CS 1112: Introduction To Programming

Loops: While-loops and For-loops

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Friendly Reminders

- Your ***safety*** and ***comfort*** is important!
  - If you choose to wear a mask you are welcome to do so
  - *We will interpret wearing a mask as being **considerate and caring** of others in the classroom (not that you are sick), and realize that some may choose to mask to **remain distanced***
- Be an ***active*** participant in your learning!
  You're welcome and ***encouraged*** to ask questions during class!
- If you feel ***unwell***, or think you are, please stay home
  - *We will work with you!*
  - Get some rest ☺
  - View the recorded lectures – *please allow 24-48 hours to post*
  - *Contact us!*

Announcements

- **Quiz 4** is due by 11:00pm on Monday (***tonight***)!
  - No late quizzes accepted
  - No make-up quizzes allowed
  - If you believe your computer is glitching, it's a good idea to copy down your answers to each of the questions in a word document. In the event something happens, you can send me your solutions.
  - *Note: in general, will **cannot and will not** accept quiz solutions via **email**. We will only accept them in the case where your quiz may have glitched and we no longer have your submitted answers.*
  - **Take quiz on:** Sherlock.cs.virginia.edu
- **PA03** is due by 11:00pm on Wednesday (***2/21***)!
  - Submit on Gradescope: your .py file
- **Exam 1** is coming up… on February 28, 2024!
  - If you have **SDAC** *time and/or distraction-free accommodations*, please **book** a time slot with SDAC to take the exam at their facility. Book any time on Feb. 28.

Earlier in the Semester We Mentioned the Building Blocks of Programs

- **Sequence**
  - We start with the instruction written at the top
  - We go in order, one instruction at a time
  - Each line is “one” thing to do
- **Repetition** – repeat something
  - Repeat a fixed number of times (e.g., repeat 5 times)
  - Repeat until something happens (e.g., repeat until input is valid)
- **Conditions/Decisions** – maybe do something
  - Check something first, i.e., if there is a file present, read it
- **Named actions**
  - Grouping many lower-level actions in to one higher level name
    - Definition of the name action
    - Use of the named action

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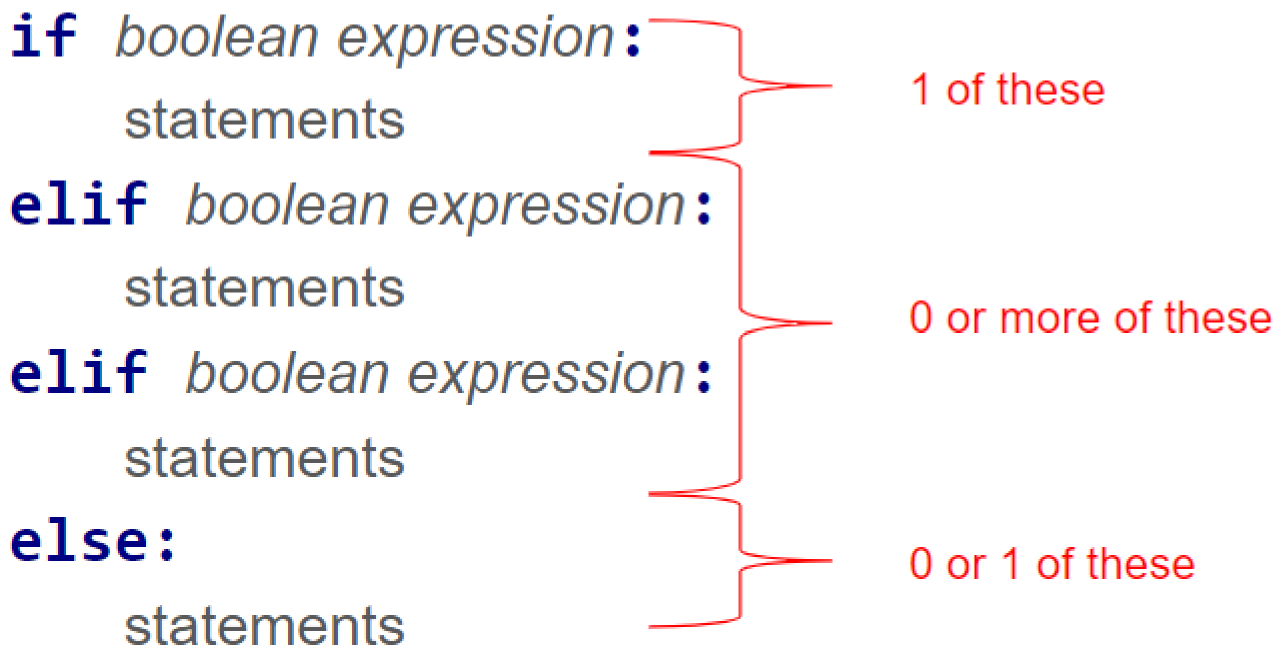
We have been introduced to for-loops earlier, so we will start with while-loops and then review for-loops!

Conditional Decision Statement

- ***Recall***: To define code that sometimes runs:



```
if boolean expression:
    statements
elif boolean expression:
    statements
elif boolean expression:
    statements
else:
    statements
```

Agenda

- While-loops
- For-loops *(we've seen before, but we will formalize)*
- Contras these two kinds of loops

While-loops

While loops

- Define code that runs until a **condition** is False

Guard Condition

```
while boolean_expression:
  statement(s)
```

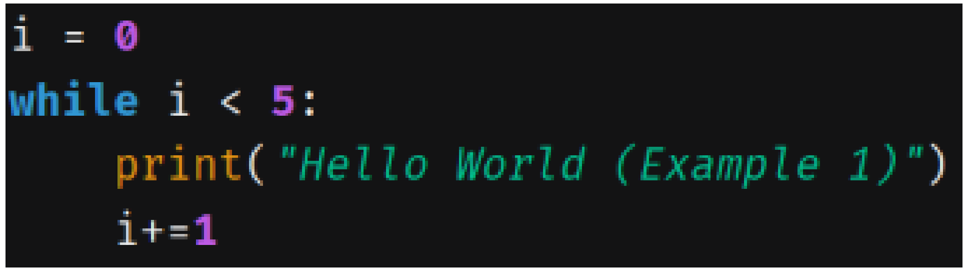
Keeps doing the action over and over so long as the boolean expression is **True**.

- Example:

```
x = 147
while x >= 100:
    x = int(input('Enter a number less than 100: ‘))
    . . .
```

While Loops

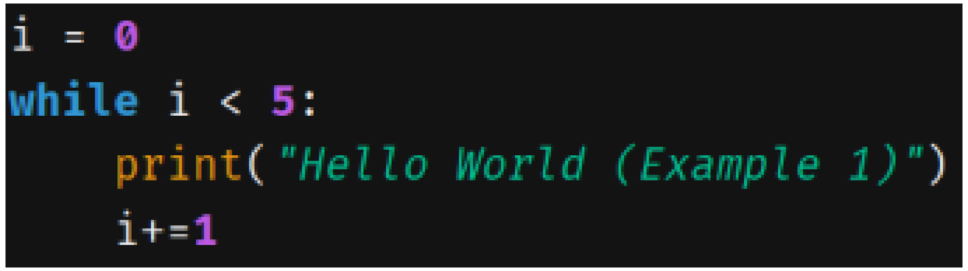
The condition of the while loop is checked BEFORE the subsequent iteration.
If the condition is TRUE, then the code inside the loop is executed.
If the condition is FALSE, the loop stops.



```
i = 0
while i < 5:
    print("Hello World (Example 1)")
    i+=1
```

1. A while loop evaluates the *Boolean condition (“Guard condition”)*
2. If the condition evaluates to **True**, the code inside the while loop is *executed*
3. The condition is *evaluated* again
4. This process continues **until** the condition is **False**
5. When the condition evaluates to **False**, the loop ***stops***

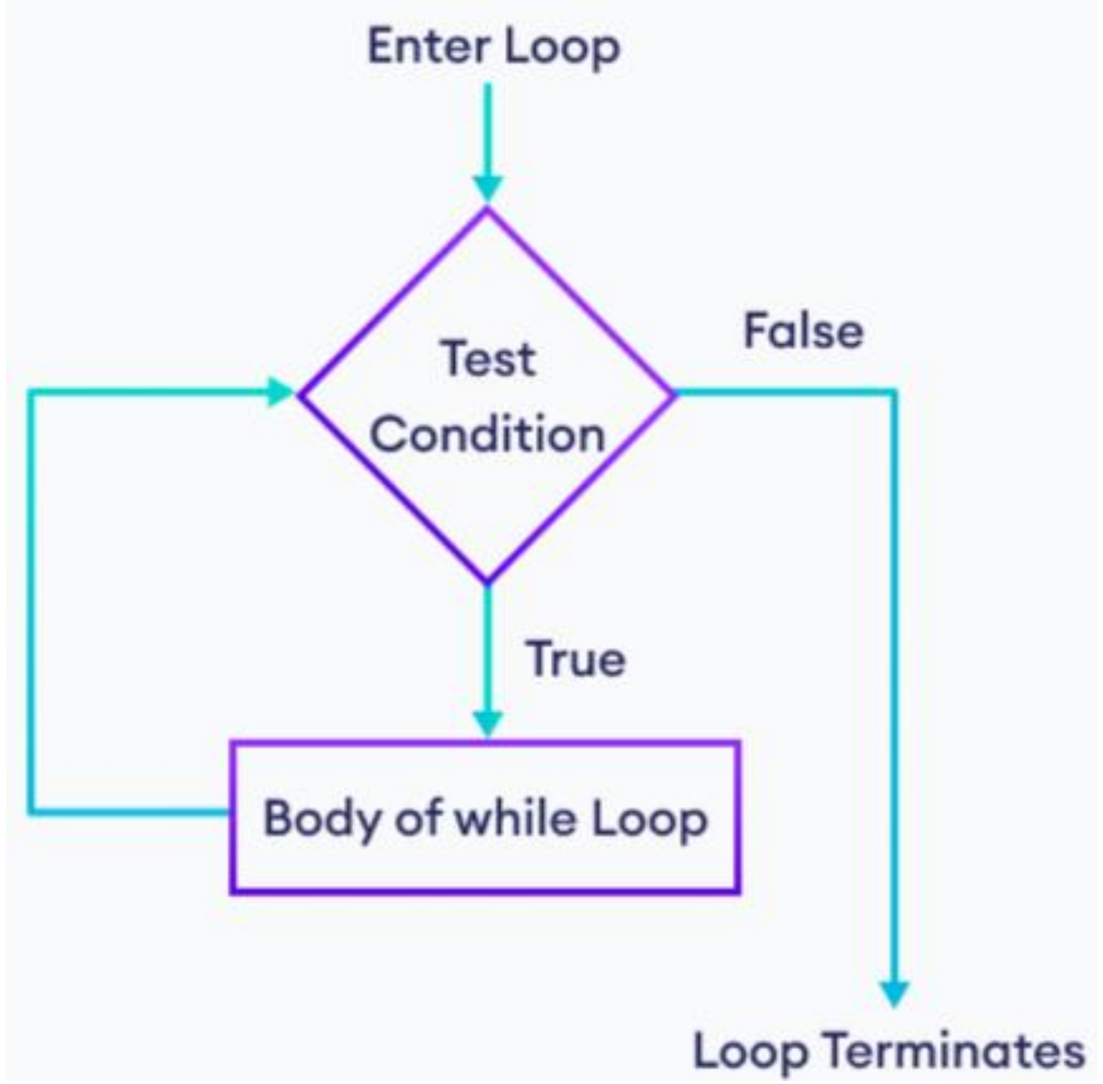
Rules for While Loops



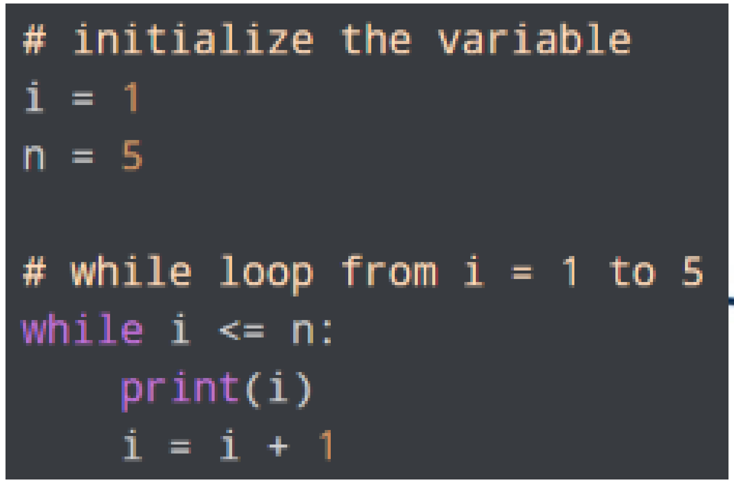
```
i = 0
while i < 5:
    print("Hello World (Example 1)")
    i+=1
```

- Some aspect of your *guard condition* must change in the **body**
- The *condition* must **change** in such a way that the Boolean expression will eventually become **False**
- Every statement in the body of the while loop is finished *before checking the guard again*
- **Note**: The guard will only be checked after we get to the **end** of the body of the while loop, *not after each statement*

Flowchart of Python While-loop

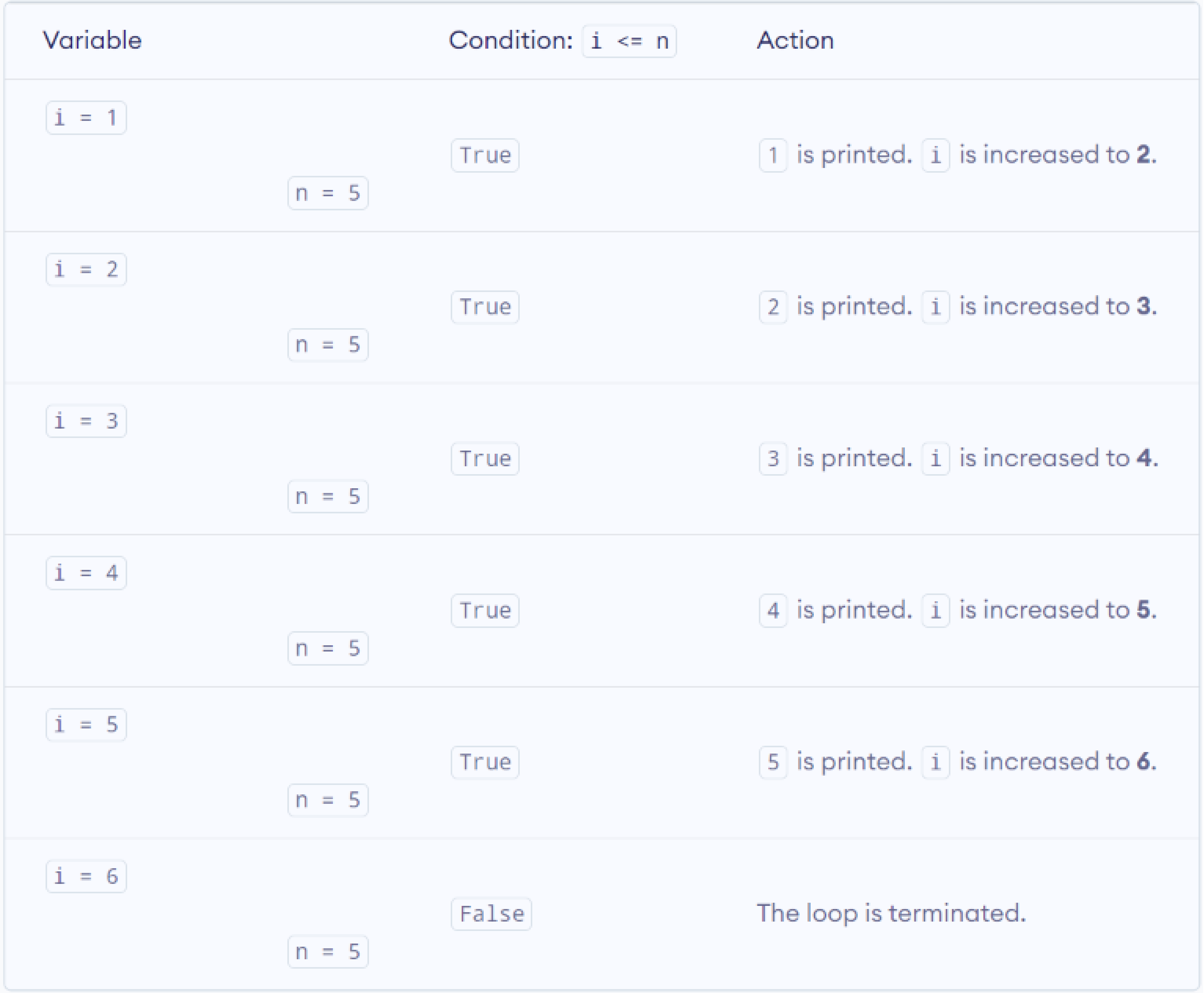


Worked Example: While-loop



```
# initialize the variable
i = 1
n = 5

# while loop from i = 1 to 5
while i <= n:
    print(i)
    i = i + 1
```



Variable	Condition: `i <= n`	Action
`i = 1` `n = 5`	`True`	`1` is printed. `i` is increased to **2**.
`i = 2` `n = 5`	`True`	`2` is printed. `i` is increased to **3**.
`i = 3` `n = 5`	`True`	`3` is printed. `i` is increased to **4**.
`i = 4` `n = 5`	`True`	`4` is printed. `i` is increased to **5**.
`i = 5` `n = 5`	`True`	`5` is printed. `i` is increased to **6**.
`i = 6` `n = 5`	`False`	The loop is terminated.

Q1: How many times will this run?

```
x = 0
while x > 5:
    print(x)
```

Q1: How many times will this run? Zero (0) times

```
x = 0
while x > 5:  # x starts out by being < 5, so condition is False
    print(x)
```

Q2: How many times will this run?

```
x = 0
while x < 5:
    print(x)
```

Q2: How many times will this run? Infinite

```
x = 0
while x < 5:    # x is less than 5, but it NEVER CHANGES… so infinite!
    print(x)
```

Q3: How many times will this run?

```
x = 0
while x < 5:
    print(x)
    x += 1
```

Q3: How many times will this run? 5 times

```
x = 0
while x < 5:
    print(x)
    x += 1 # the guard condition IS changed in the body of the loop
```

Repetition with incrementing

```
x = 0
while x < 5:
    print(x)
    x += 1
```

This repeats the code inside the `while` loop body **five** times:

- The first time through the loop, `x = 0`
- The second time through the loop, `x = 1`
- The third time through the loop, `x = 2`
- The fourth time through the loop, `x = 3`
- The fifth time through the loop, `x = 4`

- We do *not* repeat the loop when **x = 5**

Q4: What is the last line in the body of this while loop?

```
2     target = 77
3     count = 10
4     while count > 0:
5         z = int(input("Enter a number: "))
6         if z == target:
7             print("You win a prize!")
8         else:
9             print(str(count - 1), "left")
10        count -= 1
11    print("Program finished")
```

Q4: What is the last line in the body of this while loop?

```
2     target = 77
3     count = 10
4     while count > 0:
5         z = int(input("Enter a number: "))
6         if z == target:
7             print("You win a prize!")
8         else:
9             print(str(count - 1), "left")
10        count -= 1
11    print("Program finished")
```

Line 10

Body of While Loop

Other Kinds of While Loops

- There is also a
  - While-Else loop
  - A version of a Do-While loop

- We’ll see examples of these in the Python file

Python Demonstration

Let's jump on PyCharm!

while_loops.py

```
# while loops

# Example - Are we there yet?
# Keep checking until we are there....
#
text = input("Are we there yet? ")  # what happens if we do not give
answer
                                    # a value before the loop?
while text == 'no':   # the condition is - <text == 'no'>
  print("Whatever...")
  text = input("Are we there yet? ")  # but if we changed text to text1?

print("Program Finished")




# use a while loop to count up
#
# How many dozen eggs do I need to buy?
#
eggs_bought = 0
target = int(input("How many eggs do you need? "))
while (eggs_bought * 12) < target:
   eggs_bought += 1

print("You should buy", eggs_bought, "dozen")
```

```
# This is called an *Input Validation* loop

# *force* the user to enter a number from 1 to 100

number = int(input("Enter a number from 1 and 100: "))
# Inclusive: we want numbers >= 1 but <= 100
while number < 0 or number > 100:
  number = int(input("That number won't work. Try again: "))

print("Okay, your number was", number)
```

Review this code on your own.
Don't hesitate to ask the TAs or the professor questions if you have any!

```python
# Example - Countdown timer
# 10-1 Blastoff
print("COUNTDOWN STARTING")
current_num = 10
while current_num > 0:
  print(current_num,'.......')
  current_num-=1
print('BLASTOFF!!!')


# Now create a function that counts down from a given number to 0.
# Show each number as the countdown happens, at 0 print "Blastoff!"
#
def countdown(seconds):
  # What condition should we use?
  while seconds > 0:  # This is better than using 'seconds != 0' Why?
     print(seconds)
     seconds-=1  # what if we used seconds+=1
  print("Blastoff!!!")

countdown(10)
print("Program Finished")
```

```python
# Example - Fizzbuzz
# Look at every number in a given range to see which are fizzbuzz numbers.
# if the number is divisible by 3, print 'fizz'
# if the number is divisible by 5, print 'buzz'
# if the number is divisible by both, print 'fizzbuzz'
#
def fizzbuzz(x):
  while x >= 0:  #
     print(x," ",end="") # print out each number as we count down
     if x % 3 == 0: # if the number is divible by 3
        print("fizz",end="") # don't go to a new line yet
     if x % 5 == 0:
        print("buzz",end="")
     print() # move the cursor to the next line
     x-=1 # What if we move this back to the left one indentation level?

fizzbuzz(30)
print("Program Finished")
```

Review this code on your own.
Don't hesitate to ask the TAs or the professor questions if you have any!

For-loops

We've Seen For-loops Before!

- We saw **for-loops** in the context of **Turtles**!
- We didn't formally cover for-loops, but we showed them in use, and all of you wrote code using them!
- Today we will cover for-loops more formally, so most of this section should be a review!

For-loops

- Define code that runs once for each thing in a collection

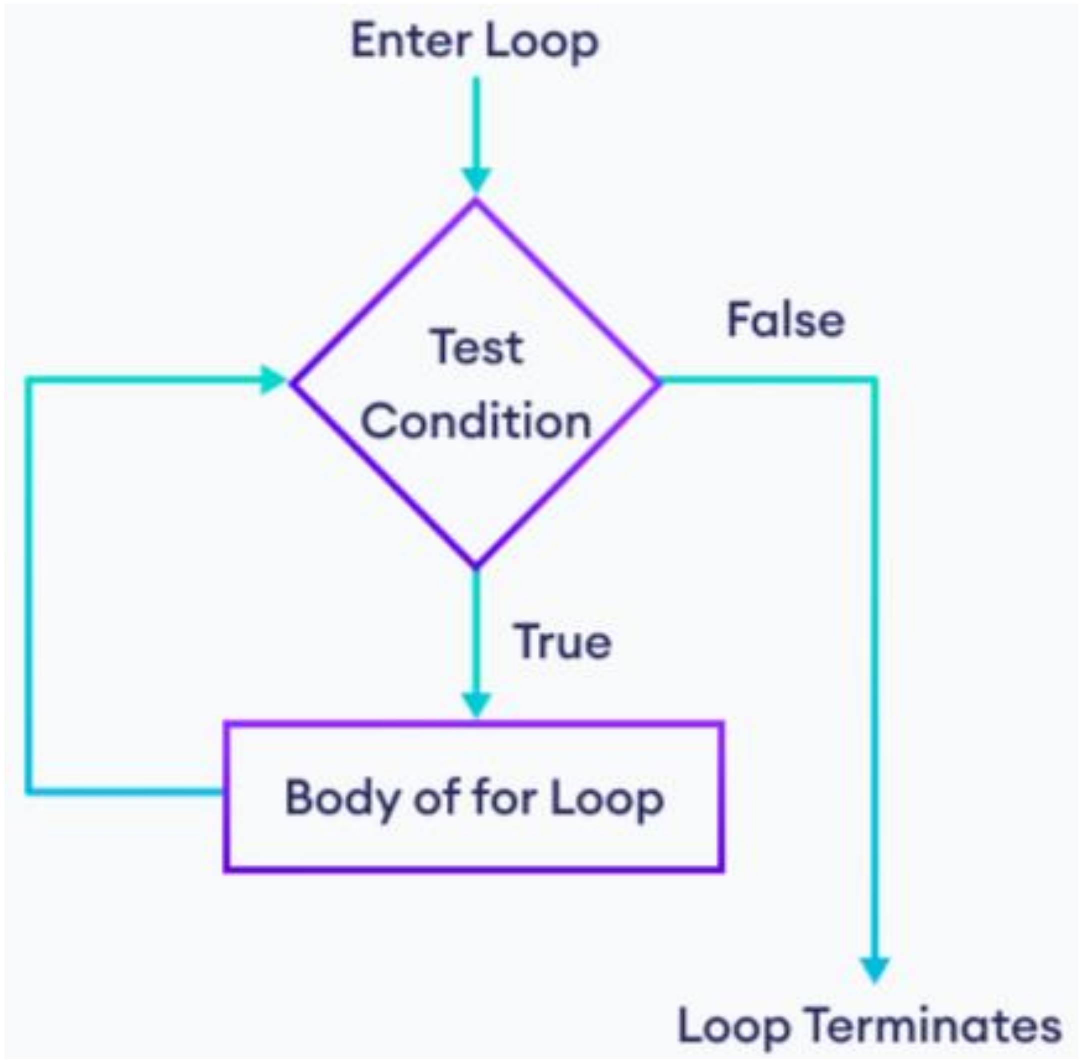
```
for <variable> in <collection>:
    statements
```

strings -
```
for each in "desk":
print(each)
```

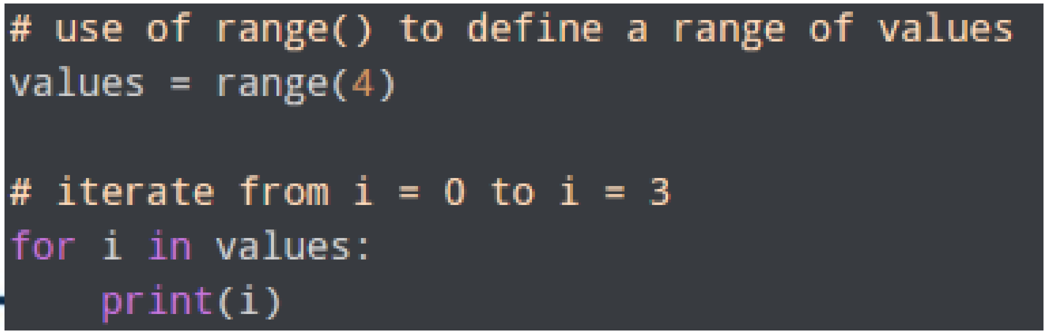
lists -
```
for item in ['apple','banana','orange’]:
print(item)
```

integers -
```
for i in range(5):
print(i, 'hi')
```

Flowchart of Python For-loop

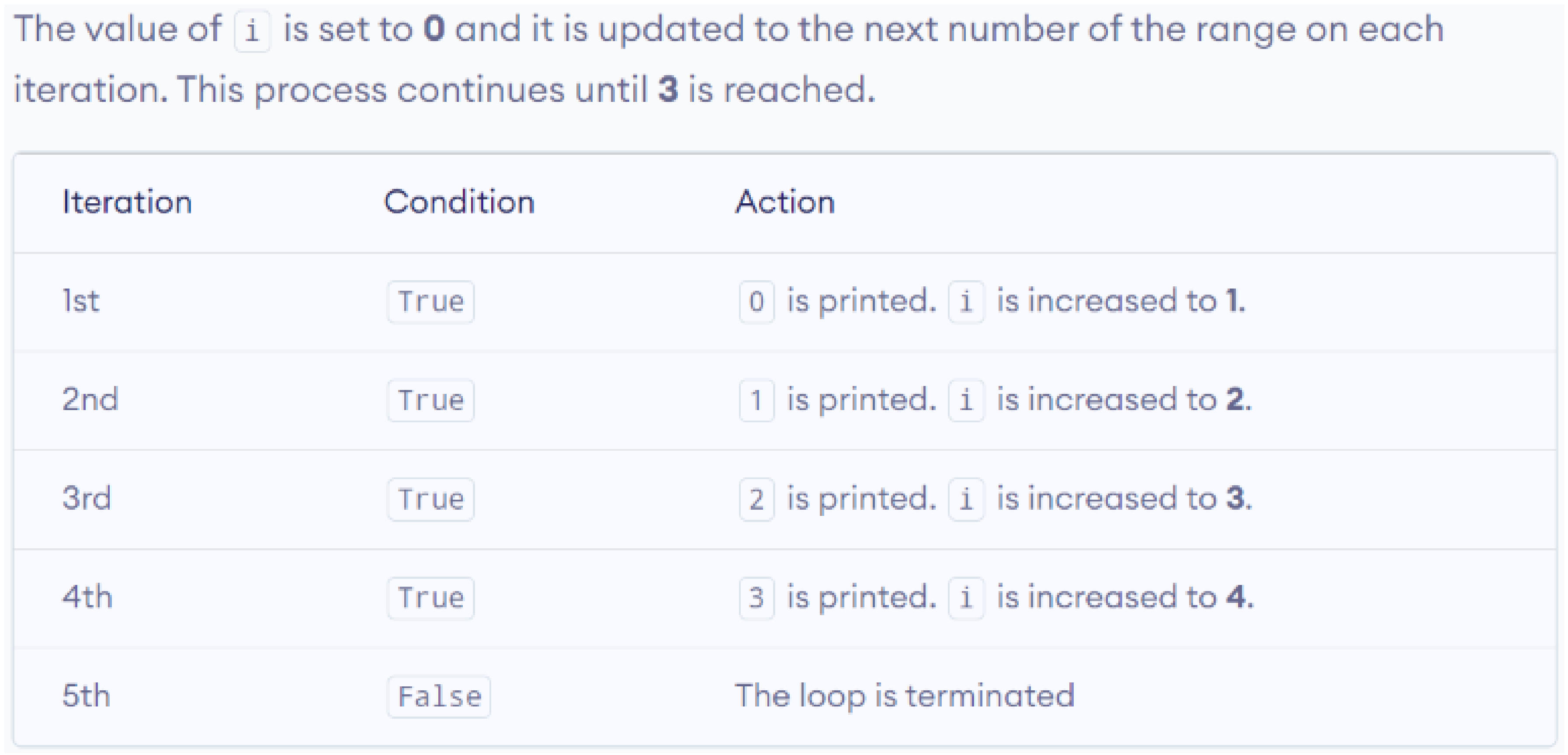


Worked Example: For-loop



```python
# use of range() to define a range of values
values = range(4)

# iterate from i = 0 to i = 3
for i in values:
    print(i)
```



The value of `i` is set to **0** and it is updated to the next number of the range on each iteration. This process continues until **3** is reached.

Iteration	Condition	Action
1st	`True`	`0` is printed. `i` is increased to **1**.
2nd	`True`	`1` is printed. `i` is increased to **2**.
3rd	`True`	`2` is printed. `i` is increased to **3**.
4th	`True`	`3` is printed. `i` is increased to **4**.
5th	`False`	The loop is terminated

Looping through integers - using the range() function

See Supplemental slides at the end of this presentation for additional information about for-loops and range()!

- `range(stop):`
  - Gives all integers from 0 (inclusive) to stop (exclusive)
  - range(5) -> 0, 1, 2, 3, 4
- `range(start, stop):`
  - Gives all integers from start (inclusive) to stop (exclusive)
  - range(2,6) -> 2, 3, 4, 5
  - start defaults to 0
- `range(start, stop, step):`
  - Gives all integers from start (inclusive) to stop (exclusive), but it takes only every step item
  - The 3rd argument is the step-size, or increment size. It defaults to 1 (increase by 1).

Note that `range(start, stop)` and `range(start, stop, step)` behave similarly to string slicing

Repetition with incrementing

```
total = 0
for count in range(5):
    total = total + count
print(total)
```

- This repeats the code inside the `for` loop body **five times**:
  - The first time through the loop, `count = 0`, total = 0
  - The second time through the loop, `count = 1`, total = 1
  - The third time through the loop, `count = 2`, total = 3
  - The fourth time through the loop, `count = 3`, total = 6
  - The fifth time through the loop, `count = 4`, total = 10
- We do *not* repeat the loop when `count = 5`

Let’s See What We Can Remember:
What is printed?

```
x = "123"

for i in x:

    print("a")
```

Let’s See What We Can Remember: --Answer:

```
x = "123"

for i in x:

    print("a")
```

```
a

a

a
```

Let’s See What We Can Remember:
What is printed?

```
x = "123"

for i in x:

    print()

print("a")
```

Let’s See What We Can Remember: --Answer:

```
x = "123"
for i in x:
    print()
print("a")
```

```
<blank line>
<blank line>
<blank line>
a
```

Let’s See What We Can Remember:
What is printed?

```
total = 0
for count in range(1,5):
    total += count
print(total)
```

Let’s See What We Can Remember: --Answer:

```
total = 0
for count in range(1,5):  # 1, 2, 3, 4
    total += count  # 1 + 2 + 3 + 4 = 10
print(total)
```

```
10
```

Let’s See What We Can Remember:
What is printed?

```
total = 0
for count in range(1,10):
    double = count * 2
    total = total + double
print(total)
```

Let’s See What We Can Remember:
--Answer:

```
total = 0
for count in range(1,10): #  1, 2, 3, 4, 5, 6, 7, 8, 9
    double = count * 2
    total = total + double # 2 + 4 + 6 + 8 + 10 + 12 + 14 + 16 + 18
print(total)
```

```
90
```

For-loop with Lists

```
dogs = ["stewart", "apollo", "bolt", "mitsy", "maggie"]
for name in dogs:
   print(name, type(name))
   go_to_vet(name) # Call the go_to_vet() function
print(“Program finished")
```

```
temperature = [83.4, 78.3, 87.2]
for current_temp in temperature:
   if current_temp > 80:
      print("It's hot", current_temp)
   else:
      print("It's only warm", current_temp)

print(temperature)
```

Accumulator pattern

- Idea: loop through some collection and "accumulate" some stuff
- Start with **nothing** (*initialize the accumulator variable*)
- **Repeat**:
-     Add to it (*modify the accumulator variable*)
- **Done**: the accumulator has all of your stuff

```
total = 0
for count in range(1,101):
    total = total + count
print(total)
```

```
vowels = ''
for letter in 'Guido is my hero':
  if letter in 'aeiou':
     vowels = vowels + letter
print(vowels)
```

"Accumulator" in a factory - *https://youtu.be/PFu70A_ZmHo?t=85*

Practice Problem: Average Rainfall

- You have several numbers representing daily rainfall over the course of several days
- Calculate the average daily rainfall
- A value of 0 means that no rain was recorded that day
- Note: On some days the sensors *failed* and recorded a negative number. **Don't** use those days as part of the average.

```
data = [0, 1.3, 2.2, -565, 0, 16, -2.1, 0, 2.1]
```

```python
# Rainfall problem:
#   - Given a list of values representing daily rainfall
#   - Calculate average daily rainfall
#   - Disregard negative values (faulty/incorrect data)

data = [0, 1.3, 2.2, -565, 0, 16, -2.1, 0, 2.1]
total_rainfall = 0
total_items = 0

for item in data:
  if item >= 0: # disregard negative values
      total_rainfall = total_rainfall + item
      total_items = total_items + 1

print(total_rainfall/total_items)
```

Comparison

☆Recap on Loops☆

`for` loops behave like blocks of statements that have been copied and pasted a certain number of times

```
for thing in collection:
  Do stuff (probably use thing)

thing = collection[0]
Do stuff (probably use thing)
thing = collection[1]
Do stuff (probably use thing)
thing = collection[2]
Do stuff (probably use thing)
```

`while` loops behave like lots of if statements

```
while boolean_expression:
  Do stuff (expression values should change)

if boolean_expression:
  Do stuff
if boolean_expression:
  Do stuff
if boolean_expression:
  Do stuff
```

When to use each kind of loop

For

- We know how many times we should repeat something
- We want to do something per each item in a collection

While

- We only know what should make us stop
- We want to continue doing something under certain circumstances

Python Demonstration

Let's jump on PyCharm!

`for_loops.py`

```
        mirror_mod.use_x = False
        mirror_mod.use_y = True
        mirror_mod.use_z = False
elif _operation == "MIRROR_Z":
        mirror_mod.use_x = False
        mirror_mod.use_y = False
        mirror_mod.use_z = True

        #selection at the end -add back the deselec
mirror_ob.select= 1
modifier_ob.select=1
bpy.context.scene.objects.active = modifier_ob
print("Selected" + str(modifier_ob)) # modifier
        #mirror_ob.select = 0
```

In-Class "lab" Activity!

Activity on Loops

- In pairs or groups up to three work on the following activity.
- **loops_ica.py**
- *Practice writing a solution that requires you to use a for-loop and a while-loop*

Remember to check-in with a TA before leaving class today!

Reminder: CS Laptop Loaner Program

- This course requires students to have a **laptop**
- I realize that not everybody might have one (nor necessarily need one for their desired major / path…)
- If you do not have a laptop for any reason… ***not to worry!***
- The CS department's Systems staff has a notebook / laptop loaner program and will be able to loan you a notebook / laptop computer for the duration of the semester if you don't have one or if you cannot afford one.
  - Also available if your laptop is broken and under repair, we can arrange for you to receive a loaner laptop for a week or two until your own laptop is fixed

Interested? Link: https://www.cs.virginia.edu/wiki/doku.php?id=cs_laptop_loaner

I am happy to be your sponsor. Please let me know.

Supplemental Slides

Looping through integers ~ some more information

Looping through integers - using the range() function

- `range(stop):`
  - Gives all integers from 0 (inclusive) to stop (exclusive)
  - range(5) -> 0, 1, 2, 3, 4
- `range(start, stop):`
  - Gives all integers from start (inclusive) to stop (exclusive)
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  - start defaults to 0
- `range(start, stop, step):`
  - Gives all integers from start (inclusive) to stop (exclusive), but it takes only every step item
  - The 3rd argument is the step-size, or increment size. It defaults to 1 (increase by 1).

Note that `range(start, stop)` and `range(start, stop, step)` behave similarly to string slicing

An example of range(y, x, z)

- range(4, 8, 2)

- We start at 4, 4 < 8, so we add it

An example of range(y, x, z)

- range(4, 8, 2)

- 4

- We start at 4, 4 < 8, so we add it

An example of range(y, x, z)

- range(4, 8, 2)

- 4

- We start at 4, 4 < 8, so we add it
- 4 + 2 = 6, 6 < 8 so we add it

An example of range(y, x, z)

- range(4, 8, 2)
- 4, 6
- We start at 4, 4 < 8, so we add it
- 4 + 2 = 6, 6 < 8 so we add it

An example of range(y, x, z)

- range(4, 8, 2)

- 4, 6

- We start at 4, 4 < 8, so we add it
- 4 + 2 = 6, 6 < 8 so we add it
- 6 + 2 = 8, 8 is not < 8 so we don’t add it and stop (since the end is *exclusive*)

Repetition using range()

```
for x in range(0, 5):
    print(x)
```

- This repeats the code inside the **`for`** loop body **five times**:
  - The first time through the loop, `x = 0`
  - The second time through the loop, `x = 1`
  - The third time through the loop, `x = 2`
  - The fourth time through the loop, `x = 3`
  - The fifth time through the loop, `x = 4`
- We do *not* repeat the loop when `x = 5`

More on range()

```
# The range function works like this:
range(start=0,stop,step=1)

for a in range(5):  # 0,1,2,3,4
for b in range(1,5): # 1,2,3,4
for c in range(0,5,2) # 0,2,4
for d in range(10,-1,-1): # [10,9,8,7,6,5,4,3,2,1,0]

for e in range(-7):  # []
```

More on range()

```
# count up
for i in range(7): # calling range with one argument
   print(i)

for i in range(1276, 8512): # range with two arguments
   print(i)
```

Augmented Assignment Operators

Can be used to shorten the form of some basic math statements

- Only when the variable that is being assigned is also part of the expression on the right, i.e. -
  - `x = x + 1`
  - `num1 = num1 * num2`
- The variable name does not need to be repeated if one of these operators is used -
  - `+=    -=    *=    /=    %=    **=    //=`
- Examples of use -
  - `a += 1   # a = a + 1`
  - `b -= 2   # b = b - 2`
  - `c *= 5   # c = c * 5`
  - `d /= 2   # d = d / 2`
- These operators are also sometimes called “update operators”
- Notice that the variable must have a value first before using it with one of these operators

Q1: What numbers are printed?

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

Q1: What numbers are printed?

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

```
0
1
2
3
4
```

Q2: What numbers are printed?

```
for x in range(5, 2):
    print(x)
```

Q2: What numbers are printed?

```
for x in range(5, 2):
    print(x)
```

```
<nothing>
```

Q3: What numbers are printed?

```
for j in range(2, 5):
    print(j)
```

Q3: What numbers are printed?

```
for j in range(2, 5):
    print(j)
```

```
2
3
4
```

Q4: What numbers are printed?

```
for i in range(6, 2, -2):
    print(i)
```

Q4: What numbers are printed?

```python
for i in range(6, 2, -2):
    print(i)
```

```
6
4
```

Q5: What is the value of y?

```python
y = 3
for x in range(3):
    y *= 2
print(y)
```

Q5: What is the value of y?

```python
y = 3
for x in range(3):
    y *= 2
print(y)
```

```
24
```

Repetition with incrementing

```
total = 0
for count in range(5):
    total = total + count
print(total)
```

- This repeats the code inside the `for` loop body **five times**:
  - The first time through the loop, `count = 0`, total = 0
  - The second time through the loop, `count = 1`, total = 1
  - The third time through the loop, `count = 2`, total = 3
  - The fourth time through the loop, `count = 3`, total = 6
  - The fifth time through the loop, `count = 4`, total = 10
- We do *not* repeat the loop when `count = 5`