Introduction to:
Computers & Programming:
Loops in Python

Adam Meyers
New York University
Outline

• What is a Loop?
• While Loops
• For Loops
• Examples
• Nested Loops
What is a Loop?

- Loops are control structures
  - A block of code repeats
  - The extent of the repetition is usually limited in some way

- Two kinds of Loops in Python
  - `while` loops
    - The evaluation of a boolean expression determines when the repetition stops
    - Changes in values of variables lead to different evaluations of the boolean expression on each repetition
    - When the expression is evaluated as `False`, the loop halts
    - If the expression can never evaluate as `False`, the loop is endless
  
  - `for` loops
    - The length of a “sequence” determines how many times the body executes
      - A sequence is an object that is made up of other objects (arranged in an order), e.g., a string is a sequence of characters: “duck” = “d”, “u”, “c”, “k”.
    - The loop uses one member of the sequence at a time, ending with the last one
An Endless Loop: keeping time

• Example

```python
def endless_timer():
    import time
    now = 0
    while True:
        time.sleep(1)
        now = now + 1
        print(now)
```

• This loop will keep counting seconds until stopped with a Control-C
What is a `while` Loop?

- A while loop consists of:
  - The word `while`
  - A boolean expression (**True** on the last slide)
  - A colon :
  - The body: an indented block of instructions

- The body of the loop repeats
  - until the boolean expression is False

- The loop on the previous slide is endless
  - because **True** does not change in value
  - And **True** does not equal **False**.

- Any program can be stopped using Control-C
A “normal” while Loop

• Normal loops iterate until some condition is True (endless loops are unusual)

```python
def timer(total_seconds):
    import time
    now = 0
    while (now < total_seconds):
        time.sleep(1)
        now = now + 1
        print(now)
```

• If we call `timer` with 5 as an argument
  – The variable `now` is initialized to 0
  – The loop iterates 5 times
  – Each time: a second passes, 1 is added to now and now is printed
  – In this way, 1 to 5 is printed over 5 seconds

• How many times would a loop beginning while False: repeat?
Loops for Guiding User Input

- def get_yes_or_no_answer():
  
  ## User must respond “yes” or “no”
  output = 'initial_input' # initialize the variable output
  output = output.lower() # convert to lowercase
  while(not ((output == 'yes') or (output == 'no'))):
    if output != 'initial_input':
      print('Invalid Input!')
    output=(input("Please respond: 'yes' or 'no'"))
    output = output.lower() # convert to lowercase
  if output=='yes':
    return(True)
  elif output=='no':
    return(False)

- def get_integer_from_user():
  
  ## User must respond with a single digit
  output = 'initial_input' # initialize variable output
  while (not (output in '0123456789')):
    if output != 'initial_input':
      print('Invalid Input!')
    output = input('choose an integer. ') # convert to lowercase
  return(output)
A sample `for` loop

- This function simulates a 60 second timer

```python
def one_minute_timer ():
    print(0)
    for second in range(60):
        time.sleep(1)
        print(second + 1)
```

- The function prints 0, then enters a `for` loop
  - The loop iterates through a list of numbers from 0 to 59
    - The variable `second` is assigned that number as a value
    - The system waits one second
    - The system prints `second + 1`
The range function

- **range** takes three arguments:
  - *START*: An optional 1st argument (starts at START)
  - *MAXIMUM*: A required 2nd argument (ends before MAXIMUM)
  - *INCREMENT*: An optional 3rd argument

- When left out, START defaults to 0
- When left out, INCREMENT defaults to 1
- creates a sequence of numbers from *START* to *MAXIMUM-1* such that consecutive items in the sequence differ by *INCREMENT*

- Examples:
  - *range(5) → [0,1,2,3,4]*
  - *range(2,5) → [2,3,4]*
  - *range(0,10,2) → [0,2,4,6,8]*
  - *range(10,2,-2) → [10,8,6,4]*

  - if negative increment, numbers count down
  - range still ends at 1 less than max
Looping Through a Range

• def factorial(number):
  total = 1  ## example of accumulator variable
  for num in range(1,number+1):
    total=total*num
  return(total)
Looping through String

• `def accum_spaces_and_add_stars(word):
  output = ' * ' ## also an accumulator variable
  for letter in string:
    output = output+letter+' '
  output = output+' *'
  return(output)"
The **for** loop

- The first line – *for variable in sequence:*
  - *for* and *in* are keywords
  - *variable* can be any legal variable name
  - *sequence* is an ordered set of items
    - Python sequences includes data types like: *range, list, string, …*
- The body of the loop repeats once for each item in the sequence
- On each iteration, the variable is bound to the next item in the sequence
- Examples:
  - *for character in 'multi-character':*
    - `print(character)`
  - *for number in range(5):*
    - `print(number)`
Looping Through a String

- **Using a `for` loop**
  ```python
def for_string_loop (string):
    for letter in string:
      print(letter)
  
  for_string_loop('Downward')
```

- **Using a `while` loop**
  ```python
def while_string_loop (string):
    position = 0  ## counter
    while(position < len(string)):
      print(string[position])
      position = 1 + position
  ```
Lengths and elements of Sequences

- The function `len` returns a sequence's length
  - The number of characters – `len('Downward')`
  - The number of integers in a range – `len(range(60))`
- Elements in a sequence can be identified by their position, beginning with 0 and ending in one less than the length.
  - 'Downward'[0], range(5,10)[0]
  - 'Downward'[7], range(5,10)[4]
  - 'Downward'[8], range(5,10)[5] --- these are errors
- The number in square brackets refers positions around items in sequences
  - Example: 'cat' consists of 3 letters
    - starts at position 0 and ends at position 3
    - `c a t`
    - `cat[2] → 't'` --- because 't' starts at position 2
**for loops vs. while loops**

- With some code modification, it is always possible to replace a *for* loop with a *while* loop, but not the other way around.

- *for* loops are used for situations where you know the number of iterations ahead of time.
  - e.g., looping through sequences.

- There is no significant efficiency difference.

- The difference relates to ease in which humans can read/write code.
Simple Examples of Nested Loops

• What do you expect to be returned from the following loop within a loop?
  – def print_1_to_4_by_a_to_d():
    for number in [1,2,3,4]:
      for letter in 'abcd':
        print(number,letter)

• Function based on above example
  – def print_two_item_combinations(seq1,seq2):
    for item1 in seq1:
      for item2 in seq2:
        print(item1,item2)

• Notice that embedded loops are indented under higher loops
Example: Printing a Multiplication table

• def multiplication_table (high_num):
  for num1 in range(1, 1+high_num):
    for num2 in range(1, 1+high_num):
      print(num1,'X',num2, '==', num1*num2)

• How does this work?
**break**: causes a loop to exit

- keep counting while num is less than 10
  ```python
def count_to_ten_with_while():
    num = 0
    while num < 10:
        num = num + 1
        print(num)
  ```
- Equivalently, break out of loop when num equals 10
  ```python
def count_to_ten_with_break():
    num = 0
    while True:
        if num >= 10:
            break
        num = num + 1
        print(num)
  ```
pass and continue

• **pass** does nothing
  
  – def print_every_other_number(max):
    for num in range(1,max+1):
      if num%2==0:
        pass
      else:
        print(num)

• **continue** skips to next iteration of loop
  
  – def skip_every_fifth_number(max):
    for num in range(1,max+1):
      if num%5==0:
        continue
      print(num)
A Few More Details About “print”

- print takes 2 optional arguments:
  - sep='*' – prints asterisk between arguments
    - Default: prints spaces between arguments
  - end='$' – prints dollar sign at the end of line
    - Default – prints newline character at end of line

- def test1():
  print('New','York','University',sep='*',end='$')
  print('Blah','Blah','Blah',sep='*',end='$')

- def test2():
  print('New','York','University')
  print('Blah','Blah','Blah')
Example: Drawing an asterisk triangle

• def draw_n_asterisks(n):
    for current_length in range(n):
        print('*', end='')
    – Printing nothing (the empty string) at the end of each line, instead of the newline character

• def asterisk_triangle(base_size):
    for current_length in range(1, base_size+1):
        draw_n_asterisks(current_length)
    print()
Drawing an asterisk triangle 2

• Nested Loops – a single function

```python
def asterisk_triangle2(base_size):
    for current_length in range(1, base_size+1):
        for n in range(current_length):
            print('*', end='')
        print()
```

• Python indicates depth of nesting via indentation
  – Suppose the last line was indented once
Sample Problem for Class

• Write a function that:
  – Takes three arguments:
    • base_size
    • repetitions
    • hour_glass_or_diamond
  – This function makes a pattern of asterisks that repeats the number of times indicated by repetitions
  – Each cycle consists of two triangles, one the upside down version of each other, both of which have a base of size base_size
  – If hour_glass_or_diamond is in the 'hour glass' setting, the function draws an upside down triangle and then a right side up triangle
  – If hour_glass_or_diamond is in the 'diamond' setting, the function draws the right side up triangle first and the upside down one second
Summary

• Loops provide a way to repeat blocks of instructions
• While loops are the most general
  – They require a condition for exiting the loop
    • If the condition is never false, the loop is endless
• For loops provide a simple way of repeating a block
  – once for each element in a sequence
  – or a fixed number of times
• A For loop can always be replaced by an equivalent While loop
• It is often useful to have nested loops (loops within loops)
Homework

• Go to HW part of website:
  – http://cs.nyu.edu/courses/fall17/CSCI-UA.0002-007/#Homework%20Schedule
  – http://cs.nyu.edu/courses/fall17/CSCI-UA.0002-011/#Homework%20Schedule
  – See Homework due October 4
    • Modules/readings before class
    • Written assignment at midnight