Programming Principles in Python (CSCI 503/490)

Control Statements

Dr. David Koop

(some slides adapted from Dr. Reva Freedman)
Identifiers

• A sequence of letters, digits, or underscores, but...
• Also includes unicode "letters", spacing marks, and decimals (e.g. $\Sigma$)
• Must begin with a letter or underscore (_)
• Why not a number?
• Case sensitive (a is different from A)
• Conventions:
  - Identifiers beginning with an underscore (_) are reserved for system use
  - Use underscores (a_long_variable), not camel-case (aLongVariable)
  - Keep identifier names less than 80 characters
• Cannot be reserved words
Types

• Don't worry about types, but think about types
• Variables can "change types"
  - a = 0
  a = "abc"
  a = 3.14159
• Actually, the name is being moved to a different value
• You can find out the type of the value stored at a variable v using type(v)
• Some literal types are determined by subtle differences
  - 1 vs 1. (integer vs. float)
  - 1.43 vs 1.43j (float vs. imaginary)
• Can do explicit type conversion (int, str, float)
Assignment

• The = operator: \( a = 34; c = (a + b)^2 \)

• Python variables are actually **pointers** to objects

• Also, augmented assignment: `+=`, `-=`, `*=`, `/=`, `//=`, `**=`

\[
\begin{align*}
  x &= 42 \\
  y &= x + 1 \\
  x &= x + 1 \\
  y &= x
\end{align*}
\]
Simultaneous Assignment & Assignment Expressions

- Simultaneous assignment leaves less room for error:
  - \( x, y = y, x \)

- Assignment expressions use the walrus operator :=
  - \((my\_pi := 3.14159) \times r^{2} + a^{0.5}/my\_pi\)

- Use cases: if/while statement check than use, comprehensions
Assignment 1

• Due Tonight
• Get acquainted with Python using notebooks
• Make sure to follow instructions
  - Name the submitted file a1.ipynb
  - Put your name and z-id in the first cell
  - Label each part of the assignment using markdown
  - Make sure to produce output according to specifications
• ipynb files are in a JSON format. Please maintain the .ipynb extension!
• Questions?
Assignment 2

- Out soon
Quiz Wednesday
Control Statements
Boolean Expressions

• Type `bool`: True or False

• Note **capitalization**!

• Comparison Operators: `<`, `<=`, `>`, `>=`, `==`, `!=`
  - Double equals (`==`) checks for equal values,
  - Assignment (`=`) assigns values to variables

• Boolean operators: `not`, `and`, `or`
  - Different from many other languages (`!`, `&&`, `||`)

• More:
  - `is`: exact same object (usually `a_variable` is `None`)
  - `in`: checks if a value is in a collection (`34 in my_list`)
if and else

• Blocks (suites) only executed if the condition is satisfied

• if <boolean expression>:  
  <then-block>

• if <boolean expression>:  
  <then-block>  
  else:  
  <else-block>

• Remember colon (:)

• Remember indentation

• if a < 34:  
  b = 5
else:  
  b = a - 34
elif is a shortcut

• if a < 10:
  print("Small")
else:
  if a < 100:
    print("Medium")
  else:
    if a < 1000:
      print("Large")
    else:
      print("X-Large")

• if a < 10:
  print("Small")
elif a < 100:
  print("Medium")
elif a < 1000:
  print("Large")
else:
  print("X-Large")

• Indentation is critical so else-if branches can become unwieldy (elif helps)
pass

- pass is a no-op
- Python doesn't allow an empty block so pass helps with this
- Used when commenting out code blocks

```python
if a < 10:
    print("Small")
elif a < 100:
    print("Medium")
elif a < 1000:
    # print("Large") < block would be empty (comments don't count)
    pass
else:
    print("X-Large")
```
while

- while repeats the execution of the block
- while `<boolean expression>`:
  - `<loop-block>`
- Condition is checked at the beginning and before each repeat
- If condition is `False`, loop will never execute
- Don't use a while loop to iterate (use for loop instead)
- Example:
  ```python
  - d = 100
    while d > 0:
      a = get_next_input()
      d -= a
  ```
break and continue

- **break**: immediately exit the current loop
- **continue**: stop loop execution and go back to the top of the loop, checking the condition again

```python
while d > 0:
    a = get_next_input()
    if a > 100:
        break
    if a < 10:
        continue
    d -= a
```

- These are similar to goto statements in that they can jump from one statement to another part of the code but scoped to the current loop
"...I became convinced that the go to statement should be abolished from all 'higher level' programming languages... The go to statement as it stands is just too primitive; it is too much an invitation to make a mess of one's program."

D. Koop, CSCI 503/490, Spring 2024
The Go To Statement Debate

```
for i := 1 to n
  do begin
    for j := 1 to n do
      if x[i, j]<>0
        then goto reject;

    writeln
      ('The first all-zero row is ', i);
    break;
  reject: end;
```

```
i := 1;
repeat
  j := 1;
  allzero := true;
  while (j <= n) and allzero
    do begin
      if x[i, j]<>0
        then allzero := false;
      j := j + 1;
    end;
  i := i + 1;
until (i>n) or allzero;
if i<=n
  then writeln
    ('The first all-zero row is ', i-1);
```

"All of my experiences compel me to conclude that it is time to part from the dogma of GOTO-less programming. It has failed to prove its merit"

[ Rubin, 1987]
Programming Principles: break, continue, goto

• ACM the published a number of critiques of Rubin's letter, Dijkstra also wrote some notes on this: bugs, maybe the language is bad...

• Most computer scientists agree that the problem was over-use, not that the statement is never useful

• Break and continue are more structured gotos because they apply only to the current block

• Breaks and continues at the top of a loop are better

• Multi-level breaks are annoying (compare with return statements in functions)
Continue at the beginning of a loop

• Like `elif`, can help with indentation

```python
while d >= 0:
    d = get_data()
    if d is not None:
        # do stuff
```

• While `d` is 

```python
while d >= 0:
    d = get_data()
    if d is None:
        continue
    # do stuff
```
Loop Styles

• Loop-and-a-Half

\[
d = \text{get\_data()} \quad \# \text{priming rd}
\]

while check(d):
    # do stuff
    d = \text{get\_data()}

• Better way?

• Infinite-Loop-Break

while True:
    d = \text{get\_data()}
    if not check(d):
        break
    # do stuff
Loop Styles

• Loop-and-a-Half

```python
    d = get_data() # priming rd
    while check(d):
        # do stuff
        d = get_data()
```

• Infinite-Loop-Break

```python
    while True:
        d = get_data()
        if not check(d):
            break
        # do stuff
```

• Assignment Expression (Walrus)

```python
    while check(d := get_data()):
        # do stuff
```
do-while

- do-while loops always execute at least once
- There is no do-while loop construct in Python
- Can set the condition so that it is always True first time through the loop
- …or move the break to the end of the loop
Looping Errors

- # while loop - summing the numbers 1 to 10
  
n = 10
  cur_sum = 0
  # sum of n numbers
  i = 0
  while i <= n:
    i = i + 1
    cur_sum = cur_sum + i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Looping Errors

• # while loop - summing the numbers 1 to 10
  
  n = 10
  cur_sum = 0
  # sum of n numbers
  i = 0
  while i <= n:
      cur_sum = cur_sum + i
      i = i + 1

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
### Looping Errors

- # while loop - summing the numbers 1 to 10

```python
n = 10
cur_sum = 0
# sum of n numbers
i = 0
while i != n:
    cur_sum = cur_sum + i
    i = i + 1

print("The sum of the numbers from 1 to", n, "is ", cur_sum)
```

D. Koop, CSCI 503/490, Spring 2024
For Loop

• for loops in Python are really for-each loops
• Always an element that is the current element
  - Can be used to iterate through iterables (containers, generators, strings)
  - Can be used for counting
• for i in range(5):
  print(i) # 0 1 2 3 4
• range(5) generates the numbers 0,1,2,3,4
Range

- Python has lists which allow enumeration of all possibilities: [0,1,2,3,4]
- Can use these in for loops
  ```python
  for i in [0,1,2,3,4]:
      print(i)  # 0 1 2 3 4
  ```
- **but** this is less efficient than range (which is a generator)
  ```python
  for i in range(5):
      print(i)  # 0 1 2 3 4
  ```
- List must be stored, range doesn't require storage
- Printing a range doesn't work as expected:
  - `print(range(5))` # prints "range(0, 5)"
  - `print(list(range(5)))` # prints "[0, 1, 2, 3, 4]"
Range

• Different method signatures
  - `range(n) → 0, 1, …, n-1`
  - `range(start, end) → start, start + 1, …, end - 1`
  - `range(start, end, step) → start, start + step, … < end`

• Negative steps:
  - `range(0,4,-1) # <nothing>`
  - `range(4,0,-1) # 4 3 2 1`

• Floating-point arguments are not allowed
Looping Errors

• # for loop - summing the numbers 1 to 10
  n = 10
cur_sum = 0
  for i in range(n):
    cur_sum += i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Looping Errors

• # for loop - summing the numbers 1 to 10
  
n = 10
  cur_sum = 0
  for i in range(n+1):
      cur_sum += i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Looping Errors

• # for loop - summing the numbers 1 to 10
  n = 10
  cur_sum = 0
  for i in range(1, n+1):
      cur_sum += i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Functions
Functions

• Call a function $f$: $f(3)$ or $f(3, 4)$ or … depending on number of parameters

• def <function-name>(<parameter-names>):
  """Optional docstring documenting the function""
  <function-body>

• def stands for function definition

• docstring is convention used for documentation

• Remember the **colon** and **indentation**

• Parameter list can be empty: def f(): …
Functions

• Use `return` to return a value

```python
def <function-name>(<parameter-names>):
    # do stuff
    return res
```

• Can return more than one value using commas

```python
def <function-name>(<parameter-names>):
    # do stuff
    return res1, res2
```

• Use **simultaneous assignment** when calling:
  ```python
  - a, b = do_something(1,2,5)
  ```

• If there is no return value, the function returns `None` (a special value)
Default Values & Keyword Arguments

- Can add `=<value>` to parameters

```python
def rectangle_area(width=30, height=20):
    return width * height
```

- All of these work:
  - `rectangle_area()` # 600
  - `rectangle_area(10)` # 200
  - `rectangle_area(10, 50)` # 500

- If the user does not pass an argument for that parameter, the parameter is set to the default value

- Can also pass parameters using `<name>=<value>` (keyword arguments):
  - `rectangle_area(height=50)` # 1500
Return

- As many return statements as you want
- Always end the function and go back to the calling code
- Returns do not need to match one type/structure (generally not a good idea)

```
def f(a, b):
    if a < 0:
        return -1
    while b > 10:
        b -= a
        if b < 0:
            return "BAD"
    return b
```