Introduction to Computational and Algorithmic Thinking

LECTURE 2 – COMPUTER PROGRAMMING FUNDAMENTALS

1

Announcements

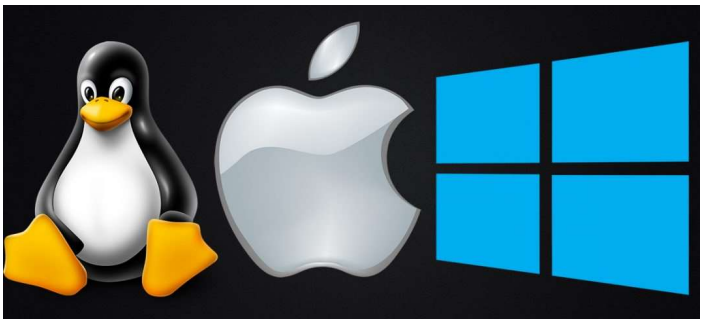
This lecture: Computer Programming Fundamentals

Reading: Read Chapter 2 of Conery

2

What is an Operating System?

Operating System is a program that manages computer hardware and software resources, and provide common services for computer applications.



3

What is Python?

- Python is a computer programming language
  - Relatively simple **syntax** (set of rules programmers must follow when writing programs)
- Python can be used to write simple programs that do basic calculations or very complicated ones
  - Can write basic games!
  - Python is popular with scientists because they can do complex data analysis by writing short programs
- Python can be installed on a wide variety of computer types and operating systems

4

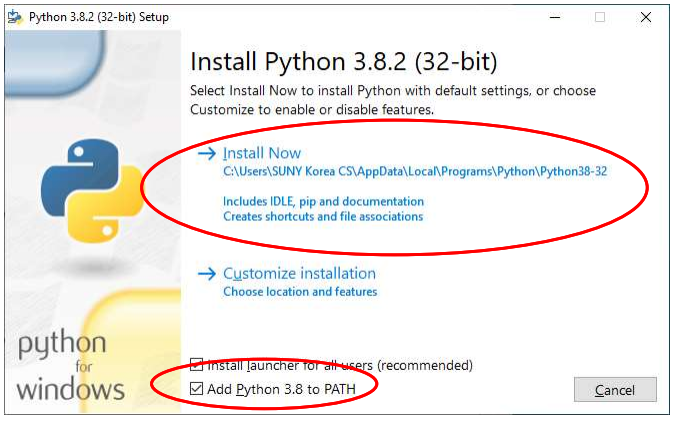
Python Installation on Windows

https://www.python.org/downloads/

5

Python Installation on Windows

https://www.python.org/downloads/



6

Python Installation on Mac

1. Go to https://www.python.org/downloads/
2. Download Python 3.8.2. It should save a file named "python-3.8.2-macosx10.9.pkg" to your computer.
3. Double click on the file and run the install with default options and agree with the license. You'll need to type in your password to install it.

Video tutorial:

https://www.youtube.com/watch?v=8BiYGIDCvvA

7

What is a computer program?

- A computer program is a sequence of instructions the computer executes to solve a well-defined problem
- The instructions or steps the programmer writes constitute the **source code** of the program
- In Python, many of these instructions look like regular, everyday English with some extra punctuation thrown in
- There are two basic ways to give commands written in Python to the computer:

1. Type individual instructions via a **shell**, an interactive program that executes the commands
2. Write a complete, stand-alone **application** that we can run over and over

8

Python console / interactive shell

- The **console** (or interactive shell) is
  - a window where a single command or short set of commands can be typed to the computer
  - the computer tries to execute those command
- Python **interpreter**
  - Reads Python instructions typed into the console by the user
  - The interpreter converts them into a form the computer's hardware understands
  - The language that the hardware understands is called **machine language**
- No matter what language is used, at some point the source code must be translated into machine code for the computer to execute it

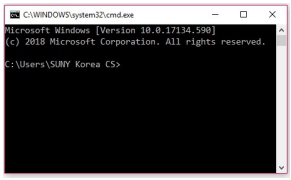
Opening a Terminal

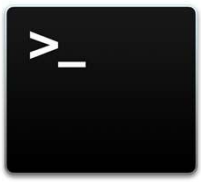
Windows

- Press "Win-R," type "cmd" and press "Enter" to open a Command Prompt session using just your keyboard.

Mac OS

- Finder -> Applications -> Utilities -> Terminal





Start the Python Interpreter

In your terminal:

On Windows:

Type "python " and press "Enter "

On Mac:

Type "python3" and press "Enter"

11

Some Python Statements

- print (“helloworld”)
- 1 + 1
- a = 1;
- b = 2;
- a + b
- name = “SUNY”
- country = “Korea”
- print (name + country)
- Pi = 22/7
- print (type(name))
- print (type(Pi))

12

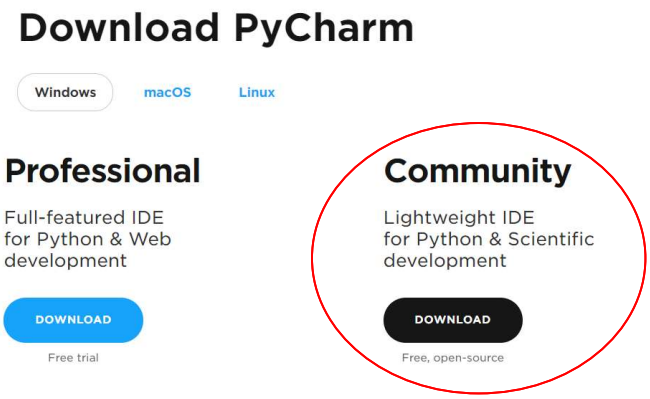
The PyCharm IDE

- In this course, an **integrated development environment** (IDE) called PyCharm will be used
- PyCharm is industry-grade software used by professional software developers
  - still easy enough for novice programmers to use
  - First download and install Python from www.python.org (ignore if already done)
  - Go to www.jetbrains.com/pycharm/download to download and install the free Community Edition of PyCharm

13

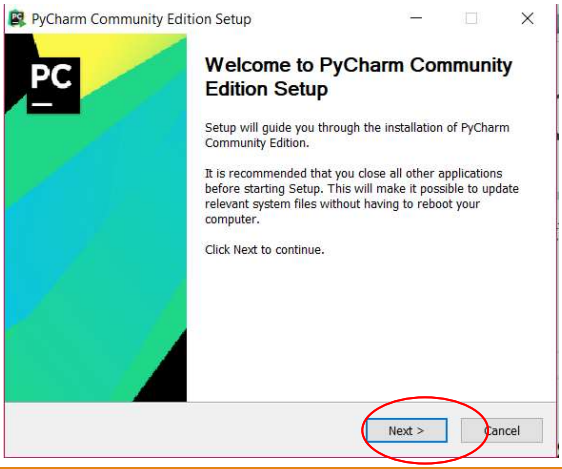
PyCharm Installation

https://www.jetbrains.com/pycharm/download/#section=windows



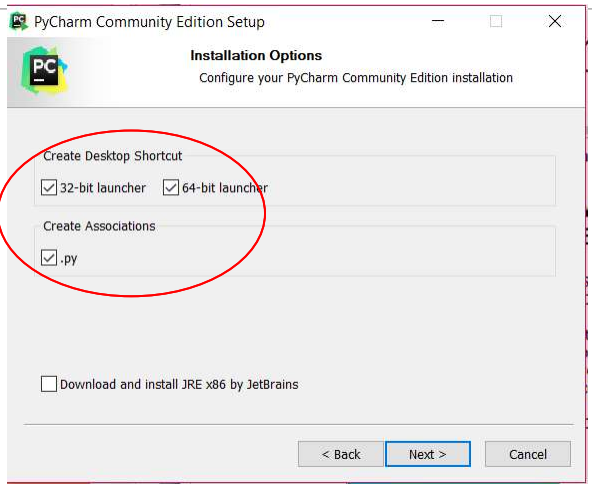
14

PyCharm Installation



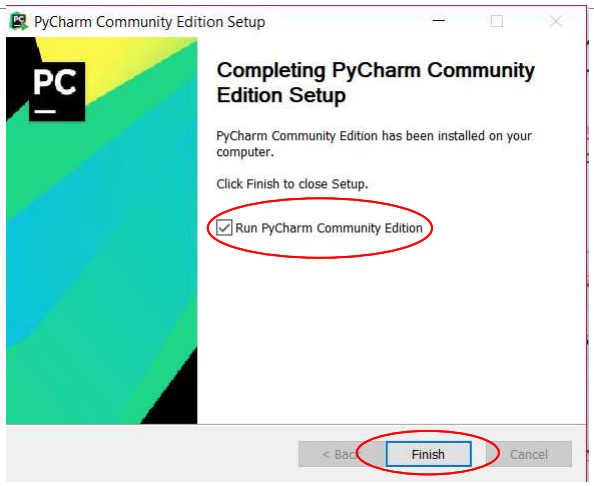
15

PyCharm Installation



16

PyCharm Installation



17

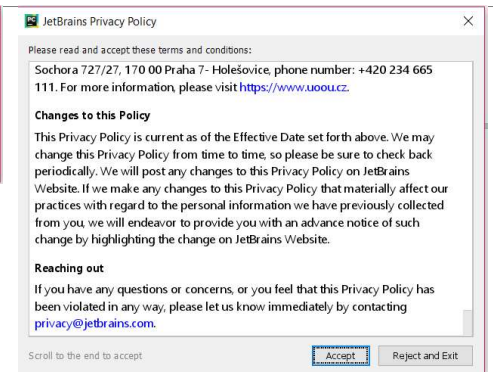
PyCharm Installation on Mac

1. Go to https://www.jetbrains.com/pycharm/download/ to download and install the **free Community Edition of PyCharm**.
2. Now, go to the Applications folder and start **PyCharm CE.app**. You might want to put it on the dock.

Video tutorial: https://www.youtube.com/watch?v=wb4HNqQtIlI

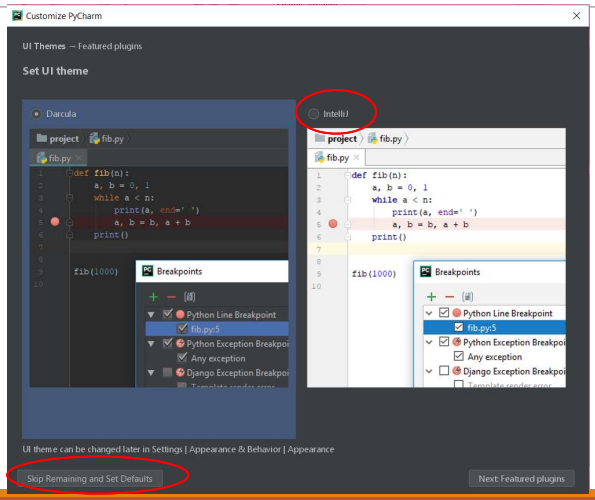
18

PyCharm Configuration for the first time



19

PyCharm Configuration for the first time

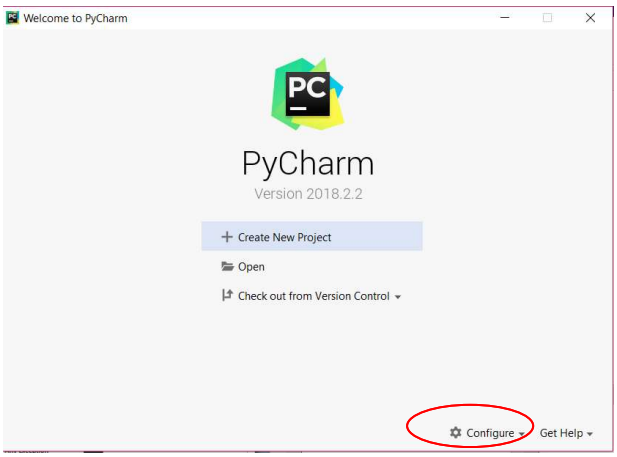


20

Setting default interpreter

Step 1:

Select Configure -> Preferences



21

Setting Default Python Interpreter in PyCharm

Step 2: Find out installation location of Python program:

Windows terminal command
- **where python**

Mac terminal command
- **which python3**

Note down the paths of python installation.

Note the path that is printed out. This is where your Python is installed – you will need this next.

The path can be different for each computer.

On Mac it may be: /Library/Frameworks/Python.framework/Versions/3.8/bin/python3

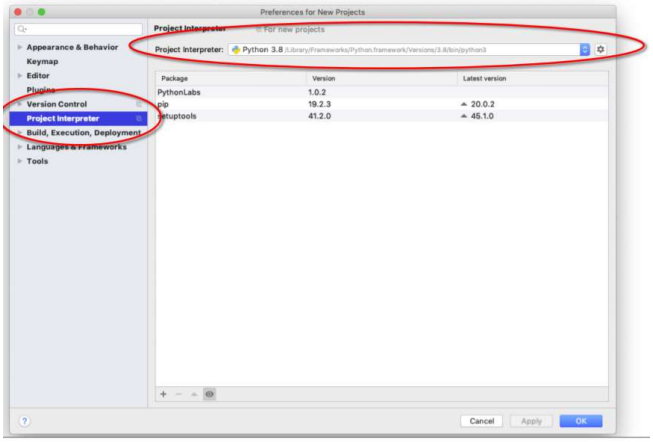
On the Windows machine it may be: C:\Users\SUNYCS\AppData\Local\Programs\Python\Python38-32\python.exe

22

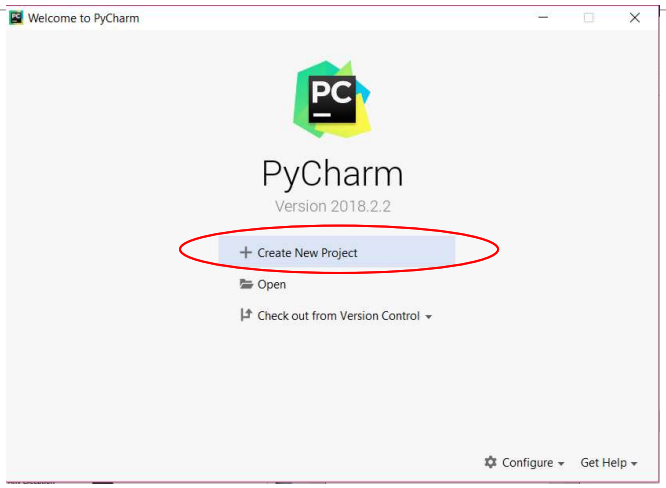
Setting Default Python Interpreter in PyCharm

Step 3: Configure project settings (and New Project Settings) in PyCharm:

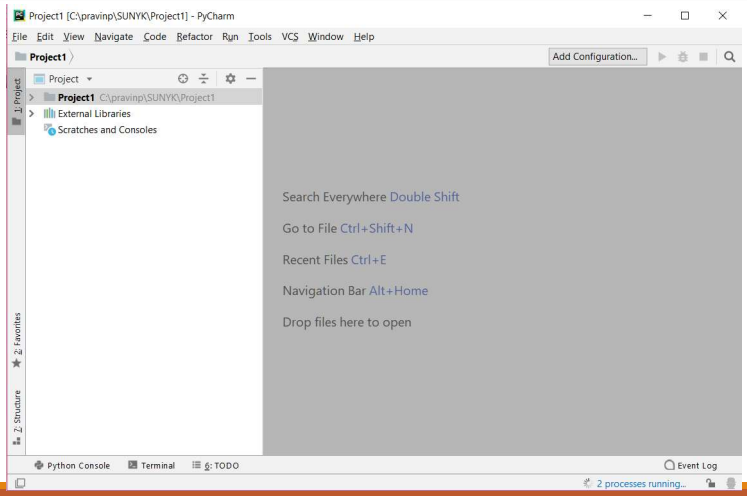
Go back to PyCharm's Configuration Screen. Click on the Project Interpreter tab on the left side. Then click on the "Project Interpreter" box and select or add the Python 3.8 interpreter. This box should have the same path you noted in the last step.



PyCharm Project

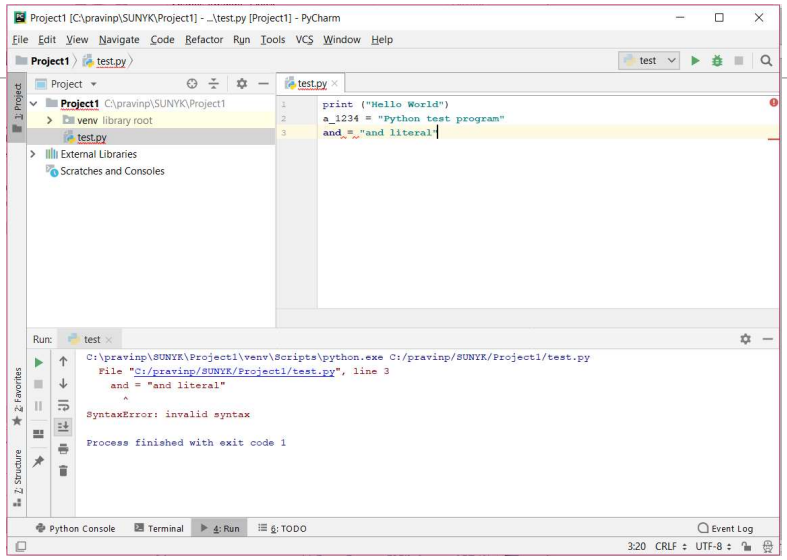


PyCharm IDE



25

PyCharm IDE



26

27

PyCharm basics

- To create and run a stand-alone Python program:
  1. Start PyCharm and press the “Create New Project” button.
  2. Pick a “Location” and name for the Project (e.g., “CSE 101”).
  3. Select File Menu > New > Python File and enter the name of the file for the source code.
  4. Write the program and save the file.
  5. After saving, go to Run Menu > Run.
  6. Select the name of the program file to run it.
- The next time the program is to be run:
  - Hit the green triangle in the lower-left corner of the screen.
  - Or, right-click the name of the file and choose Run.

28

Expressions

- **Expression** represent something like a number, string or value
- **'Hello, world!'** is an expression
  - It has a value
  - In this case, it's a **string** (a sequence of characters)
- Numbers are also expressions
  - 5 is an **integer** expression
    - recall that an integer is zero, or a positive or negative whole number with no fractional part
  - 12.36 is a **floating-point** expression
    - **floating-point** is a format that computers use to represent **real** numbers
    - recall that a real number is zero, or a positive or negative number that might have a fractional part

29

Expressions

- An expression may consists of operators and operands
  - **2 * 9** is an expression and represents a multiplication
- Python also has **Boolean** expressions, which are expressions that can be **True** or **False**
  - Boolean expressions allow programs to change their behavior from one run to the next. (More soon).
- So there are least three kinds of data in Python programming:
  - Strings
  - Numbers
  - true/false (Boolean) values
- In computer programming, there is a wide variety of data because there is a wide variety of problems that computers can help to solve

30

Arithmetic in Python

- Some of the simplest statements in Python involve arithmetic expressions, which contain numbers (operands) and mathematical operators
- Arithmetic in Python follows the PEMDAS rule:
  1. First, evaluate all expressions in parentheses (P)
  2. Then, perform exponentiations (E)
  3. Next, perform multiplications (M) and divisions (D) in left-to-right order
  4. Finally, perform additions (A) and subtractions (S) in left-to-right order

31

Arithmetic in Python

- The symbols used for operators are commonly used in other languages and applications (e.g., spreadsheets)
  - add: +
  - subtract: -
  - multiplication: *
  - division for real numbers: /
  - division for integers: // (when a remainder is not needed or desired)
  - remainder: % (gives the remainder of an *integer* division)
  - exponentiation: **

32

Examples of arithmetic in Python

- **11 + 5 ➔ 16**
- **11 – 5 ➔ 6**
- **11 * 5 ➔ 55**
- **11 / 5 ➔ 2.2**
- **11 // 5 ➔ 2**
  - This example shows **integer division**. Any remainder is discarded.
- **11 % 5 ➔ 1**
  - The computer divides 11 by 5 and returns the remainder (which is 1) instead of the quotient (which is 2).
  - Use the remainder operator only with integers.

33

Arithmetic in Python

- The ** operator does exponentiation or raises a number to a power
- For example, 2 ** 5 would be 32 because $2^5 = 32$
- Recall raising a number to the power ½ is the same as taking a square root
  - So 16 ** 0.5 would be the same as √16 which is 4

34

Arithmetic in Python

- The constant π is built into Python
- First the programmer must make it available by **import**ing the **math module**:
  - **import math**
- Then the expression **math.pi** can be used in expressions
  - **math.pi * 2 + 1**
- A Python module is a file consisting of Python source code that are all related somehow
  - For example, the **math** module contains code pertaining to mathematical functions and constants

Variables

- A **variable** in computer programming is similar to the concept of a variable in mathematics
  - A name for some value or quantity of interest in a given problem
- In a program, variables can store a person's age, GPA, name, or almost any other kind of information
  - Value is temporarily stored in the main memory (RAM) of the computer while the program is running
  - A variable is a kind of **identifier** because it identifies (names) something in source code
- It is important to choose identifiers (e.g., variable names) that are informative and helpful
  - Example: **first_name** would be a good variable to store a person's first name, whereas **fn** would not be as good because it's less informative
  - Note how the underscore is used to separate words that define the identifier
  - Spaces are not allowed in variable names

Variables

- A Python variable name may contain lowercase letters, uppercase letters, digits and underscores
  - First character must be a letter or underscore
- Lowercase and uppercase letters are treated as completely different characters
  - Because of this we say that Python is a **case-sensitive language**
  - **First_Name**, **first_name** and **FIRST_NAME** would all be treated as different identifiers
- There are a number of **keywords** built into the Python language that have pre-defined meanings
  - Predefined keywords may not be used as variables

37

Assignment statements

- To give a value to a variable, write an **assignment statement**
- An assignment statement consists of a variable name, the equals sign, and a value or expression
- Examples:

  count = 3 (“count is 3” or “count becomes 3”)

  total = 3.85 + 12.9

  firstName = ‘Susan’
- These examples show three different data types: an integer, a real number, and a string

38

Assignment statements

- After assigning a value to a variable, you can change the value of the variable with another assignment statement:

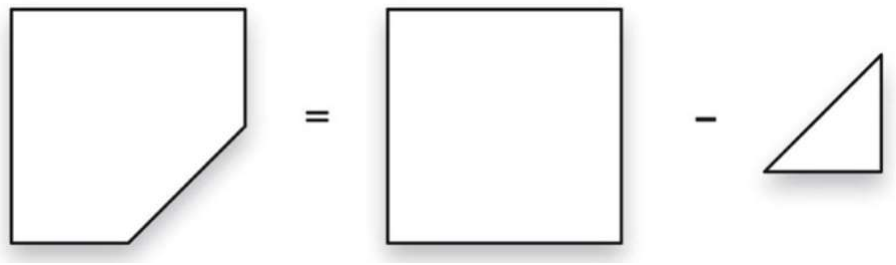
```
total = 5 + 8 + 3
... other code here ...
total = 17 + 6
... etc. ...
```

- Variables can also appear on the right-hand side (RHS) of an assignment statement:

```
next_year = this_year + 1
total_bill = subtotal + tax + tip
```


Example: Area calculation

Want to compute the area of a square countertop with one corner cut off, as shown here



Example: Area calculation

- Assume that the triangular cut-out begins halfway along each edge
- If the computation is needed only once, say for a 100cm-long countertop, can write a statement like this:

```
area = 100**2 - 50*50/2
```

- Note that this code has a few issues with it:
  - It's just a formula of sorts with no explanation of what the numbers mean
  - The code works only for countertops exactly 100 cm long. What if we had countertops of other sizes?

41

Example: Area calculation

- Consider the first issue: lack of clarity

```
# area = area of square - area of triangle
# area of triangle is 1/2 base*height
area = 100**2 - 50*50/2
```

- The lines beginning with the # symbol are called **comments**
  - Comments are notes that the programmer writes to explain what the program does
  - Comments do not affect the input or output of the program or anything about how it runs

42

Example: Area calculation

- Now let's address the other issue: lack of generality

```
side = 100
square = side**2
triangle = (side/2)**2 / 2
area = square – triangle
```

- To compute the area for a countertop of a different size, simply change the first line:

```
side = 100
```

- This code is also more readable; comments aren't needed
  - This is an example of **self-documenting code**
- The spacing in between variables, numbers, and operator is optional, but is included here to make the formulas easier to read

Aside: input statements

- To improve the code further, make it interactive so that the user can provide the value for **side**
- Do this by writing an **input statement**
- An input statement reads a string from the keyboard
- As part of an input statement, the programmer must give a **prompt** message that tells the user what they should enter
- Example: **name = input('What is your name? ')**
- The person's name will be *assigned to* the **name** variable
  - You could also say that we are *saving* the person's name in the **name** variable

Example: Area calculation

- In the case of the area calculation, the user should enter a number, not a string
- Use the following:

  side = int(input('Enter side length:'))
- To collect a floating-point number, use:

  side = float(input('Enter side length:'))
- The type chosen – **int** vs. **float** – depends on the application
- For this program, read in a float so the user could enter a fraction of a centimeter if desired
- The last piece of the puzzle is how to display the final result on the computer screen

Aside: print statements

- **print** is a Python command
- It tells Python to display some text on the screen
  - All Python commands are lowercase
- The syntax to print a basic message is just this:

  print('Hello, world!')
- Any text printed with additional print commands will appear on a new line
- For Python to print the next output on the same line, do this instead:

  print('Hello, world!', end='') # for python3
- This means *print this message, but do not automatically go to the next line*

Aside: print statements

- To print a number, it must first be converted into a string, like so:
  print('The area is ' + str(area))
  - The assumption here is that **area** is a variable that contains the value we want to print
- When used in this fashion, the + symbol performs **string concatenation**
  - This simply means Python will join the two strings together into one

47

Example: countertop.py

```
# This program prints the area of a
# countertop formed by cutting the
# corner off a square piece of material
# (e.g., granite).

side = float(input('Enter side length: '))
square = side**2
triangle = (side/2)**2 / 2
area = square - triangle
print('The area is ' + str(area))
```


48

Example: coins.py

- Here is an example of the remainder operator in integer division
- Given a total number of cents, the computer should print how many dimes, nickels, and pennies are needed to make that change while minimizing the number of coins
  - The code will make good use of variables
  - It will use the **str** command to print variables containing numbers to the screen
    - Recall that **str** converts a number to a string so that it can be concatenated with other strings
  - A dime = 10 cents
  - 1 nickel = 5 cents
  - 1 penny = 1 cent

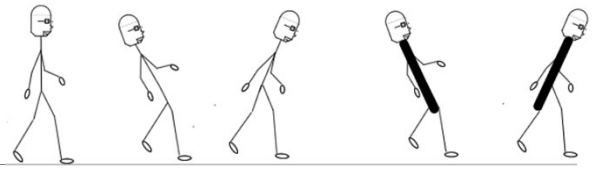
Example: coins.py

```
cents = int(input("Enter the number of cents: "))

dimes = cents // 10
cents = cents % 10
nickels = cents // 5
cents = cents % 5
pennies = cents

print("That number of cents is equal to " +
      str(dimes) + " dimes, " + str(nickels) + "
      nickels and " + str(pennies) + " pennies.")
```

Escape sequences



- Escape sequences in programming languages like Python allow printing characters (symbols) on the screen that perform special functions
- In Python, some of the escape sequences are:
  - **\t** shifts the text to the right by one tab stop
  - **\n** prints a newline
  - **\"** prints a double quotation mark
  - **\'** prints a single quotation mark
- A lone backslash character is called the **line-continuation character** (it's not really an escape sequence, though)
  - This symbol is a signal to Python that the current statement spans two or more lines of a file

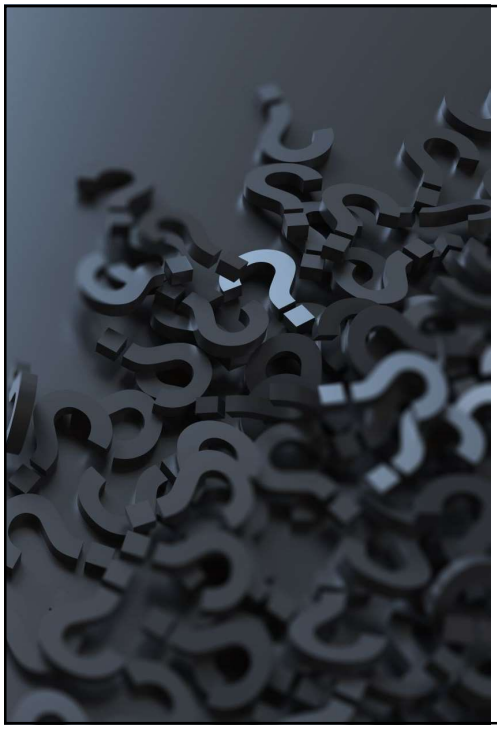
Example: limerick.py

Source code:

```
print('There was an old man with a beard\n\
Who said, \"It\'s just how I feared!\"\n\
\tTwo owls and a hen\n\
\tFour larks and a wren\n\
Have all built their nests in my beard.')
```

Output:

```
There was an old man with a beard
Who said, "It's just how I feared!"
        Two owls and a hen
        Four larks and a wren
Have all built their nests in my beard.
```



Questions?