Last Class We Covered

• Using `for` loops
  – Syntax
  – Using it to iterate over a list
  – Using it for “counting” the number of actions

• The `range()` function
  – Syntax
  – Three forms: one, two, or three numbers
Any Questions from Last Time?
Today’s Objectives

• To learn about and use a **while** loop
  – To understand the syntax of a **while** loop
  – To use a **while** loop for interactive loops

• To learn two different ways to mutate a list
  – `append()` and `remove()`

• To apply our knowledge to created nested loops

• To touch (briefly) on two-dimensional lists
Review: Looping
Remember our Average **for** Loop?

- **Use a** **for** **loop** **to** find the average from a list of numbers

```python
nums = [98, 75, 89, 100, 45, 82]
total = 0  # we have to initialize total to zero
for n in nums:
    total = total + n  # so that we can use it here
avg = total / len(nums)
print("Your average in the class is: ", avg)
```
Getting Flexible Input

• What if we only want positive numbers?
• And we want to re-prompt the user if they enter a negative number?
  – And keep re-prompting until they enter a positive

• We can’t do this with a for loop – why?
  – They only run a pre-set number of times
  – We don’t know how many times to re-prompt
Looping

• Python has two kinds of loops, and they are used for two different purposes

• The **for** loop:
  – Good for *iterating* over a list
  – Good for counted iterations

• The **while** loop
  – Good for almost everything else

what we’re covering today
while Loops: Syntax and Uses
The **while** Loop

- The **while** loop is used when we’re not
  - Iterating over a list
  - Doing a “counted” loop

- Works the way its name implies:
  
  **While** a certain condition is not yet met:
  
  Continue to repeatedly do a thing
Parts of a `while` Loop

• Here’s some example code... let’s break it down

```python
date = 0

while date < 1 or date > 31:
    date = int(input("Enter the day: "))

print("Today is September", date)
```
Parts of a `while` Loop

• Here’s some example code... let’s break it down

1. initialize the variable the `while` loop will use for its decision
   ```python
date = 0
   ```

2. the loop’s Boolean condition (loop runs until this is `False`)
   ```python
   while date < 1 or date > 31
   ```

3. the body of the loop (must change the value of the loop variable)
   ```python
   date = int(input("Enter the day: "))
   ```

4. print("Today is September",
   ```python
   print("Today is September",
   ```
How a `while` Loop Works

• The `while` loop requires a Boolean condition
  – That it then evaluates to either `True` or `False`

• If the condition is `True`:
  – Body of `while` loop is executed

• If the condition is `False`:
  – Body of `while` loop is skipped
Example **while** Loop

- We can use a **while** loop to do a “counting” loop, just like we used a **for** loop.

```python
num = 1  # we have to initialize num to zero

while num <= 20:  # so that we can use it here
    print(num)
    num = num + 1  # change the loop variable
```
Example **while** Loop

Start → num = 1

```plaintext
while
num >= 20
```

TRUE: Display num → num = num + 1

FALSE: End

num = 1

num >= 20

true
false
Infinite Loops and Other Problems
Infinite Loops

• An *infinite loop* is a loop that will run forever

• Can we have an infinite loop using *for*?
  – No! – the *for* loop goes through a set number of steps (iterating or counting) and will always end

• Can we have an infinite loop using *while*?
  – Yes! – the *while* loop’s loop variable is controlled by us, and we can make mistakes
Infinite Loop Example #1

• Why doesn’t this loop end? What will fix it?

```python
age = 0
while age < 18:  # can’t vote until 18
    print("You can’t vote at age", age)

print("Now you can vote! Yay!")
```

Control+C to break an infinite loop in Python!
Infinite Loop Example #1

• Why doesn’t this loop end? What will fix it?

```python
age = 0
while age < 18:    # can’t vote until 18
    print("You can’t vote at age", age)

print("Now you can vote! Yay!")
```

the loop variable (age) never changes, so the condition will never evaluate to True
Infinite Loop Example #2

• Why doesn’t this loop end? What will fix it?

```python
while True:
    # ask user for name
    name = input("What is your name? ")

    print("Hello", name + "!")
```
Infinite Loop Example #2

• Why doesn’t this loop end? What will fix it?

```python
while True:
    # ask user for name
    name = input("What is your name? ")
    print("Hello", name + "!")
```

True will never evaluate to False, so the loop will never exit.
Infinite Loop Example #3

• Why doesn’t this loop end? What will fix it?

cookiesLeft = 50

while cookiesLeft > 0:
    # eat a cookie
    cookiesLeft = cookiesLeft + 1

print("No more cookies!")
Infinite Loop Example #3

• Why doesn’t this loop end? What will fix it?

cookiesLeft = 50

while cookiesLeft > 0:
    # eat a cookie
    cookiesLeft = cookiesLeft + 1

print("No more cookies!")

the loop body is INCREASING the number of cookies, so we’ll never reach zero!
Loop Body Isn’t Being Run

- Unlike most `for` loops, a `while` loop’s body may be skipped over entirely
  - If the Boolean condition is initially `False`

```python
militaryTime = 1300

while (militaryTime < 1200):
    print("Good morning!")
    militaryTime = militaryTime + 1```
Updating and Changing Lists
Mutating Lists

• Remember that lists are defined as “mutable sequences of arbitrary objects”
  – “Mutable” just means we can change them

• So far, the only thing we’ve been able to change about our lists are their contents
  – But we can also change their size, by adding and removing elements
Two List Functions

• There are two functions we’ll cover today that can add and remove things to our lists

  append()
  remove()

• There are more, but we’ll cover them later
List Function: `append()`

- The `append()` function lets us add items to the end of a list, increasing its size
  ```python
  LISTNAME.append(ITEM_TO_APPEND)
  ```

- Useful for creating a list from flexible input
  - Allows the list to expand as the user needs
  - No longer need to initialize lists to `[None] * NUM`
Example of `append()`

- We can use `append()` to create a list of numbers (continuing until the user enters 0)

```python
values = []  # initialize the list to be empty
userVal = 1  # give our loop variable a value

while userVal != 0:
    userVal = int(input("Enter a number, 0 to stop"))
    if userVal != 0:
        # only append if it's valid
        values.append(userVal)  # add value to the list
```
Example of `append()`

- We can use `append()` to create a list of numbers (continuing until the user enters 0)

```python
while userVal != 0:
    userVal = int(input("Enter a number, 0 to stop"))
    if userVal != 0:  # only append if it's valid
        values.append(userVal)  # add value to the list
```

```
values = [17, 22, 5, -6, 13]
```

```text
0 1 2 3 4
```
List Function: \texttt{remove()} 

- The \texttt{remove()} function lets us remove an item from the list – specifically, it finds and removes the first instance of a given value. 
  \[
  \text{LISTNAME} \texttt{.remove(ITEM_TO_REMOVE)}
  \]

- Useful for deleting things that no longer matter
  - For example, removing students who have dropped the class from the class roster
  - Keeps the list from having empty elements
Example of `remove()`

- We can use `remove()` to remove students who have dropped the class from the roster.

```python
roster = ["Adam", "Alice", "Andy", "Ariel"]

roster.remove("Adam")  # Adam has dropped the class

# Bob is not in roster, so this causes an error
roster.remove("Bob")
```
Example of `remove()`

- We can use `remove()` to remove students who have dropped the class from the roster.

```python
roster = ["Adam", "Alice", "Andy", "Ariel"]
```

```
roster = [Adam, Alice, Andy, Ariel]
```

<table>
<thead>
<tr>
<th></th>
<th>Adam</th>
<th>Alice</th>
<th>Andy</th>
<th>Ariel</th>
</tr>
</thead>
<tbody>
<tr>
<td>index</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Example of `remove()`

- We can use `remove()` to remove students who have dropped the class from the roster.

```python
roster = ['Adam', 'Alice', 'Andy', 'Ariel']
roster.remove('Adam')  # Adam has dropped the class
```

```
roster = Adam Alice Andy Ariel
0 1 2 3
```
Example of `remove()`

- We can use `remove()` to remove students who have dropped the class from the roster

```python
roster = ["Adam", "Alice", "Andy", "Ariel"]
roster.remove("Adam")  # Adam has dropped the class
roster.remove("Bob")   # Bob is not in the class
```

```
roster = [Alice, Andy, Ariel]
```

```
0 1 2
```

**Error**
Interactive while Loops
When to Use `while` Loops

- `while` loops are very helpful when you:
  - Want to get input from the user that meets certain specific conditions
    - Positive number
    - A non-empty string
  - Want to keep getting input until some “end”
    - User inputs a value that means they’re finished
    - Reached the end of some input (a file, etc.)
Example while Loop

- We can use a `while` loop to get correct input from the user by re-prompting them.

```python
num = 0  # we have to initialize num to zero

while num <= 0:  # so that we can use it here
    num = int(input("Enter a positive number: "))

# the while loop has exited b/c num is positive
print("Thank you. The number you chose is:", num)
```
Nested Loops
Nesting

• You have already used nested statements
  – In HW3, you used nested `if/elif/else` statements to help you diagnose a patient

• We can also nest loops!
  – First loop is the `outer loop`
  – Second loop is the `inner loop`
Nested Loop Example

• What does this code do?

```python
scores = []
for i in range(10):
    num = 0
    while num <= 0:
        num = int(input("Enter a positive #: "))
    scores.append(num)

print(scores)
```
Nested Loop Example

• What does this code do?

```python
scores = []  # creates an empty list
for i in range(10):  # will run 10 times
    num = 0  # will keep running until num is positive
    while num <= 0:
        num = int(input("Enter a positive #: "))
    scores.append(num)
print(scores)  # after the while loop exits, num is positive, so add it to the scores list
```
Two-Dimensional Lists
Two-Dimensional Lists

• We’ve looked at lists as being one-dimensional
  – But lists can also be two- (or three- or four- or five-, etc.) dimensional!

• Lists can hold any type (int, string, float, etc.)
  – This includes holding another list
Two-Dimensional Lists: A Grid

• May help to think of 2D lists as a grid

\[
twoD = [ [1,2,3], [4,5,6], [7,8,9] ]
\]
Two-Dimensional Lists: A Grid

- You access an element by the index of its row, then column (remember – index starts at 0!)

```
<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>
```
Two-Dimensional Lists: A Grid

- You access an element by the index of its row, then column (remember – index starts at 0!)

<table>
<thead>
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<th></th>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

- index: [0][2]
- index: [1][0]
- index: [2][1]
- index: [2][2]
Lists of Strings

• Remember, a string is a list of characters
• So what is a list of strings?
  – A two-dimensional list!

• We have the index of the string (the row)
• And the index of the character (the column)
Lists of Strings

• Lists in Python don’t have to be rectangular
  – They can also be jagged (rows different lengths)

• Anything we could do with a one-dimensional list, we can do with a two-dimensional list
  – Slicing, index, appending

```
0 | Alice
1 | Bob
2 | Evan
```
names
NOTE: Strings vs Lists of Characters

• Strings and lists of characters do not behave the same way in Python; they have different functions, and different things that are allowed

• Strings – can use `upper()` and `lower()`
  ```python
  names = ['Alice', 'Bob', 'Evan']
  ```

• List of characters – can use `append()`
  ```python
  names = [list("Alice"), list("Bob"), list("Evan")]
  ```
  ```python
  [['A', 'l', 'i', 'c', 'e'], ['B', 'o', 'b'], ['E', 'v', 'a', 'n']]
  ```
Practice: Two-Dimensional Lists

1. Using a loop, print all five numbers from the first row of `ex_nums`.
2. Replace the 4 with the word “four”.
3. Add a 3 to the end of the last row.
4. Delete the 5 from the list.
Answers: Two-Dimensional Lists

1. for i in ex_nums[0]:
   print(i)

2. ex_nums[0][3] = "four"

3. ex_nums[2].append(3)

4. ex_nums[0].remove(5)
Practice: List of Lists of Characters

1. Add a “b” and a “y” to the end of “Bob”
2. Print out the second letter in “Evan”
3. Change “Alice” to “Alyce”

```python
names[1].append('b')
names[1].append('y')
print(names[2][1])
names[0][2] = 'y'
```
Announcements

• (Pre) Lab 5 has been released on Blackboard
  – Future ones will be available the weekend prior

• Homework 4 is out
  – Due by Tuesday (Oct 6th) at 8:59:59 PM

• Homework 1 re-grade and re-submit petitions must be made to your TA before Friday @ 3 PM