Introduction to:
Computers & Programming:
Loops in Python

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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 boolean expression is never False.
  - Any program can be stopped using Control-C
What is a **while** Loop? 2

- A loop that iterates a limited number of times
  ```python
def seconds_stop_watch (total_seconds):
    import time
    now = 0
    while (now < total_seconds):
        time.sleep(1)
        now = now + 1
        print(now)
  ```
- If we call `seconds_stop_watch` 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 getting the Right Input

• Suppose you want to make sure that the user responds 'yes' or 'no'

```python
def get_yes_or_no_answer():
    output = 'initial_input'  # initialize the variable output
    while(not ((output == 'yes') or (output == 'no'))):
        if output != 'initial_input':
            print('Invalid Input!')
        output=(input("Please respond: 'yes' or 'no')")
    if output=='yes':
        return(True)
    elif output=='no':
        return(False)
```

• Suppose you want to make sure the user enters a one digit integer.

```python
def get_integer_from_user():
    output = 'initial_input'  # initialize variable output
    while (not (output in '0123456789')):
        if output != 'initial_input':
            print('Invalid Input!')
        output = input("choose an integer. ")
    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
Indents in Embedded Loops

• The indent determines which loop a statement is in. Try moving the statement \texttt{print()}

• def print_looped_pattern(char1,num1,char2,num2,char3,num3):
  for n1 in range(num1):
    print(char1,end='')
  for n2 in range(num2):
    print(char2,end='')
  for n3 in range(num3):
    print(char3,end='')
  print()

• print_looped_pattern('A',4,'B',8,'C',4)
The range function

- `range` takes three arguments:
  - `START`: An optional 1st argument
  - `MAXIMUM`: A required 2nd argument
  - `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(10,2,-2) → [10,8,6,4]`
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 = '* '
  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':**
    
    ```python
    print(character)
    ```
  – **for number in range(5):**
    
    ```python
    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))`
  – Etc.

• Elements in a range 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
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)`
A Few More Details About “print”

• print takes 2 optional arguments
• optional arguments have default values
• def testPrintDefaults(val1, val2=' ', val3='\n'):
  
  print('Using print defaults:','end='')
  print('A', val1, 'B', val2, val3)
  print('Done')

  print('Using nondefaults sep and end:','end='')
  print('A', val1, 'B', sep=val2, end=val3)
  print('Done')
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?
Example: Drawing an asterisk triangle

• def draw_n_asterisks(n):
    for current_length in range(n):
        print('*',end='')

    – print can take a named argument
      • End='' indicates what to print at the end of the string
        – the character in between the single quotes
      • In this case, nothing
      • The default is a 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

• Read Chapter 5
• Do E-learning Modules 5 and 6 (due 1 week apart)
  – http://cs.nyu.edu/elearning/CSCI_UA_0002/module05.php
  – http://cs.nyu.edu/elearning/CSCI_UA_0002/module06.php
• Do Quizzes 5 and 6 in NYUClasses (due 1 week apart)
• Write function that will make a rectangle consisting of any character:
  – Make_character_rectangle(height, width, char)
    • Should make \textbf{height} rows of \textbf{width} instances of \textbf{char}
• Write a function that makes a parallelogram of characters:
  – Make_character_parallelogram(height, width, char)
    • The loop should add height-N spaces to the beginning of each line, where N
      starts out at 1 (the first line) and ends with height (the last line). Thus the
      parallelogram leans right, but touches the left margin.
• Write a timer that prints out every one tenth of a second
  – It should use the format: Hours:Minutes:Seconds.fraction
  – For example, 00:00:00.0, 00:00:00.1, 00:00:00.2, etc.