

Programming Principles in Python (CSCI 503/490)

Syntax & Types

Dr. David Koop

(some slides adapted from Dr. Reva Freedman)

Administrivia

- Course Web Site
- TA: Sufiyan Abdullah Ghorl Mohammed
- Syllabus
 - Plagiarism
 - Accommodations
- Assignments
- Tests: 2 (Feb. 19, Apr. 2) and Final (May 5)
- Course is offered to both undergraduates (CS 490) and graduates (CS 503)
 - Grad students have extra topics, exam questions, assignment tasks

Office Hours & Email

- TA office hours will be held in person in TA Offices
 - Tu 9:15am-12:15pm, Th 9:15-11:15am, 3:30-4:30pm
- Prof. Koop's office hours will be held in person in PM 461
 - M: 1:45-3:00pm, W: 10:45am-12:00pm, or by appointment
 - You do not need an appointment to stop by during scheduled office hours,
 - If you wish to meet virtually, please schedule an appointment
 - If you need an appointment, please email me with **details** about what you wish to discuss and times that would work for you
- Many questions can be answered via email. **Please consider writing an email before scheduling a meeting.**

Using Python & JupyterLab on Course Server

- <https://tiger.cs.niu.edu/jupyter/>
- Login with your Z-ID (lowercase z)
- You should have received an email with your password
- Advanced:
 - Can add your own conda environments in your user directory

Using Python & JupyterLab Locally

- www.anaconda.com/download/
- Consider mamba (faster) and conda-forge
- Anaconda includes JupyterLab
- Use Python 3.12 (may have to install)
- Anaconda Navigator
 - GUI application for managing Python environment
 - Can install packages & start JupyterLab
- Can also use the shell to do this:
 - `$ jupyter lab`
 - `$ conda install <pkg_name>`



Zen of Python

- Written in 1999 by T. Peters in a message to Python mailing list
- Attempt to channel Guido van Rossum's design principles
- 20 aphorisms, 19 written, 1 left for Guido to complete (never done)
- Archived as PEP 20
- Added as an easter egg to python (`import this`)
- Much to be deciphered, in no way a legal document
- Jokes embedded
- Commentary by A.-R. Janhangeer

Explicit Code

- Goes along with complexity
- Bad:

```
def make_complex(*args):  
    x, y = args  
    return dict(**locals())
```

- Good

```
def make_complex(x, y):  
    return {'x': x, 'y': y}
```


Don't Repeat Yourself

- "Two or more, use a for" [Dijkstra]
- Rule of Three: [Roberts]
 - Don't copy-and-paste more than once
 - Refactor into methods
- Repeated code is harder to maintain

- Bad

```
f1 = load_file('f1.dat')
r1 = get_cost(f1)
f2 = load_file('f2.dat')
r2 = get_cost(f2)
f3 = load_file('f3.dat')
r3 = get_cost(f3)
```

- Good

```
for i in range(1,4):
    f = load_file(f'f{i}.dat')
    r = get_cost(f)
```


Object-Oriented Programming

- Encapsulation (Cohesion): Put things together than go together
- Abstraction: Hide implementation details (API)
- Inheritance: Reuse existing work
- Polymorphism: Method reuse and strategies for calling and overloading

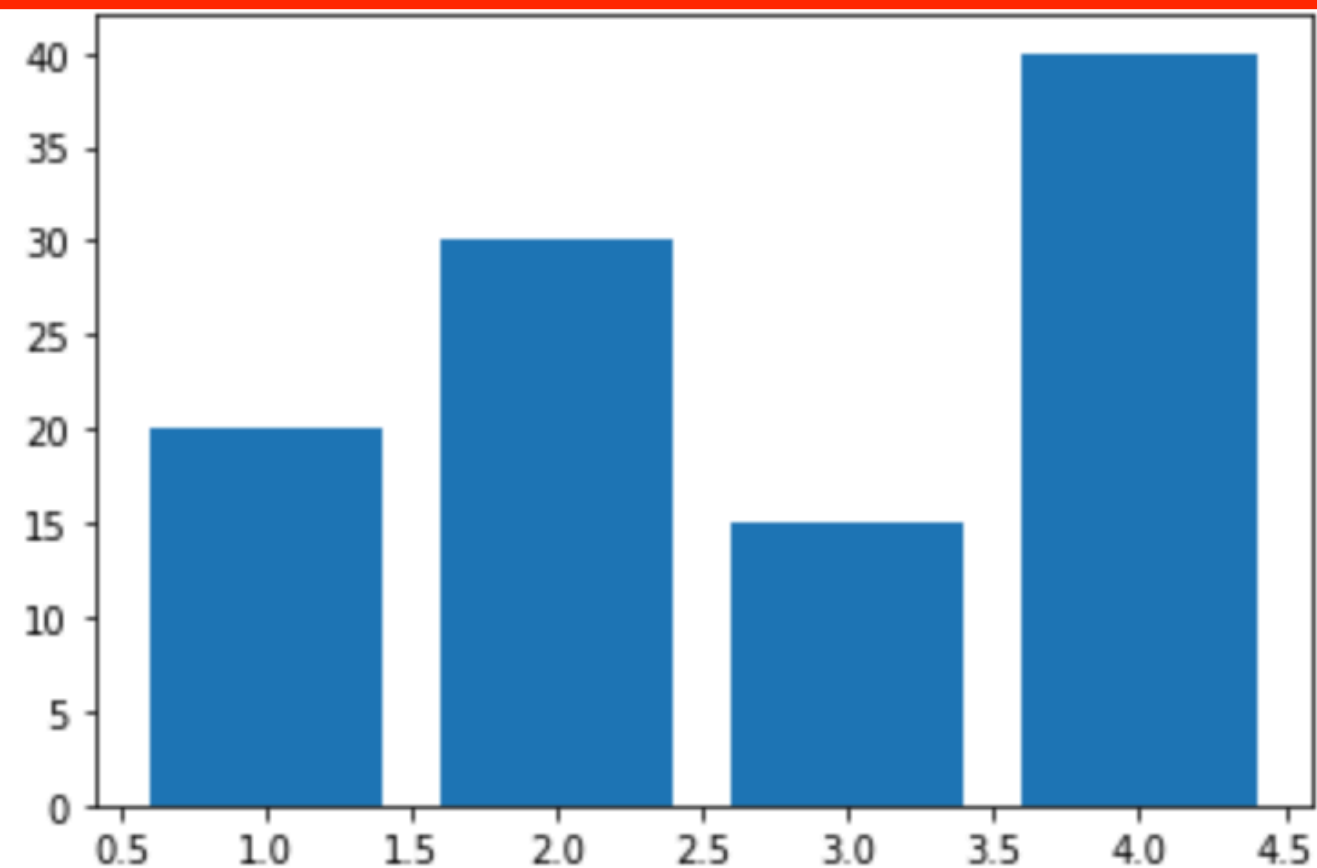
Multiple Types of Output

```
[2]: a = 12
     for i in range(3):
         print("Some output")
     plt.bar([1,2,3,4],[20,30,15,40])
     plt.show()
     a + 3
```

stdout

```
Some output
Some output
Some output
```

display



output

```
[2]: 15
```

```
[3]: 1 / 0
```

stderr

```
-----
ZeroDivisionError                                Traceback (most recent call last)
<ipython-input-3-bc757c3fda29> in <module>
----> 1 1 / 0

ZeroDivisionError: division by zero
```

Assignment 1

- Released Tuesday, due Monday, Jan. 27 at 11:59pm
- Goal: Become 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

Python Variables and Types

- No type declaration necessary
- Variables are names, not memory locations

```
a = 0
a = "abc"
a = 3.14159
```
- Don't worry about types, but think about types
- Strings are a type
- Integers are as big as you want them
- Floats can hold large numbers, too (double-precision)

Python Strings

- Strings can be delimited by single or double quotes
 - `"abc"` and `'abc'` are exactly the same thing
 - Easier use of quotes in strings: `"Joe's"` or `'He said "Stop!"'`
- Triple quotes allow content to go across lines and preserves linebreaks
 - `"""This is another string"""`
- String concatenation: `"abc" + "def"`
- Repetition: `"abc" * 3`
- Special characters: `\n` `\t` like Java/C++

Python Math and String "Math"

- Standard Operators: +, -, *, /, %
- Division "does what you want" (new in v3)
 - $5 / 2 = 2.5$
 - $5 // 2 = 2$ # use // for integer division
- Shortcuts: +=, -=, *=
- No ++, --
- Exponentiation (Power): **
- Order of operations and parentheses: $4 - 3 - 1$ vs. $4 - (3 - 1)$
- "abc" + "def"
- "abc" * 3

Comments in Python

- # for single-line comments
 - everything after # is ignored
 - `a = 3 # this is ignored`
 - `# this is all ignored`
- Triple-quoted strings also used for comments (technically, any string can be)
 - A literal string without assignment, etc. is basically a no-op
 - `"""This is a string, often used as a comment"""`
 - `"""This string
has multiple
lines"""`

Identifiers

- A sequence of letters, digits, or underscores, but...
- Also includes unicode "letters", spacing marks, and decimals (e.g. Σ)
- Must begin with a letter or underscore (`_`)
- Why not a number?

Identifiers

- A sequence of letters, digits, or underscores, but...
- Also includes unicode "letters", spacing marks, and decimals (e.g. Σ)
- Must begin with a letter or underscore (`_`)
- Why not a number? Ambiguity, `8j` is a complex number, `8e27` is a float
- 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

Reserved Words and Reassigning builtins

- Some words cannot serve as identifiers (called keywords in Python)
 - `import keyword`
`keyword.kwlist`
 - `['False', 'None', 'True', 'and', 'as', 'assert', 'async', 'await', 'break', 'class', 'continue', 'def', 'del', 'elif', 'else', 'except', 'finally', 'for', 'from', 'global', 'if', 'import', 'in', 'is', 'lambda', 'nonlocal', 'not', 'or', 'pass', 'raise', 'return', 'try', 'while', 'with', 'yield']`
 - `False = True` # `SyntaxError`
- Some other words (python's builtins) can, but this can cause problems
 - `int = 34`
`int("12")` # `TypeError`

Programming Principle: Use Meaningful Identifiers

- Show intention:
 - Bad: `var34`
 - Good: `time_difference`
- Easy pronunciation: Not `egészségedre` (perhaps ok if you're Hungarian)
- Simple but technical:
 - Bad: `in_order_list_of_jobs`
 - Good: `job_queue`
- Be consistent:
 - Bad: `user_list` and `groups`
 - Good: `user_list` and `group_list`

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)
 - `'234'` vs `b'234'` (string vs. byte string)

Type Conversion

- Python converts integers to floats when types are mixed
 - `1 + 3.4` # evaluates to `4.4` (float)
- Functions can return different types than inputs
 - `round(3.9)` # evaluates to `4` (int)
- Can do explicit type conversion
 - `int(3.9)` # evaluates to `3` (int)
 - `float(123)` # evaluates to `123.` (float)
 - `int("123")` # evaluates to `123` (int)
 - `str(123)` # evaluates to `"123"` (string)

Numeric Precision

- Integers have infinite precision and are as big as you want them
 - 93326215443944152681699238856266700490715968264381621468592963895217599993229915608941463976156518286253697920827223758251185210916864000000000000000000000000
- Floats do not have infinite precision but still hold large numbers (double-precision)
 - 9.33262154439441e+157
 - Python keeps 17 significant digits
 - Python by default only prints up to 12 (many times less)
- Python has support for infinite precision (Decimal)
- How might this work; how could you store a floating point number with infinite precision using python?

Expression Rules

- Involve
 - Literals (1, "abc"),
 - Variables (a, my_height), and
 - Operators (+, -, *, /, //, **)
- Spaces are **irrelevant** within an expression
 - a + 34 # ok
- Standard precedence rules
 - Parentheses, exponentiation, mult/div, add/sub
 - **Left to right** at each level
- Also **boolean** expressions

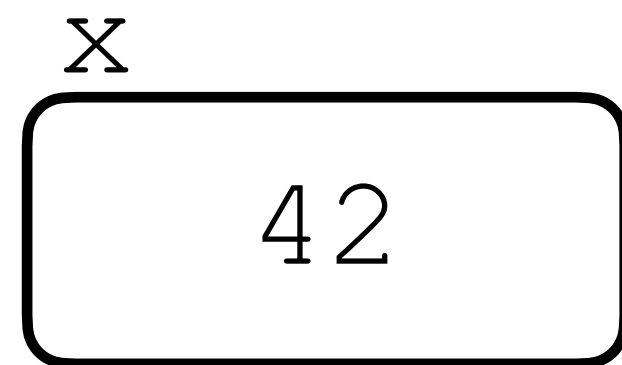
Assignment

- The = operator
- Can assign a literal, another variable, or any expression
 - `a = 34`
 - `b = a`
 - `c = (a + b) ** 2`
- Cannot use this operator in the middle of an expression, like in C++
- However, Python 3.8 added a new operator (the "walrus") that allows this

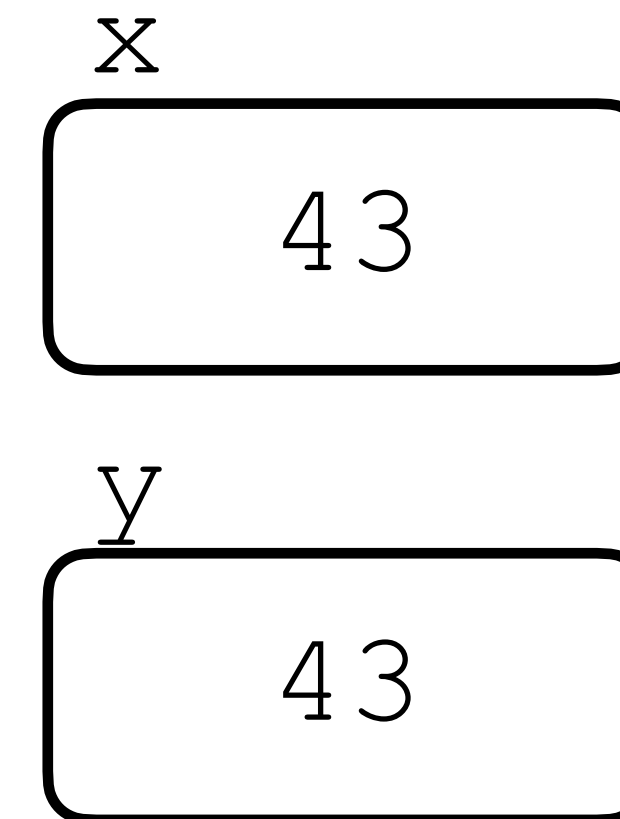
Assignment

- Other languages: set aside memory space for value and give that space a name; space can be updated with a new value

```
int x = 42;
```



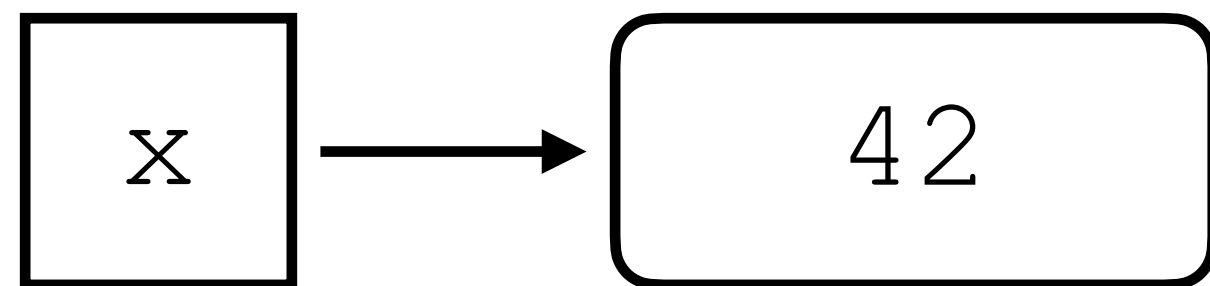
```
x = x + 1;  
int y = x;
```



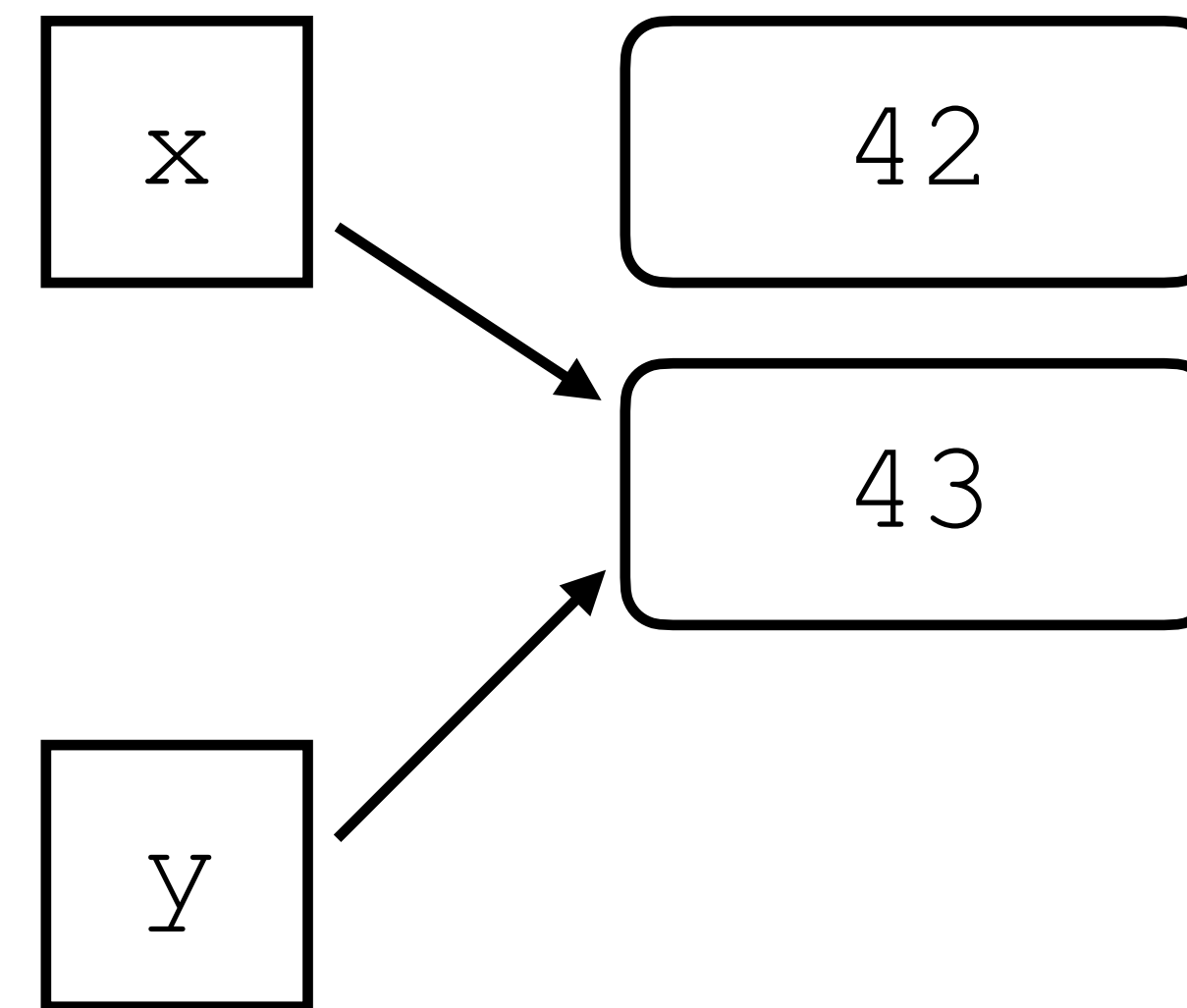
Assignment

- Python variables are actually **pointers** to objects (names for values)

`x = 42`



`x = x + 1`
`y = x`



Augmented Assignment

- Shorthand for mutation of a variable's value stored back in the same variable
- `i += 1` # same thing as `i = i + 1`
- `+=`, `-=`, `*=`, `/=`, `//=`, `**=`
- Python does not have `++` or `--`

Simultaneous Assignment

- Feature that doesn't appear in many other languages
- Allows multiple expressions to be assigned to different variables with one assignment
 - `a, b = 34 ** 2, 400 / 24`
- Commas separate the variables and expressions
- Most useful for swapping variables
 - `a, b = b, a`
- How does this usually work?

Simultaneous Assignment

- In most languages, this requires another variable
 - `x_old = x`
`x = y`
`y = x_old`
- Simultaneous assignment leaves less room for error:
 - `x, y = y, x`
- Also useful for unpacking a collection of values:
 - `dateStr = "03/08/2014"`
`monthStr, dayStr, yearStr = dateStr.split("/")`

Assignment Expressions

- AKA the "walrus" operator `:=`
- Names a value that can be used but also referenced in the rest of the expression
- `(my_pi := 3.14159) * r ** 2 + a ** 0.5/my_pi`
- Use cases: if/while statement check then use, comprehensions
- Supported in Python 3.8+

Assignment Expressions

- Contentious discussion on adding to the language
 - "There should be one-- and preferably only one --obvious way to do it"
 - Leads to different coding styles
- Adopted, and community moving on to best practices