# Strings in Python

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# Strings

- Basic data type in Python
  - Strings are immutable, meaning they cannot be shared
    - Why?
      - It’s complicated, but string literals are very frequent. If strings cannot be changed, then multiple occurrences of the same string in a program can be placed in a single memory location.
      - More importantly, strings can serve keys in key-value pairs.

# String Literals

- String literals are defined by using quotation marks
  - Example:

```
>>> astring = "Hello World"
>>> bstring = 'Hello World'
>>> astring == bstring
True
```

- To create strings that span newlines, use the triple quotation mark

```
>>> cstring = """This is a very
complicated string with a few
line breaks."""
>>> cstring
'This is a very\ncomplicated string with a few\nline breaks.'
```

# Escapes

- Python is very good at detecting your intentions when processing string literals
  - E.g.: `"It's mine"`
  - Still sometimes need to use the escape character
    - \t, \n, \", \', \\, \r
    - \xhh —> character with hex value 0xhh
  - Python 3 uses machine conventions for endings
- Python 3 uses utf-8 natively
  - `greetings = ("शुभ प्रभात", "સુપ્રભાત", "শুভ প্রভাত")`

# Docstrings

- Doc strings
  - String literals that appear as the first line of a module, function, class, method definition
  - All these items should have a docstring
  - The docstring replaces the help string in Idle and IPython/Jupyter
  - Indent them under the indentation of the object they describe

# Docstrings

- Always use triple quotation marks
  - Even for one-liners

```
def is_anagram(string):
    """checks whether a string is the same spelled forward or backward."""
    return string == string[::-1]
```

```
>>> help(is_anagram)
Help on function is_anagram in module __main__:

is_anagram(string)
    checks whether a string is the same spelled forward or backward.
```

# Docstrings

- Example

```
def change_vowels_for_numbers(astring):
    """ takes all the vowels in the input and replaces them with
        numbers:
        a,A --> 1, e,E --> 2, i,I --> 3, o,O --> 4, u,U -->5
    """
    result = []
    for letter in astring:
        if letter in 'aA':
            result.append('1')
        elif letter in 'eE':
            result.append('2')
        elif letter in 'iI':
            result.append('3')
        eli
        eli
        els
    return
```

```
>>> change_vowels_for_numbers("Thomas Johannes Emil Schwarz")
'Th4m1s J4h1nn2s 2m3l Schw1rz'
>>> help(change_vowels_for_numbers)
Help on function change_vowels_for_numbers in module __main__:

change_vowels_for_numbers(astring)
    takes all the vowels in the input and replaces them with
    numbers:
    a,A --> 1, e,E --> 2, i,I --> 3, o,O --> 4, u,U -->5
```

# String Methods

- Strings are classes and have many built in methods
- `s.lower(), s.upper()` : returns the lowercase or uppercase version of the string
- `s.strip()`: returns a string with whitespace removed from the start and end
- `s.isalpha() / s.isdigit() / s.isspace()` tests if all the string chars are in the various character classes
- `s.startswith('other'), s.endswith('other')` tests if the string starts or ends with the given other string

# String Methods

- There are a number of methods for strings. Most of them are self-explaining
  - `s.find('other')` : searches for the given other string (not a regular expression) within s, and returns the first index where it begins or -1 if not found
  - `s.replace('old', 'new')`: returns a string where all occurrences of 'old' have been replaced by 'new'
  - `len(s)` returns the length of a string

# Strings and Characters

- Python does not have a special type for characters
  - Characters are just strings of length 1.

# Accessing Elements of Strings

- We use the bracket notation to gain access to the characters in a string
  - a_string[3]  is character number 3, i.e. the fourth character in the string

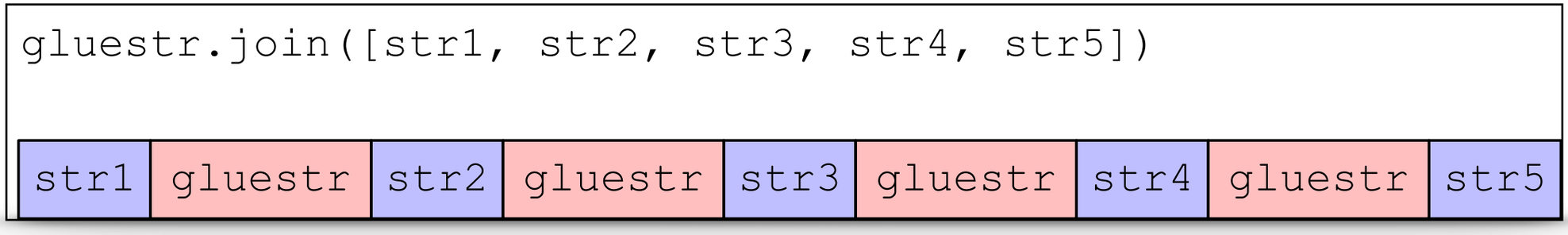
# String Processing

- Since strings are immutable, we process strings by turning them into lists, then processing the list, then making the list into a string.
    - String to list:  Just use the list-command

```
>>> a_string = "Milwaukee"
>>> list(a_string)
['M', 'i', 'l', 'w', 'a', 'u', 'k', 'e', 'e']
```

# String Processing

- Turn lists into strings with the join-method
  - The join-method has weird syntax
    - `a_string = "".join(a_list)`
    - The method is called on the empty string ""
    - The sole parameter is a list of characters or strings
- You can use another string on which to call join
  - This string then becomes the glue



# String Processing

- Examples

```
>>> a_list = ['M', 'a', 'h', 'a', 'r', 'a', 's', 'h', 't', 'r', 'a']
>>> "".join(a_list)
'Maharashtra'
>>> " ".join(a_list)
'M a h a r a s h t r a'
>>> "_".join(a_list)
'M_a_h_a_r_a_s_h_t_r_a'
>>> "oho".join(a_list)
'Mohoaohohohoaohorohoaohosohohohotohorohoa'
```

# String Processing

- Procedure:
  - Take a string and convert to a list
  - Change the list or create a new list
  - Use join to recreate a new string

- Alternative Procedure:
  - Build a string one by one, using concatenation ( + -operator)
  - Creates lots of temporary strings cluttering up memory
    - Which is bad if you are dealing with large strings.

# String Processing

- Example:  Given a string, change all vowels to increasing digits.
  - This is used as a (not very secure) password generator
  - Examples:
    - `Wisconsin -> W1sc2ns3n`
    - `AhmedabadGujaratIndia -> 1hm2d3b4dG5j6r7t8nd90`

# String Processing

- Implementation:
  - Define an empty list for the result
  - We return the result by changing from list to string

```
def pwd1(string):
    result = [ ]


    return "".join(result)
```

# String Processing

- Need to keep a counter for the digits

```
def pwd1(string):
    result = [ ]
    number = 1
```

# String Processing

- Now go through the string with a for statement
- Create the list that will be returned converted into a string

```
def pwd1(string):
result = [ ]
number = 1
for character in string:

#append to result here


return "".join(result)
```

# String Processing

- We either append the letter from the string or we append the current integer, of course cast into a string

```
def pwd1(string):
    result = [ ]
number = 1
for character in string:
    if character not in "aeiouAEIOU":
        result.append(character)
    else:
        result.append(str(number))
        number = (number+1)%10
return "".join(result)
```

# String Processing

- Argot
  - A variation of a language that is not understandable to others
    - E.g. Lufardo — an argot from Buenos Aires that uses words from Italian dialects
      - Invented originally to prevent guards from understanding the inmates
      - Some words are just based on changing words
        - vesre -  al reves (backwards)
        - chochamu - vesre for muchacho (chap)
        - lorca - vesre for calor (heat)

# String Processing

- Argot
  - Pig Latin
    - Children’s language that uses a scheme to change English words
    - Understandable to practitioners, but not to those untrained

# String Processing

- Argot:
  - Efe-speech
    - A simple argot from Northern Argentina no longer in use
    - Take a word:  “muchacho”
    - Replace each vowel with a vowel-f-vowel combination
    - “Muchacho” becomes Mufuchafachofo
    - “Aires” becomes “Afaifirefes”

# String Processing

- Implementing efe-speech
  - Walk through the string, modifying the result list

```
def efe(string):
    result = [ ]
    for character in string:
        result.append(SOMETHING)
    return "".join(result)
```

# String Processing

- We need to be careful about capital letters
  - We can use the string method lower
    - Which you find with a www-search

```
def efe(string):
    result = [ ]
    for character in string:

        elif character in "AEIOU":
            result.append(character+'f'+character.lower())

    return "".join(result)
```

# String Processing

```
def efe(string):
    result = [ ]
    for character in string:
        if character in "aeiou":
            result.append(character+'f'+character)
        elif character in "AEIOU":
            result.append(character+'f'+character.lower())
    else:
        result.append(character)
return "".join(result)
```

# String Processing

```
>>> efe("Alejandria")
'Afalefejafandrifiafa'
>>>
```

# Try it out:

- Implement pig latin
  - Use wikipedia
  - Use testing

# Slices

- We already know two sequence types: lists and strings
  - Sequences can be sliced: A slice is a new object of the same type, consisting of a subsequence
  - Use a bracket cum colon notation to define slices.
    - sequence[a:b] are all elements starting with index a and stoping before index b.

# Slices

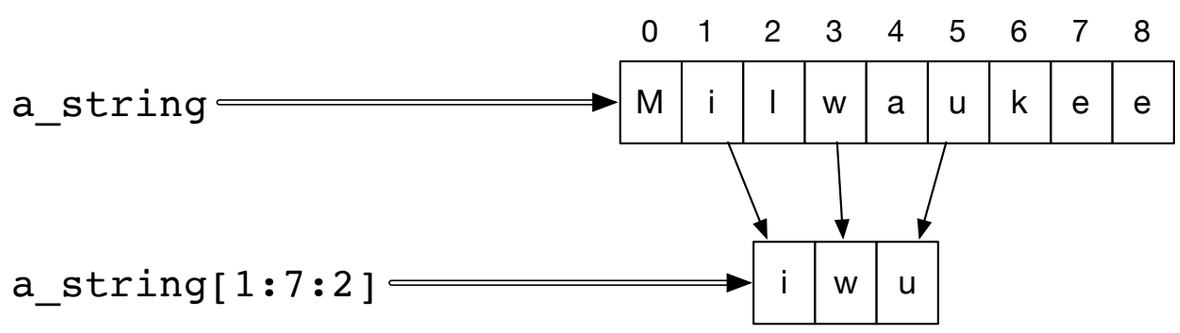
- String slices
  - Number before colon:
    - Start
  - Number after colon:
    - Stop
  - Default value before colon:
    - Start with first character
  - Default value after colon
    - End with the string

```
>>> a_string = "Milwaukee"
>>> a_string[3:6]
'wau'
>>> a_string[1:5]
'ilwa'
>>> a_string[:6]
'Milwau'
>>> a_string[4:]
'aukee'
```

# Slices

- String slices:
  - Optional third parameter is Stride
    - First character is character 1
    - Next one is character 1+2
    - Next one is character 1+2+2
    - Next one would be character 1+2+2+2, but that one is >= the stop value.

```
>>> a_string = "Milwaukee"
>>> a_string[1:7:2]
'iwu'
```




start value is index 1

stop value is index 7

stride is 2

# Slices

- Negative strides are allowed.
  - Create a new string that is reversed using default values

```
>>> a_string = "Milwaukee"
>>> b_string = a_string[::-1]
>>> b_string
'eekuawliM'
```

# Slices

- Negative strides are allowed

```
>>> a_string = "Ahmedabad, Gujarat, India"
>>> a_string[20:3:-3]
'ItaGda'
```

- Character 20 is “I” of India
- Next character is 17, the “t” in Gujarat
- Stop before character 3 (the fourth character)

Ahmedabad, Gujarat, India

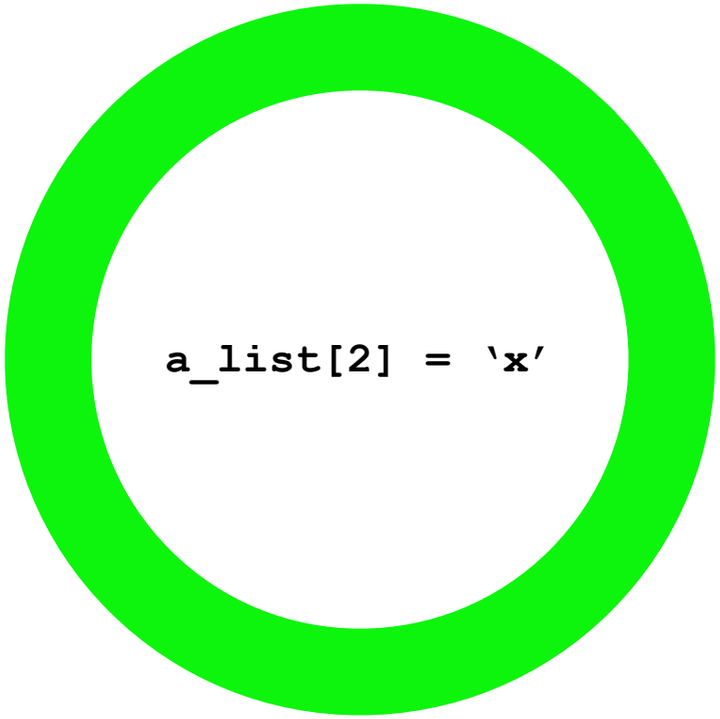
# Lists and Strings

- Both lists and strings are sequences
  - Length: `len(a_string), len(a_list)`
  - Concatenation: `a_string + b_string, a_list + b_list`
  - Repetition: `3*a_string, 3*a_list`
  - Membership: `if 'x' in a_string, if a in a_list`
  - Iteration: `for ele in a_string, for ele in a_list`

# Lists and Strings

- Strings are immutable


- Lists are mutable



# Try it out

- Write a function that determines whether a word is a palindrome (spelled forward the same as backward)
- Write a function that checks whether two words are anagrams (have exactly the same letters).
    - Hint: Without counting letters, you just create an ordered list of the letters in each word
        - For extra credit: remove all non-letters
            - Use string.ascii_letters

# Formatting Strings

- We really need to learn how to format strings
  - Python has made several attempts before settling on an efficient syntax.
  - You can find information on the previous solutions on the net.
- Use the `format` function
  - Distinguish between the **blueprint**
  - and the **string to be formatted**
  - Result is the formatted string.

# Formatting Strings

- Blueprint string
  - Uses { } to denote places for variables
  - Simple example
    - `"{} {}".format('one', 'two')`

Blueprint

Calling format

String to be formatted

- Result `'one two'`

# Formatting Strings

- Inside the brackets, we can put indices to select variables
  - 0 means first variable, 1 second, …
  - Can reuse variables

```
>>> "{0}, {0}, {1}, just {0}".format("great", "extraordinary")
'great, great, extraordinary, just great'
```

# Formatting Strings

- Additional formatting inside the bracket after a colon
- Can assign the number of characters to print out

```
>>> "{0:10}, {1:10}, {0:10}".format("funny", "nuts")
'funny     , nuts      , funny     '
```

- Default alignment is to the left

# Formatting Strings

- Use ^ to center
- Use < to left-align
- Use > to right-align

```
>>> "{0:10}|{1:^10}|{0:>10}".format("sheep", "wolf")
'sheep     |   wolf   |     sheep'
```

# Formatting Strings

- Numbers are handled without specifying format instructions.

```
>>> "{} divided by {} is {} modulo {}".format(143, 29, 143//29, 143%29)
'143 divided by 29 is 4 modulo 27'
```

- Or we can insist on special types
  - Use s for string
  - Use d for decimal
  - Use f for floating point
  - Use e for floating point in exponential notation

# Formatting Strings

- By specifying “f” we ask for floating point format
- By specifying “e” we ask for scientific format

```
>>> "{0:f}, {0:e}".format(3.141)
'3.141000, 3.141000e+00'
```

# Formatting Strings

- Padding
  - If the variable needs more space to print out, it will be provided automatically

```
>>> "{:10s}".format("Pneumonoultramicroscopicsilicovolcanoconiosis")
'Pneumonoultramicroscopicsilicovolcanoconiosis'
```

  - This is actually the longest officially recognized word in English

# Formatting Strings

- Padding:
  - On the reverse, we can give the number of significant digits after a period

```
>>> "{:8.2f}".format(3.14159265358979323846264338327950288419716939937510582097494459230781640628620899862803482534211706798214808651328230664709384460955058223172535940812848 1)
'    3.14'
```

  - We only want to keep two decimal digits after the period
  - But use a total of 8 spaces for the number.

# Formatting Strings

- Escaping curly brackets:
  - If we want to write strings with format containing the curly brackets “{“  and “}”, we just have to write “{{“ and “}}”

```
>>> "{{ {}, {} }}".format(3, 4)
'{ 3, 4 }'
```

  - A single bracket is a placeholder, a double curly bracket is a single one in the resulting string.

# Application: Pretty Printing

- Develop a mortgage payment plan
  - Accountants have formulae for that, but it is fun to do it directly
  - Assume you take out a loan of L$ dollars
    - The loan is financed at a rate of r% annually
    - Interest is paid monthly, i.e. at a rate of r/12%
- Each month you make a repayment
  - Part of the repayment is to pay the interest
  - The remainder pays down the debt

# Mortgage Payments

- Use a while-loop
  - Condition is that there is still an outstanding debt
  - Adjust outstanding debt
  - Count the number of payments
- Need to initialize values

# Mortgage Payments

- We need values for:
  - Monthly Rate (interest in percent)/1200
  - Principal
  - Repayment
- Get those from the user
  - A true application would contain code that checks whether these numbers make sense.

# Mortgage Payments

- Initialization

```
princ = float(input("What is the prinipal “))
rate = float(input("What is the interest rate (in percents)? "))/1200
print("Your minimum rate is ", rate*princ)
paym = float(input("What is the monthly payment? “))
month = 0
```

# Mortgage Payments

- We continue until we paid down the principal to zero

```
while princ > 0:
```

# Mortgage Payments

- Update the situation in the while loop
- Last payment does not need to be full, so we calculate it

```
intpaid = princ*rate
princ = princ + princ*rate - paym
if princ < 0:
        lastpayment = paym + princ
        princ = 0
month += 1
```

```
**********************************
**  The Ultimate Mortgage Calculator  **
**********************************
What is the prinipal 40000
What is the interest rate (in percents)? 4
Your minimum rate is 133.33
What is the monthly payment? 1950
This is what your mortgage scheme looks like
Month   Interest        Principal
-------------------------------
  1       133.33         38183.33
  2       127.28         36360.61
  3       121.20         34531.81
  4       115.11         32696.92
  5       108.99         30855.91
  6       102.85         29008.76
  7        96.70         27155.46
  8        90.52         25295.98
  9        84.32         23430.30
 10        78.10         21558.40
 11        71.86         19680.26
 12        65.60         17795.86
 13        59.32         15905.18
 14        53.02         14008.20
 15        46.69         12104.89
 16        40.35         10195.24
 17        33.98          8279.22
 18        27.60          6356.82
 19        21.19          4428.01
 20        14.76          2492.77
 21         8.31           551.08
 22         1.84             0.00
You paid of the loan in 22 months, and your last payment was 552.92
>>>
```

# Pretty-Printing Tables

- Format Strings revisited:
  - Format string — blueprint
  - Uses { } to denote spots where variables get inserted

# Pretty-Printing Tables

- Syntax
  - {a:^10.3f}
    - a — the number of the variable
      - Can be left out
    - : — what follows is the formatting instruction
    - 10 — number of spaces for the variable
    - . — what follows is the precision
    - 3 — precision
    - f — print in floating point format

# Pretty-Printing Tables

- If the variable is larger than the space given:
  - Full value is printed out
  - Alignment by default is
    - left (<) for strings
    - right (>) for numbers

# Pretty-Printing Tables

- Task:
  - A program that gives a table for the log and the exponential function between 1 and 10
  - Hint: `x=1+i/10`

```
  x    |     exp(x)     |     log(x)
-------------------------------------
 1.00  |        2.71828 |        0.00000
 1.10  |        3.00417 |        0.09531
 1.20  |        3.32012 |        0.18232
 1.30  |        3.66930 |        0.26236
 1.40  |        4.05520 |        0.33647
 1.50  |        4.48169 |        0.40547
 1.60  |        4.95303 |        0.47000
 1.70  |        5.47395 |        0.53063
```

# Why another formatting method

- The format method allows very fine-grained control
- But it is verbose
- Python has two type of special strings:
  - r-strings for raw strings: no escapes
  - f-strings for formatting
  - Using f-strings results in more compact and readable code

# f-strings

- f-strings are defined with a pair of quotation marks preceded immediately by an “f” or “F”

```
fstring = f'hello world'
```

- An f-string can contain a variable name surrounded by brackets in its definition
- The bracket is then replaced by the value of the variable

# f-strings

- Example:

```
number = 6.35
astring = “hello"
fstring = f"{astring}, the number is {number}"
```

- Variable fstring is then

```
'hello, the number is 6.35'
```

# f-strings

- The expression in brackets inside an f-string gets evaluated at run time.
- For example, we can say

```
f"{2+3*4}"
```

- or

```
astring = “hello"
string = f"{astring.upper()} World"
```

which evaluates to

```
'HELLO World'
```

# r-strings

- Because of their similarity with f-strings, we mention r-strings
- An r-string uses the escape character only as an escape character, so there is no escaping at all
- This is useful for strings containing the backslash such as Windows file names

```
address = r"c:\Windows\System32\system.ini"
```