```
class Knight(Warrior, TitleBearer):

    def __init__(self, name):
        ...

    def go_on_quest(self, quest):
        ...
```

```
>>> k1 = Knight("Galahad")
>>> k2 = Knight("Robin")
>>> k1.fight(k2)
>>> k2.eat("bacon")
```



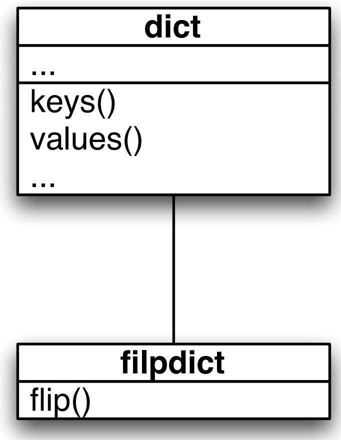
Sub-classing ‘object’

- Base class for all class defined
  - All should begin from object
- Implements basic methods

```
>>> dir(object)
['__class__', '__delattr__', '__doc__', '__format__',
'__getattribute__', '__hash__', '__init__', '__new__',
'__reduce__', '__reduce_ex__', '__repr__', '__setattr__',
'__sizeof__', '__str__', '__subclasshook__']
>>> obj = object()
<object object at 0x10191f090>
```

Built-in Types as Base Classes

```
class FlipDict(dict):
    “””A dictionary that can be inverted
    “””
    def flip(self):
        “””Return a dictionary of values to
           sets of keys
        “””
        res = {}
        for k in self:
            v = self[k]
            if not v in res:
                res[v] = set()
            res[v].add(k)
        return res
```




```
>>> import flipdict
>>> x = flipdict.FlipDict([(1,'a'), (2, 'b'),
(3,'a')])
>>> x
{1: 'a', 2: 'b', 3: 'a'}
>>> x.flip()
{'a': set([1, 3]), 'b': set([2])}
```

http://www.cs.columbia.edu/~jikk/teaching/3101-3/files/flipdict.py

Polymorphism

```
class Shape(object):
    def permeter(self):
        """abstact method
        """
        return
```

```
class Square(Shape):
    def permeter(self)
        return self.side ** 2
```

```
class Circle(Shape):
        def perimeter(self):
            return self.radius * \
                2 * math.pi
```

- Inheritance allows to override methods of base classes in different ways

```
def get_perimeter(shape):
    ""”method to get perimeter for shape objects
    """
    if isinstance(shape, Shape):
        return shape.getPerimeter()
    else:
        # Error handling follows
```

Class Type Checking with isinstance()

```
>>> s = Square(4)
>>> type(s)
<class 'shape.Square'>
>>> isinstance(s, Shape)
True
>>> isinstance(s, Square)
True
>>> isinstance(s, Circle)
False
```

- Two ways of testing object types : built-in functions of type(), isinstance()
- type(object): returns the type of the object
- isinstance(object, class):
  - if the object is an instance of the class, or of a subclass thereof
  - recommended for testing

Calling Base Class Implementations of Overloaded Methods

- Sometimes we want to call the base class version of a method
- This is often the case for __init__
- Use unbound method attribute the base class

```
class Shape(object):
    def __init__(self, dimension):
        self.dimension = dimension
        self.name = name
...

class Square(Shape):
    def __init__(self, dimension, side):
        self.side = side
        Shape.__init__(self, dimension)
```

```
>>> s = Square('2d', 4)
>>> s.dimension
'2d'
```

Polymorphism: Duck Typing

- Python is dynamically typed. Any variable can refer to any object
- Explicit type checking (`isinstance`) at runtime is considered bad style
- Instead use *'duck typing'*! (plus error handling)

Duck Typing

"When I see a bird that walks like a duck and swims like a duck and quacks like a duck, I call that bird a duck."

- As long as an object implements functionality, its type does not matter
- Example: Equality (==), convert to string(str())

get_perimeter(): Duck-Typed

```
def get_perimeter_dt(shape):
    """
    duck-typed get_perimeter()
    """
    try:
        return shape.perimeter()
    except TypeError:
        print("the object does not support perimeter()")
        return 0
```

- isinstance() removed
  - By assuming shape parameter object support 'perimeter()'
- We will learn about exception handling (try … except) from the next class

Special Methods (1)

- __init__(self) is called when an instance is created
- __str__(self) returns a string representation of the object
- __repr__(self) returns the 'official' string representation

```
class FarmersMarket(object):
    def __init__(self, name, state, town, zipc):
        self.name = name
        self.state,self.town,self.zipc = state,town,zipc
    def __str__(self):
        return '{0} \n{1}, {2} {3}'.format(self.name, self.town, \
                self.state, self.zipc)
    def __repr__(self):
        return 'FarmersMkt:<{0}:{1},{2} {3}>'.format(self.name, \
                self.town, self.state, self.zipc)
```

```
>> mkt = farmers.FarmersMarket('CU Greenmarket', 'New York', 'NY', 10027)
>>> print mkt  # str(mkt)
CU Greenmarket
NY, New York 10027
> mkt
FarmersMkt:<CU Greenmarket:NY,New York 10027>
```

http://www.cs.columbia.edu/~jikk/teaching/3101-3/files/farmers.py

Special Methods (2) - Comparisons

- __eq__(self, other) used for == comparisons
- __lt__ (self, other) used for < comparisons
- __le__, __gt__, __ge__, __ne__

```
class Shape(object):
    def __eq__(self, other):
        return self.area() == other.area()
    def __ne__(self, other):
        return not self.__eq__(other)

class Rectangle(Shape):
    def __init__(self, l, w):
            self.l, self.w = l, w
    def area(self):
        return self.l * self.w
```

```
>>>Rectangle(2,3) == Rectangle(1,6)
True
# equivalent by operator overloading
>>> Rectangle(2,3).__eq__(Rectangle(1,6))
True
```

http://www.cs.columbia.edu/~jikk/teaching/3101-3/files/shape.py

Special Methods (2) - Comparisons

- If none of the previous comparisons operators are defined, __cmp__(self, other) is called
  - Return 0, if self and other are equal
  - negative integer, if self < other
  - positive integer if self > other

```
class Shape(object):
    def __cmp__(self, other):
        return self.area() - other.area()

class Circle(Shape):
    def __init__(self, r):
        self.r = r
    def area(self):
        return math.pi * self.r ** 2
```

```
>>>Circle(1) < Rectangle(4, 2)
True
```

Special Methods (3) - Arithmetic

- __add__(self, other) used for + operations
  - x + y ⇔ x.__add__(y)
- __iadd__ (self, other) used for += operations
- __sub__, __mul__, __div__, __radd__, __rsub__ …

```
class Complex(object):
    def __init__(self, x, y):
        self.x, self.y = x, y
    def __add__(self, other):
        return Complex(self.x + other.x, self.y + other.y)
    def __iadd__(self, other):
        self.x += other.x
        self.y += other.y
        return self
```

```
>>> c1 = Complex(1, 2)
>>> temp = c1
>>> c2 = Complex(3, 4)
>>> c1 += c2
>>> temp.x, temp.y
(4, 6)
```

http://www.cs.columbia.edu/~jikk/teaching/3101-3/files/complex.py

MODULES AND PACKAGES

Modules

- Module is another programming abstract that
  - Defines independent grouping of code and data
  - Contains multiple variable / function / class definitions in it
- A typical Python program consists of several source files, each correspond to a module
  - A module can include other module:
    can cause circular import problem
- Packages are collection of modules
  - Use ‘import’ statement to load modules or packages

Structure of a Module File

- A module corresponds to any Python source file
- The module ‘name’ is typically in file ‘name.py’
- Can contain a docstring (string in first non-empty line)

```
""" A module to illustrate modules.
"""
class A(object):
    def __init__(self, *args):
        self.args = args

def quadruple(x):
    return x**4

x = 42

print("This is an example module.")
```

http://www.cs.columbia.edu/~jikk/teaching/3101-3/files/sample_module.py

Importing and Using Modules

```
import modulename [as newname]
```

- Imports a module and creates a module objects
- All statements are executed upon import
- All defined variables/classes/functions become attributes of the module

```
>>> import sample_module as sm
>>> sm.x
42
>>> a = sm.A(1,2,3)
>>> a
```

Importing Specific Attributes of a Module

```
from modulename import attr [as newname]
```

- loads the module and make attr (a class, function, variable ..) available in the namespace of the importing modules

```
>>> from sample_module import A
This is an example module.
>>> a = A(1,2,3)
>>> testmodule
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'testmodule' is not defined
```

- Can also import all attributes (considered bad style!)

```
>>> x = 100
>>> from sample_module import *
>>> x
42
```

Executing Module as a Script

- Problem: Modules often contain some test code that we do not want to run every time it is imported
- A special variable '__name__'
  - contains module name when imported
  - contains '__main__' when it is executed as a script

sample_module.py

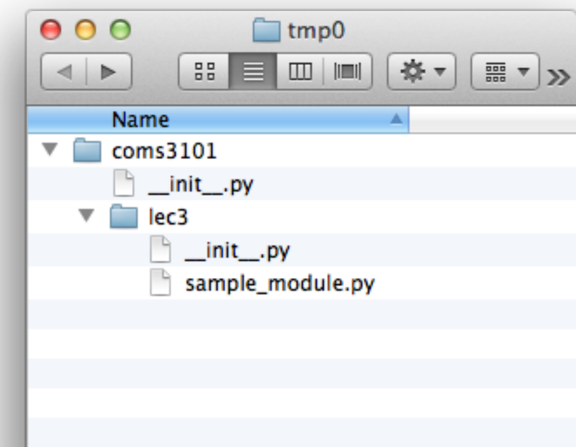
```
...
print("This is an example module. {0}".format(__name__))

if __name__ == "__main__":
    a = A(1, 2, 3)
    print("script mode")
```

script execution

```
dhcp102:Desktop jikk$ python sample_module.py
This is an example module. __main__
script mode
```

Packages

- Packages group modules
  - Packages contains modules as attributes
  - Packages therefore span trees of modules
- A package corresponds to a directory
  - coms3101.lec3.sample_module indicates coms3101/lec3/sample_module.py
- Package directories must contain a file __init__.py
  - __init__.py contains package initialization code




```
jikk$ cat __init__.py
print (“__init__: {0} from {1}".format(__name__, \
__file__))
```

```
>>> import coms3101.lec3.sample_module
__init__: coms3101 from coms3101/__init__.py
__init__: coms3101.lec3 from coms3101/lec3/
__init__.pyc
This is an example module.
coms3101.lec3.sample_module
```

Backup Slides

stdin and stdout

- Can access terminal input (sys.stdin) and terminal output (sys.stdout) as file object
- These objects are defined globally in the module ‘sys’
  - ‘sys’ is loaded with import statement

```
>>> import sys
>>> sys.stdout.write('Hello world!\n')
Hello world!
>>> sys.stdin.read(4)
COMS3101-3
'COMS'
```

File Operation with 'os'

- 'os' module defines interfaces that enable interactions with operating systems
  - Most frequently used component of standard library
  - Implements majority subset of OS system call API

```
>>> import os
>>> os.system('date')  # OS specific command
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```

- 'os.path' sub-module defines interfaces for filename manipulation

```
>>> os.path.isdir("/tmp")  # some folder
True
```

os.path Module – manipulate pathnames

- os.path.abspath(path) – Returns the absolute pathname for a relative path

```
>>> os.path.abspath('python')
'/opt/local/bin/python'
```

- os.path.basename(path) – Returns the absolute pathname for a relative path

```
>>> os.path.abspath('python')
'/opt/local/bin/python'
```

- os.path.getsize(path) – Returns the size of path in byte

```
>>> os.path.getsize("python")
13404
```

- os.path.isfile(path) – Returns True if the path points to a file
- os.path.isdir(path) – Returns True if the path points to a directory

os Module – list, walk content of a directory

- os.listdir(path) lists files in a directory

```
>>> os.listdir("/tmp")
['.font-unix', '.ICE-unix', ... , android-jikk']
```

- os.walk(path) returns generator object traverse sub-directories in depth-first fashion

```
>>> w = os.walk('/tmp')
>>> loc = w.next()
>>> while w:
...     print loc
...     loc = w.next()
```