Module 3: Strings and Input/Output

Topics:
• Strings and their methods
• Printing to standard output
• Reading from standard input

Readings: ThinkP 8, 10
Strings in Python: combining strings in interesting ways

```python
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: \texttt{s in t}
  – Returns \texttt{True} if the string \texttt{s} appears as a substring in the string \texttt{t}
    \begin{itemize}
      \item "astro" in "catastrophe" => True
      \item "car" in "catastrophe" => False
      \item "" in "catastrophe" => True
    \end{itemize}

• String length: \texttt{len(s)}
  – Returns the number of characters in string \texttt{s}
    \begin{itemize}
      \item \texttt{len(""')} => 0,
      \item \texttt{len("Billy goats gruff!")} => 18
    \end{itemize}
Extracting substrings

- \( s[i:j] \) returns the substring from string \( s \), containing all the characters in positions \( i, i+1, i+2, \ldots, j-1 \)
- \( s[i:j:k] \) steps by \( k \), instead of 1
- 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`:

```python
s = "abcde"
s[3] = "X"   # causes an error
```

but

```python
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 name of the string type in Python (used in contracts)
- **str** is the name of a class in Python
- Like the **math** module, **str** contains many functions to process strings
- To use the functions in **str**:
  ```python
  s = "hi"
  str.upper(s) => "HI"
  ```
- Even easier – use special dot notation:
  ```python
  s.upper() => "HI"
  ```
- Note that **none** of the string methods modify the string itself
Partial listing of string methods

```python
>>> dir("abc")
['__class__', '__delattr__', '__dict__', ...
, '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.split()
s.split('a')
s.startswith('abc')
s.endswith('b')
Getting more information about a str method

```python
>>> 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"`
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`

• Note: the following is not valid Python:
  ```python
  print (x = 4)
  ```
  Why?
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 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 \texttt{print} statements

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

It may also include a \texttt{return} statement.
Example: Write a function that prints a string three times – once per line

```python
# print_it_three_times(s) prints s three times, once per line
# Effects: Prints three lines, with s
# print_it_three_times: Str -> None
# Example: Calling print_it_three_times("a") prints a once on each of three lines.

def print_it_three_times(s):
    print(s)
    print(s)
    print(s)
```
Testing Screen Output

• Give a description of expected screen output:
  `check.set_screen("CS 116 on three lines")`

• Call 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.**
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

None was correctly returned by our function.

-----

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

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

-----

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

Complete the full design recipes for $f_1$ and $f_2$.

```python
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 throughout 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

```python
user_input = input()
```

- Program stops
- Nothing happens until the user types at keyboard
- When user hits return, 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, and mentioned in the Effects statement
  – Describe what happens with the value entered by the user
  – Use parameter names in your description, where relevant
A Simple Program using input:

Design Recipe steps

# 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
# * One string is printed
# repeat_str: None -> None
# Example: 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`

```python
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

```python
check.set_input(["CS116","3"])
```

- Call appropriate `check` function for returned value of 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

```python
import check

# add_two_inputs: None -> Int
def add_two_inputs():
    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
  ```python
  print("my dog has fleas")
  ```
- We can print integers
  ```python
  fleacount = 12
  print(fleacount)
  ```
- We can even combine them
  ```python
  print("my dog has", fleacount, "fleas")
  ```
  ```python
  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

```python
fleestring = "My dog has {0} fleas".format(fleacount)
print(fleestring)
```
The string you are building contains \{\#\} and is followed by \texttt{.format(a_0, a_1, \ldots, a_n)}

Uses the embedded \{\#\} to show where a value should be inserted in the new string

The \# indicates which of the \texttt{format} arguments (0 \textendash n) should appear at that location of the string

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

```python
>>> print("\{0\} {1} {2}\".format(42.0, 12))
IndexError: tuple index out of range
```
Printing on one line

• Recall that

```python
print("this goes","on","one line")
print("this on the next")
print("and so on")
```
goes on three separate lines

• However,

```python
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`

\[\text{print("one line\nanother\nand another ")}\]
  – Despite taking 2 characters to type, it counts as one in string length

\[\text{len("A\nB\nC\n") } \rightarrow 6\]
Goals of Module 03

• You should be comfortable the following in Python:
  – Strings and their methods
  – Printing to the screen
  – Reading from the keyboard
Extra practice in class