Strings

Kelly M. Thayer

Week 6 Lecture 5

2017-02-28

Contact info:
kthayer@wesleyan.edu
Office Hours: M 8:30-10:30 AM, T 10:10-11:15 AM, W 5:00-6:00 PM
Office: Exley 322/325

Announcements

- Upcoming Exam: **Tuesday March 7, 2016**
  - Administered during normal lecture time
  - No computers; paper based.
  - Please bring a pen or pencil
  - No cell phone use (including calculator)
  - Format: Multiple choice, short answer, long open ended problem solving
- If you require accommodations, please coordinate with your instructor
- This week's HW on strings will be accepted until Thursday (instead of Tuesday) due to the exam
- Report to labs March 8 (Wed) & 9 (Thurs) as usual

Learning Objectives

- Recall information on strings from previous lectures
- Use built in string functions on strings
- Use the index operator on strings
- Use the slice operator to extract substrings
- Iterate over strings using while loops
- Compare strings
- Use the `in` operator to search for a substring within a string
- Write for loops to iterate over a string
- Combine new string skills with flow control and functions to write programs

Strings: A Quick Review

String Skills So Far

- Print

```
>>> print ("Welcome to the Land O'Lakes!")
Welcome to the Land O'Lakes!
```

- **String** – a sequence of characters

- Input

```
>>> big_lake = input("Which of the five US Great Lakes it the largest?\n")
Which of the five US Great Lakes it the largest?
Superior
>>> big_lake
'Superior'
```

- Convert numeric values to strings

```
>>> nlake = input('How many Great Lakes are fresh water lakes?\n')
How many Great Lakes are fresh water lakes?
5
>>> print('There are ', str(nlake), 'fresh water Great Lakes')
There are  5 fresh water Great Lakes


>>> depth_km = input ("L. Michigan's max depth is 281m. How many km?\n")
L. Michigan's max depth is 281m. How many km?
0.281
>>> print("Lake Michigan's max depth is 281m, which is ", str(depth_km),"km.")
Lake Michigan's max depth is 281m, which is  0.281 km.
```

String Skills So Far, Cont'd

- Concatenate using +

```
'Green Bay Packers '
>>> team = 'Green ' + 'Bay ' + 'Packers'
>>> team
'Green Bay Packers'
```

- Repeat using *

```
>>> cheer = (team + '!')*3
>>> cheer
'Green Bay Packers!Green Bay Packers!Green Bay Packers!'
```

- Compare for equality using ==

```
>>> 'Green Bay Packers' == 'New England Patriots'
False
```

Built ins Pertaining to Strings

Length Function

- The length function returns the number of characters in a string
- Spaces and punctuation ***do*** count as characters
- The length of the empty string is 0

Syntax:

`len(<str>)`

Examples:

```
>>> len('12345')
5
>>> len('1, 2, 3!') # 3 numeric + 3 punctuation + 2 spaces
8
>>> len('') # empty string
0
```

String Methods: Syntax

Syntax:
<variable>.<string_function>() # method notation

Example:

```
>>> s = 'Huron'
>>> s.upper()
'HURON'
```

- s is the string 'Huron'
- **upper** is a function included in the **string** import.
- This function returns the input string s in upper case letters

String Methods:
Useful Methods Available

isdigit returns True if all characters of a nonempty string are numerical characters

```
>>> '123'.isdigit()
True
>>> 'abc'.isdigit()
False
```

isalpha returns True if all characters of a nonempty string are alphabetic characters

```
>>> '123'.isalpha()
False
>>> 'abc'.isalpha()
True
```

islower returns True if all alphabetic characters are lower case

```
>>> 'abc'.islower()
True
>>> 'AbC'.islower()
False
```

issuper returns True if all alphabetic characters are lower case

```
>>> 'ABC'.isupper()
True
>>> 'Abe'.isupper()
False
```

String Methods:
More Useful Methods Available

upper returns the alphabetic characters in the string in upper case

```
>>> 'chicago'.upper()
'CHICAGO'
>>> 'Route66'.upper()
'ROUTE66'
```

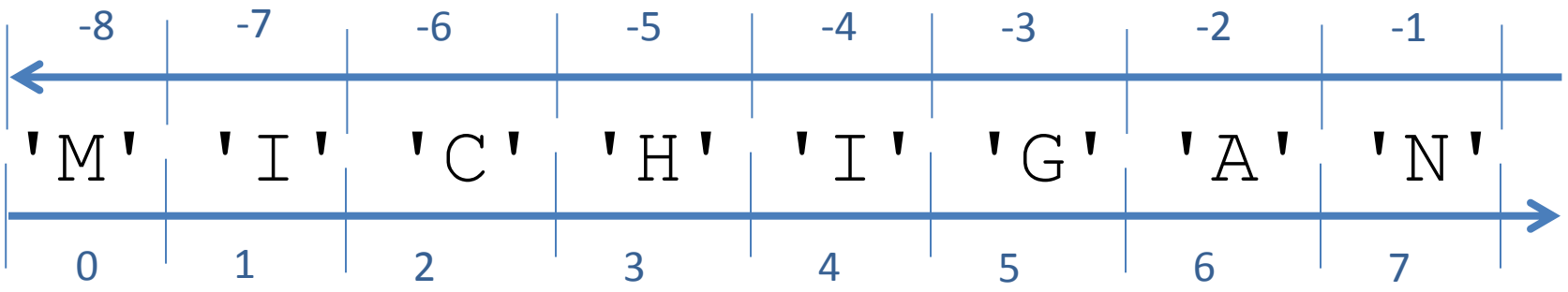
lower returns alphabetic characters in lower case

```
>>> 'E E Cummings wrote 2900 poems'.lower()
'e e cummings wrote 2900 poems'
```

String Indexing

String Indexing

- The **index operator** looks up characters in a string
- The index operator is the square brackets [ ]
- An index is used to specify which character(s) in the string to extract
- Indices may be positive, negative, or zero
- A string can be considered by its characters and they can be indexed in the forward (positive) or backward (negative) orientation
- Indices ≥ 0 begin at the left and tell the offset from that point
- Indices < 0 indicate offsets from the right end of the string
- Forward indexing begins with 0 and runs up to len-1

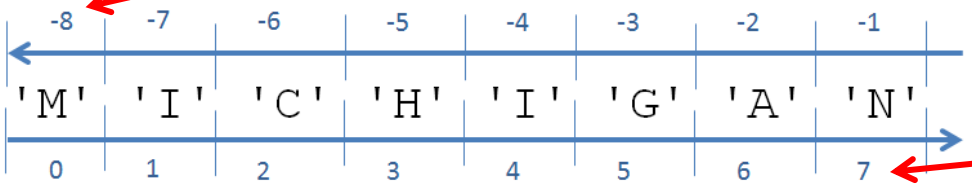


String Indexing: Syntax and Examples

- Syntax:
- <string> [<index>]

down to negative of length

Examples:



up to the length minus 1

```
>>> 'MICHIGAN'[0]
'M'
>>> 'MICHIGAN'[1]
'I'
>>> 'MICHIGAN'[2]
'C'
>>> 'MICHIGAN'[3]
'H'
>>> 'MICHIGAN'[4]
'I'
>>> 'MICHIGAN'[5]
'G'
>>> 'MICHIGAN'[6]
'A'
>>> 'MICHIGAN'[7]
'N'
```

```
>>> 'MICHIGAN'[-8]
'M'
>>> 'MICHIGAN'[-7]
'I'
>>> 'MICHIGAN'[-6]
'C'
>>> 'MICHIGAN'[-5]
'H'
>>> 'MICHIGAN'[-4]
'I'
>>> 'MICHIGAN'[-3]
'G'
>>> 'MICHIGAN'[-2]
'A'
>>> 'MICHIGAN'[-1]
'N'
```

Each position within the string can be called in two ways, using either the forward or reverse system

String Indexing: Exercise

Decode the answer to the question using the indicated indices.

```
s1='SUPERIOR'
s2='MICHIGAN'
s3='ONTARIO'
s4='HURON'
s5='ERIE'
s6='LAKE'
```

What animal was used to haul barges along the Erie Canal?
s2[0]
s4[1]
s6[-4]
s5[-1]

String Indexing: Exercise

Decode the answer to the question using the indicated indices.

```
s1='SUPERIOR'
s2='MICHIGAN'
s3='ONTARIO'
s4='HURON'
s5='ERIE'
s6='LAKE'
```

The name of strings is often given as s as a convenient convention. Here we just number them.

What animal was used to haul barges along the Erie Canal? MULE

```
>>> s2[0]
'M'
>>> s4[1]
'U'
>>> s6[-4]
'L'
>>> s5[-1]
'E'
```

Index Bounds

- Thus we see that in order to be a valid index for a string `s`:

- A non-negative integer i must satisfy

  0 ≤ **`i`** and **`i`** < **`len`**(s)

```
>>> s='ERIE'
>>> s[0]
'E'
>>> s[3]
'E'
>>> s[4]
Traceback (most recent call last):
  File "<pyshell#64>", line 1, in <module>
    s[4]
IndexError: string index out of range
```

- A negative integer j must satisfy

  - **`len`**(s) ≤ **`j`** and **`j`** < 0

```
>>> s2='HURON'
>>> s2[-1]
'N'
>>> s2[-5]
'H'
>>> s2[-6]
Traceback (most recent call last):
  File "<pyshell#69>", line 1, in <module>
    s2[-6]
IndexError: string index out of range
```

Substrings: The Slice Operator

String Slicing

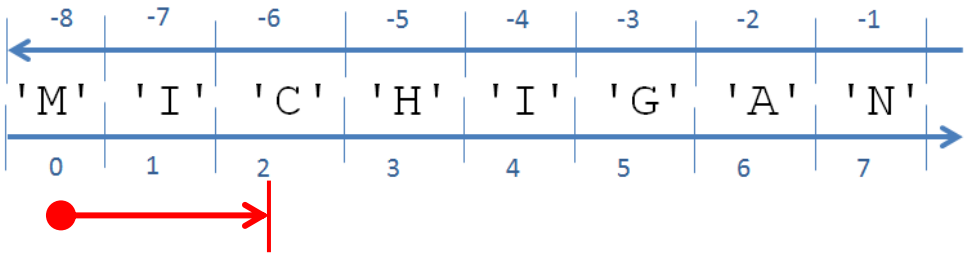
- Specifying a range to select more than one character is possible
- **slice operator -** returns the **substring** of a string between two indices
- The slice operator is **[:]**
- Use the colon to separate the start and stop indices
- The slice begins inclusive of the lower index
- The slice goes up to, but does not include, the upper index

Syntax:

<string> [<start_index> : <stop_index>]

Example:

```
>>> s = 'MICHIGAN'
>>> s[0:2]
'MI'
```



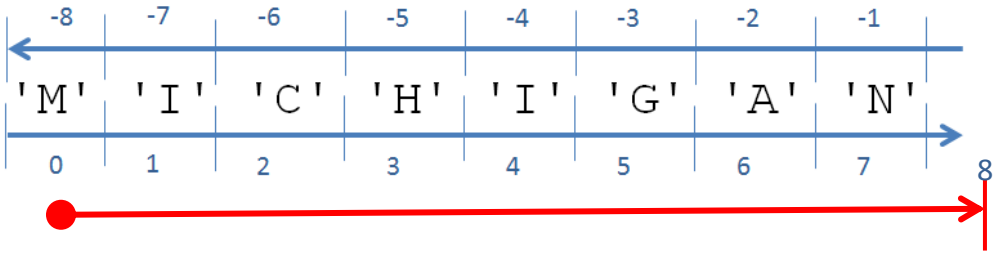
s[0:2] includes position 0 and goes up to but excludes position 2

String Slicing: Some Examples

```
>>> s = 'MICHIGAN'
```

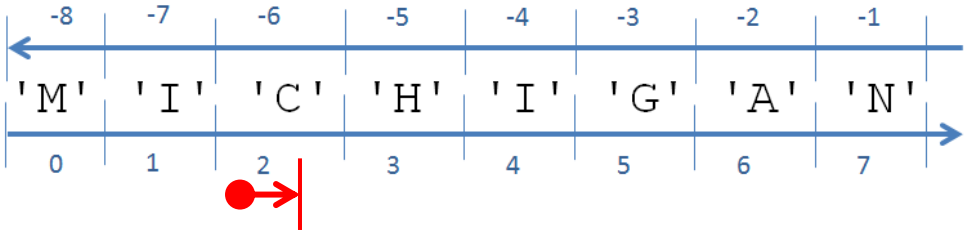
s[0:len(s)] specifies the trivial case of the whole string

```
>>> s[0:len(s)]
'MICHIGAN'
>>> s[0:8]
'MICHIGAN'
```



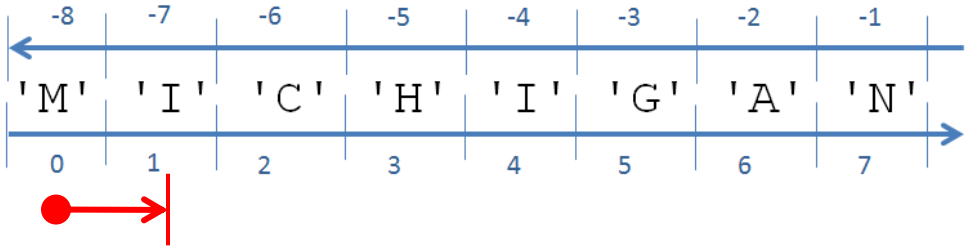
if the start index is equal to the stop index, then the substring will be empty

```
>>> s[2:2]
''
```



if stop_index = start_index+1, then :
s[<start_index> : <stop_index>] == s[<start_index>]

```
>>> s[0:1]   # Slicing operator
'M'
>>> s[0]     # Indexing operator
'M'
```

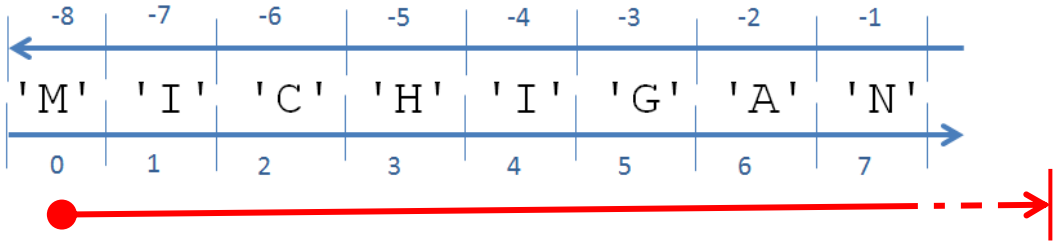


String Slicing: Some Examples

```
>>> s = 'MICHIGAN'
```

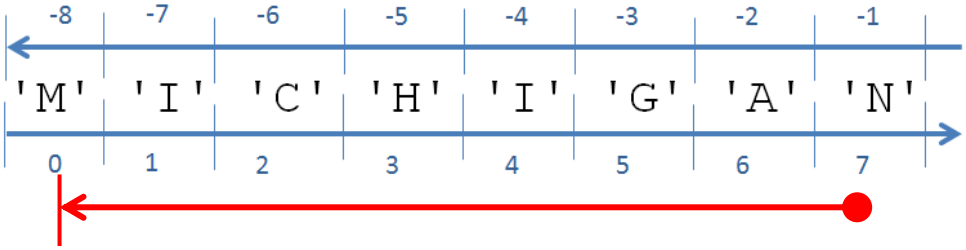
slicing beyond the length of the string adds nothing to the resulting string

```
>>> s[0:100]
'MICHIGAN'
```



if the start index is further right than the stop index, the empty string is returned

```
>>> s[7:0]
''
```

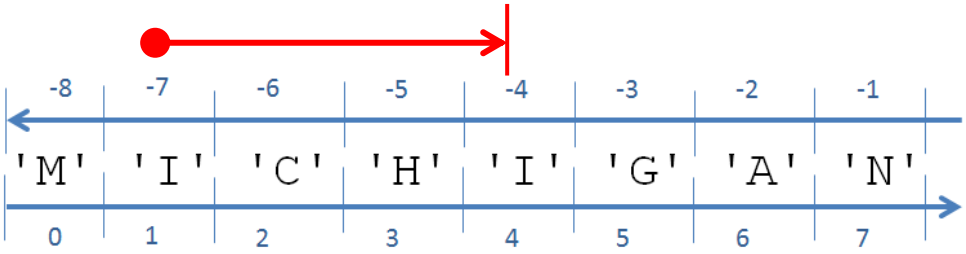


String Slicing: Some More Examples

```
>>> s = 'MICHIGAN'
```

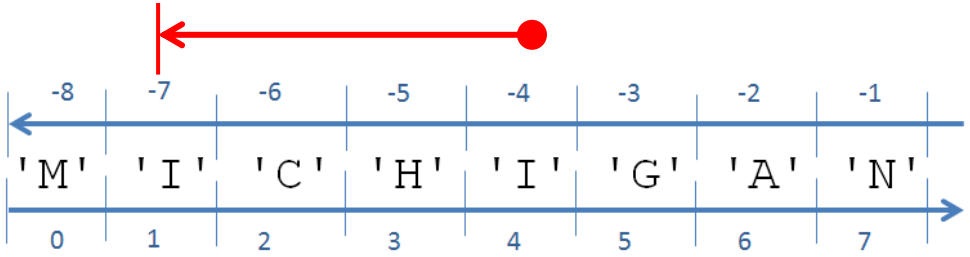
Negative indices can be used

```
>>> s[-7:-4]
'ICH'
```



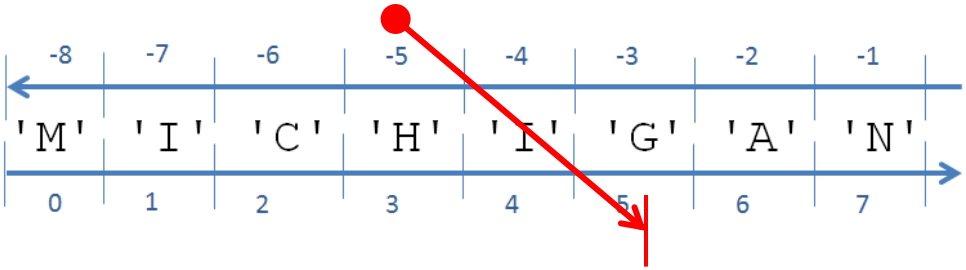
if the start index is further right than the stop index, the empty string isreturned

```
>>> s[-4:-7]
''
```



positive and negative indices can be mixed

```
>>> s[-5:5]
'HI'
```

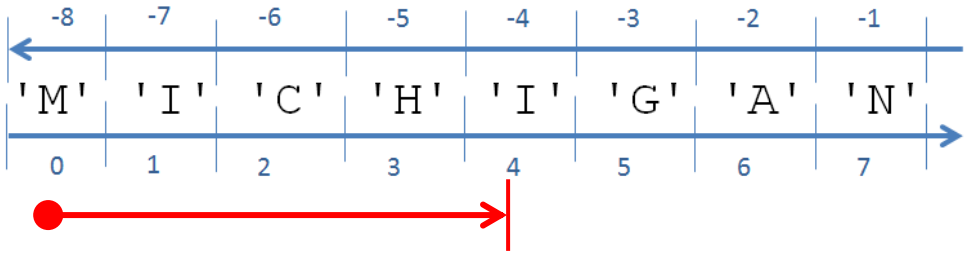


String Slicing: Implied Indices

```
>>> s = 'MICHIGAN'
```

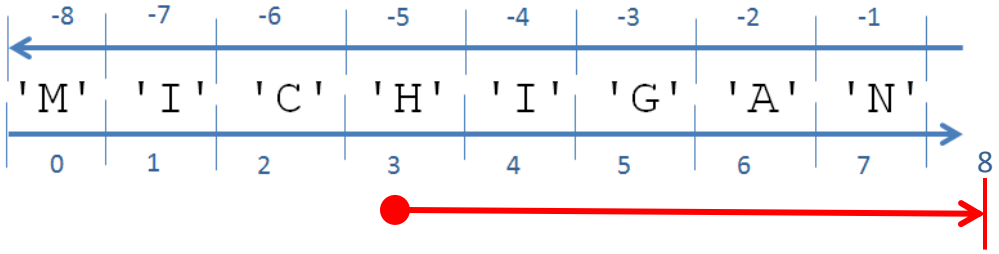
If the start index is omitted, python begins at the beginning of the string

```
>>> s[:4]
'MICH'
```



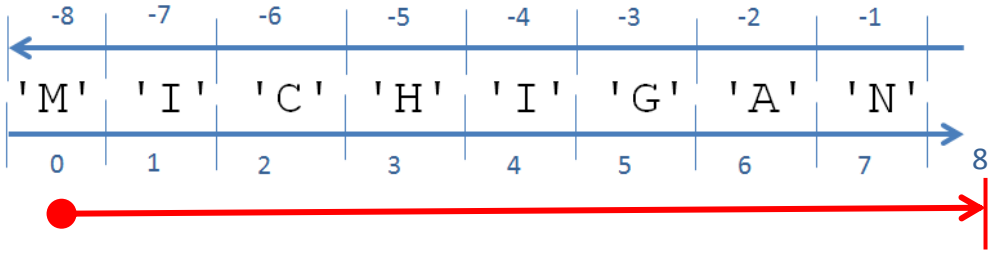
If the stop index is omitted, python ends at the end of the string

```
>>> s[3:]
'HIGAN'
```



If neither indices are specified, then the substring equals the string

```
>>> s[:]
'MICHIGAN'
```



Iteration over Strings

String Processing

- One can combine iteration with indexing to process a string
- Use a **`while`** loop

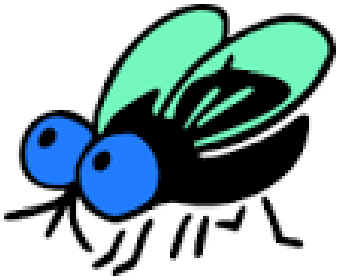
```
# string processing

def loop_my_string(s):
    # signature: str -> NoneType
    # prints each character of the string

    i = 0 # initialization of the counter
    while i < len(s):
        print(s[i])
        i += 1 # augmented assignment
    return
```

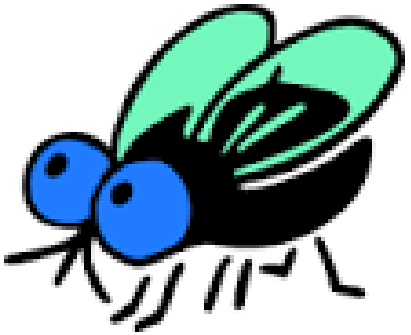
```
===== RESTART: F:/09_Python_course  S17/01_Lecture/lecture_05_Strings.py =====
>>> loop_my_string('abc')
a
b
c
```

String Processing
Spot the bugs!



```
def count_s_bug(river):
    # signature: str -> int
    # counts times letter s appears
    # this version has bugs!
    i = 1
    counts = 0

    while i < len(river):
        if river[i] == 's':
            counts += 1
    return counts
```



- What will the output be? Test with ‘Mississippi’
- How can this be remedied?
- What can you do to help you debug the code?

String Processing: Working Example

Index of strings starts at 0 and not 1

Index also needs to be incremented

```
def count_s(river):
    # signature: str -> int
    # counts times letter s appears
    i = 0 # count for the loop
    counts = 0 # counter for number of s

    while i < len(river):
        if river[i] == 's':
            counts += 1
        i += 1
    return counts
```

```
===== RESTART: F:/09_Python_course  S17/01_Lecture/lecture_05_Strings.py =====

>>> count_s("Mississippi")
4
```

String Comparisons

String Comparisons

- The **comparison operators** <, <=, >, >=, ==, and != are overloaded to compare strings
  - Within the same case, they are compared in alphabetical order
  - The set of upper case letters comes before the set of lower case letters

  ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz

Examples:

```
# Being 'less than' means 'comes before'
>>> 'a'<'b'
True
```

'a' comes before 'b'

```
# Being 'greater than' means 'comes after'
>>> 'Z'>'Y'
True
```

'Z' comes after 'Y'

```
# Upper case letters come before lower case
>>> 'Z'<'a'
True
```

```
# Precedence moves from left to right as normal alphabetization
>>> 'Z'<'a'
True
>>> 'Za'<'aZ'
True
>>> 'ZA'<'AZ'
False
>>> 'zA'<'Az'
False
>>> 'za'<'az'
False
```

String Comparisons

0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz

Positive integers can be compared as strings, but…

```
>>> '0'<'1'
True
```

As strings precedence follows alphabetic convention and not numeric

```
>>> 100 < 20          # Compared as integers
False
>>> '100' < '20'      # Compared as strings
True
```

rules involving special characters such as punctuation, negative sign, decimal point, and so forth are ordered somewhat arbitrarily and need not be memorized

- If you need to know, look it up or test with Python
- Numbers should generally be compared using their proper type and not as strings

String Comparisons: T or F?

Exercise: Determine if python will return True or False:

- 'huron'.upper() > 'erie'.upper()
- 'SUPERIOR'.lower() < 'Michigan'
- 'OnTaRiO' < 'Ontario'
- 'OnTaRiO'.lower() != 'Ontario'.lower()

String Comparisons: T or F?

Exercise: Determine if python will return True or False:

- 'huron'.upper() > 'erie'.upper()

```
>>> 'huron'.upper() > 'erie'.upper()
True
```

- 'SUPERIOR'.lower() < 'Michigan'

```
>>> 'SUPERIOR'.lower() < 'Michigan'
False
```

- 'OnTaRiO' < 'Ontario'

```
>>> 'OnTaRiO' < 'Ontario'
True
```

- 'OnTaRiO'.lower() != 'Ontario'.lower()

```
>>> 'OnTaRio'.lower() != 'Ontario'.lower()
False
```

`in` Operator

`in` Operator

- **`in` operator** – takes two strings as operands and returns a Boolean
  - Returns **`True`** if and only if the left operand can be found within the right operand
  - Otherwise it returns **`False`**

Syntax:
'<left_operand>' in '<right_operand>'

Example:


```
>>> 'Super' in 'Superior'
True
>>> 'Great' in 'Superior'
False
```

Superior

`in` Operator: Examples

Examples:

the substring must be consecutive

```
>>> 'Sir' in 'Superior'
False
```

Superior returns **`False`**

the search is case sensitive

```
>>> 'Ron' in 'Huron'
False
```

Huron

forward search only

```
>>> 'rat' in 'Ontario'
False
```

Ontario

`in` Operator: Exercise

Write a function called **`wordsearch`** that:

- takes two strings **`s1`** and **`s2`** as input
- Checks if **`s1`** is a substring of **`s2`** and returns **`True`** if it is and **`False`** otherwise
- The search should be case independent
- Test with **`on`** in **`Ontario`**

```
>>> wordsearch('on', 'Ontario')
True
```

`in` Operator: Exercise Solution

Write a function called **`wordsearch`** that:

- Takes two strings **`s1`** and **`s2`** as parameters
- Checks if **`s1`** is a substring of **`s2`** and returns **`True`** if it is, and returns **`False`** otherwise
- The search should be case independent
- Test with **`on`** in **`Ontario`**

```
def wordsearch(s1,s2):
    # signature str, str -> Bool
    # case insensitve search for s1 in s2
    return s1.upper() in s2.upper()
```

```
===== RESTART: F:/09_Python_course  S17/01_Lecture/lecture_05_Strings.py =====
>>> wordsearch('on', 'Ontario')
True
```

For loops

`for` Loops with Strings

- Processing each character in a string in turn is a common task
- we already saw looping with while and a counter to do this earlier in the lecture
- A simplified looping construct exists: the **`for` loop**
- Automatically assign each character of the string to the loop variable in turn in the loop body; note there is no updated assignment explicitly; it's automatic

Syntax:

```
for <loop_variable> in <string>:
        <loop_body>
```

a new variable is defined

a string

may contain any number of lines of code

Example:

```
for x in 'Erie':
    print(x)
```

```
===== RESTART: F:/09_Python
E
r
i
e
```

`for` Loop Example: Counting Vowels

- Write a function that will count how many vowels are present in some input string **`s`**
- Process **`s`** using a **`for`** loop
- Call another function **`is_vowel`** to determine if each letter in **`s`** is a vowel or not
  - Should be case independent
  - If it is, increment an accumulator **`count`** to keep track of how many vowels have been found as the loop progresses
  - increment the accumulator
  - Assume the vowels are a, e, i, o, u

```
>>> count_vowels('Erie')
3
```

`for` Loop Example: Counting Vowels

```
def is_vowel(char):
    # signature: str -> bool
    # precondition: len(char)==1
    # tests if char is a vowel aeiou
    return char.lower() in 'aeiou'

def count_vowels(s):
    # signature: str -> int
    # returns number of vowels in a string
    count = 0
    for char in s:
        if is_vowel(char): # calls is_vowel
            count += 1
    return count
```

```
===== RESTART: F:/09_Python_course  S17/01_Lecture/lecture_05_Strings.py =====
>>> count_vowels('Erie')
3
```

Loops: Exercise

Rewrite this while loop using a for loop instead.

```
# while loop version
def count_s(river):
    # signature: str -> int
    # counts times letter s appears
    i = 0 # count for the loop
    counts = 0 # counter for number of s

    while i < len(river):
        if river[i] == 's':
            counts += 1
        i += 1
    return counts


===== RESTART: F:/09_Python_course  S17/01_Lecture/lecture_05_Strings.py =====
>>> count_s('Mississippi')
4
```

Loops: Exercise Solution

Rewrite this while loop using a for loop instead.

while loop version

```
def count_s(river):
    # signature: str -> int
    # counts times letter s appears
    i = 0 # count for the loop
    counts = 0 # counter for number of

    while i < len(river):
        if river[i] == 's':
            counts += 1
        i += 1
    return counts
```

```
===== RESTART: F:/09_Python_course  S17/01_
>>> count_s('Mississippi')
4
```

for loop version

```
def count_s_for(river):
    # signature: str -> int
    # counts times letter s appears
    # uses for loop instead of while
    counts = 0

    for i in river:
        if i == 's':
            counts += 1
    return counts
```

```
===== RESTART: F:/09_Python_course  S17/01_
>>> count_s_for('Mississippi')
4
```

Strings Summary of Syntax

- len(<string>) # returns string length
- <string>.isdigit() # True if only contains digits
- <string>.isalpha() # True if only contains alpha
- <string>.isupper() # True if all upper case
- <string>.islower() # True if all lower case
- <string>.upper() # converts to upper case
- <string>.lower() # converts to lower case
- <string> [<index>] # returns char at position index
- <string> [<start_index>:<stop_index>] # slice
- <string> <comparison_operator> <string> # Returns Bool

- Looping over a string using while and counter

```
i = 0
while i < len(s):
    <loop_body>
    i += 1
```

- '<left_operand>' in '<right_operand>' # Bool for substring
- Looping over a string using for loops

```
for <loop_variable> in <string>:
        <loop_body>
```

THE END