Advanced Interactions

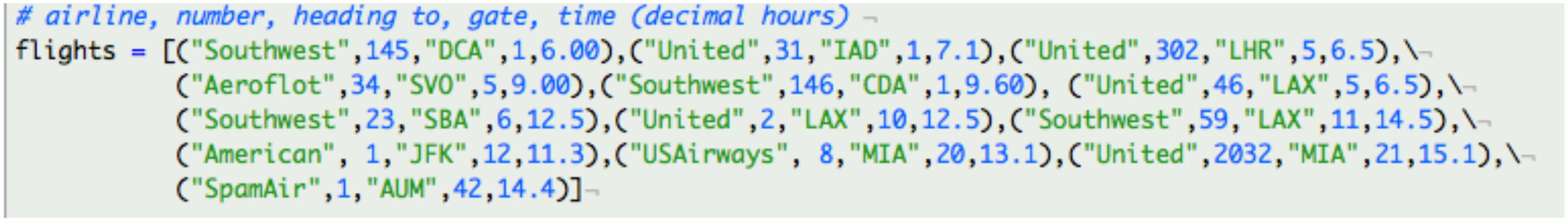
Lambda Functions

(anonymous functions)

from Lisp & functional programming

```
>>> tmp = lambda x: x**2
>>> type(tmp)
<type 'function'>
>>> tmp(2)
4
>>> (lambda x,y: x**2+y)(2,4.5) # forget about creating a new function name...just do it!
8.5
>>> ## create a list of lambda functions
>>> lamfun = [lambda x: x**2, lambda x: x**3, \
              lambda y: math.sqrt(y) if y >= 0 else "Really? I mean really? %f" % y]
>>> for l in lamfun: print l(-1.3)
1.69
-2.197
Really? I mean really? -1.300000
>>>
```

lambda functions are meant to be short, one liners. If you need more complex functions, probably better just to name them



```
# airline, number, heading to, gate, time (decimal hours) ¬
flights = [("Southwest",145,"DCA",1,6.00),("United",31,"IAD",1,7.1),("United",302,"LHR",5,6.5),\¬
          ("Aeroflot",34,"SVO",5,9.00),("Southwest",146,"CDA",1,9.60), ("United",46,"LAX",5,6.5),\¬
          ("Southwest",23,"SBA",6,12.5),("United",2,"LAX",10,12.5),("Southwest",59,"LAX",11,14.5),\¬
          ("American", 1,"JFK",12,11.3),("USAirways", 8,"MIA",20,13.1),("United",2032,"MIA",21,15.1),\¬
          ("SpamAir",1,"AUM",42,14.4)]¬
```

```
>>> help(flights.sort)
    L.sort(cmp=None, key=None, reverse=False) -- stable sort *IN PLACE*;
    cmp(x, y) -> -1, 0, 1

>>> flights.sort(key=lambda x: x[4]) ; flights
[('Southwest', 145, 'DCA', 1, 6.0),
 ('United', 46, 'LAX', 5, 6.5),
 ('United', 302, 'LHR', 5, 6.5),
 ('United', 31, 'IAD', 1, 7.0999999999999996),
 ('Aeroflot', 34, 'SVO', 5, 9.0),
 ('Southwest', 146, 'CDA', 1, 9.5999999999999996),
 ('American', 1, 'JFK', 12, 11.300000000000001),
 ('Southwest', 23, 'SBA', 6, 12.5),
 ('United', 2, 'LAX', 10, 12.5),
 ('USAirways', 8, 'MIA', 20, 13.1),
 ('SpamAir', 1, 'AUM', 42, 14.4),
 ('Southwest', 59, 'LAX', 11, 14.5),
```

Multiple column sorting

`operator.`**`itemgetter`**(*item*[, *args...*])¶
Return a callable object that fetches *item* from its operand using the operand’s `__getitem__()` method. If multiple items are specified, returns a tuple of lookup values.

http://docs.python.org/library/operator.html#module-operator

```
>>> flights.sort(key=operator.itemgetter(4,1,0))
[('Southwest', 145, 'DCA', 1, 6.0),
 ('United', 46, 'LAX', 5, 6.5),
 ('United', 302, 'LHR', 5, 6.5),
 ('United', 31, 'IAD', 1, 7.0999999999999996),
 ('Aeroflot', 34, 'SVO', 5, 9.0),
 ('Southwest', 146, 'CDA', 1, 9.5999999999999996),
 ('American', 1, 'JFK', 12, 11.300000000000001),
 ('United', 2, 'LAX', 10, 12.5),
 ('Southwest', 23, 'SBA', 6, 12.5),
 ('USAirways', 8, 'MIA', 20, 13.1),
 ('SpamAir', 1, 'AUM', 42, 14.4),
 ('Southwest', 59, 'LAX', 11, 14.5),
 ('United', 2032, 'MIA', 21, 15.1)]
```

filter, map, reduce, zip

Filter is a certain way to do list comprehension

`filter(`*function*`, `*sequence*`)`" returns a sequence consisting of those items from the sequence for which *function*`(`*item*`)` is true

```
>>> mylist=[num for num in range(101) if (num & 2) and (num & 1) and (num % 11 != 0.0)]
>>> print mylist
[3, 7, 15, 19, 23, 27, 31, 35, 39, 43, 47, 51, 59, 63, 67, 71, 75, 79, 83, 87, 91, 95]
>>> def f(num): return (num & 2) and (num & 1) and (num % 11 != 0.0)
>>> mylist = filter(f,xrange(101))
```

if the input is a string, so is the output...

```
>>> ## also works on strings...try it with lambdas!
>>> a="Charlie Brown said \"!@!@$@!\""
>>> filter(lambda c: c in string.ascii_letters,a)
'CharlieBrownsaid'
>>> filter(lambda num: (num & 2) and (num & 1) and (num % 11 != 0.0),xrange(101))
```

aside: xrange() is an iterable version of range():
range(10) creates a 10-element list, xrange(10) creates an iterable object which returns 0 the first time it's called, 1 then next time etc.

let's see the computational advantage of xrange
use the ipython magic called %timeit to time how long it takes

```
>>> def f(num): return (num & 2) and (num & 1) and (num % 11 != 0.0)
>>> %timeit len(filter(f,range(1L)))
1000000 loops, best of 3: 973 ns per loop
>>> %timeit len(filter(f,xrange(1L)))
1000000 loops, best of 3: 799 ns per loop
>>> # try more
>>> %timeit len(filter(f,range(10000000L)))
1 loops, best of 3: 5.89 s per loop
>>> %timeit len(filter(f,xrange(10000000L)))
1 loops, best of 3: 2.88 s per loop
```

note: xrange (like range) can be reversed

```
>>> for i in reversed(xrange(1,10,2)): print i,
9 7 5 3 1
```

filter, map, reduce, zip

Map is just another way to do list comprehension

`map(`*function*`, `*sequence*`)` calls *function*`(`*item*`)` for each of the sequence's items and returns a list of the return values

```
>>> def cube_it(x): return x**3
>>> map(cube_it,xrange(1,10))
[1, 8, 27, 64, 125, 216, 343, 512, 729]
>>> map(lambda x: x**3, xrange(1,10))
[1, 8, 27, 64, 125, 216, 343, 512, 729]
```

Reduce returns one value

`reduce(`*function*`, `*sequence*`)` returns a single value constructed by calling the binary function *function* on the first two items of the sequence, then on the result and the next item, and so on

```
>>> reduce(lambda x,y: x + y, xrange(1,11))   # sum from 1 to 10
55
>>> %timeit reduce(lambda x,y: x + y, xrange(1,11))
100000 loops, best of 3: 2.07 us per loop
>>> %timeit sum(xrange(1,11))    # sum() is a built in function...it's bound to be faster
1000000 loops, best of 3: 647 ns per loop
```

filter, map, reduce, zip

zip()

built in function to pairwise concatenate items in iterables into a list of tuples

```
>>> zip(["I","you","them"],["=spam","=eggs","=dark knights"])
[('I', '=spam'), ('you', '=eggs'), ('them', '=dark knights')]
>>> zip(["I","you","them"],["=spam","=eggs","=dark knights"],["!","?","#"])
[('I', '=spam', '!'), ('you', '=eggs', '?'), ('them', '=dark knights', '#')]
>>> zip(["I","you","them"],["=spam","=eggs","=dark knights"],["!","?"])
[('I', '=spam', '!'), ('you', '=eggs', '?')]
>>>
>>> questions = ['name', 'quest', 'favorite color']
>>> answers = ['lancelot', 'the holy grail', 'blue']
>>> for q, a in zip(questions, answers):
...     print 'What is your %s?  It is %s.' % (q, a)
...
What is your name?  It is lancelot.
What is your quest?  It is the holy grail.
What is your favorite color?  It is blue.
```

not to be confused with zipfile module which exposes file compression

Try/Except/Finally

Billy: Let's keep going with "Airplanes", for $200.

Bobby Wheat: "Airplanes" for $200: "And *what* is the Deal With the Black Box?" [Tommy buzzes in] Tommy!

Tommy: It's the *only* thing that survives the crash - why don't they build the **whole** plane out of the Black Box!

http://snltranscripts.jt.org/91/91rstandup.phtml

Wrap volatile code in try/except/finally

```
>>> tmp = raw_input("Enter a number and I'll square it: ") ; print float(tmp)**2
Enter a number and I'll square it: monty
ValueError: invalid literal for float(): monty
```

instead....

```
>>> def f():
try:
   tmp = raw_input("Enter a number and I'll square it: ")
   print float(tmp)**2
except:
   print "dude. I asked you for a number and %s is not a number." % tmp
finally:
   print "thanks for playing!"
>>> f()
Enter a number and I'll square it: 3
9.0
thanks for playing!
>>> f()
Enter a number and I'll square it: monty
dude. I asked you for a number and monty is not a number.
thanks for playing!
```

Wrap volatile code in try/except/finally

```
try:
   tmp = raw_input("Enter a number “ + \
                   and I'll square it: ")
   print float(tmp)**2
except:
   print "dude. I asked you for a number and " + \
         "%s is not a number." % tmp
finally:
   print "thanks for playing!"
```

volatile stuff

upon error, jump here inside except and execute that code

regardless of whether you hit an error, execute everything inside the finally block

- errors in Python generate what are called “exceptions”
- exceptions can be handled differently depending on what kind of exception they are
  (we’ll see more of that later)
- except “catches” these exceptions
- you do not have to catch exceptions (try/finally) is allowed. Finally block is executed no matter what!

```
>>> try:
  print "eat at" % joes
finally:
  print "bye."
bye.
------------------------------------------------------------
Traceback (most recent call last):
  File "<ipython console>", line 2, in <module>
NameError: name 'joes' is not defined
```

exec & eval

`exec` is a statement which executes strings as if they were Python code

```
>>> a = "print 'checkit'"
>>> exec a
checkit
>>> a = "x = 4.56"
>>> exec a
>>> print x
4.56
>>> exec "del x"
>>> print x
------------------------------------------------------------
Traceback (most recent call last):
  File "<ipython console>", line 1, in <module>
NameError: name 'x' is not defined
```

- dynamically create Python code (!)
- execute that code w/ implication for current namespace

exec & eval

```
>>> import math
>>> while True:
    bi = raw_input("what built in function would you like me to coopt? ")
    nn = raw_input("what new name would you like to give it? ")
    exec "%s = %s" % (nn,bi)
...
what built in function would you like me to coopt? math.sin
what new name would you like to give it? monty_sin
what built in function would you like me to coopt? range
what new name would you like to give it? python_range
>>> monty_sin (math.pi/2)
1.0
>>> python_range(3)
[0, 1, 2]
```

exec & eval

`eval` is an expression which evaluates strings as Python expressions

```
>>> x = eval('5')                 # x <- 5
>>> x = eval('%d + 6' % x)        # x <- 11
>>> x = eval('abs(%d)' % -100)    # x <- 100
>>> x = eval('print 5')           # INVALID; print is a statement, not an expression (in Python 2.x).
------------------------------------------------------------
   File "<string>", line 1
     print 5
         ^
SyntaxError: invalid syntax

>>> x = eval('if 1: x = 4')       # INVALID; if is a statement, not an expression.
------------------------------------------------------------
   File "<string>", line 1
     if 1: x = 4
      ^
SyntaxError: invalid syntax
```

breakout

Write a code which generates python code that approximates the function $x^2 + x$.

<u>hints:</u>

randomly generate lambda functions using a restricted vocabulary:

```
voc =["x","x"," ","+","-","*","/","1","2","3"]
```

evaluate these lambda functions at a fix number of x values and save the difference between those answers and $x^2 + x$

catch errors!

```
import random
import numpy

voc =["x","x"," ","+","-","*","/","1","2","3"]

nfunc       = 1000000L
maxchars = 10  # max how many characters to gen
eval_places = numpy.arange(-3,3,0.4)
sin_val     = eval_places**2 + eval_places
tries       = []
for loop...
```