Working with basic types and collections

Objectives

- Work with fundamental types (numbers, strings, etc.)
- Convert between types
- Work with collections
- Use slice operations

Fundamental types

- There are a few types in Python that you must be fluent in
- These include:
  – numbers
  – strings
  – dates and times

Numerical types

- Python has deep support in the scientific computing community
  - One good reference is 10 Reasons Python Rocks for Research
- This is due to several reasons
  - Simplicity with generality
  - Good numerical support with NumPy
  - Scientific libraries like SciPy
- Python supports
  - Integers (very long integers)
  - Floating point numbers
  - Complex numbers

http://docs.python.org/2.4/lib/typesnumeric.html

Numerical types [details]

- Defining numerical types

```
n = 1                        # int
a = 10000000000000000000     # int
x = 0.0                      # float
y = 5 * x                    # float
z = 7 + 11j                  # complex
```

http://docs.python.org/2.4/lib/typesnumeric.html
https://docs.python.org/3/library/stdtypes.html#numeric-types-int-float-complex

Numerical types [operations]

- Python has the **standard mathematical operators**
  - some may surprise you.

```
n = 14
m = 5
x = 7.2
y = 4.1
z = 3 + 2j

-n       => -14
 n * m   => 70
 x * y   => 29.52
 x / y   => 1.7560975609756 1
 n % m   => 4
 n / m   => 2.8
 n // m => 2
 n ** m => 537,824
 z * z   => (5+12j)
```

Conversions [between numerical types]

- You can explicitly convert between numerical types

```
n = 14
x = float(n)
z = complex(n)
m = int(x)

n => 14
x => 14.0
z => 14+0j
m => 14
```

Conversions [from strings]

- More common is to convert from strings

```
n = int("14")
x = float("14.7")
z = complex("7+2j")

n => 14
x => 14.7
z => 7+2j
```

Strings [defining]

- All strings in Python 3 are Unicode and immutable
- Can be defined with
  - Double quotes
  - Single quotes
- Have escape characters similar to C++ / C#
  - However, you can treat them as 'raw' strings with **r** prefix

```
s = "is a string"
t = 'is also a string'

para = "strings can\t\thave escape\nchars including\nnewlines"
print(para)
# strings can         have escape
# chars including
# newlines

raw = r"I wouldn\t escape this\n."
print(raw) # I wouldn\t escape this\n.
```

Strings [multiple lines]

- There are several techniques for spanning lines
  - Any continuation char: **** or **( )**
  - """ (three quotes) or ''' (three single quotes)

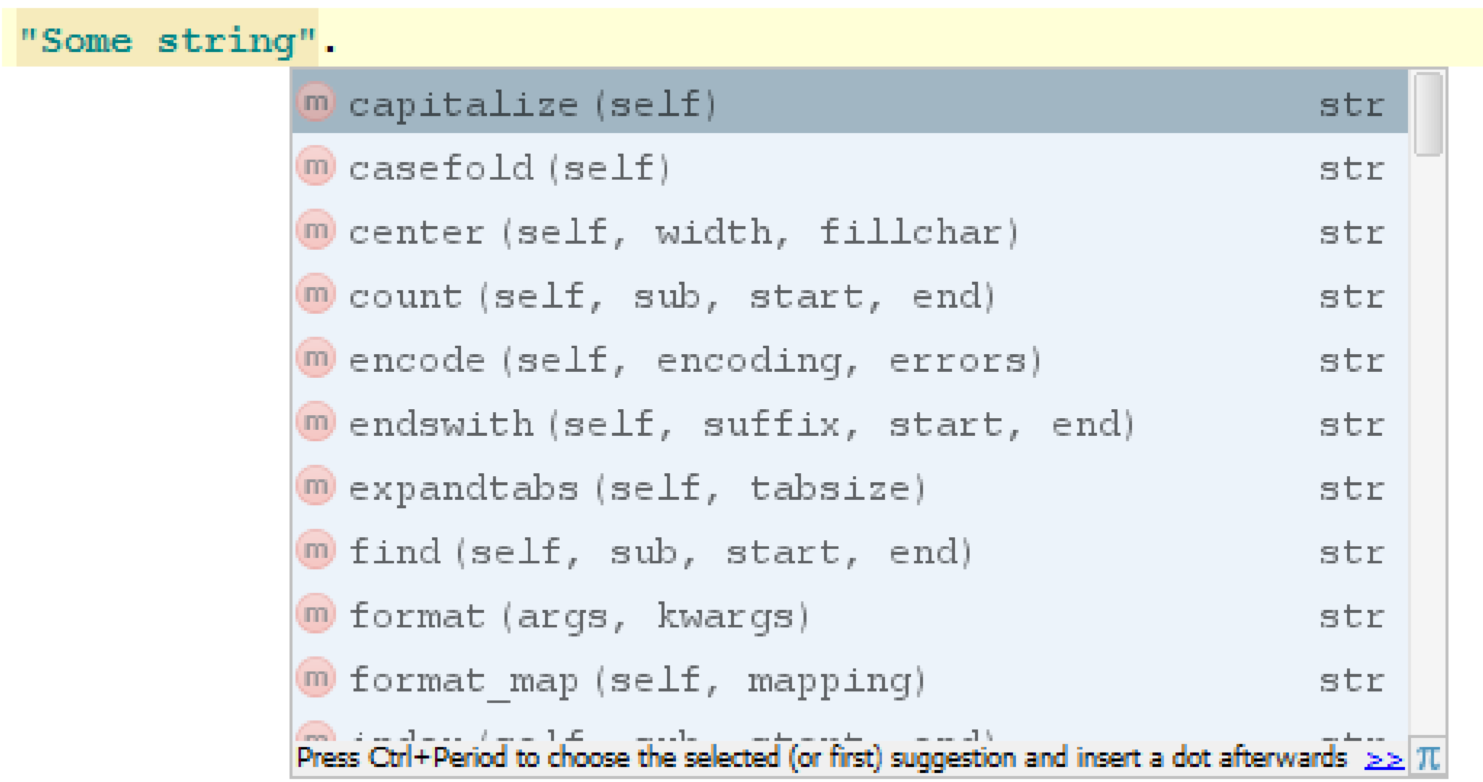
```
crossLine1 = "This spans" + \
             "a code line"

crossLine2 = ("This spans" +
              "a code line")

crossLine3 = \
"""
This string is designed to span
lines and be exactly as you see
it (including line breaks)
"""
# this one includes line breaks.
```

Strings [methods]

- Strings have many utility methods including:
  - upper()
  - lower()
  - find() / index()



Strings [formatting]

- **string.format()** is a powerful string construction method.

```
"Hello {0}, today is {1}. Right {0}?“
    .format("Michael", "Monday"))
# Hello Michael, today is Monday. Right Michael?

"{0:,} is pretty big!".format(1234567890)
# 1,234,567,890 is pretty big!

"You can name your args {jeff} and {tony}!"
    .format(jeff="bigj", tony="t-boy")
# You can name your args bigj and t-boy!

"v3.1 added empty {} and {}!".format("placeholders", "such")
# v3.1 added empty placeholders and such!

vals = dict(path="C:\\dir", file="logfile.txt")
"It even accepts named vals: {path}\\{file}".format(**vals)
# It even accepts named vals: C:\dir\logfile.txt
```

Strings [miscellanea]

- String length is computed via **`len`**`(txt)` method.
- Strings can be indexed
  - **`txt[2]`** => 3rd character (zero based)
  - **`txt[-3]`** => 3rd from last character (-1 based)
- They are 'mathy'
  - **`"hi" * 2 + "bye"`** => "hihibye"
- They can be combined via + or just adjacency
  - `"Combine " + "this" => "Combine this"`
  - `"Combine " "this" => "Combine this"`

Dates and times

- Python has support for dates, times, timespans, and calendars.
- Defined within the **datetime** module
  - `from datetime import date`
  - `from datetime import time`
  - `from datetime import datetime`

```
today = date.today()
print("Today is {month}/{day}/{year}"
    .format(month=today.month, day=today.day, year=today.year))

# Prints: Today is 11/25/2013

now = datetime.now()
print("Right now it's {0}h:{1}m:{2}.{3}sec"
       .format(now.hour, now.minute, now.second,
       now.microsecond//1000))

# Prints: Right now it's 16h:20m:5.867sec
```

Dates and times [timespans]

- **`timedelta`** class manages time spans.
- Defined within the **`datetime`** module
  - `from datetime import timedelta`
- Result of subtraction between two datetimes
  - `dt = t1 - t0 # dt is a timedelta`

```
dt = timedelta(hours=1, minutes=5)

now = datetime.now()
later = now + dt

print("Now it's {0} but will be {1}.".format( now, later))

# Prints:
# Now it's 2013-11-25 16:27:22 but will be 2013-11-25 17:32:22.
```

Dates and times [parsing]

- Parse text with **datetime.strptime**

```
txt = "Monday, November 21, 2013"
day = datetime.strptime(txt, "%A, %B %d, %Y")

print(day)
# 2013-11-21 00:00:00
```

There are many options for the format string:
http://docs.python.org/3.4/library/datetime.html#strftime-strptime-behavior

Collections

- Python has a rich set of collection classes
  - lists
  - sets
  - dictionaries
  - tuples
- The interfaces of each is generally consistent
- Many operations are very efficient (implemented in C)
- Python idioms rely heavily on collections

Lists

- Lists are the most fundamental collection type in Python
- Highly efficient
  - Implemented in C [1]
  - Pre-allocates space to grow
- Lists are essentially Python's array type
- Lists are defined using the **list** class or **[ ]** (square brackets)

```
numbers = []         # an empty list
numbers = list()     # another empty list
numbers = [1,2,3]    # a list with items

# lists can be heterogeneous
numbers = [1,2,3,"not a number"]
```

Lists [accessing values]

- Lists are iterable and indexable
  - Forward **Indexes** are zero-based
  - **Backwards Indexes** are negative-one-based
  - **for** loops pull out the values one at a time

```
num = [1,2,3,4,5]

first = num[0]              # value = 1
last  = num[len(num) - 1]   # value = 5
Last  = num[-1]             # value = 5

for n in num:
    even_text = "even" if n % 2 == 0 else "odd"
    print("{0} is {1}.".format(n, even_text))
```

Lists [building lists]

- Lists can be built-up dynamically
  - one item at a time via **`list.append()`**
  - via unions (**+**)
  - via **`list.extend()`**

```
num = []
num.append(7)
num.append(11) # num = [7, 11]

num = [7, 11] + [13, 17, 19]
num.extend([23,97])

# num = [7, 11, 13, 17, 19, 23, 97]
```

Lists [removing items]

- List items can be changed and removed

Indexer is read/write

Removes first occurrence by value

Removes last

```
num = [7, 11, 14, 17, 19, 17, 23, 97]

num[2] = 4      # [7, 11, 4, 17, 19, 17, 23, 97]
num.remove(17) # [7, 11, 4, 19, 17, 23, 97]

v = num.pop()
# v   => 97
# num => [7, 11, 4, 19, 17, 23]

del num[2] # [7, 11, 19, 17, 23]
```

removed by index via **del** keyword

Slicing

- Python has a technique for dissecting **strings** and **lists**
- Highly efficient
  - slice algorithm implemented in C [1]
- Takes the form of
  - **`item[ startIndex : endIndex : step ]`**

```
num = [7, 11, 13, 17, 19]

num[2:4]  # [13, 17]
num[2:]   # [13, 17, 19] omit end = len(num)
num[:3]   # [7, 11, 13]  omit start = 0
num[::2]  # [7, 13, 19]  omit start and end

num[-2:]  # [17, 19] reverse

s = "This also works on strings"
s[-10:]    # on strings
```

Slicing [cloning]

- Slicing provides a simple way to make a shallow **copy**

```
num = [7, 11, 13, 17, 19]
other = num[:]  # make a shallow copy

num[1] = 2      # modify original

num             # [7, 2, 13, 17, 19]
other           # [7, 11, 13, 17, 19]
```

Collections [sets]

- Sets are an unordered collection of distinct hashable objects
  - Supports set theoretic operations [1]

```
# defining sets
s = set() # not { }, {} is a dictionary.
s = {1,2,2,2,5}

# modifying sets
s.add(3)
s.add(3)

print(s) # prints {1, 2, 3, 5}
```

Collections [dictionaries]

- Dictionaries map hashable values (keys) to arbitrary objects (values).

```python
# defining dictionaries
d = dict()
d = {}
d = {"one": "monday",
     "two": "tuesday",
     "three": "wednesday"}

# adding items
d["four"] = "thursday"

# checking for items
"three" in d # True
"seven" in d # False

# accessing items
d["three"] # "thursday"
d["seven"] # KeyError exception
```

Collections [tuples]

- Tuples are immutable sequences, typically used to store collections of heterogeneous data

```
# create a tuple
t = (1, 2, "orange")
t[1] # => 2

# assignment to multiple variables
x, y, color = t # x=1, y=2, color=orange
```

Tuples are often return values from methods

```
for (index, item) in enumerate(["first", "middle", "last"]):
    print("{}: {}".format(index, item))

# prints
0: first
1: middle
2: last
```

Collections [named tuples]

- Tuple heavy code can be difficult to manage and maintain.

```
# find_user returns a tuple full of the columns from db
row = db.find_user(42)

print("User {} {} with email {} has {} subscriptions".
    format(row[1], row[2], row[4], row[7]) )
```

How maintainable is this code if the user table changes?
How legible is it?

Collections [named tuples]

- Named tuples can help dramatically here.

```
from collections import namedtuple

UserRow = namedtuple('UserRow',
    ['id', 'first', 'last', 'email', 'subscriptions'])

row = db.find_user(42)
u = UserRow._make(row)

print("User {} {} with email {} has {} subscriptions".
    format(u.first, u.last, u.email, u.subscriptions) )
```

namedtuple allows us to treat the standard tuple like a lightweight class (think DTO pattern).

Summary

- Strong support for scientific / numerical operations
- Variety of numerical types: integers, floats, and complex
- Convert between types using integer(), str(), etc.
- All strings are Unicode in Python 3
- Strings support a clean format style
- There are 4 fundamental collection types: lists, sets, dictionaries, and tuples
- Slicing allows us to work with subsets of collections