CSc 120

Introduction to Computer Programing II

01: Python review

getting started

Python language and environment

- Language: Python 3
  - Use Visual Studio Code for assignments
  https://code.visualstudio.com/

  - But you’ll see IDLE in these slides
  - https://www.python.org/
    - Very simple environment
    - tutorial
    - beginner's guide
    - language reference
    - setup and usage, HOWTOs, FAQs

Surprises if coming from C, C++, Java

- No variable declarations
- Indentation instead of `{}`
- Flexible `for` loop
- Built-in data structures (lists, dictionaries, tuples, sets)
- Arbitrary-precision integers
- Garbage collection (also in Java)
  - no explicit allocation/deallocation

python review: variables, expressions, assignment

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

>>> : python interpreter's prompt
black: user input (keyboard)
blue: python interpreter output

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

variables

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

expressions

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

assignment statements

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

typing in an expression causes its value to be printed

python basics

```
>>> x = 4
>>> y = 5
>>> z = x + y
>>> x
4
>>> y
5
>>> z
9
>>> y = z * 2
>>> y
18
>>>
```

- variables:
  - names begin with letter or '_'
  - don't have to be declared in advance
    - type determined at runtime

- expressions:
  - all the usual arithmetic operators

Multiple (aka parallel) assignment

```
>>>
>>> x, y, z = 11, 22, 33
>>> x
11
>>> y
22
>>> z
33
>>>
```

Assigns to multiple variables at the same time

$$x_1, x_2, \ldots, x_n = exp_1, exp_2, \ldots, exp_n$$

Behavior:

1. $exp_1, \ldots, exp_n$ evaluated (L-to-R)
2. $x_1, \ldots, x_n$ are assigned (L-to-R)

Comparison and Booleans

```
>>> x, y, z = 11, 22, 33
>>> x
11
>>> y
22
>>> z
33
>>> x < y
True
>>> y == z
False
```

Comparision operations:

<, >, ==, >=, <=, !=

Lower precedence than arithmetic operations.

Yield boolean values:

True

False

EXERCISE

```
>>> x = 3
>>> y = 4
>>> z = (2*x – 1 == y+1)
>>> z
```

← *what value is printed out for z?*

EXERCISE

```
>>> x = 3
>>> y = 4
>>> sum, diff, prod  =  x + y,  x – y,  x * y
>>> prod+diff
```

← *what is the value printed out?*

python review: basics of strings

Basics of strings

```
>>> x = "abcd"
>>> y = 'efgh'
>>> z = "efgh"
>>>
```

a string is a sequence of characters
(letters, numbers, and other symbols)

Basics of strings

```
>>> x = "abcd"
>>> y = 'efgh'
>>> z = "efgh"
>>>
```

a string is a sequence of characters
(letters, numbers and other symbols)

a string literal is enclosed in quotes

- single-quotes (at both ends)
- double-quotes (at both ends)

Basics of strings

```
>>> text = 'abcdefghi'
>>>
>>> text
'abcdefghi'
>>> text[0]
'a'
>>> text[1]
'b'
>>> text[27]
Traceback (most recent call last):
  File "<pyshell#153>", line 1, in <module>
    text[27]
IndexError: string index out of range
>>>
```

a string is a sequence of characters

- we can index into a string to get the characters

Basics of strings

```
>>> text = 'abcdefghi'
>>>
>>> text
'abcdefghi'
>>> text[0]
'a'
>>> text[1]
'b'
>>> text[27]
Traceback (most recent call last):
  File "<pyshell#153>", line 1, in <module>
    text[27]
IndexError: string index out of range
>>>
```

a string is a sequence of characters

- we can index into a string to get the characters

indexing beyond the end of the string gives an **`IndexError`** error

Basics of strings

```
>>> text = 'abcdefghi'
>>>
>>> text
'abcdefghi'
>>> text[0]
'a'
>>> text[1]
'b'
>>> text[27]
Traceback (most recent call last):
  File "<pyshell#153>", line 1, in <module>
    text[27]
IndexError: string index out of range
```

a string is a sequence of characters

- we can index into a string to get the characters
- each character is returned as a string of length 1

Intuitively, a *character* is a single letter, digit, punctuation mark, etc.

E.g.: 'a'
'5'
'$'

Basics of strings

```
>>> x = '0123456789'
>>>
>>> x[0]
'0'
>>> x[1]
'1'
>>> x[2]
'2'
>>>
>>> x[-1]
'9'
>>> x[-2]
'8'
>>> x[-3]
'7'
>>>
```

x[i] : if $i \geq 0$ (i.e., non-negative values):

- indexing is done from the beginning of the string
- the first letter has index 0

x[i] : if $i < 0$ (i.e., negative values):

- indexing is done from the end of the string
- the last letter has index -1

Basics of strings

```
>>> x = '0123456789'
>>>
>>> x[0]
'0'
>>> x[1]
'1'
>>> x[2]
'2'
>>>
>>> x[-1]
'9'
>>> x[-2]
'8'
>>> x[-3]
'7'
>>>
```

x[*i*] : if $i \geq 0$ (i.e., non-negative values):

- indexing is done from the beginning of the string
- the first letter has index 0

x[*i*] : if $i < 0$ (i.e., negative values):

- indexing is done from the end of the string
- the last letter has index -1

EXERCISE

```
>>> x = 'a'
>>> x == x[0]
```

what do you think will be printed here?

EXERCISE

```
>>> x = 'apple'
>>> x[2] == x[-2]
```

what do you think will be printed here?

Basics of strings

```
>>> x = 'abcDE_fgHIJ_01234'
>>> x
'abcDE_fgHIJ_01234'
>>>
>>>
>>> len(x)
17
>>> y = x.lower()
>>> y
'abcde_fghij_01234'
>>>
>>> y = x.upper()
>>y
'ABCDE_FGHIJ_01234'
>>>
```

len(x) : length of a string x

Basics of strings

```
>>> x = 'abcDE_fgHIJ_01234'
>>> x
'abcDE_fgHIJ_01234'
>>>
>>>
>>> len(x)
17
>>> y = x.lower()
>>> y
'abcde_fghij_01234'
>>>
>>> y = x.upper()
>> y
'ABCDE_FGHIJ_01234'
>>>
```

len(x) : length of a string x

x.lower(), x.upper() : case conversion on the letters in a string x

- note that non-letter characters are not affected

Basics of strings

```
>>> x = 'abcDE_fgHIJ_01234'
>>> x
'abcDE_fgHIJ_01234'
>>>
>>>
>>> len(x)
17
>>> y = x.lower()
>>> y
'abcde_fghij_01234'
>>>
>>> y = x.upper()
>> y
'ABCDE_FGHIJ_01234'
>>>
```

len(x) : length of a string x

x.lower(), x.upper() : case conversion on the letters in a string x

- note that non-letter characters are not affected
- does not modify x

Python supports a wide variety of string operations

- see www.tutorialspoint.com/python3/
  python_strings.htm

Basics of strings

```
>>> x = 'abc'
>>>
>>> x
'abc'
>>>
>>> ",".join(x)
'a,b,c'
>>>
```

str.join(x)

str.join(x): produces a string in which the characters of x have been joined by the string str

does not modify x

Basics of strings

```
>>> x = 'abcdefgh'
>>>
>>> x
'abcdefgh'
>>> x[3]
'd'
>>>
>>> x[3] = 'z'
Traceback (most recent call last):
  File "<pyshell#193>", line 1, in <module>
    x[3] = 'z'
TypeError: 'str' object does not support item assignment
>>>
```

Basics of strings

```
>>> x = 'abcdefgh'
>>>
>>> x
'abcdefgh'
>>> x[3]
'd'
>>>
>>> x[3] = 'z'
Traceback (most recent call last):
  File "<pyshell#193>", line 1, in <module>
    x[3] = 'z'
TypeError: 'str' object does not support item assignment
>>>
```

strings are ***immutable***, i.e., cannot be modified or updated

EXERCISE

```
>>> text = "How are you?"
>>>
```

Write code that operates on text and produces the string

```
'H-O-W- -A-R-E- -Y-O-U-?'
```

Basics of strings

```
>>> x = "abcd"
>>> y = 'efgh'
>>> z = 'efgh'
>>> y == z
True
>>> x == y
False
>>>
>>> w = x + y
>>> w
'abcdefgh'
>>>
>>> u = x * 5
>>> u
'abcdabcdabcdabcdabcd'
```

+ applied to strings does concatenation

Basics of strings

```
>>> x = "abcd"
>>> y = 'efgh'
>>> z = 'efgh'
>>> y == z
True
>>> x == y
False
>>>
>>> w = x + y
>>> w
'abcdefgh'
>>>
>>> u = x * 5
>>> u
'abcdabcdabcdabcdabcd'
```

+ applied to strings does concatenation

'*' applied to strings:

- does repeated concatenation *if one argument is a number*
- generates an error otherwise

Basics of strings

```
>>> x = "abcd"
>>> y = 'efgh'
>>> z = 'efgh'
>>>
>>> w = x + y
>>> w
'abcdefgh'
>>>
>>> u = x * 5
>>> u
'abcdabcdabcdabcdabcd'
>>> x - y
Traceback (most recent call last):
  File "<pyshell#39>", line 1, in <module>
    x - y
TypeError: unsupported operand type(s) for -: 'str' and 'str'
>>>
```

+ applied to strings does concatenation

* applied to strings:

- does repeated concatenation *if one argument is a number*
- generates an error otherwise

not all arithmetic operators carry over to strings

Basics of strings

```
>>> x = "abcdefg"
>>> y = 'hijk'
>>>
>>> x[3:6]
'def'
>>> x[2:5]
'cde'
>>>
>>> x[:2]
'ab'
>>> x[4:]
'efg'
>>> x[4:] + y[:2]
'efghi'
```

slicing: produces substrings

- characters from 3 (included) to 6 (excluded)
- characters from 2 (included) to 5 (excluded)

- characters from the beginning to 2 (excluded)
- characters from 4 (included) to the end

EXERCISE

```
>>> x = "whoa!"
>>> y = x[2] * len(x)
>>> z = x[3] + x[0] + y
>>> z
```

what is printed here?

EXERCISE

Write an expression that, for any string text, results in the last two characters of text. Assume text has length of 2 or greater.

python review: reading user input I: input()

Reading user input I: **input()**

```
>>> x = input()
13579
>>> x
'13579'
>>> y = input('Type some input: ')
Type some input: 23
>>> y
'23'
>>> z = input('More input: ')
More input: 567
>>> z
'567'
>>>
```

Reading user input I: **input()**

```
>>> x = input()
13579
>>> x
'13579'
>>> y = input('Type some input: ')
Type some input: 23
>>> y
'23'
>>> z = input('More input: ')
More input: 567
>>> z
'567'
>>>
```

input statement:

- reads input from the keyboard
- returns the value read
  - ○ (a string)

Reading user input I: **input()**

```
>>> x = input()
13579
>>> x
'13579'
>>> y = input('Type some input: ')
Type some input: 23
>>> y
'23'
>>> z = input('More input: ')
More input: 567
>>> z
'567'
>>>
```

input statement:

- reads input from the keyboard
- returns the value read as a string

- takes an optional argument
  - if provided, serves as a prompt

Reading user input I: **input()**

```
>>>
>>> x = input()
12
>>> x
'12'
>>> y = x / 2
Traceback (most recent call last):
  File "<pyshell#59>", line 1, in <module>
    y = x / 2
TypeError: unsupported operand type(s) for /: 'str' and 'int'
>>>
```

the value read in is represented as a string

Reading user input I: **input()**

```
>>>
>>> x = input()
12
>>> x
'12'
>>> y = x / 2
Traceback (most recent call last):
  File "<pyshell#59>", line 1, in <module>
    y = x / 2
TypeError: unsupported operand type(s) for /: 'str' and 'int'
>>>
```

the value read in is represented as a string

- string ≡ sequence of characters

- TypeError: indicate an error due to wrong type

Reading user input I: **input()**

```
>>>
>>> x = input()
12
>>> x
'12'
>>> y = x / 2
Traceback (most recent call last):
  File "<pyshell#59>", line 1, in <module>
    y = x / 2
TypeError: unsupported operand type(s) for /: 'str' and 'int'
>>> y = int (x) / 2
>>> y
6.0
>>>
```

the value read in is represented as a string

- string ≡ sequence of characters
- TypeError: indicates an error due to a wrong type

- Fix: explicit type conversion

EXERCISE

```
>>> x = input()
12
>>> y = 2*x
```

is this valid?

EXERCISE

```
>>> x = input()
>>> y = x + x
>>> int(x) == int(y)
True
```

what input value(s) will cause this to work as shown?

python review: conditionals

Conditional statements: **if/elif/else**

```
>>> var1 = input()
100
>>> var2 = input()
200
>>> x1 = int(var1)
>>> x2 = int(var2)
>>>
>>> if x1 > x2:
            print('x1 is bigger than x2')
elif x1 == x2:
            print('x1 and x2 are equal')
else:
            print('x1 is smaller than x2')
x1 is smaller than x2
>>>
```

Conditional statements: **if/elif/else**

```
>>> var1 = input()
100
>>> var2 = input()
200
>>> x1 = int(var1)
>>> x2 = int(var2)
>>>
>>> if x1 > x2:
        print('x1 is bigger than x2')
elif x1 == x2:
        print('x1 and x2 are equal')
else:
        print('x1 is smaller than x2')
x1 is smaller than x2
>>>
```

- **if**-statement syntax:

```
if  BooleanExpr :
        stmt
        …
elif BooleanExpr :
        stmt
        …
elif …
        …
else:
        stmt
        …
```

elifs are optional (use as needed)

Conditional statements: **if/elif/else**

```
>>> var1 = input()
100
>>> var2 = input()
200
>>> x1 = int(var1)
>>> x2 = int(var2)
>>>
>>> if x1 > x2:
        print('x1 is bigger than x2')
elif x1 == x2:
        print('x1 and x2 are equal')
else:
        print('x1 is smaller than x2')
x1 is smaller than x2
>>>
```

- **if**-statement syntax:

```
if  BooleanExpr :
        stmt
        …
elif BooleanExpr :
        stmt
        …
elif …
        …
else:
        stmt
        …
```

elifs are optional (use as needed)

else is optional

EXERCISE

Prompt the user for input and assign the result to text.

Set s to the last two characters of text. If text has length less than 2, s should be assigned to an empty string.

Solution

```
text = input()
if len(text) > 2:
    s = text[-2:]
else:
    s = ''
```

python review:
while loops

Loops I: while

```
>>> n = input('Enter a number: ')
Enter a number: 5
>>> limit = int(n)
>>> i = 0
>>> sum = 0
>>> while i <= limit:
        sum += i
        i += 1

>>> sum
15
>>>
```

Loops I: **while**

```
>>> n = input('Enter a number: ')
Enter a number: 5
>>> limit = int(n)
>>> i = 0
>>> sum = 0
>>> while i <= limit:
        sum += i
        i += 1

>>> sum
15
>>>
```

- **while**-statement syntax:

```
while  BooleanExpr :
        $stmt_1$
        …
        $stmt_n$
```

- $stmt_1$ … $stmt_n$ are executed repeatedly as long as *BooleanExpr* is True

EXERCISE

```
>>> text = "To be or not to be, that is the question."
>>> c = "o"
```

Write the code to count the number of times c occurs in text.

Solution

```
# count the occurrences of c in text
text = "To be or not to be, that is the question.”
c = "o"

n, i = 0, 0
while i < len(text):
    if text[i] == c:
        n += 1
    i += 1
```

python review:
lists

Lists

```
>>> x = [ 'item1', 'item2', 'item3', 'item4' ]
>>>
>>> x[0]
'item1'
>>> x[2]
'item3'
>>> len(x)
4
>>> x[2] = 'newitem3'
>>> x
['item1', 'item2', 'newitem3', 'item4']
>>> x[1:]
['item2', 'newitem3', 'item4']
>>> x[:3]
['item1', 'item2', 'newitem3']
```

Lists

```
>>> x = [ 'item1', 'item2', 'item3', 'item4' ]
>>>
>>> x[0]
'item1'
>>> x[2]
'item3'
>>> len(x)
4
>>> x[2] = 'newitem3'
>>> x
['item1', 'item2', 'newitem3', 'item4']
>>> x[1:]
['item2', 'newitem3', 'item4']
>>> x[:3]
['item1', 'item2', 'newitem3']
```

a list is a sequence of values

Lists

```
>>> x = [ 'item1', 'item2', 'item3', 'item4' ]
>>>
>>> x[0]
'item1'
>>> x[2]
'item3'
>>> len(x)
4
>>> x[2] = 'newitem3'
>>> x
['item1', 'item2', 'newitem3', 'item4']
>>> x[1:]
['item2', 'newitem3', 'item4']
>>> x[:3]
['item1', 'item2', 'newitem3']
```

a list is a sequence of values

accessing list elements (i.e., indexing), computing length: similar to strings

- non-negative index values (≥ 0) index from the front of the list
  - the first element has index 0
- negative index values index from the end of the list
  - the last element has index -1

Lists

```
>>> x = [ 'item1', 'item2', 'item3', 'item4' ]
>>>
>>> x[0]
'item1'
>>> x[2]
'item3'
>>> len(x)
4
>>> x[2] = 'newitem3'
>>> x
['item1', 'item2', 'newitem3', 'item4']
>>> x[1:]
['item2', 'newitem3', 'item4']
>>> x[:3]
['item1', 'item2', 'newitem3']
```

a list is a sequence of values

accessing list elements (i.e., indexing), computing length: similar to strings

lists are *mutable*, i.e., can be modified or updated

- different from strings

Lists

```
>>> x = [ 'item1', 'item2', 'item3', 'item4' ]
>>>
>>> x[0]
'item1'
>>> x[2]
'item3'
>>> len(x)
4
>>> x[2] = 'newitem3'
>>> x
['item1', 'item2', 'newitem3', 'item4']
>>> x[1:]
['item2', 'newitem3', 'item4']
>>> x[:3]
['item1', 'item2', 'newitem3']
```

a list is a sequence of values

accessing list elements (i.e., indexing), computing length: similar to strings

lists are ***mutable***, i.e., can be modified or updated

- different from strings

slicing : similar to strings

Lists

```
>>> x = [11, 22, 33]
>>> y = [44, 55, 66, 77]
>>>
>>> x + y
[11, 22, 33, 44, 55, 66, 77]
>>>
>>>
>>> x * 3
[11, 22, 33, 11, 22, 33, 11, 22, 33]
>>>
```

concatenation (+) : similar to strings

multiplication (*) similar to strings

EXERCISE

```
>>> x = [ “abc”, “def”, “ghi”, “jkl” ]
>>> x[1] + x[-1]
```

what do you think will be printed here?

Lists

```
>>>nums = [18, 3, 24, 63, 18, 4]
>>>num.append(7)
>>>nums
[18, 3, 24, 63, 18, 4, 7]
```

list.append(value)

appends the value to the list.

Lists

```
>>>w = []
>>>w.append(' hello' )
>>>w
[' hello' ]
>>>w.append(' there' ]
>>>w.append(2)
>>>w
[' hello' , ' there' , 2]
```

Empty list

Use append to add additional elements.

Lists

```
>>>w = []
>>>w.append(' hello' )
>>>w
[' hello' ]
>>>w.append(' there' ]
>>>w.append(2)
>>>w
[' hello' , ' there' , 2]
```

Empty list

Use append to add additional elements.

Elements can be of any type

EXERCISE

Write the code to create a list of the even numbers of num. Use a while loop and append.

```
>>> num = [18, 3, 24, 63, 18, 4, 7]
```

Solution

```
# create a list of the even elements of num
nums = [18, 3, 24, 63, 18, 4, 7]
i = 0
evens = []
while i < len(nums):
    if nums[i] % 2 == 0:
        evens.append(nums[i])
    i += 1
```

Lists: sorting

```
>>> x = [1, 4, 3, 2, 5]
>>> x
[1, 4, 3, 2, 5]
>>> x.sort()
>>>
>>> x
[1, 2, 3, 4, 5]
>>>
>>> y = [1, 4, 3, 2, 5]
>>> y
[1, 4, 3, 2, 5]
>>> sorted(y)
[1, 2, 3, 4, 5]
>>> y
[1, 4, 3, 2, 5]
>>>
```

sort() : sorts a list

sorted() : creates a sorted copy of a list;
the original list is not changed

python review: functions

Functions

- **`def`** *fn_name* (arg_1 , …, arg_n):
  - defines a function *fn_name* with n arguments arg_1 , …, arg_n
- **`return`** *expr*
  - optional
  - returns the value of the expression *expr* to the caller
- *fn_name*($expr_1$, …, $expr_n$):
  - calls *fn_name* with arguments expr_1, …, expr_n

Functions

```
>>> def double(x):
        return x + x
>>> double(7)
14
```

- **`def`** *fn_name* (arg_1 , …, arg_n):
  - defines a function *fn_name* with n arguments arg_1 , …, arg_n

- **`return`** *expr*
  - optional
  - returns the value of the expression *expr* to the caller

Functions

```
>>> def double(x):
        return x + x
>>> double(7)
14
>>>
>>> def num_occurences(text, c):
        n, i = 0, 0
        while i < len(text):
            if text[i] == c:
                n += 1
            i += 1
        return n
>>> num_occurences("To be or not to be, that is the question.", "o")
5
```

- **`def`** *fn_name* (arg_1 , …, arg_n):
  - defines a function *fn_name* with n arguments arg_1 , …, arg_n

- **`return`** *expr*
  - optional
  - returns the value of the expression *expr* to the caller

Lists of Lists

a list can consist of elements of many types, including lists

```
>>> x = [ [1,2,3], [4], [5, 6]]
>>> x
[[1, 2, 3], [4], [5, 6]]
>>>
>>>
>>> y = [ ['aa', 'bb', 'cc'], ['dd', 'ee', 'ff'], ['hh', 'ii', 'jj']]
>>> y
[['aa', 'bb', 'cc'], ['dd', 'ee', 'ff'], ['hh', 'ii', 'jj']]
>>>
```

a list of lists is called a 2-d list

Lists of Lists

```
>>> x = [ [1,2,3], [4], [5, 6]]
>>> x
[[1, 2, 3], [4], [5, 6]]
>>>
>>>
>>> >>> y = [ ['aa', 'bb', 'cc'], ['dd', 'ee', 'ff'], ['hh', 'ii', 'jj']]
>>> >>> y
[['aa', 'bb', 'cc'], ['dd', 'ee', 'ff'], ['hh', 'ii', 'jj']]
>>>
```

a list can consist of elements of many types, including lists

a list of lists is called a 2-d list

if the number of rows and columns are equal, it is a grid

Lists of Lists

```
 >>> y
[['aa', 'bb', 'cc'], ['dd', 'ee', 'ff'], ['hh', 'ii', 'jj']]
>>>
>>> y[0]
['aa', 'bb', 'cc']
>>> y[1]
['dd', 'ee', 'ff']
>>> y[2]
['hh', 'ii', 'jj']
>>>
>>> len(y)
3
>>> len(y[0])
3
>>>
```

a list can consist of elements of many types, including lists

a list of lists is called a 2-d list

if the number of rows and columns are equal, it is a grid

*must check the length of each row

EXERCISE

```
 >>> y
[['aa', 'bb', 'cc'], ['dd', 'ee', 'ff'], ['hh', 'ii', 'jj']]
>>>
>>> y[0]
['aa', 'bb', 'cc']
>>> y[1]
['dd', 'ee', 'ff']
>>> y[2]
['hh', 'ii', 'jj']
>>>
```

how do we access 'bb'?

EXERCISE

```
>>> x = [ [1,2,3], [10,20,30], [100,200, 300]]
>>> x
[[1, 2, 3], [10,20,30], [100,200,300]]
>>>
>>>
```

write the code to sum the first column of x

Helpful hint: first write x out as a grid.
Label the rows

Solution

```
x = [ [1,2,3], [10,20,30], [100,200, 300]]

# sum the first column of a 2-d list x
sum, i = 0, 0
while i < len(x):
    sum = sum + x[i][0]
    i += 1
```

python review:
for loops

Loops II: for

- The for statement iterates over the items of any sequence (or iterable object) in order
- **for**-statement syntax (the *general form*)

```
for  Var in Expr :
        $stmt_1$
        …
        $stmt_n$
```

- *Expr* is evaluated. *stmt*$_1$ … *stmt*$_n$ are executed for each element of the sequence that *Expr* produces; the value each successive element is assigned to *Var* in turn.

Loops II: for

```
>>> nums = [18, 3, 24, 63, 18, 4, 7]
>>> evens = []
>>>
>>> for n in nums:
       if n % 2 == 0:
         evens.append(n)

>>> evens
[18, 24, 18, 4]
>>>
```

sequence: a list or string
(there are more, as you will see)

range

- **range(...)** creates an object that represents a sequence of numbers

- A range can be created in three ways:

  range(*stop*)

  0, 1, ..., stop-1

  range(*start, stop*)

  start, start+1, start+2, ..., stop-1

  range(*start, stop, step*)

  *start, start+step, start+step*2, ..., stop – 1*

- Note that *stop* is always exclusive

for with range

```
>>> nums = [18, 3, 24, 63, 18, 4, 7]
>>> evens = []
>>>
>>> for i in range(len(nums)):
        if nums[i] % 2 == 0:
            evens.append(nums[i])

>>> evens
[18, 24, 18, 4]
>>>
```

represents the sequence 0,1,2,3,4,5,6

EXERCISE-Whiteboard

```
>>> grid = [ [18, 25, 36], [23, 25, 18], [20, 54, 7] ]
>>> grid
[ [18, 25, 36], [23, 25, 18], [20, 54, 7] ]
>>>
>>> total = 0
>>> for i in range(len(grid)):
        total += grid[i][0]

>>> total
61
>>>
```

write the code to sum the first column of grid using for and range

EXERCISE-Whiteboard

write the code to sum the first column of grid using for (no range)

```
>>> grid = [ [18, 25, 36], [23, 25, 18], [20, 54, 7] ]
>>> grid
[ [18, 25, 36], [23, 25, 18], [20, 54, 7] ]
>>>
>>> total = 0
>>>for row in grid:
        total += row[0]

>>>total
61
```

python review:
lists ↔ strings

Strings → lists

```
>>> names = "John, Paul, Megan, Bill, Mary"
>>> names
'John, Paul, Megan, Bill, Mary'
>>>
>>> names.split()
['John,', 'Paul,', 'Megan,', 'Bill,', 'Mary']
>>>
>>> names.split('n')
['Joh', ', Paul, Mega', ', Bill, Mary']
>>>
>>> names.split(',')
['John', ' Paul', ' Megan', ' Bill', ' Mary']
>>>
```

split() : splits a string on whitespace
returns a list of strings

split(*delim*) :
delim, splits the string on *delim*

Lists → strings

```
>>> x = ['one', 'two', 'three', 'four']
>>>
>>> "-".join(x)
'one-two-three-four'
>>>
>>> "!.!".join(x)
'one!.!two!.!three!.!four'
>>>
```

delim.join(*list*) : joins the strings in *list* using the string *delim* as the delimiter

returns a string

String trimming

```
>>> x = '     abcd      '
>>>
>>> x.strip()
'abcd'
>>>
>>> y = "Hey!!!"
>>>
>>> y.strip("!")
'Hey'
>>> >>> z = "*%^^stuff stuff stuff^%%%**"
>>>
>>> z.strip("*^%")
'stuff stuff stuff'
```

x.strip() : removes whitespace from both ends of the string *x*

returns a string

x.strip(*string*) : given an optional argument *string*, removes any character in *string* from both ends of *x*

String trimming

Speculate: What do the lstrip() and rstrip() methods do?

```
>>> line = '...testing  \n'
>>> line.rstrip()
'...testing'
>>> line.rstrip().lstrip(".")
'testing'
```

EXERCISE-Whiteboard

```
 >>> text = "Bear Down, Arizona. Bear Down, Red and Blue."
>>> words = text.split()
>>> words
['Bear', 'Down,', 'Arizona.', 'Bear', 'Down,', 'Red', 'and', 'Blue.']
>>> words_lst = []
>>> for w in words:
        words_lst.append(w.strip(".,"))

>>> words_lst
['Bear', 'Down', 'Arizona', 'Bear', 'Down', 'Red', 'and', 'Blue']
>>>
```

create a list of words with no punctuation

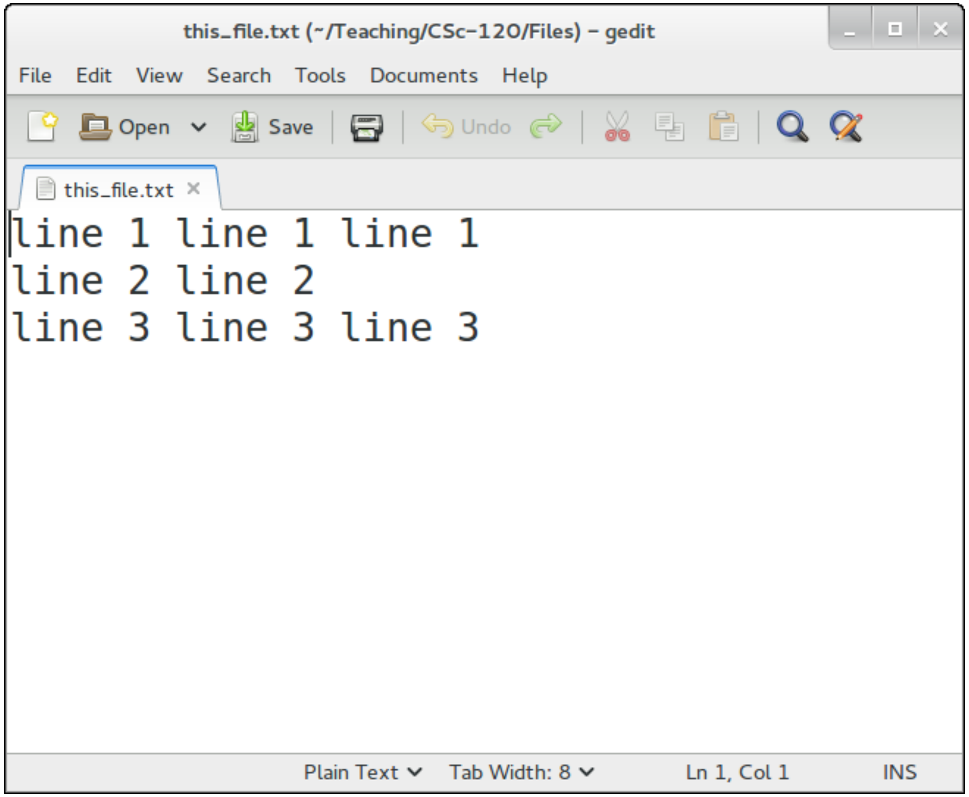
EXERCISE-ICA-2 p.1-3

- Go to the class website
- Do problems 1-3 in ICA-2

python review:
reading user input II: file I/O

Reading user input II: file I/O

suppose we want to read (and process) a file "this_file.txt"



this_file.txt (~/Teaching/CSc-120/Files) - gedit
File Edit View Search Tools Documents Help
Open
Save
Undo
this_file.txt ×
Plain Text
Tab Width: 8
Ln 1, Col 1
INS

```
line 1 line 1 line 1
line 2 line 2
line 3 line 3 line 3
```

Reading user input II: file I/O

```
>>> infile = open("this_file.txt")
>>>
>>> for line in infile:
            print(line)


line 1 line 1 line 1

line 2 line 2

line 3 line 3 line 3

>>>
```

- *fileobj* = **`open`**(*filename*)
  - *filename*: a string
  - *fileobj*: a file object

Reading user input II: file I/O

```
>>> infile = open("this_file.txt")
>>>
>>> for line in infile:
            print(line)


line 1 line 1 line 1


line 2 line 2


line 3 line 3 line 3


>>>
```

- *fileobj* = **`open`**(*filename*)
  - *filename*: a string
  - *fileobj*: a file object
- **`for`** *var* **`in`** *fileobj*:
  - reads the file a line at a time
  - assigns the line (a string) to *var*

Reading user input II: file I/O

```
>>> infile = open("this_file.txt")
>>>
>>> for line in infile:
            print(line)


line 1 line 1 line 1

line 2 line 2

line 3 line 3 line 3

>>> print(repr(line))
'line 3 line 3 line 3\n'
```

- *fileobj* = **`open`**(*filename*)
  - *filename*: a string
  - *fileobj*: a file object
- **`for`** *var* **`in`** *fileobj*:
  - reads the file a line at a time
  - assigns the line (a string) to *var*

Note that each line read ends in a newline ('\n') character

Reading user input II: file I/O

```
>>> infile = open("this_file.txt")
>>>
>>> for line in infile:
        print(line)


line 1 line 1 line 1

line 2 line 2

line 3 line 3

>>>
```

At this point we've reached the end of the file and there is nothing left to read

Reading user input II: file I/O

```
>>> infile = open("this_file.txt")
>>>
>>> for line in infile:
        print(line)


line 1 line 1 line 1

line 2 line 2

line 3 line 3

>>>
>>> infile.close()
>>>
```

at this point we've reached the end of the file so there's nothing left to read

housekeeping: close the file when we're done with it

Reading user input II: file I/O

```
>>> infile = open("this_file.txt")
>>>
>>> for line in infile:
        print(line.strip())


line 1 line 1 line 1
line 2 line 2
line 3 line 3


>>>
```

NOTE: we use strip() to get rid of the newline character at the end of each line

Writing output to a file

```
>>> out_file = open("names.txt", "w")
>>>
>>> name = input("Enter a name: ")
Enter a name: Tom
>>>
>>> out_file.write(name  +  '\n')
4
>>> name = input("Enter a name: ")
Enter a name: Megan
>>> out_file.write(name  +  '\n')
6
>>> out_file.close()
>>>
```

`open`(*filename*, **`"w")`** : opens *filename* in write mode, i.e., for output.

If the file doesn't exist, is it created.

If it does exist, it is truncated.

Writing output to a file

```
>>> out_file = open("names.txt", "w")
>>>
>>> name = input("Enter a name: ")
Enter a name: Tom
>>>
>>> out_file.write(name  +  '\n')
4
>>> name = input("Enter a name: ")
Enter a name: Megan
>>> out_file.write(name  +  '\n')
6
>>> out_file.close()
>>>
```

`open`(*filename*, **`"w"`**) : opens *filename* in write mode, i.e., for output

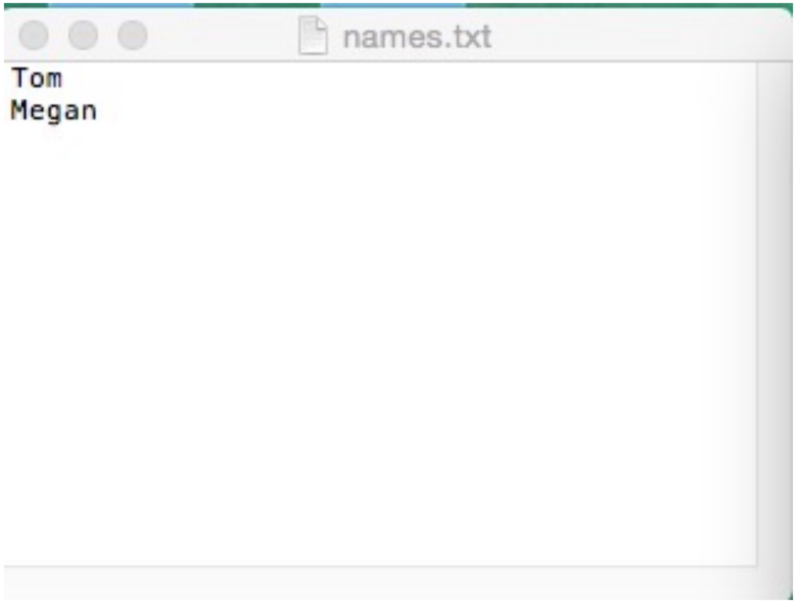
fileobj **`.write`**(*string*) : writes *string* to *fileobj*

Writing output to a file

```
>>> in_file = open("names.txt", "r")
>>> for line in in_file:
        print(line)
>>> in_file.close()
Tom


Megan
```

open the file in read mode ("r") to see what was written



```
Tom
Megan
```

python review:
a whole program!

Problem

Write a program that prints the number of times one or more specified characters appears in a file.

this_file.txt

```
line 1 line 1 line 1
line 2 line 2
line 3 line 3 line 3
```

Interaction:

```
File? this_file.txt
Chars? 123 io
'1': 3
'2': 2
'3': 3
' ': 13
'i': 8
'o': 0
```

Problem decomposition

We'll have three functions:

get_lines(fname)

Read the file named **fname** and return its lines as a list.

count_char(c, lines)

Returns the number of times **c** (a one-character string) appears in **lines**, a list of strings.

main()

Top-level glue

count_chars.py

```
def count_char(c, lines):
    count = 0
    for line in lines:
        for this_char in line:
            if c == this_char:
                count += 1

    return count

def get_lines(fname):
    lines = []
    f = open(fname)
    for line in f:
        lines.append(line)

    f.close()
    return lines
```

count_chars.py, continued

```
def main():
    fname = input("File? ")
    chars = input("Chars? ")

    lines = get_lines(fname)

    for c in chars:
        count = count_char(c, lines)
        print("'" + c + "': " + str(count))

main()
```

High-level structure of count_chars.py:

```
def count_char(c, lines):
    ...

def get_lines(fname):
    ...

def main():
    ...

main()
```

Notes:

- All code except "main()" is in a function.
- "main()" must be last.
- Function definitions can be in any order.
- What happens if you forget to call main?

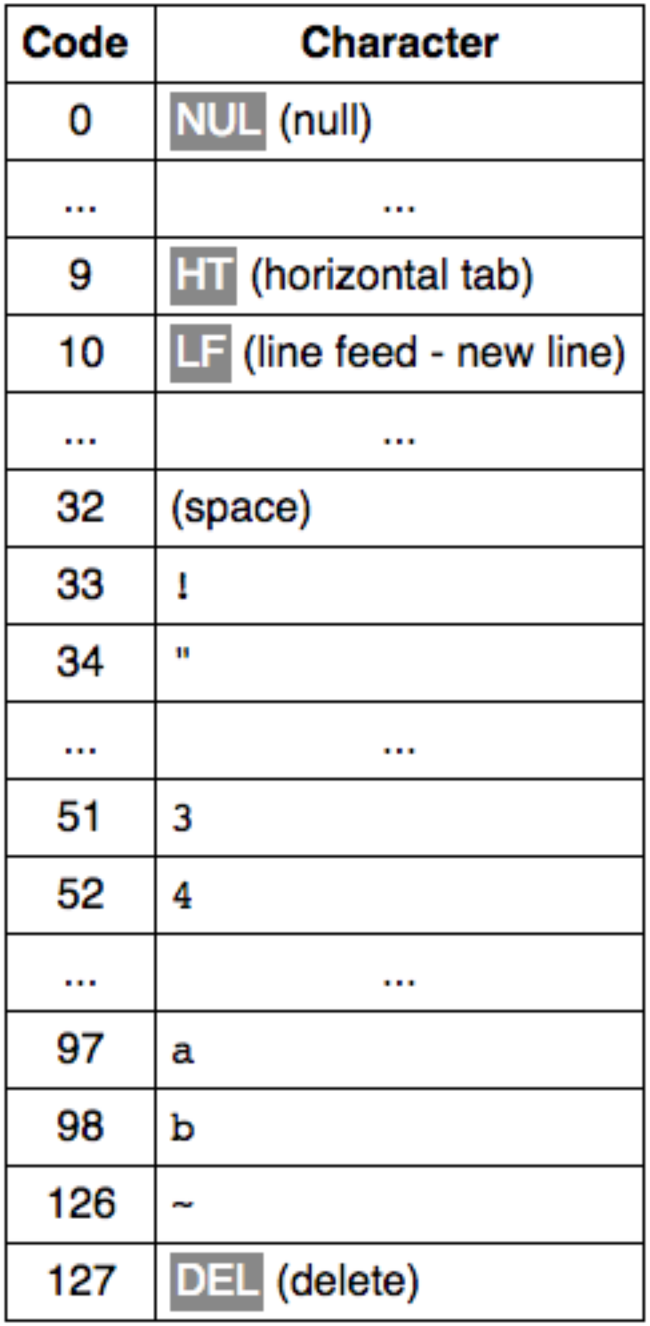
EXERCISE-ICA-3 p.1-2

- Go to the class website
- Do problems 1-2 in ICA-3

python review:
data representation

ASCII codes

- ASCII is "American Standard Code for Information Interchange"
- The ASCII standard specifies numeric codes for 128 characters.
- ASCII was developed in the 1960s
- In 1988 development began on Unicode.
- Version 14 of Unicode can accommodate 144,697 characters.
- The first 128 characters of ASCII and Unicode are the same.

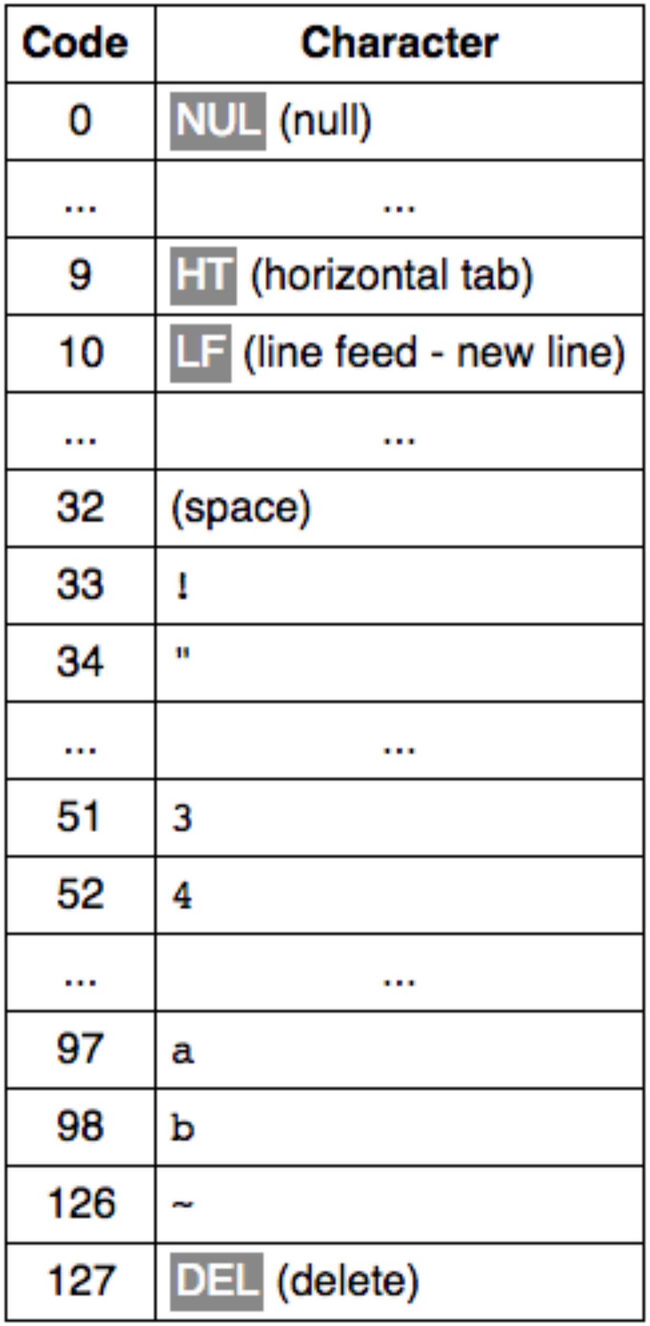


Code	Character
0	NUL (null)
...	...
9	HT (horizontal tab)
10	LF (line feed - new line)
...	...
32	(space)
33	!
34	"
...	...
51	3
52	4
...	...
97	a
98	b
126	~
127	DEL (delete)

ASCII continued

- Python provides ord() and chr() for working with ASCII codes.

```
>>> ord('a')
97
>>> chr(98)
'b'
>>> print(chr(49),chr(50),chr(51))
1 2 3
>>> ord('\n')
10
```

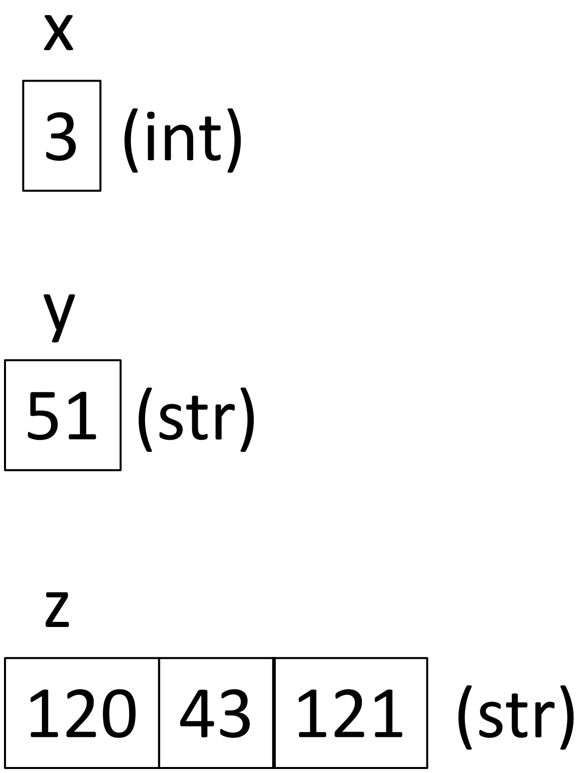


Code	Character
0	NUL (null)
...	...
9	HT (horizontal tab)
10	LF (line feed - new line)
...	...
32	(space)
33	!
34	"
...	...
51	3
52	4
...	...
97	a
98	b
126	~
127	DEL (delete)

Data representation

- Conceptually, computers store all data as numbers.
- The <u>type</u> of a data value determines the meaning of the number(s) that represent it.

```
>>> x = 3
>>> type(x)
<class 'int'>
>>> y = "3"
>>> type(y)
<class 'str'>
>>> z = "x+y"
```



x

3 (int)

y

51 (str)

z

120 43 121 (str)

Data representation

Type is considered when values are compared.

```
>>> a = "5"
>>> b = 5
>>> a == b
False
>>> [120,43,121] == "x+y"
False
>>> chr(120) + chr(43) + chr(121) == "x+y"
True
```

python review:
random numbers

The `random` module

- Python's `random` module contains methods for working with random numbers.

- To use it, put `import random` at the top of your code, below any header comments.

- The `randint` method generates a random number between two integers, inclusive.

```
>>> random.randint(0,6)
2
```

Testing trouble!

This program prints three random numbers:

```
import random
def main():
   for i in range(3):
      print(random.randint(1,100))
main()
```

Two runs in IDLE:

```
=== RESTART: rand3.py ===
31
49
26
>>>
=== RESTART: rand3.py ===
64
64
1
>>>
```

What if the program did something complicated, like generating random poetry?

I'd want to be able to get the same sequence of random numbers again and again, so I could get the same poem again and again when testing.

Testing trouble!

We can "seed" Python's random number generator to make it generate the same sequence every time.

```
import random
def main():
  random.seed("7")
  for i in range(3):
    print(random.randint(1,100))

main()
```

Two runs in IDLE:

```
=== RESTART: rand3.py ===
92
73
70
>>>
=== RESTART: rand3.py ===
92
73
70
>>>
```

python review: dictionaries

Dictionaries

- A dictionary is like a list, but it can be indexed using strings (or ints, or tuples, or any immutable type)
  - the values used as indexes for a particular dictionary are called its *keys*
  - think of a dictionary as an unordered collection of *key* : *value* pairs
  - empty dictionary: {}
- It is an error to index into a dictionary using a non-existent key

Dictionaries

A Python *dictionary* is like a Python list that can be indexed with values of (almost) any type, not just integers.

Let's make an empty dictionary and experiment with it:

```
>>> d = {}
>>> d
{}
>>> len(d)
0
>>> type(d)
<class 'dict'>
```

Dictionaries

Dictionaries hold pairs of *keys* and *values*.

Let's make a dictionary d add two key/value pairs to it:

```
>>> d = {}
>>> d["seven"] = 7
>>> d["zero"] = 0
>>> d
{'zero': 0, 'seven': 7}
>>> len(d)
2
```

Dictionaries

At hand:

```
>>> d
{'zero': 0, 'seven': 7}
```

Indexing with a key produces its associated value:

```
>>> d["seven"]
7
```

What is produced if a key doesn't exist?

```
>>> d["zeroe"]
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
KeyError: 'zeroe'
```

Dictionaries

The `in` operator can be used to see if a key is in a dictionary:

```
>>> d
{'zero': 0, 'seven': 7}
>>> k = 'zero'
>>> k in d
True
>>> 'x' in d
False
>>> 0 in d
False
```

Dictionaries

It's repetitious to use a series of assignments to populate a dictionary with literal key/value pairs:

```
>>> classrooms= {}
>>> classrooms["CSC 110"] = "ENR2 N120"
>>> classrooms["CSC 120"] = "ILC 120"
>>> classrooms["CSC 372"] = "ILC 119"
```

Alternative:

```
>>> classrooms = { "CSC 110":"ENR2 N120","CSC 120": "ILC 120",
 "CSC 372": "ILC 119"}
>>> len(classrooms)
3
>>> classrooms
{'CSC 110': 'ENR2 N120', 'CSC 120': 'ILC 120', 'CSC 372': 'ILC 119'}
```

EXERCISE

The following code is legal:

```
>>>nums = [2,4,6]
>>> d = {}
>>>d[2] = ‘hello’
>>>d[‘there’] = 14
>>>d[nums] = 3
```

True or False?

keys() and values()

Dictionaries have keys() and values() methods that both produce *iterable objects*.

```
>>> romans = {"I": 1, "V": 5, "X": 10, "L": 50}

>>> romans.keys()
dict_keys(['X', 'I', 'V', 'L'])

>>> romans.values()
dict_values([10, 1, 5, 50])
```

Q: What can we do with an iterable object?

A: Iterate over the values it produces!

ICA-4 prob. 1

Problem: Write a function print_keys(d) that prints the keys in the dictionary d, one per line.

```
>>> print_keys(classrooms)
CSC 120
CSC 110
CSC 372
>>> print_keys(romans)
X
L
V
I
```

Work with your neighbor(s) and write print_keys(d). (2')

Solution:

```
def print_keys(d):
    """Print the keys in dictionary d, one per line"""
    for k in d.keys():
        print(k)

# for testing
classrooms = { "CSC 110":"ENR2 N120","CSC 120": "ILC 120", "CSC 372": "ILC 119"}

romans = {"I": 1, "V": 5, "X": 10, "L": 50}
```

keys() and values()

Dictionaries themselves are iterable objects.   Observe:

```
>>> romans
{'I': 1, 'V': 5, 'L': 50, 'X': 10}
>>> for x in romans:
        print(x)
I
V
L
X
```

When we iterate over a dictionary what are we doing?

We're iterating over the dictionary's keys.

EXERCISE-ICA-4 p.2-3

- Do problems 2 and 3.

Problem

Write a function count_chars(s) that returns a dictionary where each key/value pair represents the occurrence count for each unique character found in the string s.

Usage:

```
    >>> count_chars("aaa")
    {'a': 3}

    >>> count_chars("aabaa")
    {'a': 4, 'b': 1}

    >>> count_chars("to be or not to be")
    {'n': 1, 't': 3, 'r': 1, ' ': 5, 'o': 4, 'e': 2, 'b': 2}
```

Pseudocode

Write a function count_chars(s) that takes a string s and returns a dictionary of the counts of all characters in the string.

Pseudocode: (a mix of English and code)

```
def count_chars(s):
    make an empty dictionary counts
        (Each key/value pair represent a character and its count)
    for each character c in s
        if the key c is present in the dictionary
            increment the associated value
        else
            counts[c] = 1
    return counts
```

Prototyping at the shell prompt

A good practice: Work out key computations using the Python shell, especially when you're learning a new feature.

```
>>> counts = {}
>>> s = "abacbacc"
>>> c = s[0]
>>> c in counts
False
>>> counts[c] = 1
>>> counts
{'a': 1}
>>> c = s[1]
>>> c in counts
False
```

```
>>> counts[c] = 1
>>> counts
{'a': 1, 'b': 1}
>>> c = s[2]
>>> c in counts
True
>>> counts[c] = counts[c] + 1
>>> counts
{'a': 2, 'b': 1}
```

Solution

```
def count_chars(s):
  """return a dictionary with key/value pairs with
    occurrence counts for the characters in s"""

    counts = {}

    for c in s:
        if not c in counts:    # First occurrence of c
            counts[c] = 1
        else:                  # We've seen c at least once
            counts[c] = counts[c] +  1

    return counts
```

EXERCISE-ICA-4 p.4

- Do problem 4.

Dictionary values can be anything!

Dictionaries can hold values of any type.

```
>>> pairs = {}
>>> pairs["s"] = "a string"
>>> pairs["i"] = 7
>>> pairs["f"] = 3.4
>>> pairs["L"] = [1,2,3]
>>> pairs["n"] = None
>>> pairs["d"] = {"AZ": "Phoenix", "NC": "Raleigh"}

>>> pairs{'f': 3.4, 's': 'a string', 'i': 7, 'n': None, 'd': {'AZ':
'Phoenix', 'NC': 'Raleigh'}, 'L': [1, 2, 3]}
```

Dictionary values can be anything!

At hand:

```
>>> pairs = {}
>>> pairs["d"] = {"AZ": "Phoenix", "NC": "Raleigh"}
```

Let's work with pairs:

```
>>> pairs["d"]
{'AZ': 'Phoenix', 'NC': 'Raleigh'}
>>> pairs["d"]["AZ"]
'Phoenix'
>>> pairs["d"]["NC"]
'Raleigh'
>>> pairs["d"]["NC"][-1]
'h'
```

A dictionary of dictionaries

Let's make some dictionaries:

```
>>> mis_units =  { 'mis 101': 4, 'mis 102': 3, 'mis 202': 2 }
>>> csc_units  =  { 'csc 110': 4,  'csc 120': 4,  'csc 352': 3 }
>>> ece_units =  { 'ece 111': 3, 'ece 222': 3,  'ece 333': 4 }
```

Let's make a dictionary of dictionaries!

```
>>> catalog =
        { "MIS" : mis_units, "CSC" : csc_units, "ECE" : ece_units
}
```

Some people would say that catalog is a "2d-dictionary” .

Others say "two-level dictionary". (First level is departments; second level is courses.)

A dictionary of dictionaries

```
>>> catalog
{'MIS': {'mis 101': 4, 'mis 102': 3, 'mis 202': 2}, 'CSC':
{'csc 110': 4, 'csc 120': 4, 'csc 352': 3}, 'ECE': {'ece
111': 3, 'ece 222': 3, 'ece 333': 4}}

>>> for dept in catalog:
        print(dept, ":", catalog[dept])

MIS : {'mis 101': 4, 'mis 102': 3, 'mis 202': 2}
CSC : {'csc 110': 4,  'csc 120': 4, 'csc 352': 3}
ECE : {'ece 111': 3, 'ece 222': 3, 'ece 333': 4}
>>>
```

Problem (ICA-5 prob. 1)

Do ICA-5 problem 1.

Problem

Write a function find_courses(catalog, units) that takes a two-level dictionary 'catalog' and an int 'units' and returns a sorted list of courses having that number of units.

Usage:

```
>>> find_courses(catalog, 4)
['csc 110', 'csc 120', 'ece 333', 'mis 101']
>>> for units in range(2,5):
        print(units, "unit courses:", find_courses(catalog,units))
2 unit courses: ['mis 202']
3 unit courses: ['csc 352', 'ece 111', 'ece 222', 'mis 102']
4 unit courses: ['csc 110', 'csc 120', 'ece 333', 'mis 101']
```

A "sketch" of a valid catalog:

```
{'MIS': {'mis 102': 3, ...}, 'CSC': {'csc 110': 4, ...}, 'ECE': {...}}
```

Pseudocode

Spec: find_courses(catalog, units) returns a list of courses in 'catalog' having 'units' units.

A "sketch" of a valid catalog:

```
{'MIS': {'mis 102': 3, ...}, 'CSC': {'csc 110': 4, ...}, 'ECE': {...}}
```

Pseudocode:

```
def find_courses(catalog, units):
    courses = []
    for each department
      for each course in department
        if course's units == units:
          add it to courses
    return sorted courses
```

Whiteboard: write find_courses!

Solution

```
def find_courses(catalog, units):
    courses = []
    for dept in catalog:
        for key in catalog[dept]:
            if catalog[dept][key] == units:
                courses.append(key)
    return sorted(courses)
```

Repetitious!

What questions do you have?

Can it be improved?

Improved

```
def find_courses2(catalog, units): # NOTES/find_courses2.py
    courses = []
    for dept in catalog:
        dept_cat = catalog[dept]
        for course in dept_cat:
            if dept_cat[course] == units:
                courses.append(course)
    return sorted(courses)
```

Introduced an intermediate variable.

- Definitely cleaner
- Maybe faster

What did we change?

Problem (ICA-5 prob. 2)

Add a 3 unit course called 'csc 245' to catalog.

```
>>> catalog
{'MIS': {'mis 101': 4, 'mis 102': 3, 'mis 202': 2},
'CSC': {'csc 110': 4, 'csc 120': 4, 'csc 352': 3},
'ECE': {'ece 111': 3, 'ece 222': 3, 'ece 333': 4}}
```

Solution

```
>>> catalog[‘CSC’][‘csc 245’] = 3
```

Problem (ICA-5 prob. 3)

```
>>> catalog
{'MIS': {'mis 101': 4, 'mis 102': 3, 'mis 202': 2}, 'CSC':
{'csc 110': 4, 'csc 120': 4, 'csc 352': 3}, 'ECE': {'ece
111': 3, 'ece 222': 3, 'ece 333': 4}}
```

To add a 3-course unit to the 'CSC' inner dictionary:

```
>>> catalog['CSC']['csc 245'] = 3
```

How to add a course for a *new* department 'ENGL’?

Solution:

```
>>> catalog['ENGL'] = {'engl 101': 3}
```

Problem (ICA-5 prob. 4)

Count the keys in a 2-d dictionary.

Experiment

What's the output?

```
def main():
    d = {}
    for c in "TIP":
        d[c] = c

    for k in d.keys():
        print(k, end=" ")
    print()

main()
```

Output with Python 3.5.2:

```
$ python3.5 dict_order.py
P T I
$ python3.5 dict_order.py
I T P
$ python3.5 dict_order.py
T P I
```

Output with Python 3.6.2:

```
$ python3.6 dict_order.py
T I P
$ python3.6 dict_order.py
T I P
$ python3.6 dict_order.py
T I P
```

IMPORTANT: The insertion order of keys is not guaranteed to be the iteration order in all versions of Python!

Dictionary Summary

Operation	Result
{k1:v1, k2: v3, ...}	Dictionary literal. {} is empty dictionary.
len(d)	Return the number of items in the dictionary d.
d[key]	Return the item of d with key key. Raises an error if key is not in the dictionary.
d[key] = value	Set d[key] to value.
del d[key]	Remove d[key] from d. Raises an error if key is not in the dictionary. (*not discussed*)
key in d	Return True in d has a key key, else False.
key not in d	Equivalent to not key in d.
keys()	Returns an iterable object that will produce all keys
values()	Returns an iterable object that will produce all value
items()	Returns an iterable object that will produce 2-tuples with key/value pairs. (Tuples coming RSN!)

Need tuples before discussing items().

python review: tuples

Tuples ("toople", not "tupple")

A Python tuple is like a Python list that is immutable—a tuple can't be changed.

Let's make a tuple:

```
>>> location = (17.2, 35.9, "Z3")
>>> location
(17.2, 35.9, 'Z3')

>>> type(location)
<class 'tuple'>
```

An item can be fetched with indexing:

```
>>> location[0]
17.2
```

Tuples

An item cannot be assigned to: (tuples are immutable!)

```
>>> location[1] = 23.7
...
TypeError: 'tuple' object does not support item assignment
```

Items cannot be added to or removed from a tuple:

```
>>> location.append(7)
...
AttributeError: 'tuple' object has no attribute 'append'
>>> location.pop(1)
...
AttributeError: 'tuple' object has no attribute 'pop'
```

Tuples

What does the following assignment do?

```
>>> location
(17.2, 35.9, 'Z3')
>>> x, y, sector = location    # parallel assignment
>>> x
17.2
>>> y
35.9
>>> sector
'Z3'
```

~~>>> x = location[0]~~
~~>>> y = location[1]~~
~~>>> sector = location[2]~~

The assignment above can be called a *destructuring assignment*.

Style note: When getting multiple values from a tuple, use parallel assignment rather than a series of indexings.

Do we need tuples?

Are tuples just impoverished lists? Do we really need them?

- Using a tuple communicates to the reader that the collection of items is fixed in size and that the items won't change.
    - (0,0)   # 2d point
    - (10,-17,-34)   # 3d point
    - (5,7,59)   # hours, minutes, seconds
    - (10,5,2,5.6)   # box dimensions and weight
    - ("Gould-Simpson", 32.229805, -110.9550234)
    - ("upper","left")

Do we need tuples?

Dictionary keys must be immutable values.

- Tuples can be keys because they are immutable.

```
>>> d = {}
>>> d[(0,0)] = "origin"

>>> d
{(0, 0): 'origin'}
```

- Lists cannot be keys because they are mutable.

```
>>> d[[75,98]] = "center"
...
TypeError: unhashable type: 'list'
```

Problem

A function can only return one value but sometimes we want that one value to consist of multiple values.

Example:

The function min_max(L) returns the smallest and largest even numbers in L, a list of integers.

What should be the type of the value returned by min_max?

A tuple!

Usage:

```
>>> min_max([5, 10, 3, 4, 7, 12, 18, 1, 25])
(4, 18)
```

Exercise

The function min_max(L) returns a tuple of the smallest and largest even numbers in L, a list of integers.

Use the min() and max() built-in functions:

Reminder:

```
>>> L = [10,5,7,12,3]
>>> min(L)
3
>>> max(L)
12
```

Work with your neighbor(s) and write min_max. (2 min)

Solution

```
def min_max(L):
    """Returns the smallest and largest even values in L"""
    evens = []
    for num in L:
        if num % 2 == 0:
            evens.append(num)

    return min(evens),max(evens)
```

Use parallel assignment to unpack the tuple

Usage:

```
>>> low, high = min_max([5, 10, 3, 4, 7, 12, 18, 1, 25])
>>> print("The range is", low, "..", high)
The range is 4 .. 18
```

dict.items()

Dictionaries have an items() method that is similiar to the keys() and values() methods.

Speculate: What does dict.items() return?

```
>>> romans
{'V': 5, 'L': 50, 'I': 1, 'X': 10}
>>> romans.items()
dict_items([('V', 5), ('L', 50), ('I', 1), ('X', 10)])
```

Let’s revisit print_pairs from earlier:

```
def print_pairs2(d):
    for key, value in d.items():
        print(key, ":",  value)
```

Speculate: What does sorted(dict.items()) return?

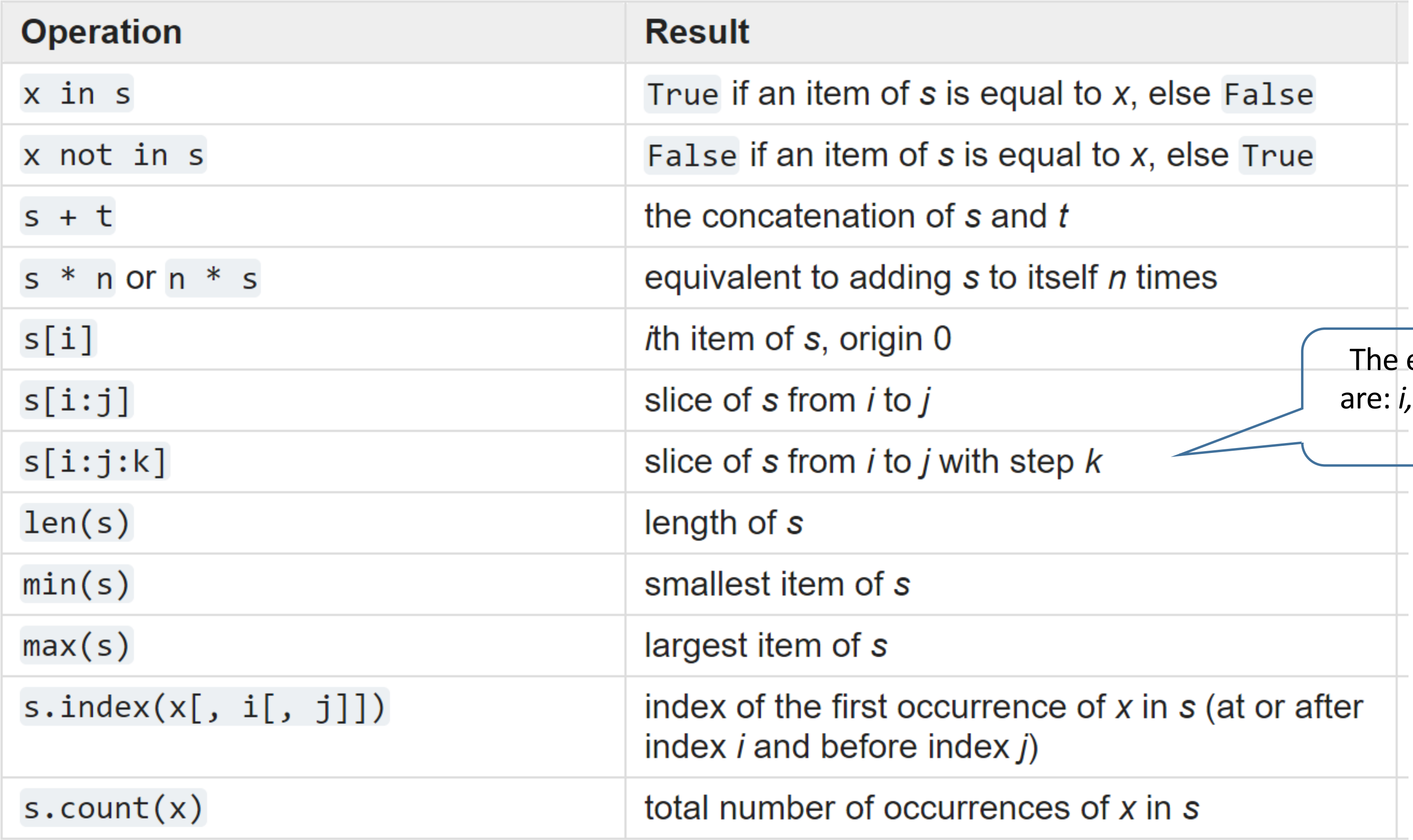
EXERCISE-ICA-6 prob 1

Print the keys and values of the catalog dictionary using items().

Work with your neighbor(s)

Tuples are sequences

Along with lists, strings, and ranges, tuples are sequences. All of the sequence operations (shown below) can used with tuples.



Operation	Result
`x in s`	`True` if an item of *s* is equal to *x*, else `False`
`x not in s`	`False` if an item of *s* is equal to *x*, else `True`
`s + t`	the concatenation of *s* and *t*
`s * n` or `n * s`	equivalent to adding *s* to itself *n* times
`s[i]`	*i*th item of *s*, origin 0
`s[i:j]`	slice of *s* from *i* to *j*
`s[i:j:k]`	slice of *s* from *i* to *j* with step *k*
`len(s)`	length of *s*
`min(s)`	smallest item of *s*
`max(s)`	largest item of *s*
`s.index(x[, i[, j]])`	index of the first occurrence of *x* in *s* (at or after index *i* and before index *j*)
`s.count(x)`	total number of occurrences of *x* in *s*

The elements are: *i, i+k, i+2k,* …

Source: https://docs.python.org/3/library/stdtypes.html#sequence-types-list-tuple-range

Tuples are sequences

Let's try some sequence operations on tuples.

```
>>> t = (10, "twenty", 30.0, [40])

>>> len(t)
4

>>> t2 = t * 2
>>> t2
(10, 'twenty', 30.0, [40], 10, 'twenty', 30.0, [40])

>>> t2[1:-1]
('twenty', 30.0, [40], 10, 'twenty', 30.0)
```

Parentheses often optional

Tuple literals can often be written without parentheses

```
>>> t = 3,4
>>> type(t)
<class 'tuple'>

>>> for item in 3,4,5:
    ...

>>> low,high = min_max([3,4,7,1,8])

def f():
    return 3,4
```

Use parentheses if needed for clarity

Lists vs. tuples

Thoughts about choosing a list vs. a tuple to store items:

- Needing to store varying numbers of items requires a list.
- Needing to assign to items requires a list.
- Grouping a fixed number of values, like coordinates in a 3D-point, suggests a tuple.
- A group of a fixed number of dissimilar values, like name, weight, birthday, and address especially suggests a tuple.
- A sequence of elements used as a dictionary key requires a tuple.

But, there are no hard and fast rules. Sometimes the choice is simply a matter of style. Experience helps, too.

Mixtures of mutabilities

```
>>> x = ( ['aa', 'bb'], ['cc', 'dd'], ['ee'] )
>>> x[0] = 'ff'
Traceback (most recent call last):
    x[0] = 'ff'
TypeError: 'tuple' object does not support item assignment
```

Tuples are immutable

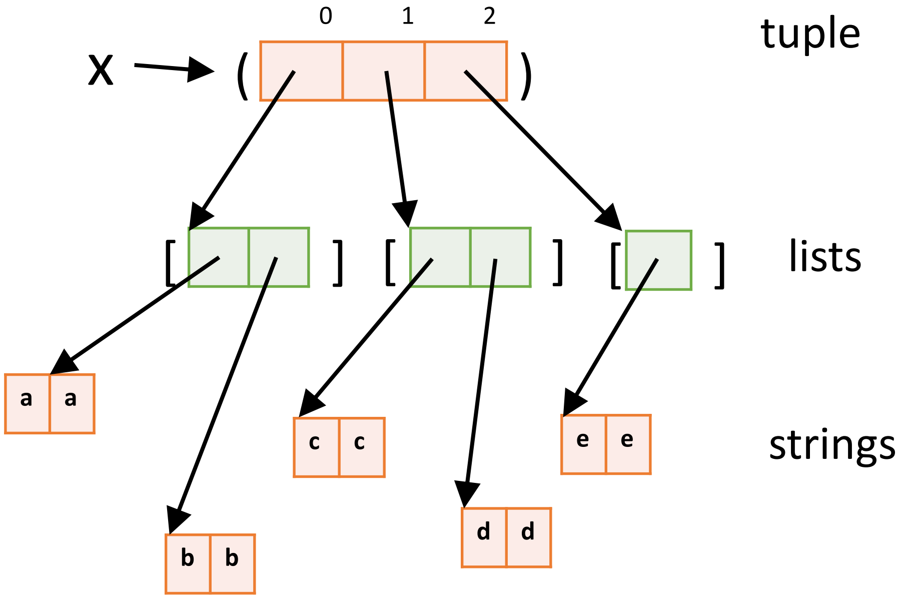
```
>>> x[0][0] = 'ff'
>>> x
(['ff', 'bb'], ['cc', 'dd'], ['ee'])
```

Lists are mutable

```
>>> x[0][0][0] = 'a'
Traceback (most recent call last):
    x[0][0][0] = 'a'
TypeError: 'str' object does not support item assignment
```

Strings are immutable

```
>>> x = ( ['aa', 'bb'], ['cc', 'dd'], ['ee'] )
>>> x[0] = 'ff'
Traceback (most recent call last):
    x[0] = 'ff'
TypeError: 'tuple' object does not support item assignment
```



```
>>> x[0][0] = 'ff'
>>> x
(['ff', 'bb'], ['cc', 'dd'], ['ee'])
```

```
>>> x[0][0][0] = 'a'
Traceback (most recent call last):
    x[0][0][0] = 'a'
TypeError: 'str' object does not support item assignment
```

EXERCISE-ICA-6 prob 2

Working with mixtures of types.

Work with your neighbor(s)

Will it work?

Which of the following assignments work?

```
>>>> t = (1,"two",[3,4,5])
>>> t[2][1] = (4,4)
>>> t
(1, 'two', [3, (4, 4), 5])

>>> t2 = 6,7
>>> t[-1].append([t2])
>>> t
(1, 'two', [3, (4, 4), 5, [(6, 7)]])

>>> t2[0] = "six"
...
TypeError: 'tuple' object does not support item assignment
```

Surprise!

Observe:

```
>>> x = [[10,20]]

>>> y = x * 3
>>> y
[[10, 20], [10, 20], [10, 20]]

>>> y[0].append(30)

>>> y
[[10, 20, 30], [10, 20, 30], [10, 20, 30]]
```

Why??

The list replication (x * 3) created a list with three references to x!

Surprise!

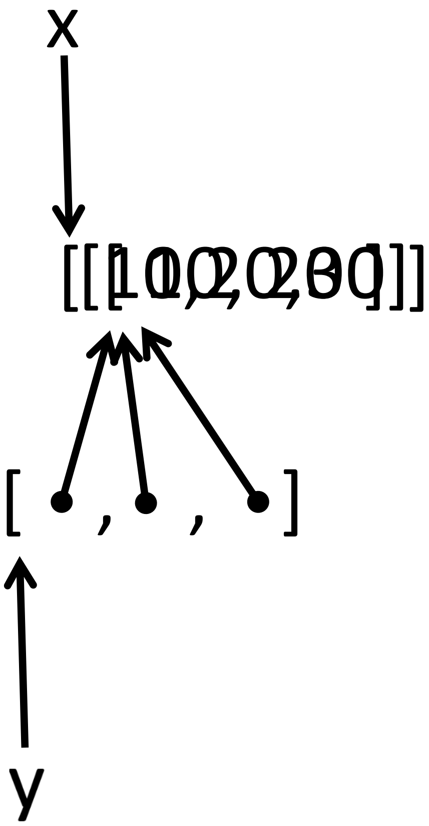
Observe:

```
>>> x = [[10,20]]

>>> y = x * 3
>>> y
[[10, 20], [10, 20], [10, 20]]

>>> y[0].append(30)

>>> y
[[10, 20, 30], [10, 20, 30], [10, 20, 30]]
```



References:

- important topic!
- will study in detail soon

python review: format()

(read on your own)

Motivation

Printing a mix of values and literals can be pretty tedious:

```
>>> a, b, c = 10, 'test', 3.4      # parallel assignment

>>> print("a = " + str(a) + ", b = " + b + ", c = " + str(3.4))
a = 10, b = test, c = 3.4
```

Here's another way:

```
>>> print("a = {}, b = {}, c = {}".format(a, b, c))
a = 10, b = test, c = 3.4
```

What is it?

At hand:

```
>>> print("a = {}, b = {}, c = {}".format(a, b, c))
a = 10, b = test, c = 3.4
```

Work with your neighbor(s):

Attempt to explain how the print() statement is being evaluated. In particular:

- What is "format"?
- What type does format produce?
- What are the curly braces doing?

What is it?

At hand:

```
>>> print("a = {}, b = {}, c = {}".format(a, b, c))
a = 10, b = test, c = 3.4
```

- format() is a string method.
- It *interpolates* each argument in turn where {} appears.
- It returns a string. (How would you "prove" that?)

Analogs in other languages:

- printf() in C
- String.format() in Java

count_chars.py improvement

For reference:

```
>>> "{}-{}".format(10,20)
'10-20'
```

Recall this loop from count_chars.py:

```
for c in chars:
    count = count_char(c, lines)
        print("'" + c + "': " + str(count))  # example:     'a': 10
```

Problem: Rewrite the print to use format.

```
>>> print("'{}': {}".format(c, count))
'a': 10
```

format() can do lots!

Here's a sampling of the many kinds of specifications that format() handles:

```
>>> "|{:6d}|>{:^20}<, third = {:7.3f}, {!r}".
    format(100,"center me!",100/3," a ")

"|   100|>     center me!     <, third =  33.333, ' a '"
```

More on format():

https://docs.python.org/dev/library/string.html#format-string-syntax