CS 134 Lecture 11:

While Loops & Mutability

Announcements & Logistics

- **HW 5** will be released today on GLOW
- **Lab 4** Part 1 due Wed/Thurs 10 pm
  - We will return feedback (including tests not found in `runtests.py`)
- Reminder that Midterm is **Thursday March 14**
  - Two exam slots: 6-7.30 pm, 8-9.30 pm
    - Room: Bronfman auditorium
- Midterm review Monday March 11 evening 7-9 pm in Bronfman Auditorium
- How to study: review lectures
  - Practice past HW and labs (using pencil and paper)
  - Additional POGIL worksheets posted on course website (resources)

Do You Have Any Questions?

Last Time

- Wrap upped up OSCAR example (more for loops and nested lists)
- Introduced list comprehensions
    - Short-hand expressions for common looping patterns
    - Anything you can do with a list comprehension can be done using the techniques we've discussed so far; very "Pythonic" idiom

Today's Plan

- New iteration statement: the **`while`** loop
- Discuss the mutability of different data types and the implications

When you don't know when to stop (ahead of time):

While Loop

Story so far: `for` loops

- Python `for` loops are used to iterate over a **fixed sequence**
    - No need to know the sequence's length ahead of time
- Interpretation of for loops in Python:

```
for thing in things:
    (do something with thing)
```

- Other programming languages (like Java) have `for` loops that require you to explicitly specify the length of the sequence or a stopping condition
- Thus Python for loops are sometimes called "**for each**" loops
- **Takeaway**: For loops in Python are meant to iterate directly over each item of a given ***iterable*** object (such as a sequence)

What if We Don't Know When to Stop?

- We always know the stopping condition of a `for` loop: when there are **no more elements in the sequence**

```
["A", "chilly", "autumn", "day"]
```

- Are there contexts where we don't know when to stop a loop?
    - Suppose you want to play a "guessing game" where a user repeatedly guesses numbers until they correctly guess the secret number

- **How many times** should the loop execute?
- **Under what condition** should the loop end?

The While Loop

A **`while`** loop executes the loop body 0 or more times, stopping once the loop condition evaluates to **`False`**:

```
while <boolean expression>:
    <loop body>
    <loop body>
    ...
```

Stopping condition

```
while False:
    print("never enters")
```

Loop body never executes

```
while True:
    print("never leaves")
```

"Infinite" loop!

While Loop Example

- Example of a **`while`** loop that depends on user input:

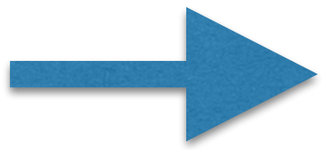
```
prompt = "Please enter a name (type quit to exit): "
name = input(prompt)
while (name != "quit"):
    print("Hi,", name)
    name = input(prompt)
print("Goodbye")
```

Stopping condition

While Loop Example: Print Halves

- Given a number, print all the positive "halves" : keep dividing **n** by **2** and printing the quotient until it becomes smaller than 0

```
def print_halves(n):
    while n > 0:
        print(n)
        n = n//2

print_halves(100)
```



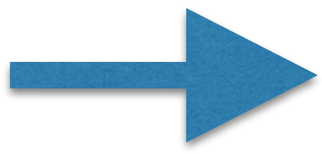
```
100
50
25
12
6
3
1
```

While Loop to Print Halves

- Given a number, print all the positive "halves" : keep dividing **n** by **2** and printing the quotient until it becomes smaller than 0

What does this do?

```
def print_halves(n):
    while n > 0:
        print(n)
        n = n//2

print_halves(100)
```



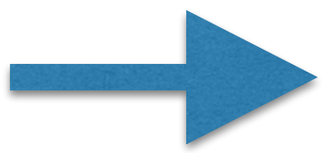
```
100
50
25
12
6
3
1
```

```
def print_halves2(n):
    while n > 0:
        print(n)
        n = n/2

print_halves2(100)
```

While Loop to Print Halves

- Given a number, print all the positive "halves" : keep dividing **n** by **2** and printing the quotient until it becomes smaller than 0

```
def print_halves(n):
    while n > 0:
        print(n)
        n = n//2

print_halves(100)
```



```
100
50
25
12
6
3
1
```

```
def print_halves2(n):
    while n > 0:
        print(n)
        n = n/2

print_halves2(100)
```

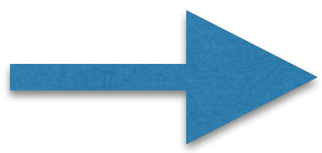
Float division!
Be careful!

While Loop to Print Halves

- Given a number, print all the positive "halves" : keep dividing **n** by 2 and printing the quotient until it becomes smaller than 0

What about this loop?

```
def print_halves(n):
    while n > 0:
        print(n)
        n = n//2

print_halves(100)
```



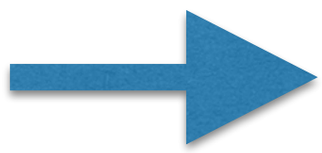
```
100
50
25
12
6
3
1
```

```
def print_halves3(n):
    while n > 0:
        print(n)
    n = n//2

print_halves3(100)
```

While Loop to Print Halves

- Given a number, print all the positive "halves" : keep dividing **n** by **2** and printing the quotient until it becomes smaller than 0

```
def print_halves(n):
    while n > 0:
        print(n)
        n = n//2

print_halves(100)
```



```
100
50
25
12
6
3
1
```

```
def print_halves3(n):
    while n > 0:
        print(n)
    n = n//2

print_halves3(100)
```

Another infinite loop!
Indentation matters!

`while` and `if` side by side

```
if boolean_expresion:
    # statement 1
    # statement 2
    ....
    ....


# end of if
```

Execute body **once** if the **boolean expression** evaluates to true

```
while boolean_expresion:
    # statement 1
    # statement 2
    ....
    ....


# end of while
```

Keep executing body **as long as** the **boolean expression** (*continues*) to evaluate to true

Side by Side: for and while loops

Iteration steps are **implicit** in a **Python** for loop: `i` takes on values 0, 1, 2, 3, 4

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

Explicitly **initialize** variable

Test stopping condition

```
i = 0
while i < 5:
    print('$' * i)
    i += 1
```

Update value of variable used in test condition

Common while loops steps that we **explicitly** write:

- **Initialize** a variable used in the test condition
- **Test** condition that causes the loop to end when `False`
- Within the loop body, **update** the variable used in the test condition

Breaking out of loops

- Stopping condition of for loop: **no more elements in sequence**
- What if we want to stop our iteration early: how did we handle this?
    - return (or, less ideally, break)
- Let's examine an example: `index_of(elem, l)`
    - Write a function `index_of(elem, l)` that takes two arguments (`elem` of any type and list `l`) and returns the first index of `elem` if `elem` is in the list `l` and `-1` otherwise

```
>>> index_of('blue', ['red', 'blue', 'blue'])
1
>>> index_of(14, [23, 1, 10, 11, 14])
4
>>> index_of('a', ['b', 'c', 'd', 'e'])
-1
```

Side by Side: `index_of`

```
def index_of(elem, l):

    for i in range(len(l)):
        # match?
        if l[i] == elem:
            # stop loop!
            return i

# if not found
return -1
```

```
def index_of(elem, l):

    found = False # flag
    index_of_elem = -1
    i = 0

    while not found and i < len(l):
        # match?
        if elem == l[i]:
            # stop the loop!
            found = True
            index_of_elem = i
        # keep going
        i += 1

    return index_of_elem
```

Mutability

Lists are Mutable

- Lists are a **mutable** data type in Python:
    - After a list is created, we can **change** its value
- There are **many ways** to mutate a list, we will only discuss two of these for now (we'll examine others after the midterm)
    - Direct assignment (e.g., lst[index] = item)
    - Appending to list using `.append(item)` notation

Direct Assignment

- Lists are a **mutable** data type in Python:
    - After a list is created, we can **change** its value
- One way to modify a list is by **direct assignment**

```
>>> my_list = ['cat', 'dog']
>>> my_list[1] = 'fish'
>>> my_list
['cat', 'fish']
```

my_list has changed!

Direct Assignment

An assignment operation to an **existing** index of a list changes the value stored at that index

```
Syntax:  my_list[index] = item
```

```
>>> my_list = ['cat', 'dog']
>>> my_list[1] = 'fish'
>>> my_list
['cat', 'fish']
>>> my_list[7] = 'oops'
IndexError: list assignment index out of range
>>>
```

What will this do?

Can only assign to existing indices

Using .append(item)

Appending to a list places a new item ***after*** the current end of the list, increasing the list's length by one.

Syntax: `my_list.append(item)`

Example.

```
my_list = [1, 7, 3, 4]

my_list.append(5)  # insert 5 after the end of list
```

myList Before	myList After
[1, 7, 3, 4]	[1, 7, 3, 4, 5]

Sneaky Appending

- We've often updated "accumulator lists" by "appending" items in loops
- So far we have been using **+=** (concatenation)
    - `var += val` normally is a shorthand for `var = var + val`
    - But when `var` is a list, Python **secretly** calls `var.append(val)`

```
>>> my_list = ['cat', 'dog']
>>> my_list += ['fish']
>>> my_list
['cat', 'dog', 'fish']
```

Python actually replaces += with append without telling us!

Explicit Appending

- If we instead explicitly use the **`.append(item)`** syntax, then the code we execute is the code that we actually wrote
- This also avoids one of the recurring errors that we've been running into in our labs! (Type mismatches with +=)

```
>>> my_list = ['cat', 'dog']
>>> my_list += ['fish']
>>> my_list
['cat', 'dog', 'fish']
```

Brackets needed here

```
>>> my_list = ['cat', 'dog']
>>> my_list.append('fish')
>>> my_list
['cat', 'dog', 'fish']
```

NO brackets here

Strings are Immutable

- Other data types we have seen are **immutable**
    - Strings, ints, floats, range() are immutable
- Once created, we **cannot** change the value of an immutable data type

```
>>> my_string = 'cat'
>>> my_string[0] = 'b'
```

Will this let us change `my_string` to `'bat'`?

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[25], line 2
      1 my_string = 'cat'
----> 2 my_string[0] = 'b'

TypeError: 'str' object does not support item assignment
```

Cannot change a string!

Mutability has Consequences!

- Mutability of data types can have **unintended consequences**

```
>>> word = "hello"
>>> copy = word
>>> word = word + "world"
>>> copy
"hello"
```

Changing `word` does not change `copy`

```
>>> word_list = ["hello"]
>>> copy = word_list
>>> word_list.append("world")
>>> copy
['hello', 'world']
```

Changing `word_list` **also changes** `copy`

Mutability has Consequences!

- Mutability of data types can have unintended consequences
- **Aliasing as a consequence of Mutability.** In Python, creating a **copy** of a mutable object creates an **alias** rather than a true copy

```
>>> word = "hello"
>>> copy = word
>>> word = word + "world"
>>> copy
"hello"
```

Changing `word` does not change `copy`

```
>>> word_list = ["hello"]
>>> copy = word_list
>>> word_list.append("world")
>>> copy
['hello', 'world']
```

Changing `word_list` **also changes** `copy`

Takeaways

- New iteration statement: `while` loop as an alternative to `for` loops are meant to iterate for a fixed number of times
    - Used when the stopping condition is determined ***"on the fly"***
    - Keeps iterating as long as Boolean condition evaluates to `True`
- Lists are mutable data types
    - Can modify the contents of a list by direct assignment or by using .append()
- Strings, ints, floats, range() are immutable: cannot be modified
- Mutability has consequences!
    - Will discuss **aliasing** in detail next lecture

Modules vs Scripts

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