CS134:

Range & Nested Lists/Loops

Announcements & Logistics

- **Lab 3** due today/tomorrow
  - More involved than previous labs, so please utilize help hours
  - Reminder: do **NOT** use utilities not discussed in class
    - We've carefully designed the labs to require only functions & concepts *discussed in class meetings*
    - We've intentionally ordered material to emphasize algorithmic thinking and benefit your development as a computer scientist rather than as a Python-specific programmer
      - This means no string.index() or list.index()! (Why?)
- **HW 4** posted today on Glow

Do You Have Any Questions?

Last Time

- `for`..Loops allow us to look at each element in a sequence
  - The **loop variable** defines what the name of that element will be in the loop
  - An optional **accumulator variable** is useful for keeping a running tally of properties of interest
    - Indentation works the same as with if--statements: if it's indented under the loop, it's executed as part of the loop
- Can extract subsequences using `[start:end:step]` syntax (slicing)
- `range` is a type of sequence that is often useful for indexing

Different problems may require different decisions with respect to loop variables, accumulator variables, and whether you need to index/slice or not!

Today's Plan

- Use more examples of the **`range`** sequence type
- Explore different combinations of loops
  - Loop(s) within a loop (called nesting)
- Exiting loops early
  - `break` vs. `return`

Review: Sequences in Python

- **Sequences** in Python represent **ordered collections of elements**: e.g., lists, strings, ranges, etc.
- Strings are immutable sequences of characters
- Ranges are immutable sequences of numbers

- Lists can be **heterogenous** (strings, ints, floats, etc)
  - Example: `my_list = ["Hello", 42, 23.5, True]`
  - In CS, we use **zero-indexing**, so we say that `'Hello'` is at **index** 0, `42` is at **index** 1, and so on
- We can access each character of a list using these **indices**

Sequence Operations

Operation	Result
`seq[i]`	The `i`'th item of `seq`, when starting with 0
`seq[si:ee]`	slice of `seq` from `si` to `ee`
`seq[si:ee:s]`	slice of `seq` from `si` to `ee` with step `s`
`len(seq)`	length of `seq`
`seq1 + seq2`	The concatenation of `seq1` and `seq2`
`x in seq`	True if `x` is contained within `seq`
`x not in seq`	False if `x` is contained within `seq`

Iterating Over Ranges

A common use of a **`range`** is to repeatedly execute some task

- With a **`for`** loop and **`range(n)`**, can repeat a loop **`n`** times

```
# what does this print?

for i in range(5):
    print('$' * i)
```

Looks a lot like `[0, 1, 2, 3, 4]`

```
        i = 0
$       i = 1
$$      i = 2
$$$     i = 3
$$$$    i = 4
```

Using Range For Parallel Iteration

- Ranges also give a convenient way for iterating over two lists in parallel
- Say we wanted to iterate over two lists:
- `chars = ['a', 'b', 'c']` and `nums = [1, 2, 3]`
- And form a new list `['a1', 'b2', 'c3']`
- Here's how we'd do it

```
chars = ['a', 'b', 'c']
nums = [1, 2, 3]
# initialize accumulation variable

# for each item in chars
    # add current char to matching num
    # accumulate in a list
```

```
>>> char_nums
['a1', 'b2', 'c3']
```

Using Range For Parallel Iteration

- This also a really convenient way for iterating over two lists in parallel
- Say we wanted to iterate over two lists
- `chars = ['a', 'b', 'c']` and `nums = [1, 2, 3]`
- And form a new list `['a1', 'b2', 'c3']`
- Here's how we'd do it

```
chars = ['a', 'b', 'c']
nums = [1, 2, 3]
char_nums = []

for i in range(0, len(chars)):
    cnum = chars[i] + str(nums[i])
    char_nums = char_nums + [cnum]
```

Accumulator Variable

Loop Variable

```
>>> char_nums
['a1', 'b2', 'c3']
```

Nested Loops

Nested Loops

- A **for loop** body can contain one (or more!) additional **for loops**:
    - Called **nesting for loops**
    - Conceptually similar to nested conditionals
- Example: What do you think is printed by the following Python code?

```
# What does this do?
def mystery_print(word1, word2):
    '''Prints something'''
    for char1 in word1:
        for char2 in word2:
            print(char1 + char2)
```

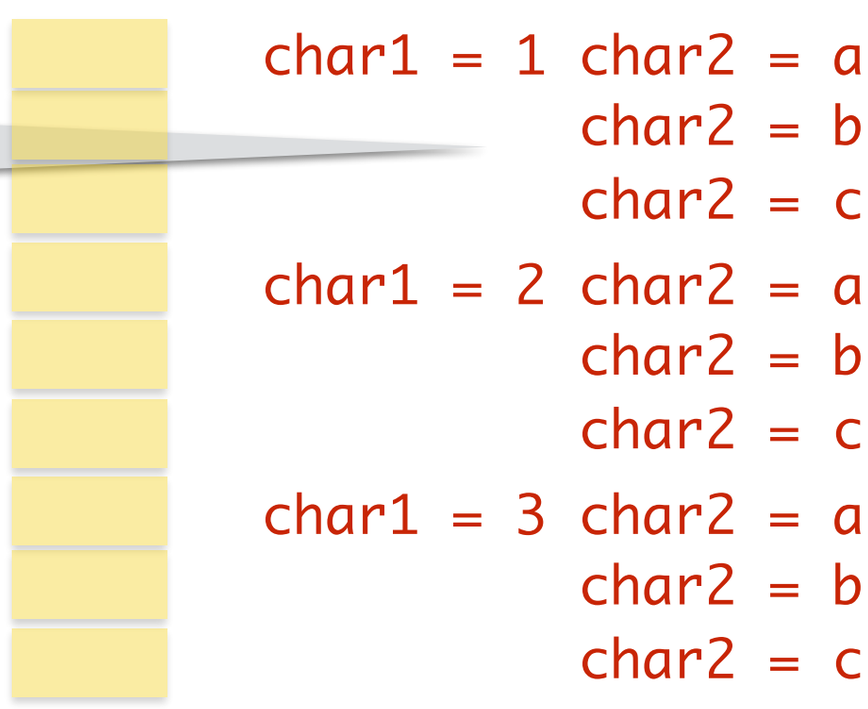
```
mystery_print('123', 'abc')
```

```python
# What does this do?
def mystery_print(word1, word2):
    '''Prints something'''
    for char1 in word1:
        for char2 in word2:
            print(char1 + char2)
```

```python
mystery_print('123', 'abc')
```

```
1a
1b
1c
2a
2b
2c
3a
3b
3c
```

Inner loop (w/ char2 and word2) runs to completion on **each iteration** of the outer loop



Nested Loops

- What is printed by the nested loop below?

```
# What does this print?
for letter in ['b', 'd', 'r', 's']:
    for suffix in ['ad', 'ib', 'ump']:
        print(letter + suffix)
```

```
# What does this print?
for letter in ['b', 'd', 'r', 's']:
    for suffix in ['ad', 'ib', 'ump']:
        print(letter + suffix)
```

```
letter = 'b'      suffix =  'ad'      bad
                            'ib'      bib
                            'ump'     bump

letter = 'd'      suffix =  'ad'      dad
                            'ib'      dib
                            'ump'     dump

letter = 'r'      suffix =  'ad'      rad
                            'ib'      rib
                            'ump'     rump

letter = 's'      suffix =  'ad'      sad
                            'ib'      sib
                            'ump'     sump
```

Inner loop (w/ suffixes) runs to completion on **each iteration** of the outer loop (w/ prefixes)

Nested Loops and Ranges

Loops and Ranges to Print Patterns

We previously used a single **for loop** and a single range to **repeat** a task.

- What if we had multiple for loops and multiple ranges? The following loops print a pattern to the screen. (Look closely at the indentation!)

```
# what does this print?

for i in range(5):
    print('$' * i)
for j in range(5):
    print('*' * j)
```

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * j)
```

What are the values of i and j???

Iterating Over Ranges

```
# what does this print?

for i in range(5):
    print('$' * i)
for j in range(5):
    print('*' * j)
```

We've seen this for loop and pattern before

Same pattern, but with '*' instead

```
          i = 0
$         i = 1
$$        i = 2
$$$       i = 3
$$$$      i = 4

          j = 0
*         j = 1
**        j = 2
***       j = 3
****      j = 4
```

These for loops are **sequential**.
One follows **after** the other.

Iterating Over Ranges

```
# what does this print?

for i in range(5):
    print('$' * i)
for j in range(5):
    print('*' * j)
```

```
i = 0
$       i = 1
$$      i = 2
$$$     i = 3
$$$$    i = 4
        j = 0
*       j = 1
**      j = 2
***     j = 3
****    j = 4
```

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * j)
```

```
i = 0
$       i = 1
            j = 0
$$      i = 2
            j = 0
*           j = 1
$$$     i = 3
            j = 0
*           j = 1
**          j = 2
$$$$    i = 4
            j = 0
*           j = 1
**          j = 2
***         j = 3
```

On right, for loops are **nested**.
One loop is **inside** the other.

Iterating Over Ranges

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * i)
```

i, not j!

```
i = 0
$       i = 1
*               j = 0
$$      i = 2
**              j = 0
**              j = 1
$$$     i = 3
***             j = 0
***             j = 1
***             j = 2
$$$$    i = 4
****            j = 0
****            j = 1
****            j = 2
****            j = 3
```

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * j)
```

```
i = 0
$       i = 1
                j = 0
$$      i = 2
                j = 0
*               j = 1
$$$     i = 3
                j = 0
*               j = 1
**              j = 2
$$$$    i = 4
                j = 0
*               j = 1
**              j = 2
***             j = 3
```

Knowing How and When to Leave

Leaving a Function

We exit from a function using a **`return`** statement.

- **`return`** causes the execution of your code to resume at the location where the function was called (or invoked)
- **`return`** can also communicate a value that "replaces" the function call

When we do not include an explicit **`return`** statement, we exit the function when our execution reaches the end of the function body, and the function implicitly returns **None**

- What happens when we have a return statement inside a loop?
  - We exit the function, so we also exit the loop!
- What happens when we have a return statement inside a nested loop?
  - We exit the function, so we exit every loop!

Leaving a Loop

We can exit from a loop using a **`break`** statement.

- **`break`** causes the execution of your code to resume at the location immediately following the loop body
- If your code breaks out of a nested loop, execution may begin a new iteration of the "outer" loop

```
def first_locations_of(string_list, char) :
    '''Returns a list that contains the index
    where char first appears within each string
    in string_list'''
    locations = []
    for string in string_list :
        i = 0
        for c in string :
            if c == char :
                break # we've found the index
            i += 1
        locations += [i]
    return locations
```

Leaving a Loop

```
def first_locations_of(string_list, char) :
    '''Returns a list that contains the index
    where char first appears within each string
    in string_list'''
    locations = []
    for string in string_list :
        i = 0
        for c in string :
            if c == char :
                break # we've found the index
            i += 1
        locations += [i]
    return locations
```

```
>>> first_locations_of(["eat", "more", "vegetables"], "e")
[0, 3, 1]
```

`break` Controversy

- `break` is a part of python, but its use is often discouraged for stylistic reasons
  - "Jumping" around in our code makes it hard to reason about what our program is doing
- We can often structure our code in a way that using break is unnecessary, so avoid it if possible
- Part of becoming a good programmer is understanding the *spirit* of the rules (and when to break them!)

```
def first_locations_of(string_list, char) :
    '''Returns a list that contains the index
    where char first appears within each string
    in string_list'''
    locations = []
    for string in string_list :
        locations += [first_location_of(string, char)]
    return locations
```

`break` Controversy

```
def first_location_of(string, char) :
    '''Returns the index where char first
    appears within string. If it does
    not appear, returns len(string)'''
    i = 0
    for c in string :
        if c == char :
            return i
        i += 1
    return i

def first_locations_of(string_list, char) :
    '''Returns a list that contains the index
    where char first appears within each string
    in string_list'''
    locations = []
    for string in string_list :
        locations += [first_location_of(string, char)]
    return locations
```

By making the "loop" a "function", we can return instead of "break"

Importing Functions vs Running as a Script

- **Question.** If you only have function definitions in a file `funcs.py`, and run it as a script, what happens?

```
% python3 funcs.py
```

- For testing functions, we want to call /invoke them on various test cases, in Labs, we do this in a separate file called `runtests.py`
  - To add function calls in `runtests.py`, we put them inside the guarded block `if __name__ == "__main__":`
- The statements within this special guarded are only run when the file is run as a ***script*** but not when it is imported as a ***module***
- Let's see an example

```python
# foo.py
# test the role of __name__ variable
print("__name__ is set to", __name__)
```

Running foo.py as a **script**

```
shikhasingh@Shikhas-iMac cs134 % python3 foo.py
__name__ is set to __main__

shikhasingh@Shikhas-iMac cs134 % python3
Python 3.10.0 (v3.10.0:b494f5935c, Oct  4 2021,
14:59:20) [Clang 12.0.5 (clang-1205.0.22.11)] on
darwin
Type "help", "copyright", "credits" or "license"
for more information.
>>> import foo
__name__ is set to foo
```

Importing it as a **module**

Takeaway: `if __name__ == "__main__"`

- If you want some statements (like test calls) to be run **ONLY when the file is run as a script**
    - Put them inside the guarded `if __name__ == "__main__"` block

- When we run our automatic tests on your functions we **import them** and this means name is NOT set to main
    - So nothing inside the guarded `if __name__ == "__main__"` block is executed
- This way your testing /debugging statements do not get in the way

Summary

- Range is a flexible sequence type often used for indexing or for executing a loop a certain number of times
- Loops can be nested inside other loops
  - Inner loops execute once *per iteration* of their containing loop
- Return is how we exit a function
- Break is how we exit a loop
  - We can often rewrite our code to avoid using break