MicroPython Introduction

MCHE 201 – Spring 2019

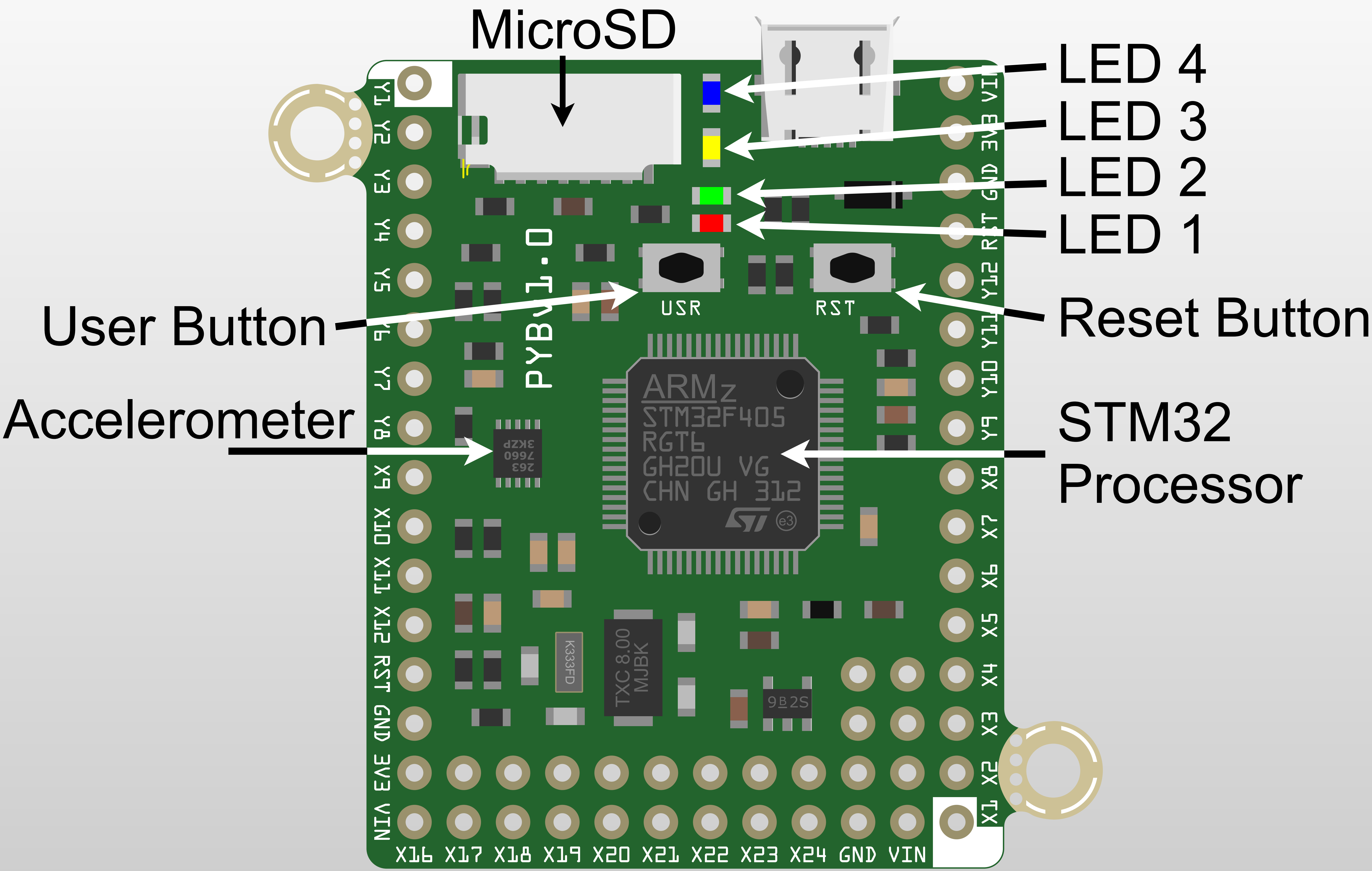
Dr. Joshua Vaughan

Rougeou 225

joshua.vaughan@louisiana.edu

@Doc_Vaughan

The pyboard


MicroSD
LED 4
LED 3
LED 2
LED 1
User Button
Reset Button
Accelerometer
STM32
Processor
USR
RST
PYBv1.0
ARM
STM32F405
RGT6
GH20U VG
CHN GH 312
TXC 8.00
MJBK
K333FD
9B2S
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Y8
X9
X10
X11
X12
RST
GND
3V3
VIN
X16
X17
X18
X19
X20
X21
X22
X23
X24
GND
VIN
X1
X2
X3
X4
X5
X6
X7
X8
Y9
Y10
Y11
Y12
RST
GND
3V3
VIN

Why Python?

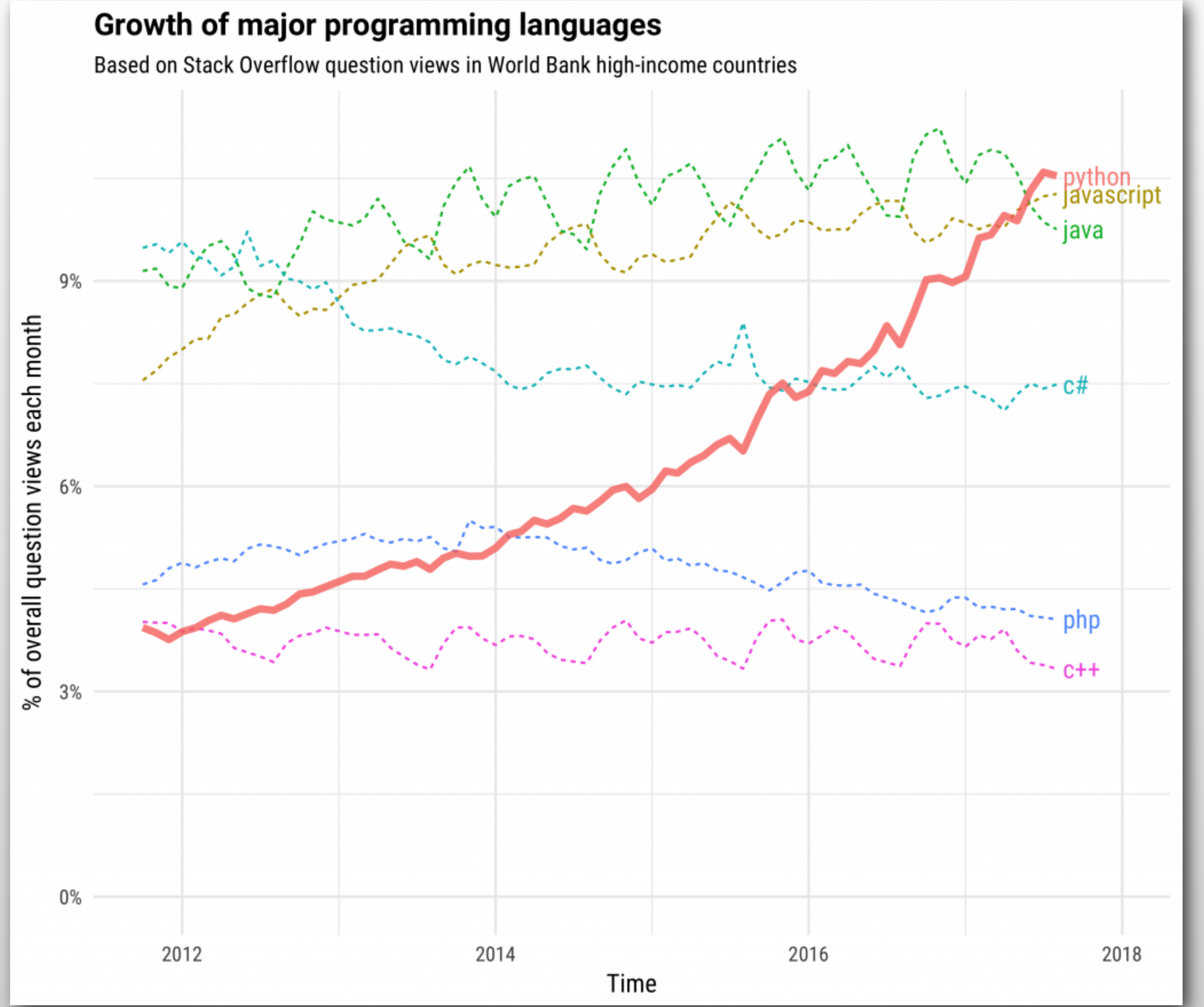


Figure via: `https://stackoverflow.blog/2017/09/06/incredible-growth-python/`

Why not Arduino?

- Python is a general-purpose language
  - Instagram, Google, *etc.* use it *extensively*
  - Many robotics tools are built around it
  - `http://lorenabarba.com/blog/why-i-push-for-python/`

- The pyboard is *significantly* more powerful than equivalently-priced Arduino boards

System Setup

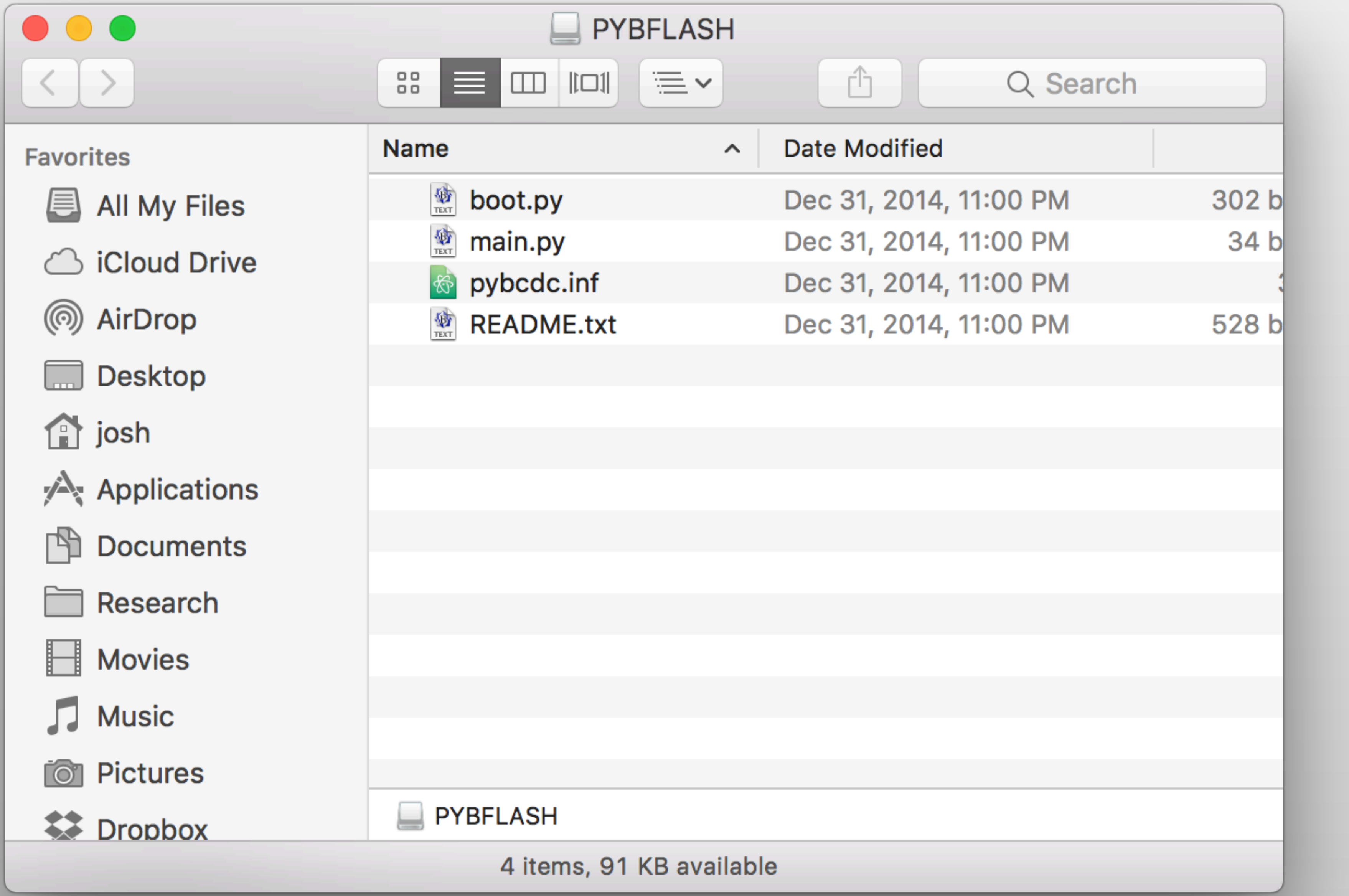
- You'll need a plain-text editor
  - *Many* options that programmers *really* argue about
  - Visual Studio Code – `https://code.visualstudio.com`

- Bookmark the documentation and quick reference
  - Full – `http://docs.micropython.org/en/latest/pyboard/`
  - Quick Ref – `http://docs.micropython.org/en/latest/pyboard/pyboard/quickref.html`
  - If you don't remember the syntax, *look it up*

Connecting to the pyboard

- Just plug in Micro-USB cable

- The board will show up as a USB disk with files:
  - `boot.py`
  - `main.py`
  - `README.txt`
  - `pybcdc.inf`



Name	Date Modified	
boot.py	Dec 31, 2014, 11:00 PM	302 b
main.py	Dec 31, 2014, 11:00 PM	34 b
pybcdc.inf	Dec 31, 2014, 11:00 PM	3
README.txt	Dec 31, 2014, 11:00 PM	528 b

4 items, 91 KB available

STOP – Before anything else

Save those default files to a safe place on your computer!

WARNING!!!

- Do ***NOT*** edit the files directly on the `PYBFLASH` drive
- Instead:
  - Work on a version on your computer
  - Then, copy that file to the pyboard
- Be sure to eject/unmount before unplugging

The pyboard’s flash memory can get corrupted much easier than a normal “thumb drive.”

On Windows…

- You may be asked to set up the device when you plug it in… *cancel* that prompt.

- Try to connect to the board first, you likely will *not* need to install the driver.

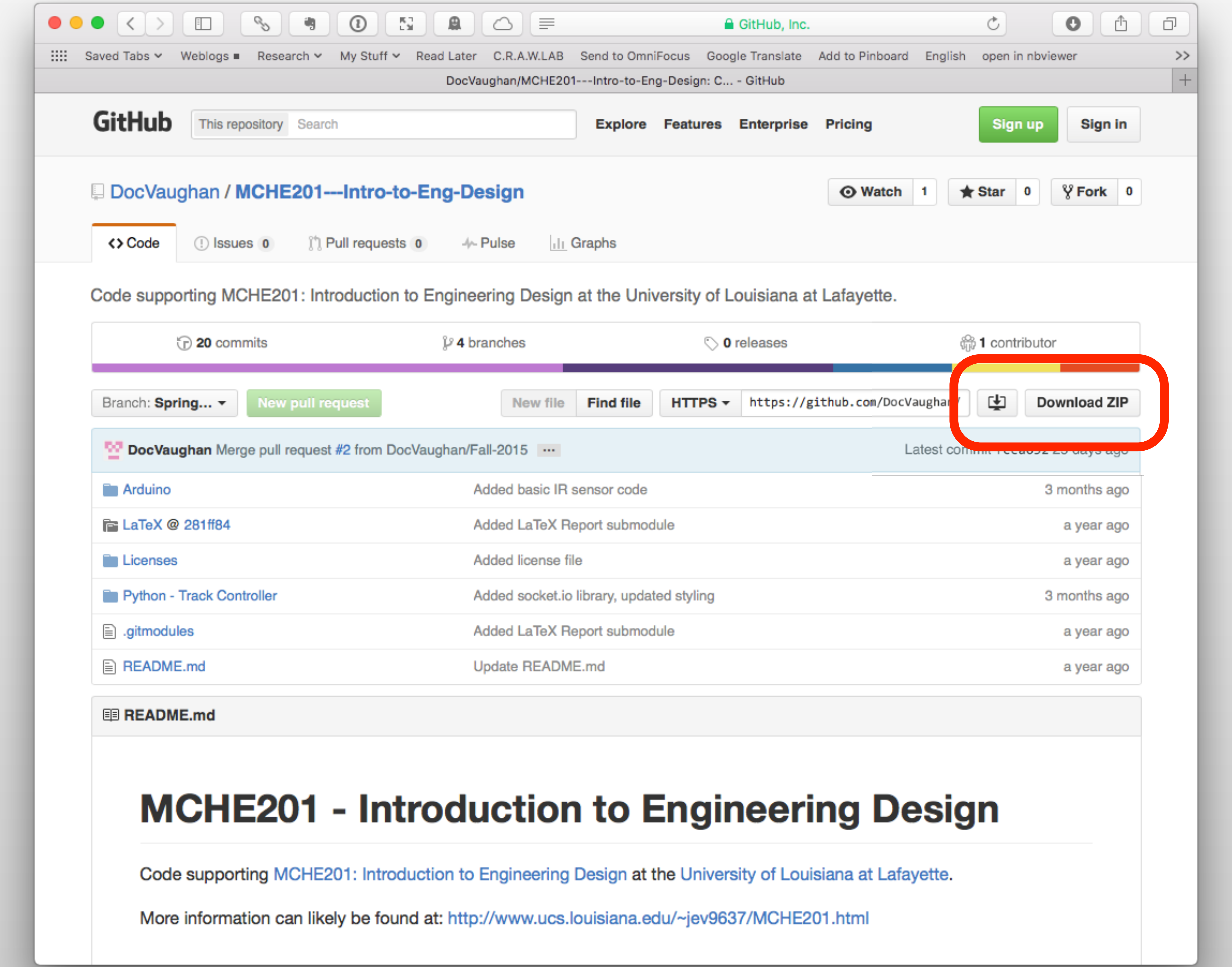
- If you do need to install a driver
  - The `pybcdc.inf` file from the disk is the driver
  - `http://micropython.org/resources/Micro-Python-Windows-setup.pdf`

Getting to the REPL

- We'll talk to the board over serial, often connecting to the Read, Evaluate, Print, Loop (REPL) prompt
- Like the text editor, there are many options
  - On macOS:
    - ✦ CoolTerm – `http://freeware.the-meiers.org`
    - ✦ Using `screen` from the Terminal app
    - ✦ goSerial – `http://www.furrysoft.de/?page=goserial`
    - ✦ Serial Tools – `http://www.w7ay.net/site/Applications/Serial%20Tools/index.html`
  - On Windows:
    - ✦ CoolTerm – `http://freeware.the-meiers.org`
    - ✦ HyperTerminal is still installed by default on some dist.
    - ✦ Putty – `https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html`

Code Sharing – GitHub.com

https://github.com/DocVaughan/MCHE201---Intro-to-Eng-Design



Code supporting MCHE201: Introduction to Engineering Design at the University of Louisiana at Lafayette.

DocVaughan Merge pull request #2 from DocVaughan/Fall-2015 … Latest commit [illegible] 25 days ago

Arduino	Added basic IR sensor code	3 months ago
LaTeX @ 281ff84	Added LaTeX Report submodule	a year ago
Licenses	Added license file	a year ago
Python - Track Controller	Added socket.io library, updated styling	3 months ago
.gitmodules	Added LaTeX Report submodule	a year ago
README.md	Update README.md	a year ago

README.md

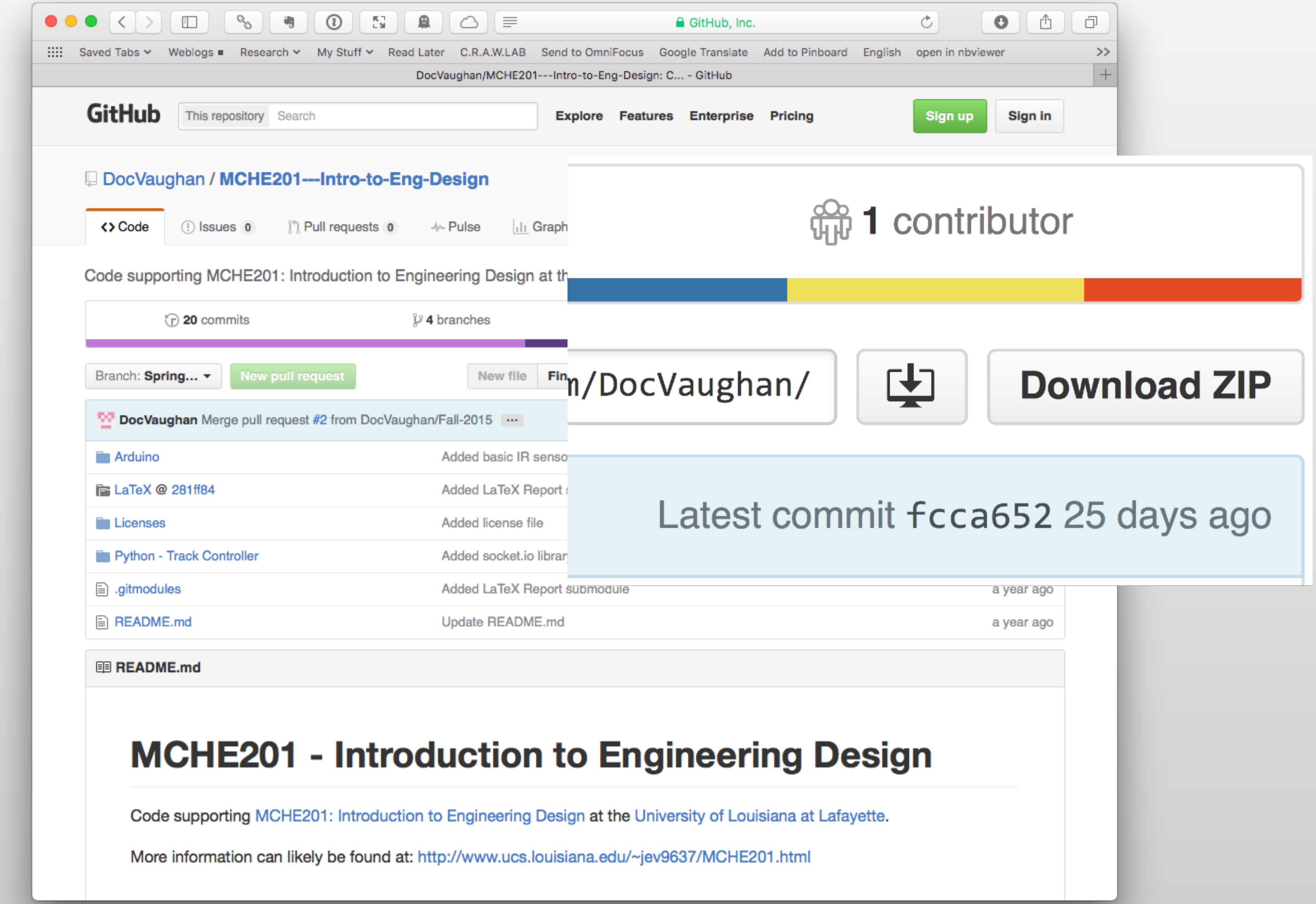
MCHE201 - Introduction to Engineering Design

Code supporting MCHE201: Introduction to Engineering Design at the University of Louisiana at Lafayette.

More information can likely be found at: http://www.ucs.louisiana.edu/~jev9637/MCHE201.html

Code Sharing – GitHub.com

https://github.com/DocVaughan/MCHE201---Intro-to-Eng-Design



DocVaughan / MCHE201---Intro-to-Eng-Design

Code supporting MCHE201: Introduction to Engineering Design at th

DocVaughan Merge pull request #2 from DocVaughan/Fall-2015

Latest commit fcca652 25 days ago

Arduino	Added basic IR senso	
LaTeX @ 281ff84	Added LaTeX Report s	
Licenses	Added license file	
Python - Track Controller	Added socket.io librar	
.gitmodules	Added LaTeX Report submodule	a year ago
README.md	Update README.md	a year ago

README.md

MCHE201 - Introduction to Engineering Design

Code supporting MCHE201: Introduction to Engineering Design at the University of Louisiana at Lafayette.

More information can likely be found at: http://www.ucs.louisiana.edu/~jev9637/MCHE201.html

Comments

- Completely ignored by the Python interpreter

- Comments allow you to explain your code inline for:
  - your co-workers/teammates
  - you, in the future

- To comment a single line, use `#` before your comment

- To create a block comment, begin with `"""` and end with `"""`

Comments

```
""" This is a block comment. It will
continue across multiple lines, until it
is closed with the proper characters """

# This is a single-line comment

x = 4 # Comments can go here too
```

Block Comments

- Block comments are also a good way to begin any file you write.

- It's good practice to include:
  - The filename
  - The purpose of the code
  - Any external requirements (other files or hardware needed to make this one work)
  - What inputs are needed, if any
  - What the output is, if any
  - The version number, recent modifications, and your contact info

Block Comments – Boilerplate

```
"""----------------------------------------------------------
filename.py

Some description of functionality

Optional links to relevant documentation

Created: mm/dd/yy - Name - email@louisiana.edu

Modified:
  * mm/dd/yy - Name (email if not same person as above)
    - major change 1
    - major change 2
  * mm/dd/yy - Name (email if not same person as above)
    - major change 1
----------------------------------------------------------"""
```

Block Comments – Boilerplate

```
# ----------------------------------------------------------
# filename.py
#
# Some description of functionality
#
# Optional Link to relevant documentation
#
# Created: mm/dd/yy - Name - email@louisiana.edu
#
# Modified:
#  * mm/dd/yy - Name (email if not same person as above)
#    - major change 1
#    - major change 2
#  * mm/dd/yy - Name (email if not same person as above)
#    - major change 1
# ----------------------------------------------------------
```

Block Comments – Example

```
###############################################################################
# main.py
#
# This script will control a single DC motor using a Texas Instruments DRV8871
# motor driver. It should work with all DRV8871 driver breakouts, but has only
# been tested with the Adafruit one:
#    https://www.adafruit.com/product/3190
#
# Motor driver spec sheet
#    https://cdn-shop.adafruit.com/product-files/3190/drv8871.pdf
#
# Adafruit Overview of the board:
#    https://learn.adafruit.com/adafruit-drv8871-brushed-dc-motor-driver-breakout
#
# Created: 11/06/17
#   - Joshua Vaughan
#   - joshua.vaughan@louisiana.edu
#   - http://www.ucs.louisiana.edu/~jev9637
#
# Modified:
#   *
#
# TODO:
#   *
###############################################################################
```

Literate Programming

- Write out what you want your code to do in plain English (or your preferred language)… Be explicit about *every* step
- Translate this into comments in your code file
- Then, write the code to implement the functionality

Key Point: **If you can't explain what you want the code to do in plain English, writing code to do that will be difficult.**

Variables in Python

- Unlike Arduino (or other C-based languages), we don't need to specify the variable type

- Python is a *dynamically-typed* language
    - It will figure out what type of variable you need
    - That type can/will change if you reassign the variable to a different type

TIP: Give your variables meaningful names. A few extra keystrokes are worth the improved understanding and easier debugging.

Variable Declaration Examples

```
# Booleans are True or False.
binaryConditionCheck = False
youCantHandleThe = True

# Integers are, well, integers
integerVariable = -1
motorSpeed = 75

# Floats are decimal numbers
floatVariable = 1.0
preciseMotorSpeed = 75.275

# Strings hold text, put between "-"
myString = "some text"
```

Variable Declaration (cont.)

```
# We can assign multiple variables at the
# same time
#
# Note: Be careful with this, only group
#       variables that make sense to
#       group logically.

small, medium, large = 1, 3, 9
IP_ADDRESS, PORT = "192.168.0.100", 2390
```

Variable Naming Conventions

- Give your variables meaningful names
  - `armLength = 15` is *much* clearer than `l = 15`
  - `delay_time = 0.25` is *much* clearer than `t = 0.25`

- Use a consistent variable style
  - *camel case* – `armLength`
  - Underscores for spaces – `delay_time`
  - All caps for constants `- LED_PIN`

} **Pick one of these and stick to it**

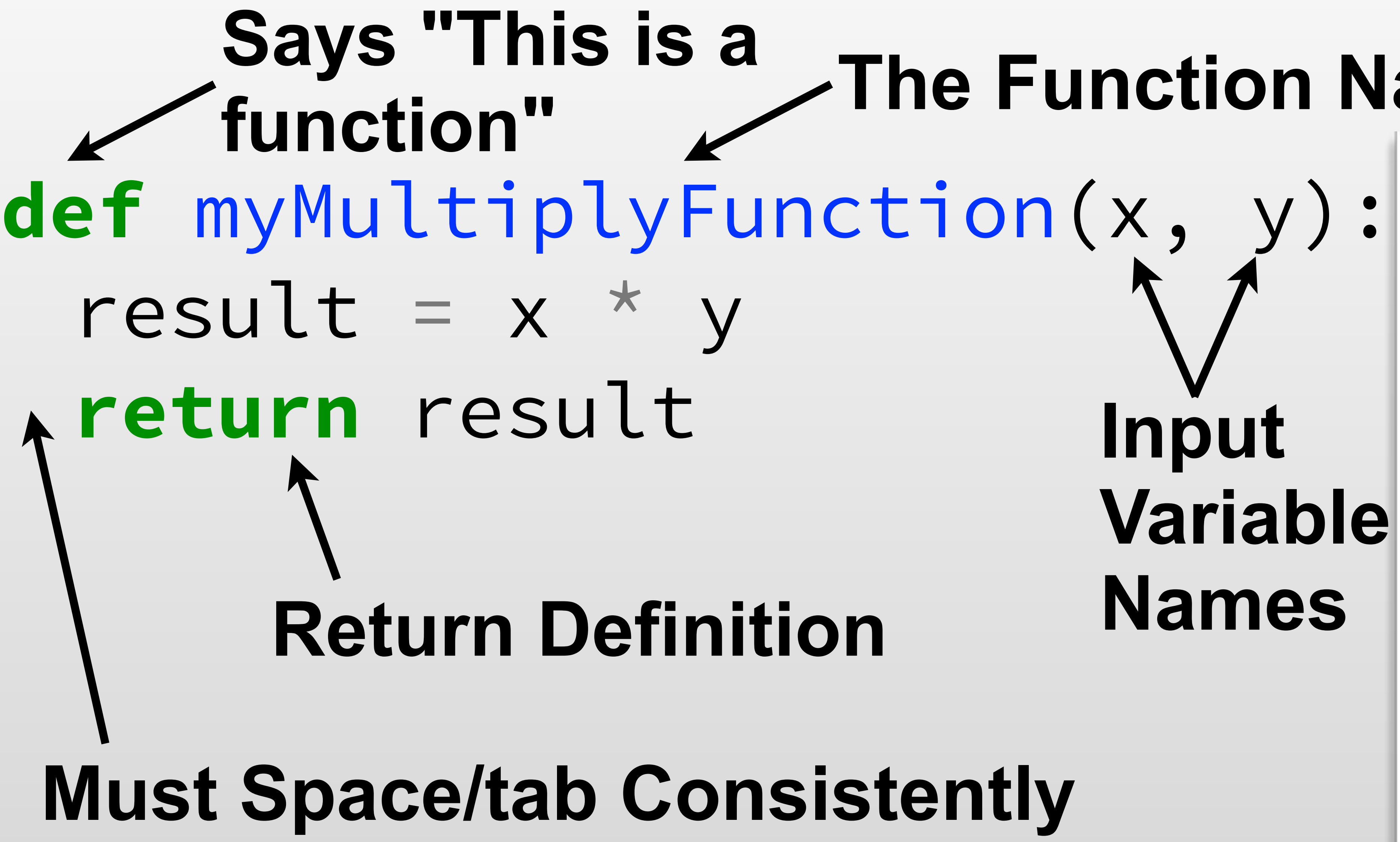
Variable Scope

- Scope – essentially what functions are able to read/ write to a particular variable

- Variables defined:
    - Outside of all functions have *global* scope
        - ✦Can be *read* anywhere
        - ✦Need some special syntax to *write* to them
    - Inside a function are accessible inside *that* function

- Limit scope to as small as possible

Python Functions



Says "This is a function"

The Function Name

```
def myMultiplyFunction(x, y):
  result = x * y
  return result
```

Input Variable Names

Return Definition

Must Space/tab Consistently

TIP: Give your functions meaningful names. A few extra keystrokes are worth the improved understanding and easier debugging.

- In Python, whitespace matters
- *Note*: All of these have more formal names.

To Use That Function

```
def myMultiplyFunction(x, y):
  result = x * y
  return result

# Assign values to a and b
a = 2
b = 3

# Call the function, and store the result in c
c = myMultiplyFunction(a, b) # c=6

# This works fine with other types too
a, b = 1.2, 3.75
c = myMultiplyFunction(a, b) # c=4.5
```

Use Functions!!!

- Aim for each function having a single function

- This makes:
  - execution more predictable and easier to debug
  - the code more-easily reusable
    - Reuse limits likelihood of typos and other bugs
    - Makes code more readable
    - Makes program logic easier to follow

***TIP*: Give your functions meaningful names. A few extra keystrokes are worth the improved understanding and easier debugging.**

Example

```
wait_for_start_button()

pyb.delay_ms(500)   # pause 500ms after start button

drive_forward(4)    # drive forward 4 seconds

rotate_arm(75)      # rotate the arm 75 deg

pyb.delay_ms(1000) # Pause for 1000ms (1s)

rotate_arm(0)       # rotate the arm back to 0

drive_backward(2)   # drive backward 2 seconds
```

How do I debug my code?

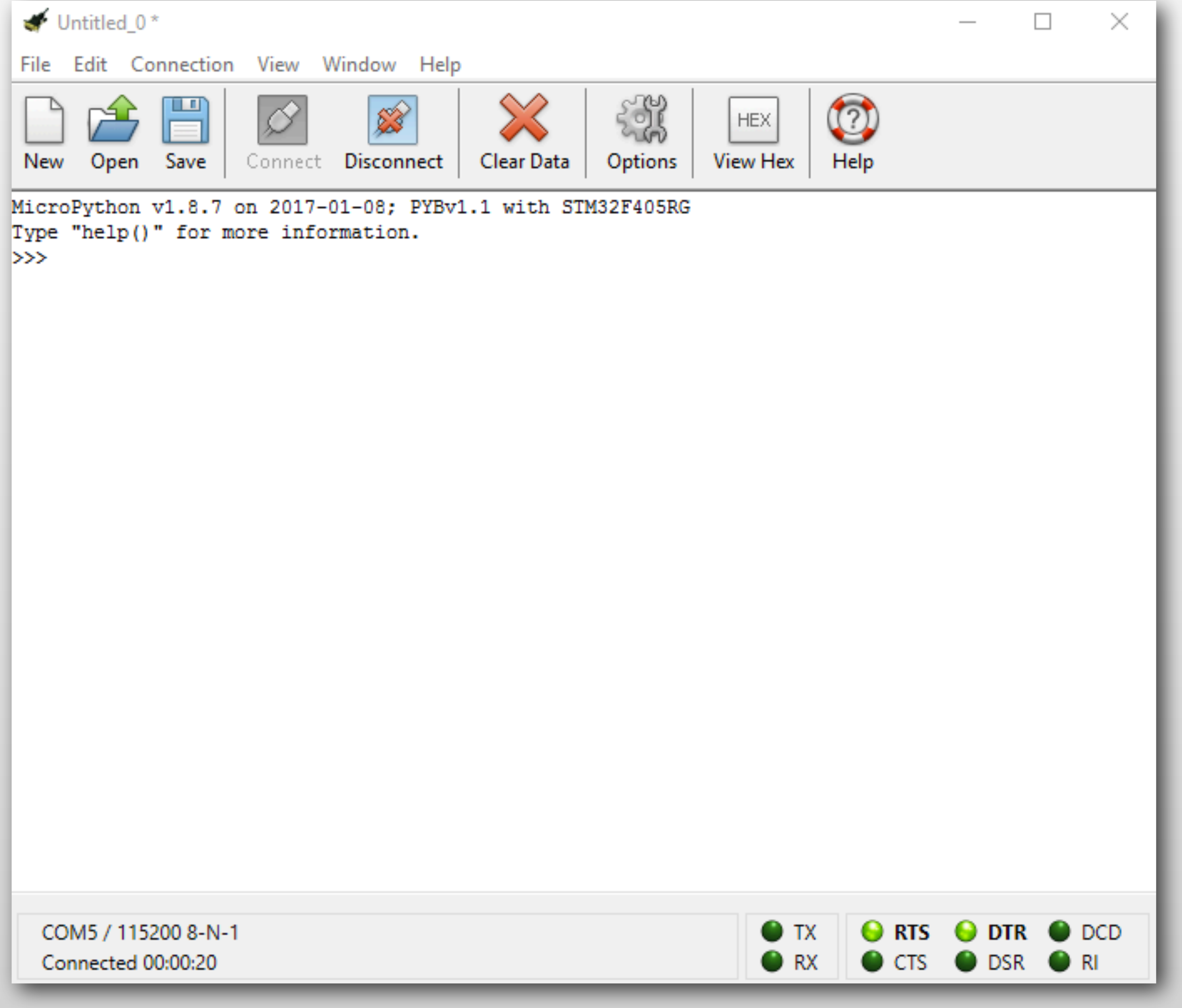
- The computer will only do *exactly* what you tell it. Nothing more. Nothing less.

- Don’t assume anything!… the computer is dumb.
  - Work line-by-line “What happens on *this* line?”
  - Output values in runtime via `print` statements

Using the REPL

- Allows the pyboard to communicate with the computer during runtime

- Can be used for:
  - Prototyping
  - Debugging
  - Execution monitoring



```
MicroPython v1.8.7 on 2017-01-08; PYBv1.1 with STM32F405RG
Type "help()" for more information.
>>>
```

COM5 / 115200 8-N-1
Connected 00:00:20

Clarity in the `print` Statements

- We can format the numbers/items that we print out.
- A great overview: `https://pyformat.info`
- Syntax is:

```
print("String {formatting spec}".format(variable))
```

Formatted Output Examples

```
# Print an integer
print("Integer {:d}.".format(42))

# Print an integer and always include +/- sign
print("Integer {:+d}.".format(42))

# Print an integer and always include at least 4
#"places"
print("Integer {:4d}.".format(42))

# Print an integer, always include at least 4
#"places," and pad with zeros
print("Integer {:04d}.".format(42))
```

Formatted Output (cont.)

```
# Print a float
print("Pi is {:f}.".format(3.141592))

# Print a float with 4 decimal places
print("Pi is {:.4f}.".format(3.141592))

# Print a float and always include at least 9
#"places" with 2 decimal places
print("Pi is {:9.2f}.".format(3.141592))

# Print a float and always include at least 9
#"places" and pad with zeros
print("Pi is {:09.2f}.".format(3.141592))
```

Special Characters to Know

- \n = new line
- \r = carriage return
- \t = tab

```
# Define pi
pi = 3.141592

print("Pi is {:.4f}.\n2pi is {:.4f}".format(pi, 2*pi))

print("Pi is {:.4f}.\t2pi is {:.4f}".format(pi, 2*pi))
```

Control Structures

- Numerous ways to control program flow

- Ways to conditionally execute
  - If… then
  - For loops
  - While loops

Comparison Operators

```
# ----- Comparison syntax -------------------------
# These evaluate to True (1) or False (0)

 x == y  # True if x is equal to y, False otherwise

 x != y  # True if x is not equal to y, False otherwise

 x <  y  # True if x is less than y, False otherwise

 x >  y  # True if x is greater than y, False otherwise

 x <= y  # True if x is less than or equal to y, False
otherwise

 x >= y  # True if x is greater than or equal to y,
False otherwise
```

If... then Example

```
# ----- if... elif... else example ---------------------
# Note: this assumes all variables have been defined,
# etc.

if (counter < 10):
  # Code indented here will run if counter is less than
  10

elif (counter >= 20):
  # Code indented here will run if counter is greater
  than or equal to 20

else:
  # Code indented here will only run if both counter is
  neither less than 10 or greater than or equal to 20
```

If… then Example 2

```
a = 2 # Define the value of a

if (a > 5):
  print("Tell me something, girl")

elif (a == 2):
  print("Are you happy in this modern world")

else:
  print("Or do you need more?")
```

Here, a is equal to 2, so the `elif` condition is True. The code indented under it is run, meaning Are you happy in this modern world would be printed.

If... then Example 3

```
a = 2 # Define the value of a
b = 3 # Define the value of b

if (a + b > 5):
  print("Kiki, do you love me?")

elif (b - a == 2):
  print("Are you riding?")

else:
  print("Say you'll never ever leave...")
```

Neither the `if` or the `elif` condition is True. So, the code in `else` is run, meaning Say you'll never ever leave... would be printed.

If… then Example 4

```python
sensedStartSignal = True # Start was sensed

if (sensedStartSignal):
  print("Sensed start signal. Starting robot.")
  # Code to run once the start signal was sensed

else:
  print("Checking start signal...")
  # Code to check the start signal
```

The `if` is True. So, the code in `if` is run, meaning Sensed start signal. Starting robot. would be printed and other code in that indented block would run.

Basic For Loops

```
# ----- for loop syntax ---------------------------
for counter in sequence:
  # do something
  # Everything indented here is run during each
  # loop until the sequence is finished
```

Basic For Loops

```
# ----- for loop syntax ---------------------------
for counter in sequence:
  # do something
  # Everything indented here is run during each
  # loop until the sequence is finished
```

Variable that's incremented

What to loop over... a few options for what

```
# ----- for loop example --------------------------
for counter in range(10):
  # do something
  # This would run 10 times
  # The values of counter would be 0, 1, 2, …, 9
```

For Loop Example

```
list_of_pies = ["apple", "cherry", "pumpkin"]

for pie in list_of_pies:
  print("I think {} pies are delicious!".format(pie))
```

Prints out to the REPL:

```
I think apple pies are delicious!
I think cherry pies are delicious!
I think pumpkin pies are delicious!
```

For Loop Example

```
list_of_pies = ["apple", "cherry", "pumpkin"]

for index, pie in enumerate(list_of_pies):
  print("The number {:d} pie in the list is
  {}.".format(index, pie))
```

Prints out to the REPL:

```
The number 0 pie in the list is apple.
The number 1 pie in the list is cherry.
The number 2 pie in the list is pumpkin.
```

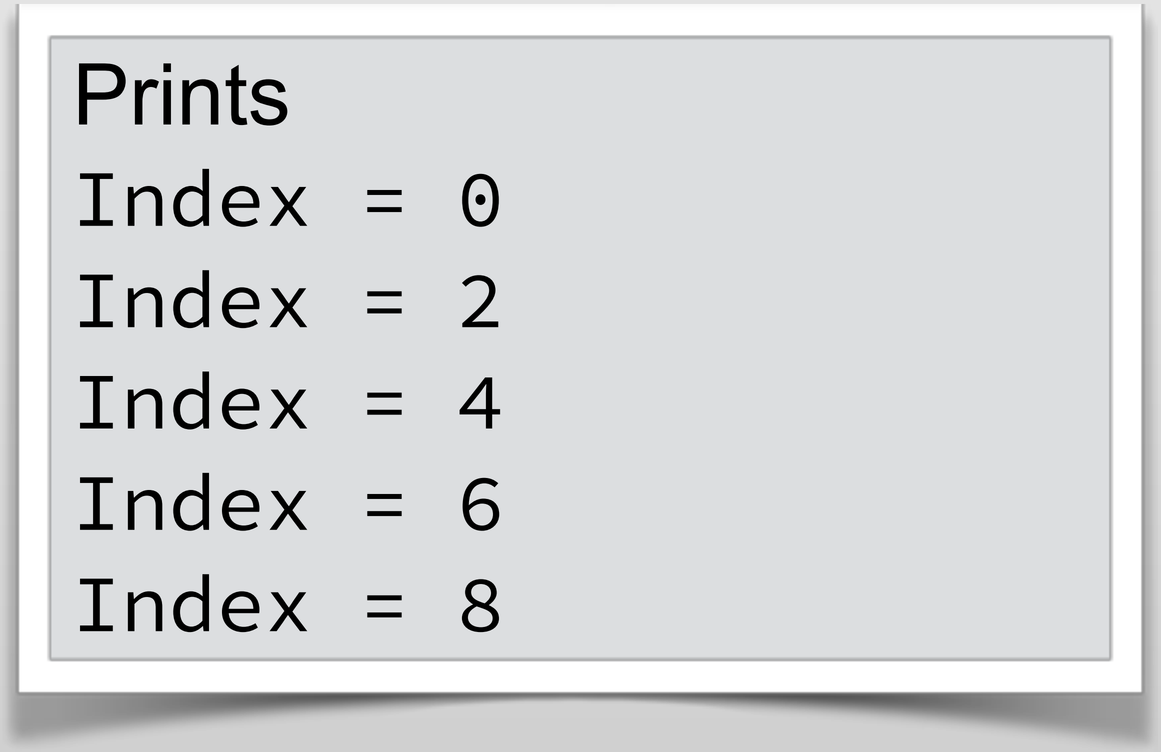
While Loops

```
// ----- while loop syntax --------------------------

while (condition == True):

   # If the condition is True, run the code here.

   # Once the code in the indented block is
   finished, check the condition and repeat.

   # If the condition is not True at the first check
   above, this will never be run.
```

← The condition is tested at the beginning of each iteration

While Loop Example

```
# ----- while loop example -----------------------
index = 0

while (index < 10):
  print("Index = {:d}".format(index))
  index = index + 2
```



Prints

```
Index = 0
Index = 2
Index = 4
Index = 6
Index = 8
```

While Loop Example 2

```
# ----- while loop example -----------------------
index = 0

while (index < 10):
  if (index == 3):
    print("Index = {}".format(index))

  index = index + 1
```

Prints to the Serial Monitor

```
Index = 3
```

While Loop Example 3

```
# ----- while loop example -----------------------
keepRunning = True
index = 0

while(keepRunning):
  print("Running.")

  if (index >= 10):
    keepRunning = False

  pyb.delay(100) # sleep 100ms

  index = index + 1

print("Stopped.")
```

Loops 10 times, printing “Running” and delaying 100ms each time. Then, prints “Stopped.”

For next Thursday…

- ***BEFORE*** next week:
  - Install the driver, if necessary for Windows.
  - Install Visual Studio Code (or other text editor) on your computer.
  - Install CoolTerm on your computer.
  - Look through these notes. These are the foundation for all the programming we'll do.
  - Review the MicroPython Getting Started Guide at `http://docs.micropython.org/en/latest/pyboard/pyboard/tutorial/index.html`

- Bring laptop and kit to class