CMSC201
Computer Science I for Majors

Lecture 09 – While Loops

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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 create nested loops
- To touch (briefly) on two-dimensional lists

Review: Looping and Range

Review of `range()` Function

```
for i in range(5):
    print(i)
```

```
0
1
2
3
4
```

What is the output of this code?

Range generates a list of numbers up to but not including the number

Review of `range()` Function

```
for i in range(-3, -13, -3):
    print(i)
```

```
-3
-6
-9
-12
```

What is the output of this code?

With three numbers, we can change the step to a negative to let us count down

The "Average" `for` Loop

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

```
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

- Can we fill the list with numbers from the user?
  - 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?
  - For loops 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 conditional evaluates to True:

  Do a thing (repeatedly, if necessary)

Parts of a `while` Loop

- Here's some example code… let's break it down

```
date = 0

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

print("Today is February", date)
```

Parts of a `while` Loop

- Here's some example code… let's break it down

initialize the variable the `while` loop will use for its decision

```
date = 0

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

print("Today is February",
```

the loop's Boolean condition (loop runs until this is `False`)

the body of the loop (must change the value of the loop variable)

How a `while` Loop Works

- The **`while`** loop requires a Boolean condition
  - That 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

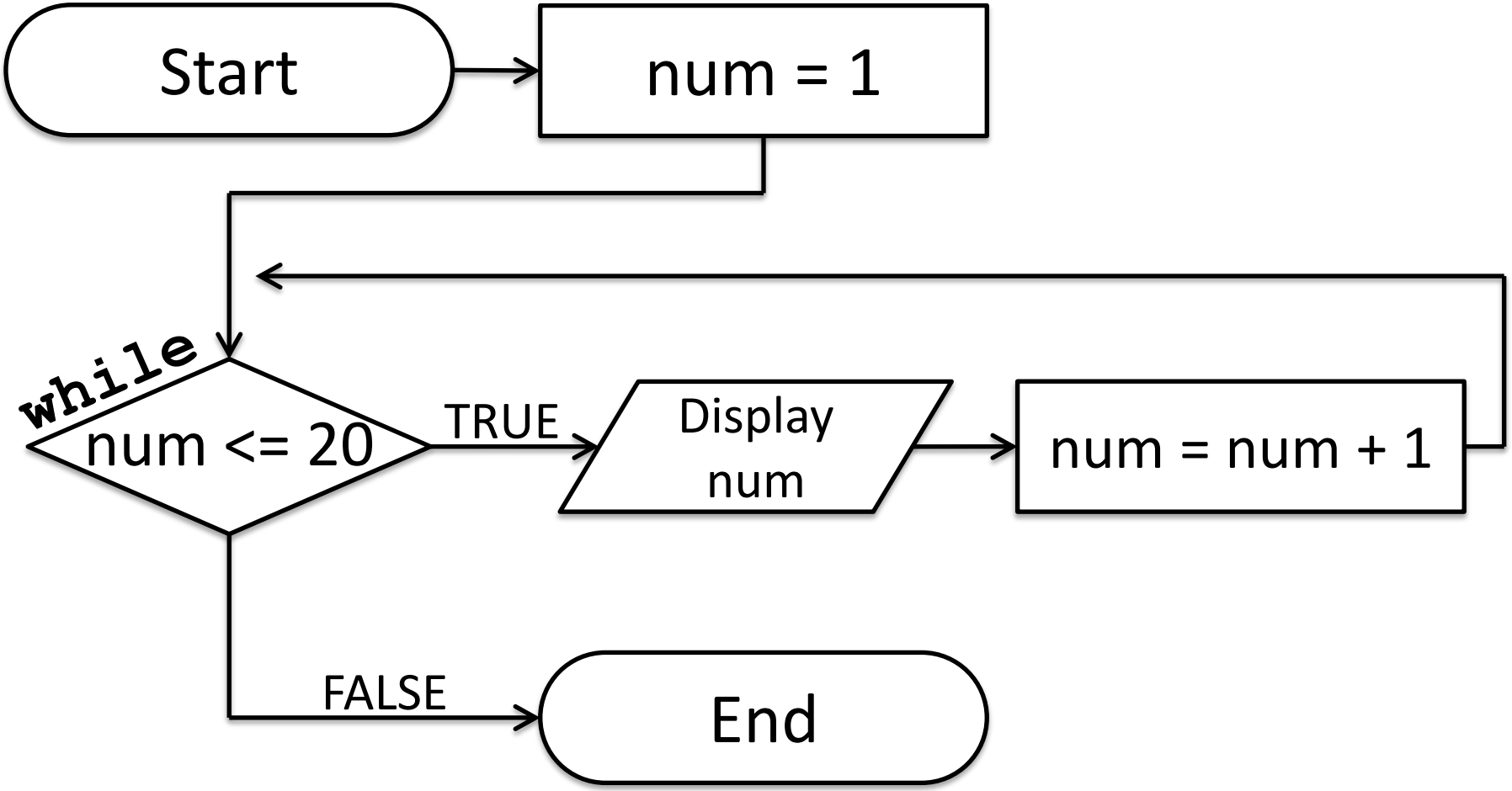
Example `while` Loop

- We can use a **`while`** loop to do a "counting" loop, just like we did using a **`for`** loop

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

while num <= 20:            # so that we can use it here
    print(num)
    num = num + 1           # don't forget to update
                            # the loop variable
```

Example `while` Loop



Differences Between the Loops

- Though they are both loops, **`for`** loops and **`while`** loops behave very differently

- What does the loop do?
  - **`for`** loop:
    - Iterate over a list
  - **`while`** loop:
    - Evaluate a conditional

Even when we use **`range()`**

What?!

Remember, range() creates a list of numbers!

Differences Between the Loops

- What is the syntax of the loop?
  - **`for`** loop:
    - **`for listVariable in listName:`**
    - Must contain list name and a list variable
  - **`while`** loop:
    - **`while CONDITIONAL == True:`**
    - Must use a conditional that contains a variable that changes as the loop is run

Differences Between the Loops

- How is the loop variable updated?
  - **`for`** loop:
    - The loop itself updates the loop variable
    - First time through, it is element at index 0, second time through, element at index 1, etc.
  - **`while`** loop:
    - Programmer must update the loop variable
    - Updating is not done automatically by Python

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?

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

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

Infinite Loop Example #1

- Why doesn't this loop end? What will fix it?

the loop variable (**age**) never changes, so the condition will never evaluate to **False**

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

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

Infinite Loop Example #2

- Why doesn't this loop end? What will fix it?

```
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?

`True` will never evaluate to **`False`**, so the loop will never exit

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

print("Hello", name + "!")
```

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!

Ending an Infinite Loop

- If you run a program that contains an infinite loop, it may seem like you've lose control of the terminal!

- To regain control, simply type **`CTRL+C`** to interrupt the infinite loop

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`**

```
militaryTime = 1300

while (militaryTime < 1200):
    print("Good morning!")
    militaryTime = militaryTime + 100
```

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 changed has been the content of the list
  - But we can also change a list's 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
  - There are more, but we'll cover them later

```
append()
remove()
```

List Function: `append()`

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

  `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`**
    - Can instead start with an empty list **`[]`**

Example of `append()`

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

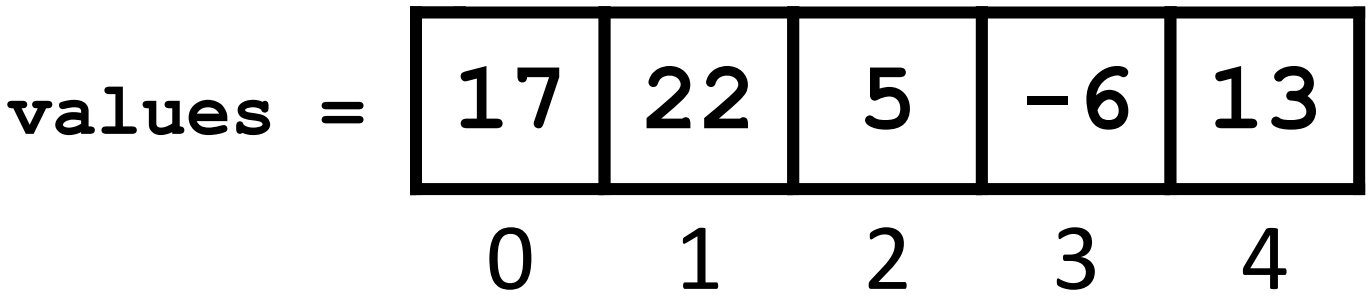
```
values = []    # initialize the list to be empty
userVal = 1    # give loop variable an initial value

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)

```
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
```



List Function: `remove()`

- The `remove()` function lets us remove an item from the list – specifically, it finds and removes the first instance of a given value

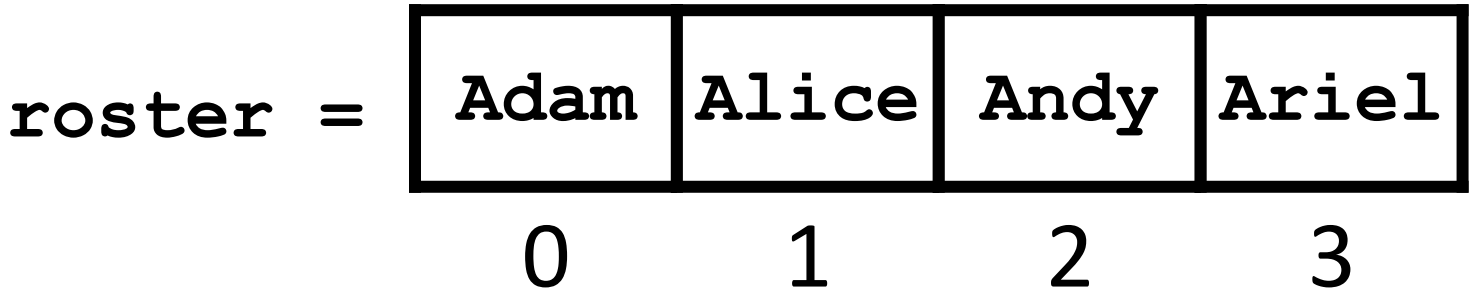
```
LISTNAME.remove(VALUE_TO_REMOVE)
```

- Useful for deleting things we don't need
  - 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

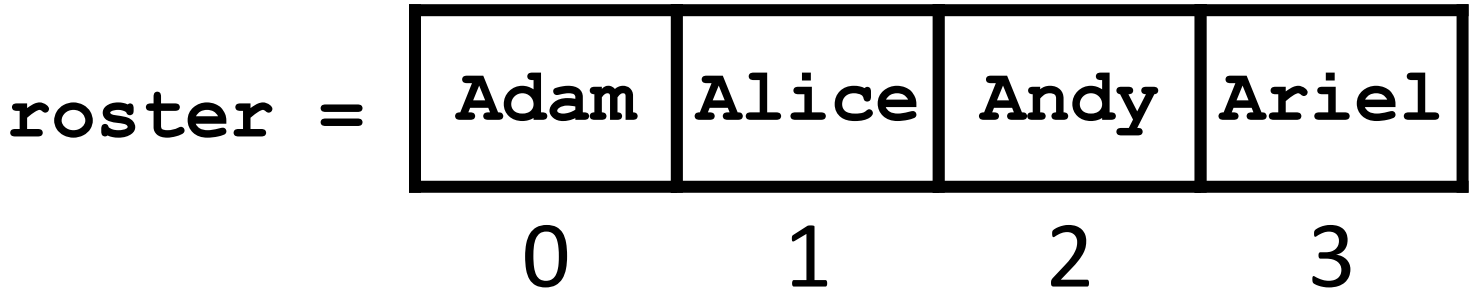
```
roster = ["Adam", "Alice", "Andy", "Ariel"]
```



Example of `remove()`

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

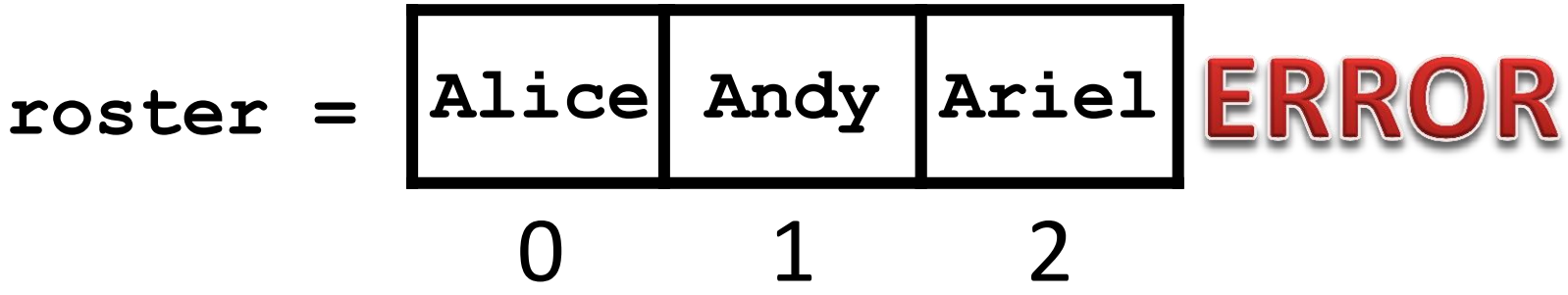
```
roster = ["Adam", "Alice", "Andy", "Ariel"]
roster.remove("Adam")    # Adam has dropped the class
```



Example of `remove()`

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

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



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

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

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

# while loop exits because 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 guess a character

- We can also nest loops!
  - First loop is called the ***outer loop***
  - Second loop is called the ***inner loop***

Nested Loop Example

- What does this code do?

```
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?

```
scores = []
for i in range(10):
    num = 0

    while num <= 0:
        num = int(input("Enter a positive #: "))
    scores.append(num)

print(scores)
```

creates an empty list

the code range(10) generates the list [0, 1, … , 8, 9]

will run 10 times

will keep running while **num** is negative

once the **while** loop exits, **num** must be 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 means they can also hold 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] ]
```

1	2	3
4	5	6
7	8	9

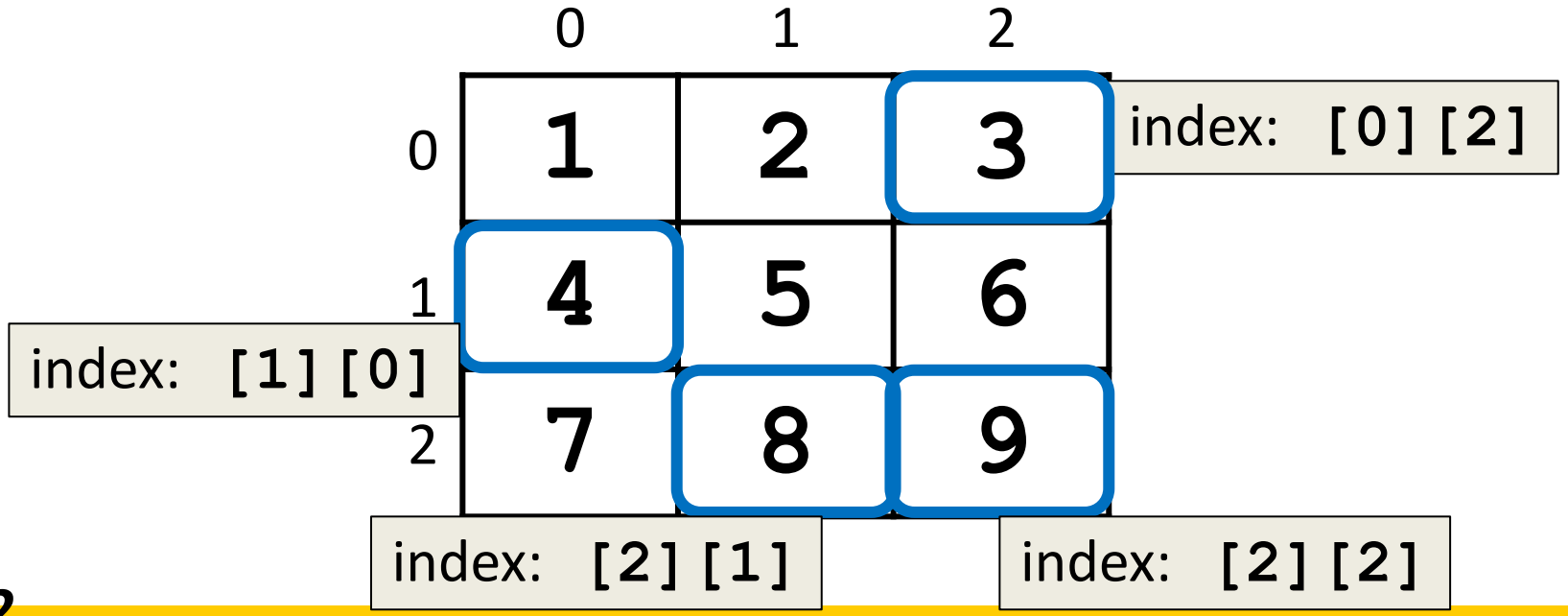
Two-Dimensional Lists: A Grid

- You access an element by the index of its row, then the column
  - Remember – indexing starts at 0!

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

Two-Dimensional Lists: A Grid

- You access an element by the index of its row, then the column
  - Remember – indexing starts at 0!



Lists of Strings

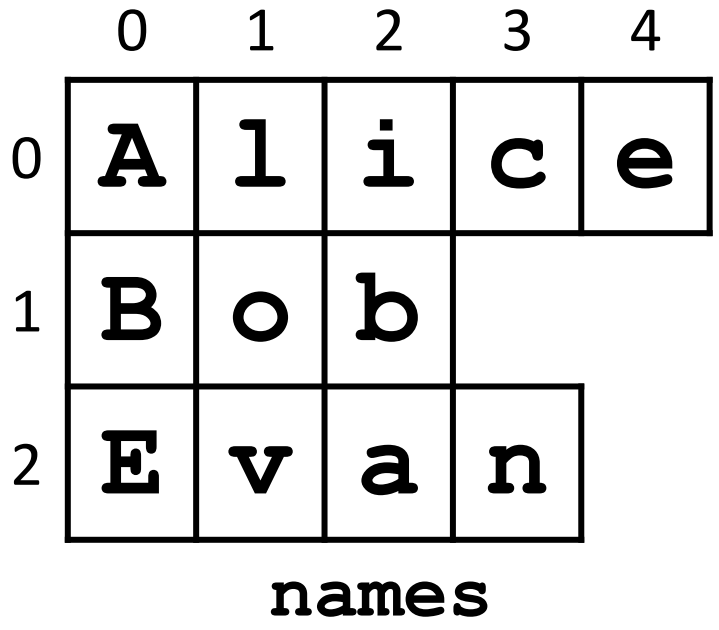
- Remember, a string is a list of characters
- So what is a list of strings?
  - A two-dimensional list!

- 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



NOTE: Strings vs Lists of Characters

- Strings and lists of characters are not exactly the same in Python; different operations are allowed

- Strings – can use **`upper()`** and **`lower()`**

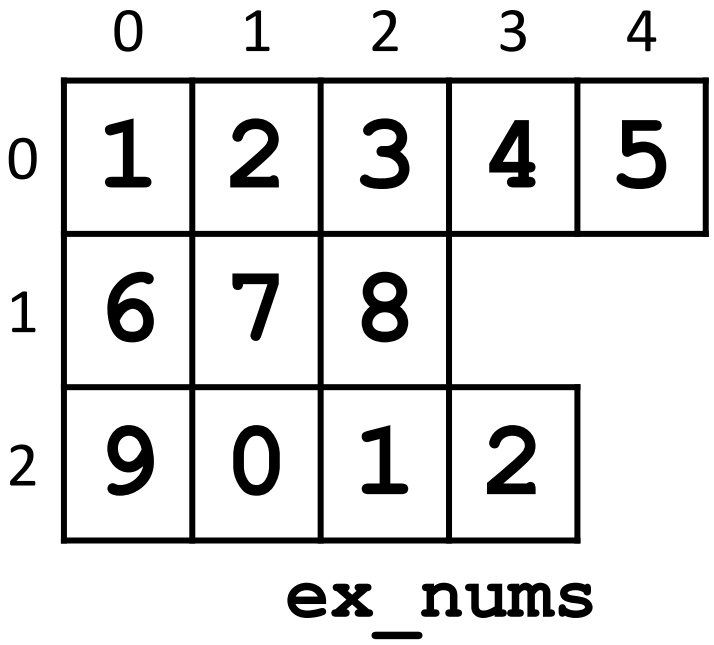
```
names = ['Alice', 'Bob', 'Evan']
```

- List of characters – can use **`append()`**

```
names = [list("Alice"), list("Bob"), list("Evan")]
[['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



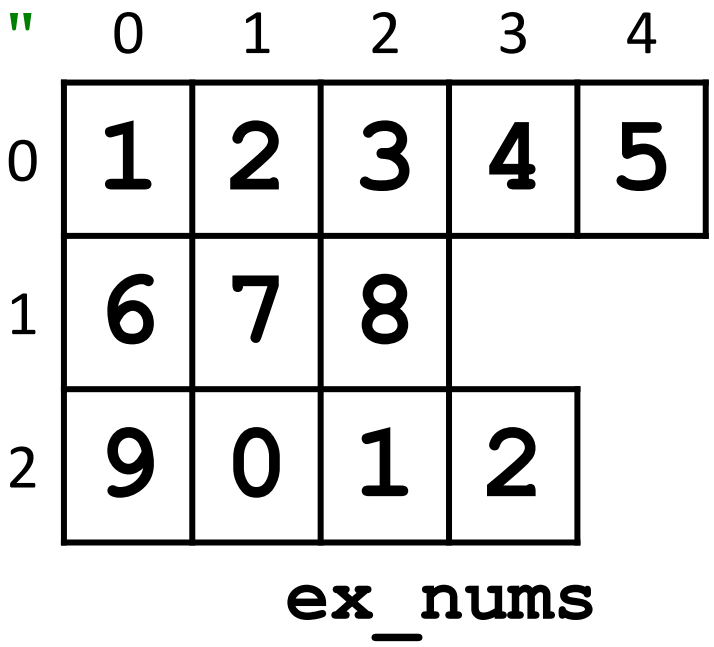
Answers: Two-Dimensional Lists

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

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

3.
```
ex_nums[2].append(3)
```

4.
```
ex_nums[0].remove(5)
```



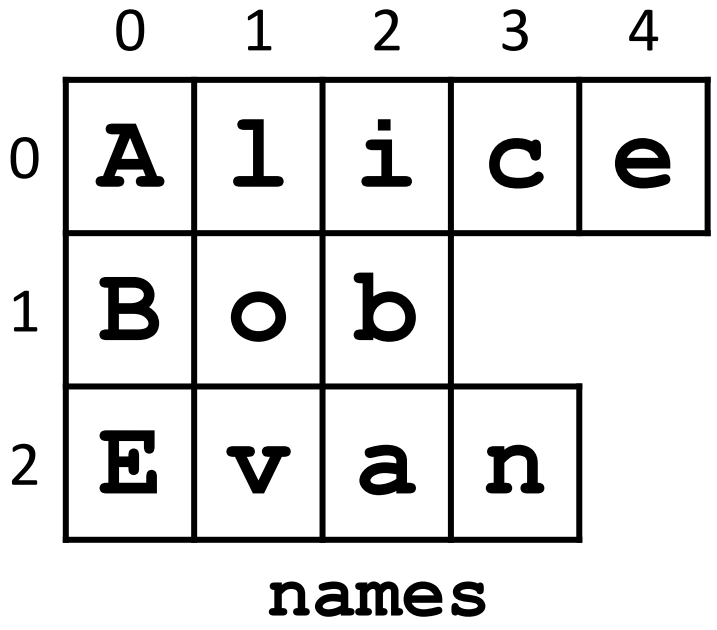
Practice: List of Lists of Characters

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”

```
names[1].append('b')
names[1].append('y')

print(names[2][1])

names[0][2] = 'y'
```



Announcements

- Lab 3 is being held this week!
  - Make sure you attend your correct section
- Homework 4 is out
  - Due by Monday (February 29th) at 8:59:59 PM
- Homeworks and Pre-Labs are on Blackboard
  - Homework 1 grades have been released

Practice Problems

- Write a program that allows the user to try and guess the password. It should allow them to guess the password up to three times before it doesn't let them guess anymore.
- Write a program that allows the user to enter numbers until they enter a -1 to stop.
  - After they enter a -1, it should output the average, the minimum, and the maximum of the numbers. Make sure not to include the -1 when calculating!