CS 1110:
Introduction to Computing Using Python

Lecture 2

Variables & Assignment

[Andersen, Gries, Lee, Marschner, Van Loan, White]

Announcements

- We want to understand what lab sections are in demand.
- **NO PROMISES.**
- If you are still unable to get into a lab section:
  - Email up to three preferred sections to:
    - Ms. Jenna Edwards: jls478@cornell.edu
  - Use subject:
    - "CS1110 - cannot register, lab preferences"
    - "CS1110 - registered, lab switch preferences"
  - Deadline: Wed. 3pm

Course Website

- www.cs.cornell.edu/courses/cs1110/2017sp/

- **LOOK FOR THE SPRING 2017 BAT!!!**

- If no bat, *you are looking at the wrong year*

Things to Do Before Next Class

Read Textbook

- Chapter 1 (browse)
- Chapter 2 (in detail)
- Chapter 3.1 – 3.4

Lab 1

- Go to your registered section
- Complete lab handout
- Have ***one week*** to complete
  - Show to TA by end of lab, or:
  - Show in consulting hours up to the day *before* your lab, or:
  - Show to TA ***within first 10 minutes*** of next week's lab

Helping You Succeed in this Class

- **Consultants.** ACCEL Lab Green Room
  - Daily office hours (see website) with consultants
  - Very useful when working on assignments
- **AEW Workshops**. Additional discussion course
  - Runs parallel to this class – completely optional
  - See website; talk to advisors in Olin 167.
- **Piazza.** Online forum to ask and answer questions
- **Office Hours.** Talk to the professors!

From last time: Types

Type: set of values and the operations on them

- Type **int**:
  - **Values**: integers
  - **Ops**: +, –, *, /, %, **
- Type **float**:
  - **Values**: real numbers
  - **Ops**: +, –, *, /, **
- Type **bool**:
  - **Values**: **True** and **False**
  - **Ops**: not, and, or
- Type **str**:
  - **Values**: string literals
    - Double quotes: "abc"
    - Single quotes: 'abc'
  - **Ops**: + (concatenation)

Converting From One Type To Another

- Command: *<type>*(*< value>*)
  - float(2) converts value 2 to type **float** (value now 2.0)
  - int(2.6) converts value 2.6 to type **int** (value now 2)
  - This kind of conversion is also called “casting”

- This is DIFFERENT from type(*< value>*)
  - type(*< value>*) **tells** you the type
  - *<type>*(*< value>*) **converts** the type

Implicit (Automatic) Conversions

- Python sometimes converts types automatically
  - **Example**: 1/2.0
    - evaluates to a ***float***: 0.5
    - internally:
      - Step 1: Python casts 1 (an **int**) to 1.0 (a **float**)
      - Step 2: Python evaluates 1.0/2.0

- Behavior depends on whether the conversion is *narrowing* or *widening*

Variable “width”

- Types differ in how much information they hold
- Can convert without losing information?
  - **float** to **int** (e.g. 4.7 to 4) information lost
  - **int** to **float** (e.g. 4 to 4.0) seems ok
- “Wide” = more information capacity
- From narrow to wide: **bool** ⇒ **int** ⇒ **float**

Widening Conversion

- from a *narrower* type to a *wider* type
- Python does **automatically** if needed:
  - **Example**: 1/2.0 evaluates to a ***float***: 0.5
  - **Example:** True + 1 evaluates to an ***int***: 2
    - True converts to 1
    - False converts to 0
- Note: does not work for string
  - **Example:** 2 + "ab" produces an error

Narrowing Conversion

- from a *wider* type to a *narrower* type
  - **Example**: int(2.6)
- causes information to be lost
- Python *never* does this automatically

- Note: you *can* just always cast
  - Instead of 1/2.0, can write float(1)/2.0

Operator Precedence

- What is the difference between the following?
  - 2*(1+3) **add, then multiply**
  - 2*1 + 3 **multiply, then add**
- Operations are performed in a set order
  - Parentheses make the order explicit
- What happens when there are no parentheses?
- **Operator Precedence**: The *fixed* order Python processes operators in *absence* of parentheses

Precedence of Python Operators

- **Exponentiation**: **
- **Unary operators**: + –
- **Binary arithmetic**: * / %
- **Binary arithmetic**: + –
- **Comparisons**: < > <= >=
- **Equality relations**: == !=
- **Logical not**
- **Logical and**
- **Logical or**

- Precedence goes downwards
  - Parentheses highest
  - Logical ops lowest
- Same line = same precedence
  - Read "ties" left to right
  - Example: 1/2*3 is (1/2)*3

- Section 2.7 in your text
- See website for more info
- Major portion of Lab 1

Operators and Type Conversions

Evaluate this Expression:

False + 1 + 3.0 / 3

A. 3
B. 3.0
C. 1.3333
D. 2
E. 2.0

Operator Precedence

- **Exponentiation**: **
- **Unary operators**: + –
- **Binary arithmetic**: * / %
- **Binary arithmetic**: + –
- **Comparisons**: < > <= >=
- **Equality relations**: == !=
- **Logical not**
- **Logical and**
- **Logical or**

Operators and Type Conversions

Evaluate this Expression:

False + 1 + $\boxed{3.0 / 3}$

$\boxed{\text{False + 1}}$ + 1.0

1 + 1.0

2.0

Operator Precedence

- **Exponentiation**: **
- **Unary operators**: + –
- **Binary arithmetic**: * / %
- **Binary arithmetic**: + –
- **Comparisons**: < > <= >=
- **Equality relations**: == !=
- **Logical not**
- **Logical and**
- **Logical or**

New Tool: Variable Assignment

- An *assignment statement* takes a *value* and stores it in a *variable*
- **Example**: x = 5

variable

equals sign
(just one!)

value

Executing Assignment Statements

```
>>> x = 5
```

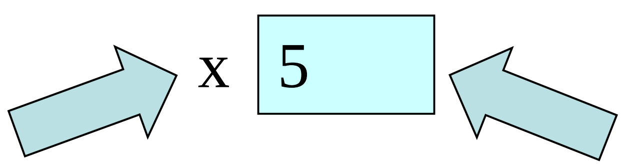
Press ENTER and…

```
>>>
```

Hm, looks like nothing happened…

- But something did happen!
- Python *assigned* the *value* 5 to the *variable* x
- Internally (and invisible to you):

memory location



stored value

Retrieving Variables

```
>>> x = 5
>>>
```

Retrieving Variables

```
>>> x = 5
>>> x
5
>>>
```

Press ENTER and…

Python tells me the stored value

In More Detail: Variables (Section 2.1)

- A **variable**
  - is a **named** memory location (**box**)
  - contains a **value** (in the box)

- Examples:

Variable names must start with a letter (or _).

The type belongs to the *value*, not to the *variable*.

x	5	Variable **x**, with value 5 (of type **int**)
area	20.1	Variable **area**, w/ value 20.1 (of type **float**)

1e2 is a **float**, but e2 is a variable name

In More Detail: Statements

>>> x = 5

Press ENTER and…

>>>

Hm, looks like nothing happened…

- This is a **statement**, not an **expression**
  - Tells the computer to DO something (not give a value)
  - Typing it into **>>>** gets no response (but it is working)

Expressions vs. Statements

Expression	Statement
• **Represents** something ▪ Python *evaluates it* ▪ End result is a value • Examples: ▪ 2.3 — Value ▪ (3+5)/4 — Complex Expression	• **Does** something ▪ Python *executes it* ▪ Need not result in a value • Examples: ▪ x = 5

Variables in Expressions

>>> x = 5

>>> x

5

>>>

This is an *expression*

So Python *evaluates* it

Variables in Expressions

```
>>> x = 5
>>> x
5
>>> x + 5
10
>>>
```

This is an *expression*

So Python *evaluates* it

Variables in Expressions

```
>>> x = 5
>>> x
5
>>> x + 5
10
>>> x ** 2 + x – 1
29
>>>
```

This is an *expression*

So Python *evaluates* it

Assignment Statements with Expressions

```
>>> x = 5
>>> x = x + 2
```

Python evaluates this *expression* first…

… then assigns the result to the *variable*

Keeping Track of Variables

- Draw boxes on pieces of paper:

  x $\boxed{5}$

- If a new variable is declared, write a new box:

  x $\boxed{5}$

  y $\boxed{5}$

- If a variable is updated, cross it out:

  x $\boxed{\cancel{5}\ 7}$

  y $\boxed{5}$

Execute the Statement: **x = x + 2**

- Draw variable x on piece of paper:

x $\boxed{5}$

Execute the Statement: `x = x + 2`

- Draw variable x on piece of paper:

x	5

- Step 1: evaluate the expression `x + 2`
  - For x, use the value in variable x
  - Write the expression somewhere on your paper

Execute the Statement: x = x + 2

- Draw variable x on piece of paper:

  x $\boxed{5}$

- Step 1: evaluate the expression x + 2
  - For x, use the value in variable x
  - Write the expression somewhere on your paper
- Step 2: Store the value of the expression in x
  - Cross off the old value in the box
  - Write the new value in the box for x

Execute the Statement: x = x + 2

- Draw variable x on piece of paper:

x $\boxed{5}$

- Step 1: evaluate the expression x + 2
  - For x, use the value in variable x
  - Write the expression somewhere on your paper
- Step 2: Store the value of the expression in x
  - Cross off the old value in the box
  - Write the new value in the box for x
- Check to see whether you did the same thing as your neighbor, discuss it if you did something different.

Which One is Closest to Your Answer?

A:

x ~~5~~ 7

B:

x 5

x 7

C:

x ~~5~~

x 7

D:

¯_(ツ)_/¯

Which One is Closest to Your Answer?

A:

x ~~5~~ 7

B:

x 5

x 7

C:

x ~~5~~

x 7

$x = x + 2$

Execute the Statement: **x = 3.0 * x + 1.0**

- You have this:

x $\boxed{\cancel{5}\ 7}$

Execute the Statement: x = 3.0 * x + 1.0

- You have this:

  x ~~5~~ 7

- Execute this command:
  - Step 1: **Evaluate** the expression 3.0 * x + 1.0
  - Step 2: **Store** its value in x

Execute the Statement: x = 3.0 * x + 1.0

- You have this:

  x ~~5~~ 7

- Execute this command:
  - Step 1: **Evaluate** the expression 3.0 * x + 1.0
  - Step 2: **Store** its value in x
- Check to see whether you did the same thing as your neighbor, discuss it if you did something different.

Which One is Closest to Your Answer?

A:

x ~~5~~ ~~7~~ 22.0

B:

x ~~5~~ 7

x 22.0

C:

x ~~5~~ ~~7~~

x 22.0

D:

¯_(ツ)_/¯

Which One is Closest to Your Answer?

A:

x ~~5~~ ~~7~~ 22.0

B:

x ~~5~~ 7

x 22.0

C:

x ~~5~~ ~~7~~

x 22.0

x = 3.0 * x + 1.0

Execute the Statement: x = 3.0 * x + 1.0

- You now have this:

  x | ~~5~~ ~~7~~ 22.0 |

- The command:
  - Step 1: **Evaluate** the expression 3.0 * x + 1.0
  - Step 2: **Store** its value in x
- This is how you execute an assignment statement
  - Performing it is called **executing the command**
  - Command requires both **evaluate** AND **store** to be correct
  - Important *mental model* for understanding Python

Exercise: Understanding Assignment

- Add another variable, interestRate, to get this:

  x ~~5~~ ~~7~~ 22.0 interestRate 4

- Execute this assignment:

  ```
  interestRate =  x / interestRate
  ```

- Check to see whether you did the same thing as your neighbor, discuss it if you did something different.

Which One is Closest to Your Answer?

A:

x ~~5~~ ~~7~~ ~~22.0~~ 5.5

interestRate ~~4~~ 5.5

B:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~

interestRate 5.5

C:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ 5.5

D:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ 5

Which One is Closest to Your Answer?

A:

x ~~5~~ ~~7~~ ~~22.0~~ 5.5

interestRate ~~4~~

B:

x ~~5~~ ~~7~~ 22.0

~~4~~

5.5

C:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ 5.5

interestRate ~~4~~ 5

E:

¯_(ツ)_/¯

Which One is Closest to Your Answer?

```
interestRate =  x/interestRate
```

B:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~

interestRate 5.5

C:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ 5.5

D:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ 5

Exercise: Understanding Assignment

- You now have this:

x | ~~3~~ ~~7~~ 22.0 | interestRate | ~~4~~ 5.5 |

- Execute this assignment:

```
intrestRate =  x + interestRate
```

- Check to see whether you did the same thing as your neighbor, discuss it if you did something different.

Which One is Closest to Your Answer?

A:

x: ~~5~~ ~~7~~ 22.0

interestRate: ~~4~~ ~~5.5~~ 27.5

B:

x: ~~5~~ ~~7~~ 22.0

interestRate: ~~4~~ 5.5

intrestRate: 27.5

C:

x: ~~5~~ ~~7~~ ~~22.0~~ 27.5

interestRate: ~~4~~ 5.5

D:

x: ~~5~~ ~~7~~ 22.0

interestRate: ~~4~~ ~~5.5~~

intrestRate: 27.5

Which One is Closest to Your Answer?

A:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~

B:

x ~~5~~ ~~7~~ 22.0

estRate ~~4~~ 5.5

27.5

E:

¯_(ツ)_/¯

C:

x ~~5~~ ~~7~~ ~~22.0~~ 2

interestRate ~~4~~ 5.5

interestRate ~~4~~ ~~5.5~~

intrestRate 27.5

Which One is Closest to Your Answer?

A:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ ~~5.5~~ 27.5

B:

x ~~5~~ ~~7~~ 22.0

interestRate ~~4~~ 5.5

intrestRate 27.5

intrestRate = x + interestRate

^
e

Spelling mistakes in Python are **bad!!**

Dynamic Typing

- Python is a **dynamically typed language**
  - Variables can hold values of any type
  - Variables can hold different types at different times
  - Use type(x) to find out the type of the value in x
- The following is acceptable in Python:

```
>>> x = 1          ← x contains an int value
>>> x = x / 2.0    ← x now contains a float value
```

- Alternative is a **statically typed language** (e.g. Java)
  - Each variable restricted to values of just one type

More Detail: Testing Types

- Command: type(<value>)

- Can test a variable:

```
>>> x = 5
>>> type(x)
<type 'int‘>
```

- Can test a type with a Boolean expression:

```
>>> type(2) == int
True
```