Module 3: Strings and Input/Output

Topics:

- Strings and their methods
- Printing to standard output
- Reading from standard input

Readings: ThinkP 8, 10

Practice: Self study exercises

Strings in Python: combining strings in interesting ways

```
s = "Great"
t = "CS116"
u = s + t
v = s + "!!!! " + t
w = s * 3
x = 2 * t
y = 'single quote works too'
z = 'strings can contain quotes" too'
```

Overloading of *

The following are all valid contracts of *:

```
*: Int Int -> Int
*: Int Float -> Float
*: Float Int -> Float
*: Float Float -> Float
*: Int Str -> Str
*: Str Int -> Str
```

What contracts apply to +? To -?

Other string operations

- Contains substring: **`s in t`**
  - Returns **`True`** if the string **`s`** appears as a substring in the string **`t`**

```
"astro" in "catastrophe" ⇨ True
"car" in "catastrophe" ⇨ False
"" in "catastrophe" ⇨ True
```

- String length: **`len(s)`**
  - Returns the number of characters in string **`s`**

```
len("") ⇨ 0,
len("Billy goats gruff!") ⇨ 18
```

Extracting substrings

- **`s[i:j]`** returns the substring from string **`s`**, containing all the characters in positions **`i, i+1, i+2, ..., j-1`**
- **`s[i:j:k]`** steps by k, instead of 1
- **`s[k]`** returns a string containing the character at position k
- Like Racket, strings in Python start from position 0

Suppose **`s = "abcde"`**, what strings are returned?

- **`s[2:4], s[0:5], s[2:3], s[3:3], s[2:20], s[8:]`**
- **`s[2:], s[:3]`**
- **`s[1:5:2], s[2::3], s[::-1]`**
- **`s[4], s[-1]`**

Strings are immutable

We cannot change the individual characters in a string **`s`**

`s = "abcde"`

`s[3] = "X"` causes an error

but

`s = s[:3] + "X" + s[4:]`

returns a new string **`"abcXe"`** and assigns it to **`s`**

Note that **`Int`**, **`Float`**, **`Str`**, and **`Bool`** values are also immutable.

Methods in Python

- **`str`** is the name of a class in Python
- By convention, **`Str`** (capital S) is used in contracts
- Like the **`math`** module, **`str`** contains many functions, in its case to process string values
- To use the functions in **`str`**:

```
s = "hi"
s.upper() ⇨ "HI"
```

- Note that none of the string methods modify the string itself

Partial listing of string methods

```
>>> dir("abc")
[ …, 'capitalize', 'center', 'count',
  'endswith', 'find', 'format',
  'index', 'isalnum', 'isalpha',
  'isdigit', 'islower', 'isspace',
  'isupper', 'join', 'lower',
  'lstrip', 'partition', 'replace',
  'rfind', 'split', 'startswith',
  'strip', 'swapcase', 'translate',
  'upper', …]
```

Using string methods

```
s = 'abcde 1 2   3 ab    '
```

What do the following calls return?

```
s.find('a')
s.find('a',1)
s.startswith('abc')
s.count('a')
s.replace(' ','')
s.strip()
```

Getting more information about a **`str`** method

```
>>> help ("".isalpha)
S.isalpha() -> bool

Return True if all characters in S
  are alphabetic and there is at
  least one character in S, False
  otherwise.
```

Exercise

Write a Python function that consumes a non-empty first name, middle name (which might be empty), and a non-empty last name, and constructs a userid consisting of first letter of the first name, first letter of the middle name, and the last name. The userid must be in lower case, and no longer than 8 characters, so truncate the last name if necessary. For example,

```
userid("Harry", "James", "Potter") ⇨
  "hjpotter"
userid("Ronald", "Bilius", "Weasley") ⇨
  "rbweasle"
```

Recursive String definition and function template

A Python String is either

- *"", or*
- ***s + t**, where **s** and **t** are strings, and **len(s)=1**.*

```
def my_string_template(s):
 if s=="":
  # base case
 else:
  # … s[0] … my_string_template(s[1:])
```

Recursion on Strings

Write a Python function **`str_score`** that consumes a string **`s`**, and returns the score for **`s`**, where

- alphabetical characters are worth 1 point,
- digits are worth their numerical value, and
- any other character is worth 0.

For example,

`str_score("CS 116")` ⇨ **`10`**

Run the following program in the Definitions window. What do you see?

```
def middle(a,b,c):
    largest = max(a,b,c)
    smallest = min(a,b,c)
    mid = (a+b+c) - largest - \
          smallest
    return mid
middle(10,20,30)
middle(0,10,-10)
middle(-1,-3,-2)
```

Python output:
printing information to the screen

```
x = 20
print(x)
print(x+5)
y = "dog"
print(y)
z = 42.8
print(z)
print(x,y,z)
```

More on `print` function

- Has an effect
  - printing to "standard output" - the screen
- Does not return a value
  - technically, we say it returns **`None`**

Displaying values in Python programs

- Interactions window, for variable **`x`**:

```
x
print(x)
```

- Result *usually* looks the same (except for strings), but they are different
- Difference is obvious in Definitions window

➔ Need to use **`print`** in our programs to see results as the program is running

New: Functions do not always need to return values

- We can write a function which only prints data
- If a function does not include a **`return val`** statement, then the returned value (and type) is **`None`**
- The purpose statement does not need to include **`"Returns None"`** as this will be included in the contract.

Design recipe changes:
If a function includes `print` statements

- Include a description of what is printed in the Purpose statement
- Add a new section: an Effects statement (immediately after the purpose) to briefly indicate a value is printed
- Examples should include a description of the actual values printed for that input

It may also include a **`return`** statement.

Example: Write a function that prints a string three times – once per line

```
def print_it_three_times(s):
    '''prints s on three lines, once per line
       Effects: Prints to the screen

       print_it_three_times: Str -> None

       Example: Calling print_it_three_times("a")
         prints a once on each of three lines.
    '''
     print(s)
     print(s)
     print(s)
```

Testing Screen Output

- Our **`check`** module contains functions for two different approaches for testing screen output:
  - **`set_screen`** – sets things up for the tester to check screen output
  - **`set_print_exact`** – will check exactly whether screen output matches the expected screen output
- Unless told otherwise on an assignment, you can choose the testing approach that you prefer.
- In both cases, the screen output testing function must be called before the function to check the return value (**`within`** or **`expect`**).

Testing Screen Output: `set_print_exact`

- Include a string for each line of expected screen output:

```
check.set_print_exact("CS 116",
    "CS 116", "CS 116")
```

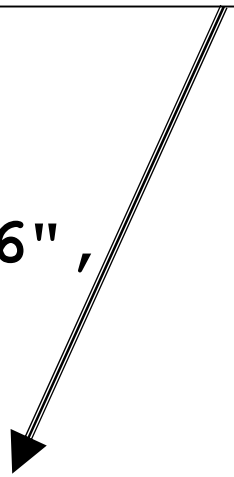
- Followed by appropriate **`check`** function to test value returned by the function (even if it is **`None`**)
- When **`expect`**/**`within`** runs, in addition to comparing expected and actual return values, the strings in **`set_print_exact`** will be compared to the actual strings printed by the function, line-by-line.

Example: Screen Output Only

```
import check
def print_it_three_times(s):
    print(s)
    print(s)
    print(s)

# Q6 Test 1: a short string - "CS 116"
check.set_print_exact("CS 116", "CS 116",
"CS 116")
check.expect("p3T1",
    print_it_three_times("CS 116"),None)
```

There is no **`return`**, so function returns **`None`**. This value is passed to **`check.expect`** to verify .



Test Output

```
p3T1: PASSED
```

`None` was correctly returned by our function.

```
p3T1 - print output: PASSED
-----
```

The strings passed to **`set_print_exact`** are exactly the strings printed by the function.

A failed test

```
def print_it_three_times(s): # Incorrect
    print(s)
    print(s)
-----

p3T1: PASSED

p3T1 - print output: FAILED; expected
CS 116
CS 116
CS 116
saw
CS 116
CS 116
```

None was correctly returned by our function.

The function did not print the expected strings, so an informative message is printed.

Testing Screen Output: `set_screen`

- Give a description of expected screen output:

```
check.set_screen(
        "CS 116 on three lines")
```

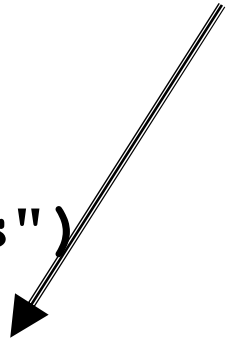
- Followed by appropriate **`check`** function to test value returned by the function (even if it is **`None`**)
- Test will print screen output along with your description of what the screen output should be.
- **You must then compare the two.**
- **No comparisons of the actual and expected string outputs are made by the `check` module.**
- **Useful if the output is very complicated and long.**

Example: Screen Output Only

```
import check
def print_it_three_times(s):
    print(s)
    print(s)
    print(s)

# Q6 Test 1: a short string - "CS 116"
check.set_screen("CS 116 on three lines")
check.expect("Q6T1",
    print_it_three_times("CS 116"),None)
```

There is no **`return`**, so function returns **`None`**. This value is passed to **`check.expect`** to verify .



Test Output

```
QT1 PASSED
-----
QT1 (expected screen output):
CS 116 on three lines

QT1 (actual screen output):
CS 116
CS 116
CS 116
-----
```

None was correctly returned by our function.

You must examine your output to see if it matches what you expected.

Printing vs Returning

Complete the full design recipes for **`f1`** and **`f2`**.

```
def f1(x):
    print(x+1)
def f2(x):
    return x+1
```

Debugging your program with `print` statements

- If you have an error in your program, place **`print`** statements at points through out your program to display values of variables
- **IMPORTANT**: Remember to remove the **`print`** statements before submitting your code.
  - Your program may fail our tests, even if it returns the correct function values!!!

A new Python feature

- Python functions can use information received in three different ways –
  - Two ways we have seen in Racket:
    - Parameters
    - Global constants
  - A new way:
    - Entered via the keyboard

User Input to a Python Program

```
user_input = input()
```

- Program stops
- Nothing happens until the user types at keyboard
- When user hits enter, a string containing all the characters before the return is returned by **`input`**
- The string value is used to initialize the variable **`user_input`**
- Program continues with new value of **`user_input`**

More on user input

- Alternate form (preferred):

```
user_input = input(prompt)
```

e.g.

```
city = input("Enter hometown:")
```

- Prints the value of **`prompt`** before reading any characters
- Value returned by **`input`** is **always** a **`Str`**

User Input and the Design Recipe

- When a function includes an **`input`** call, this must be described in the Purpose statement:
  - Describe what happens with the value entered by the user
  - Use parameter names in your description, where relevant
- It should also be mentioned (without the same detail) in the Effects statement.

A Simple Program using `input`: Design Recipe steps

```
def repeat_str():
    '''reads in a string s, and a number n, and
          prints s n times on one line
       Effects:
       * Two values are read in and
       * One string is printed
       repeat_str: None -> None
       Examples: If the user enters "abc" and 4
        when repeat_str() is called,
        "abcabcabcabc" is printed
          If the user enters "" and 100
        when repeat_str is called, "" is printed
    '''
```

A Simple Program using `input`

```
def repeat_str():
  s = input("Enter string: ")
  t = input("Enter int>=0: ")
  n = int(t)
  print(n*s)
```

Testing With User Input

- Set the user inputs needed for the test in order.
- Always use strings for the input values.
- Include one string for each call to **`input`** that happens in your test:

```
check.set_input("CS116","3")
```

- Follow with appropriate **`check`** function for value returned by the function
- Test function will automatically use these values (in order) when a value is expected from **`input`**
- You will be warned if the argument to **`set_input`** contains too few or too many values

Example: Test with User Input

```
import check
def add_two_inputs():
'''add_two_inputs: None -> Int'''
    x = int(input("Enter 1st integer: "))
    y = int(input("Enter 2nd integer: "))
    return x+y

# Test 1: two positive numbers
check.set_input("2","7")
check.expect("AddT1", add_two_inputs(), 9)
```

Example

Write the Python function **`n_times`** that reads a natural number **`n`** from the user via the keyboard, and prints out **`n`** once per line on **`n`** lines. The function returns **`None`**.

More on strings: Formatting screen output

- We can print strings

```
print("my dog has fleas")
```

- We can print integers

```
fleacount = 12
print(fleacount)
```

- We can even combine them

```
print("my dog has", fleacount,
      "fleas")
print("my dog has " +
      str(fleacount) + " fleas")
```

Creating formatted strings

The **`format`** method and placeholder **`{}`**

- We can describe the string we want to build, indicating where values should be inserted by using placeholders indicated by {#} inside the string
- Then supply the values to insert

```
fleastring = "My dog has {0} fleas".format(
  fleacount)
print(fleastring)
```

description and placeholder **{ }**

- The string you are building contains **{#}** and is followed by **.format(a_0, a_1, …, a_n)**
- Uses the embedded **{#}** to show where a value should be inserted in the new string
- The **#** indicates which of the **format** arguments (**0 – n**) should appear at that location of the string

```
s="Did {0} repay {1} ${2} from {0}'s pay?"
print(s.format("Tom", "Li", 20))
```

Examples

```
"I like {1}{0} {2}% of the time".format(
    116,"CS",500/6)
⇨ "I like CS116 83.33333333333333% of the time"

"I have taken {2}{0} and {2}{1}.".format(
   115, 116, "CS")
⇨ "I have taken CS115 and CS116."

"Temp is {0}C (or {1}F)".format(
    -10.0, (-10)*9/5+ 32 )
⇨ "Temp is -10.0C (or 14.0F)"
```

Possible errors in formatting

- Incorrect number of values to insert

```
>>> print("{0} {1} {2}".format(
  42.0, 12))
IndexError: tuple index out of
  range
```

Printing on one line

- Recall that

```
print("this goes","on","one line")
print("this on the next")
print("and so on")
```

goes on three separate lines

- However,

```
print("this goes","on","one line",end=",")
print("and this on the same",end="")
print(" and so on")
```

all goes on one line (due to value of end argument)

Special Characters

- So, we know how to use **`print`** statements to put information on one line
- Can you use a single print statement to put information over multiple lines?
  - Yes, but we need a special character \n

```
print("one line\nanother\nand another ")
```

  - Despite taking 2 characters to type, it counts as one in string length

```
len("A\nB\nC\n") ⇨ 6
```

Goals of Module 03

- You should be comfortable the following in Python:
  - Strings and their methods
  - Printing to the screen
  - Reading from the keyboard