CS 1
Introduction to Computer Programming

Lecture 8: October 19, 2015

Odds and Ends

Last time

- `while` loops
- `break`
- Files
  - opening, closing, reading from files

Today

- A smörgasbörd of töpics:
  - More on booleans
  - More on loops
    - looping over files with `for`
  - The `in` operator
  - The `range` function
  - Tuples
  - The `enumerate` function
  - Sequence slices

More on booleans

- Booleans are `True`/`False` values
- However, Python is not strict about this
- Several things besides the `False` value are considered to be `False` by Python
  - the empty string: `''`
  - the empty list: `[]`
  - the number `0`
- ... and most other values can be considered to be `True`

Boolean operators

- Python also supports three built-in boolean operators: **`not`**, **`and`** and **`or`**
  - all take booleans arguments, return booleans
- **`not`** – converts **`True`** → **`False`**, **`False`** → **`True`**

```
>>> not True
False
>>> not False
True
```

Boolean operators

```
>>> not 0
True
>>> not 1
False
>>> not ''    # empty string
True
>>> not []
True
```

Boolean operators

- `and` and `or` are operators that take two boolean arguments and return a boolean value
- `and` returns `True` if both arguments are `True`, otherwise `False`
- `or` returns `True` if either or both arguments are `True`, otherwise `False`

Boolean operators

```
>>> True and True
True
>>> True and False
False
>>> False or True
True
>>> False or False
False
```

- Usually don't use `and` and `or` this way, though

Boolean operators

- Generally use **`and`** and **`or`** with expressions that *evaluate* to booleans
  - *e.g.* relational operators

```
a = 10
b = 30
# ... later in code ...
if a > 0 and b < 50: ...
# ... later in code ...
if a < 0 or b > 50: ...
```

Example from last time

- Recall the example problem from last time:

```
temps = open('temps.txt', 'r')
sum_nums = 0.0
while True:
    line = temps.readline()
    if line == '':
        break
    sum_nums += float(line)
```

Example from last time

- We had these lines of code in the example:

```
if line == '':
    break
```

- Since the empty string `''` can be considered to be a `False` value, can write this in equivalent form:

```
if not line:
    break
```

- `not line` means "if there is no line"

Full example

- With an infinite loop and `not line`:

```
temps = open('temps.txt', 'r')
sum_nums = 0.0
while True:
    line = temps.readline()
    if not line:
        break
    sum_nums += float(line)
```

- This is OK but still somewhat long-winded

Using `for` with files

- Python allows an amazing shortcut using the `for` statement:

```
temps = open('temps.txt', 'r')
sum_nums = 0.0
for line in temps:
    sum_nums += float(line)
```

- This is the preferred way to write this

Using `for` with files

- Previously, we had:

```
for <name> in <something>:
    # block of code
```

- The `<something>` after the `in` had to be a list or a string
- Python actually allows more than just lists or strings after the `in`
  - files being one example

Using `for` with files

- Conceptually, we have

```
for <name> in <sequence>:
    # block of code
```

- Lists are sequences
- Strings are sequences
- And files can be considered to be "sequences of lines"

Using `for` with files

- However, just because files work here:

```
for <name> in <sequence>:
    # block of code
```

- Doesn't mean you can do *all* sequence operations on files!

Using `for` with files

- For instance, this won't work:

```
# assume that the file 'foo.txt' exists
f = open('foo.txt', 'r')
print f[0]  # print first line in file?
```

- Result:

```
TypeError: 'file' object is unsubscriptable
```

- *Moral*: files are *not* full-fledged Python sequences
  - but `for` does work with files

The `in` operator

- We have see the word `in` in the context of a `for` expression:

```
>>> for i in [1, 2, 3]:
...     print i
1
2
3
```

- However, `in` has a separate meaning when used as an operator (coming between operands)

The `in` operator

- An expression of this form:

```
1 in [1, 2, 3]
```

- means: does `1` occur in the list `[1, 2, 3]`?
- More generally, `<x> in <s>` asks if a value `<x>` is found in a sequence `<s>` (usually a list or a string)

```
>>> 1 in [1, 2, 3]
True
>>> 'b' in 'foobar'
True
```

The `in` operator

- You can use this with variables too:

```
>>> x = 10
>>> x in [10, 20, 30]
True
```

- However, this has no relation to this syntax:

```
>>> for x in [10, 20, 30]:
...     print x
10
20
30
```

range

- The `range` function creates lists of consecutive integers:

```
>>> range(0, 5)
[0, 1, 2, 3, 4]
>>> range(10, 20)
[10, 11, 12, 13, 14, 15, ..., 19]
>>> range(-10, -5)
[-10, -9, -8, -7, -6]
```

`range`

- The **`range`** function takes two arguments:
  - the first number in the list
  - the number *one after* the last number in the list
- So **`range(1, 10)`** gives you

```
[1, 2, 3, 4, 5, 6, 7, 8, 9]
```

and not

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

- This seems weird, but will turn out to be useful

`range` with 3 arguments

- The `range` function can take an optional third argument:

```
>>> range(0, 10, 2)
[0, 2, 4, 6, 8]
```

- The third argument is the *step size*
  - the difference between consecutive list items
- Can even have negative step sizes:

```
>>> range(10, 0, -2)
[10, 8, 6, 4, 2]
```

`range` with 3 arguments

- Another way to think about it: `range` "always" has three arguments, but the last one is `1` by default when you use the two-argument form
- So:

```
range(0, 10)
```

really means:

```
range(0, 10, 1)
```

- Python allows you to define functions which can take varying numbers of arguments (will see later in course)

`range` with 1 argument

- `range` can also be used with *one* argument
- In this case:
  - starting value is `0`
  - step size is `1`

```
>>> range(10)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

- Equivalent to:

```
>>> range(0, 10, 1)
```

- This is the most commonly-used form of `range`

Use of `range`

- `range` is often used with `for` loops:

```
>>> for i in range(1000):
...     print i
0
1
2
3
...
```

Use of `range`

- `range` is often used with `for` loops and lists:

```
>>> mylist = ['Caltech', 'is', 'great']
>>> for i in range(len(mylist)):
...     mylist[i] = mylist[i] + '-YEAH!'
>>> mylist
['Caltech-YEAH!', 'is-YEAH!', 'great-YEAH!']
```

- This `range(len(...))` idiom is quite common in Python code

range(len(<list>))

- `range(len(<list>))` gives you a list of the valid indices of a particular list `<list>`
- For example:

```
>>> lst = ['a', 'list', 'of', 'strings']
>>> len(lst)
4
>>> range(len(lst))
[0, 1, 2, 3]
```

- `0`, `1`, `2`, and `3` are the valid indices of the list `lst`

`for i in range(len(<list>))`

- **`for i in range(len(<list>))`** used when need to have the indices of the list **`<list>`** inside a **`for`** loop (*e.g.* so you can change the list elements)
- If don't need to change list elements, usually can get by with just

```
for <element> in <list>: ...
```

Example

- Need to double every element of a list of numbers

```
nums = [23, 12, 45, 68, -101]
for i in range(len(nums)):
    nums[i] = nums[i] * 2
```

- Or could write second line as just

```
    nums[i] *= 2
```

- Result: `[46, 24, 90, 136, -202]`

Example

- This works, but `range(len(nums))` is kind of clunky to write
- We will shortly see a more elegant way to write this using the `enumerate` built-in function
- But first, we need to talk about tuples
- But before that, we need an...

Interlude

- Movie clip!

Tuples

- Tuples are another Python data type
  - basically a read-only list
- Tuple syntax is simple:

```
(1, 2, 3, 4, 5)
```

- Like a list, but surrounded by parentheses, not square brackets

Tuples

- Tuples of length 1 written like this:

```
(1,)
```

- because `(1)` is just the number `1`
  - (normal use of parentheses)

- Empty tuple is written `()`

Tuples

- Tuples support many, but not all, of the list operations
- Tuples are sequences like strings or lists
  - so it's OK to do

```
for <item> in <tuple>: ...
```

  - with a tuple
- `len` gives the length of a tuple

```
>>> len((1, 2, 3, 4, 5))
5
```

Tuples

- Can concatenate tuples with the **+** operation

```
>>> (1, 2, 3) + ('foo', 'bar', 'baz')
(1, 2, 3, 'foo', 'bar', 'baz')
```

- Can index tuples as with lists

```
>>> tup = ('foo', 'bar', 'baz')
>>> tup[0]
'foo'
>>> tup[-1]
'baz'
```

Tuples

- Cannot change contents of tuple!
  - like strings, tuples are immutable

```
>>> tup = ('foo', 'bar', 'baz')
>>> tup[0] = 'hello'
TypeError: 'tuple' object does not
  support item assignment
```

Tuples

- Python sometimes lets you leave off the parentheses in a tuple

```
>>> 1, 2, 3
(1, 2, 3)
>>> tup = 4, 5, 6
>>> tup
(4, 5, 6)
```

- We recommend that you keep the parentheses (more obvious what the object is)
  - with one exception (coming up)

Tuples

- Tuples are thus basically a more restricted kind of list
- So what good are tuples, anyway?
- Not really an essential language feature
  - Python could do fine without them
- There are some cases where tuples are convenient:
  1. returning multiple values from functions
  2. tuple unpacking
  3. `for` loops with multiple bindings

Multiple return values

- Functions in Python can only return a single value
  - most of the time, this is all we need
- Sometimes, it's useful to be able to return more than one value from a function
- We do this by creating a tuple of the return values, and returning that one value

Multiple return values

- Consider the built-in function **`divmod`**:

```
>>> divmod(10, 3)
(3, 1)
>>> divmod(42, 7)
(6, 0)
>>> divmod(101, 5)
(20, 1)
```

- **`divmod`** returns the quotient and remainder of its two arguments, as a tuple

Multiple return values

- We could define **`divmod`** ourselves:

```
def divmod(m, n):
    return (m / n, m % n)
```

- (Actual definition is more complex)
- Now we can write:

```
>>> qr = divmod(101, 5)
>>> quotient = qr[0]
>>> remainder = qr[1]
```

Tuple unpacking

- We can use **`divmod`** even more elegantly:

```
>>> qr = divmod(101, 5)
>>> (quotient, remainder) = qr
```

- Now **`quotient`** is **`20`** and **`remainder`** is **`1`**
- This is called *"tuple unpacking"*
  - like a multiple assignment statement
- Python also lets us write this without parentheses:

```
>>> quotient, remainder = qr  # or:
>>> quotient, remainder = divmod(101, 5)
```

Tuple unpacking

- Structure of a tuple unpacking:

```
(a, b, c) = t
```

- (where `t` is a tuple)
- `t[0]` is assigned to `a`, `t[1]` is assigned to `b`, `t[2]` is assigned to `c`
- Tuple `t` must have the same number of elements as tuple on left-hand side
  - or it's an error

Tuple unpacking

```
>>> tup = (1, 2, 3)
>>> a, b, c = tup
>>> a
1
>>> b
2
>>> c
3
```

Tuple unpacking

```
>>> tup = (1, 2, 3)
>>> a, b, c, d = tup
ValueError: need more than 3 values to
  unpack
>>> a, b = tup
ValueError: too many values to unpack
```

Swapping two variables

- Tuple unpacking lets us do a cute trick: swapping the value of two variables

```
>>> a = 10
>>> b = 20
>>> (a, b) = (b, a)
>>> a
20
>>> b
10
```

- Why does this work?

Swapping two variables

- Like all assignments, the right-hand side is evaluated first:

```
>>> (a, b) = (b, a)
```

evaluate

- `(b, a)` evaluates to the tuple `(20, 10)`
- Then this is unpacked into `(a, b)`
  - `a` becomes `20`, `b` becomes `10`
- That's all there is to it!
- Can also write as:

```
>>> a, b = b, a
```

`for` loops with multiple bindings

- We can also use tuples with `for` loops to assign ("bind") values to multiple names every time through the loop

```
>>> for (n, s) in [(1, 'a'), (2, 'b')]:
...     print "num = %d, char = %s" % (n, s)
num = 1, char = a
num = 2, char = b
```

- We'll get back to this

The `enumerate` function

- Earlier we saw this code:

```
nums = [23, 12, 45, 68, -101]
for i in range(len(nums)):
    nums[i] *= 2
```

- The purpose of `range(len(nums))` is to produce a list of the indices of `nums`
  - which are `[0, 1, 2, 3, 4]`
- Seems like a lot of work for something so simple

The `enumerate` function

- We can also write this code like this:

```
nums = [23, 12, 45, 68, -101]
for (i, e) in enumerate(nums):
    nums[i] *= 2
```

- What **`enumerate`** does is take a sequence and outputs the indices (**`i`**) and elements (**`e`**) of the sequence one by one

The `enumerate` function

- We can leave off the parentheses from the tuple:

```
nums = [23, 12, 45, 68, -101]
for i, e in enumerate(nums):
    nums[i] *= 2
```

The `enumerate` function

- Conceptually, it's as if `enumerate` produces a list of (index, element) tuples:

```
>>> enumerate(['a', 'b', 'c'])
[(0, 'a'), (1, 'b'), (2, 'c')]
```

- This is not actually what happens!
- In reality, you get something like:

```
<enumerate object at 0x6f940>
```

- but this object behaves like a list of tuples inside a `for` loop

The `enumerate` function

- Can convert an enumerate object to a list using the `list` built-in function:

```
>>> en = enumerate(['a', 'b', 'c'])
>>> en
<enumerate object at 0x6f940>
>>> list(en)
[(0, 'a'), (1, 'b'), (2, 'c')]
```

- Note that `0`, `1`, and `2` are the indices into the list we want

The `enumerate` function

- Enumerate objects are actually examples of something called an *iterator*
  - basically, something that can be looped over in a `for` loop
- Python has several built-in iterators, and allows you to define your own
  - Will talk about this later in course
  - This is also why files work with `for`

The `enumerate` function

- Back to our example:

```
nums = [23, 12, 45, 68, -101]
for i, e in enumerate(nums):
    nums[i] *= 2
```

- Note that we don't need the `e` variable anywhere in the example
- Can name `e` anything we want (doesn't matter)
  - but can't leave it out, or `i` will become a tuple!
  - Usually we name it `_` (indicates unused name)

The `enumerate` function

- What happens when we leave `e` out?

```
>>> nums = [23, 12, 45, 68, -101]
>>> for i in enumerate(nums):
...     print i
(0, 23)
(1, 12)
(2, 45)
(3, 68)
(4, -101)
```

The `enumerate` function

- Compare:

```
for i in range(len(nums)):
```

to:

```
for i, e in enumerate(nums):
```

- Which one you use is up to you
  - both are acceptable

Sequence slices

- Python allows you to get a single element from a sequence using the square bracket notation:

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[2]
3
```

- This works for all sequences (tuples, strings), not just lists

Sequence slices

- Python also lets you get more than one element from a sequence using a slice:

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[2:4]  # a slice of a list
[3, 4]
```

- Again, this works for all sequences

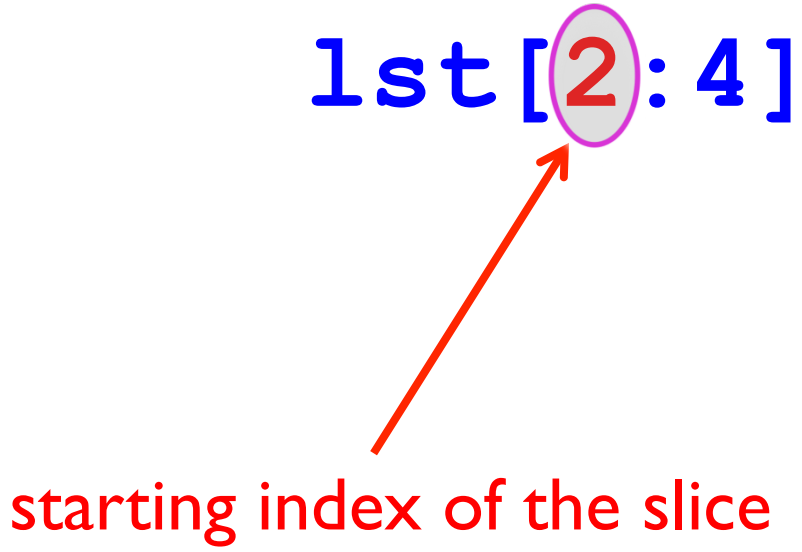
Slice notation

- Anatomy of a slice:

```
lst[2:4]
```

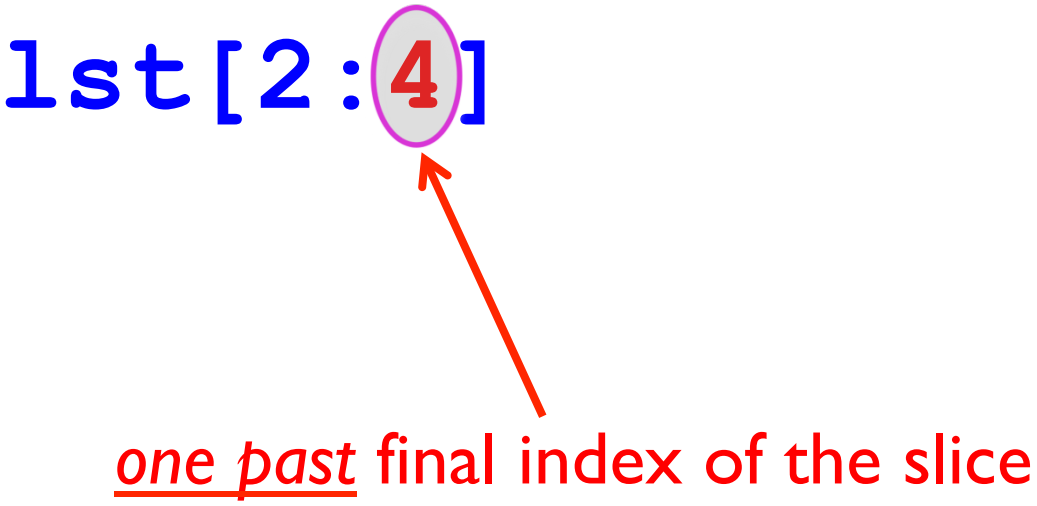
Slice notation

- Anatomy of a slice:



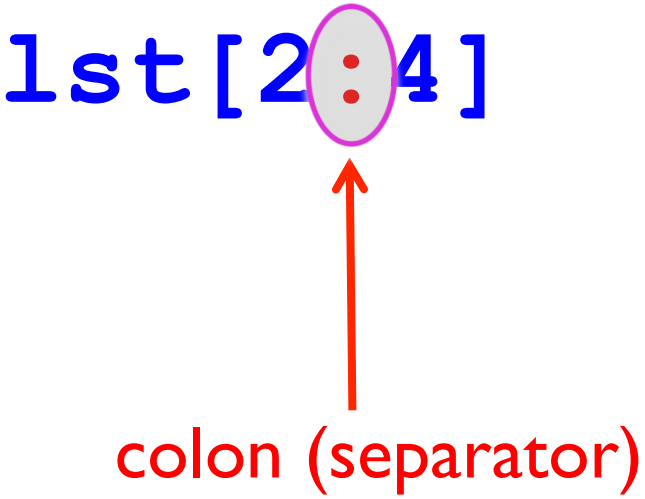
Slice notation

- Anatomy of a slice:



Slice notation

- Anatomy of a slice:



Sequence slices

- A sequence slice makes a *copy* of a chunk of the sequence
- First element of the copy is the element of the original sequence at the starting index of the slice
- Last element of the copy is the element of the original sequence *one before* the final index of the slice

Sequence slices

- Examples:

```
>>> lst = [1, 2, 3, 4, 5]
>>> tup = (6, 7, 8, 9, 10)
>>> s = 'abcdef'
>>> lst[0:5]
[1, 2, 3, 4, 5]
>>> tup[1:5]
(7, 8, 9, 10)
>>> s[1:4]
'bcd'
```

Sequence slices

- If the slice's final index is larger than the length of the sequence, the slice ends at the last element

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[3:1000]
[4, 5]
```

- If the slice's final index is left out, it's assumed to be equal to the length of the sequence

```
>>> lst[3:]
[4, 5]
```

Sequence slices

- If the slice's starting index is left out, the slice starts at the first element

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[0:3]
[1, 2, 3]
>>> lst[:3]
[1, 2, 3]
```

Sequence slices

- If *both* the slice's starting index and the slice's ending index are left out, the slice is a copy of the entire list!

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[0:5]
[1, 2, 3, 4, 5]
>>> lst[:]
[1, 2, 3, 4, 5]
```

Sequence slices

- Slices can use negative indices (counting from the end of the sequence)

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[:-1]  # -1: last element of list
[1, 2, 3, 4]
>>> lst[:-2]
[1, 2, 3]
>>> lst[-3:-1]
[3, 4]
```

Sequence slices

- Common application: remove newline character from the end of a string:

```
>>> s = 'Hello, world!\n'
>>> s[:-1]
'Hello, world!'
```

Wrap-up

- There are more "odds and ends" still to learn
- Will cover lots more in future lectures
  - as well as major new topics

Next time

- Binary numbers
- Dictionaries