

CSci 127: Introduction to Computer Science



hunter.cuny.edu/csci

Announcements

- Summer Prep Course for Discrete Mathematics:



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 - ▶ Math10N03: “Pre-Discrete Mathematics Workshop”



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 - ▶ The course is 1 hour, 1 credit, Wednesdays, 9:50-11:50am.

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 - ▶ See CUNYFirst for registration.

Today's Topics



- Recap of Python & Circuits
- High vs. Low-Level Programming
- A Simplified Machine Language
- Final Exam Overview

Python & Circuits Review: 10 Weeks in 10 Minutes



A whirlwind tour of the semester, so far...

Week 1: print(), loops, comments, & turtles

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- Introduced comments & print():

```
#Name:  Thomas Hunter
```

← *These lines are comments*

```
#Date:  September 1, 2017
```

← *(for us, not computer to read)*

```
#This program prints:  Hello, World!
```

← *(this one also)*

```
print("Hello, World!")
```

← *Prints the string "Hello, World!" to the screen*

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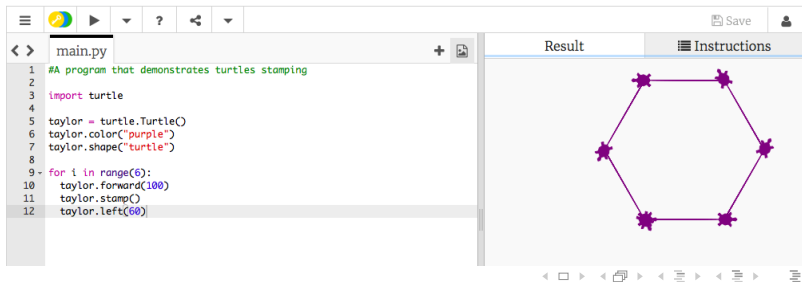
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- As well as definite loops & the turtle package:



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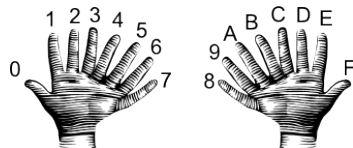
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 - ▶ **class variables**: for complex objects, like turtles.
- More on loops & ranges:

```
1 #Predict what will be printed:
2
3 for num in [2,4,6,8,10]:
4     print(num)
5
6 sum = 0
7 for x in range(0,12,2):
8     print(x)
9     sum = sum + x
10
11 print(x)
12
13 for c in "ABCD":
14     print(c)
```

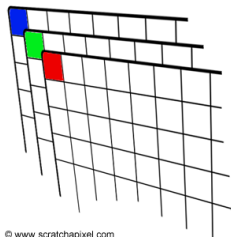
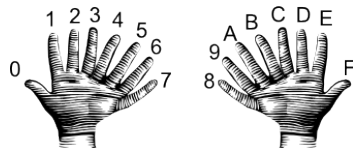
Week 3: colors, hex, slices, numpy & images

Color Name	HEX	Color
Black	#000000	
Navy	#000080	
DarkBlue	#00008B	
MediumBlue	#0000CD	
Blue	#0000FF	



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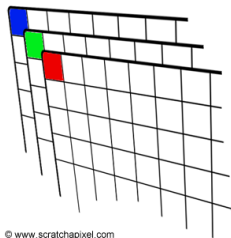
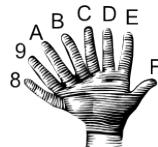
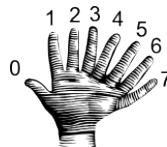
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```
>>> a[0,3:5]  
array([3,4])
```

```
>>> a[4:,4:]  
array([[44, 45],  
       [54, 55]])
```

```
>>> a[:,2]  
array([2,12,22,32,42,52])
```

```
>>> a[2::2,::2]  
array([[20,22,24]  
       [40,42,44]])
```

0	1	2	3	4	5
10	11	12	13	14	15
20	21	22	23	24	25
30	31	32	33	34	35
40	41	42	43	44	45
50	51	52	53	54	55

Week 4: design problem (cropping images) & decisions



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- First: specify inputs/outputs. *Input file name, output file name, upper, lower, left, right ("bounding box")*

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- Next: write pseudocode.
 - ① Import numpy and pyplot.
 - ② Ask user for file names and dimensions for cropping.
 - ③ Save input file to an array.
 - ④ Copy the cropped portion to a new array.
 - ⑤ Save the new array to the output file.

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- Next: translate to Python.

Week 4: design problem (cropping images) & decisions

```
yearBorn = int(input('Enter year born: '))
if yearBorn < 1946:
    print("Greatest Generation")
elif yearBorn <= 1964:
    print("Baby Boomer")
elif yearBorn <= 1984:
    print("Generation X")
elif yearBorn <= 2004:
    print("Millennial")
else:
    print("TBD")

x = int(input('Enter number: '))
if x % 2 == 0:
    print('Even number')
else:
    print('Odd number')
```

Week 5: logical operators, truth tables & logical circuits

```
origin = "Indian Ocean"
winds = 100
if (winds > 74):
    print("Major storm, called a ", end="")
    if origin == "Indian Ocean" or origin == "South Pacific":
        print("cyclone.")
    elif origin == "North Pacific":
        print("typhoon.")
    else:
        print("hurricane.")

visibility = 0.2
winds = 40
conditions = "blowing snow"
if (winds > 35) and (visibility < 0.25) and \
    (conditions == "blowing snow" or conditions == "heavy snow"):
    print("Blizzard!")
```

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```

in1		in2	returns:
False	and	False	False
False	and	True	False
True	and	False	False
True	and	True	True



Week 6: structured data, pandas, & more design

```
Source: https://en.wikipedia.org/wiki/Demographics_of_New_York_City,,,,,
All population figures are consistent with present-day boundaries,,,,,,
First census after the consolidation of the five boroughs,,,,,,
,,,,,
,,,,,
Year,Manhattan,Brooklyn,Queens,Bronx,Staten Island>Total
1698,4937,2017,,,727,7681
1771,21863,3623,,,2847,28423
1790,33131,45049,6159,1781,3827,49447
1800,40515,5740,6642,1755,4563,79215
1810,96373,40203,7444,2267,5347,119734
1820,123706,11187,8246,2782,6135,152056
1830,202589,20535,9049,3023,7082,242278
1840,312710,47613,14480,3344,10965,391114
1850,515547,138882,18593,8032,15061,696115
1860,813649,279122,32963,23593,25492,1174779
1870,942292,419921,45468,37393,33829,1470193
1880,1164673,599495,56559,51980,38991,1911690
1890,1441216,838547,87050,88908,51692,2507414
1900,1650093,1146582,152899,200507,67021,3437202
1910,2331542,1634351,284041,430980,85969,4766883
1920,2284103,2018296,469042,732016,116511,5620048
1930,1867312,2560461,1079129,1265258,159346,6306446
1940,1889924,2698295,1297634,1394711,174441,7454995
1950,1940101,2738275,1550849,1452177,191555,7893957
1960,1698281,2627319,1809578,1424815,221993,7781984
1970,1539233,2602012,1986473,1471701,295443,7894862
1980,1428285,2230936,1891325,1168972,352121,7071439
1990,1487536,2300644,1951598,1203789,378977,7322564
2000,1537195,2465326,2229379,1332650,443728,8006278
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nycHistPop.csv

In Lab 6

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Week 6: structured data, pandas, & more design

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import matplotlib.pyplot as plt
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pop = pd.read_csv('nycHistPop.csv',skiprows=5)
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1960,1698281,2627319,1809578,1624815,221993,7781384
1970,1539233,2602012,1986473,1471701,295443,7894862
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Week 6: structured data, pandas, & more design

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pop.plot(x="Year")
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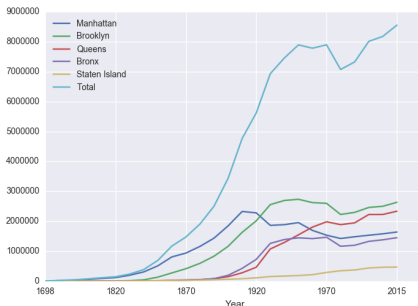
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```

nycHistPop.csv

In Lab 6

```
pop.plot(x="Year")
plt.show()
```



Week 7: functions

- Functions are a way to break code into pieces, that can be easily reused.

```
#Name: your name here
#Date: October 2017
#This program, uses functions,
#    says hello to the world!

def main():
    print("Hello, World!")

if __name__ == "__main__":
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Week 7: functions

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- Many languages require that all code must be organized with functions.

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- Functions are a way to break code into pieces, that can be easily reused.
- Many languages require that all code must be organized with functions.
- The opening function is often called `main()`
- You **call** or **invoke** a function by typing its name, followed by any inputs, surrounded by parenthesis:

Week 7: functions

```
#Name:  your name here
#Date:  October 2017
#This program, uses functions,
#      says hello to the world!

def main():
    print("Hello, World!")

if __name__ == "__main__":
    main()
```

- Functions are a way to break code into pieces, that can be easily reused.
- Many languages require that all code must be organized with functions.
- The opening function is often called `main()`
- You **call** or **invoke** a function by typing its name, followed by any inputs, surrounded by parenthesis:
Example: `print("Hello", "World")`

Week 7: functions

```
#Name:  your name here
#Date:  October 2017
#This program, uses functions,
#      says hello to the world!

def main():
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if __name__ == "__main__":
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```

- Functions are a way to break code into pieces, that can be easily reused.
- Many languages require that all code must be organized with functions.
- The opening function is often called `main()`
- You **call** or **invoke** a function by typing its name, followed by any inputs, surrounded by parenthesis:
Example: `print("Hello", "World")`
- Can write, or **define** your own functions,

Week 7: functions

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#This program, uses functions,
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def main():
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if __name__ == "__main__":
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```

- Functions are a way to break code into pieces, that can be easily reused.
- Many languages require that all code must be organized with functions.
- The opening function is often called `main()`
- You **call** or **invoke** a function by typing its name, followed by any inputs, surrounded by parenthesis: Example: `print("Hello", "World")`
- Can write, or **define** your own functions, which are stored, until invoked or called.

Week 8: function parameters, github

- Functions can have **input parameters**.

```
def totalWithTax(food,tip):  
    total = 0  
    tax = 0.0875  
    total = food + food * tax  
    total = total + tip  
    return(total)  
  
lunch = float(input('Enter lunch total: '))  
lTip = float(input('Enter lunch tip: ' ))  
lTotal = totalWithTax(lunch, lTip)  
print('Lunch total is', lTotal)  
  
dinner= float(input('Enter dinner total: '))  
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dTotal = totalWithTax(dinner, dTip)  
print('Dinner total is', dTotal)
```

Week 8: function parameters, github

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Week 8: function parameters, github

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- The “placeholders” in the function definition: **formal parameters**.

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Week 8: function parameters, github

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- The ones in the function call: **actual parameters**

Week 8: function parameters, github

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- The “placeholders” in the function definition: **formal parameters**.
- The ones in the function call: **actual parameters**
- Functions can also **return values** to where it was called.

Week 8: function parameters, github

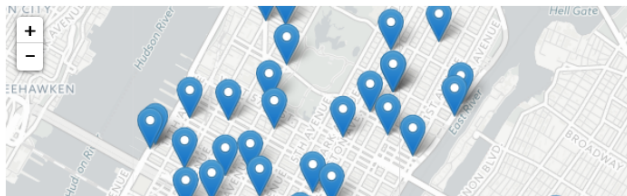
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Formal Parameters

Actual Parameters

- Functions can have **input parameters**.
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- The “placeholders” in the function definition: **formal parameters**.
- The ones in the function call: **actual parameters**.
- Functions can also **return values** to where it was called.

Week 9: top-down design, folium



```
def main():
    dataF = getData()
    latColName, lonColName = getColumnNames()
    lat, lon = getLocale()
    cityMap = folium.Map(location = [lat,lon], tiles = 'cartodbpositron', zoom_start=11)
    dotAllPoints(cityMap,dataF,latColName,lonColName)
    markAndFindClosest(cityMap,dataF,latColName,lonColName,lat,lon)
    writeMap(cityMap)
```

Week 10: indefinite loops, searching data, random()

```
dist = int(input('Enter distance: '))
while dist < 0:
    print('Distances cannot be negative.')
    dist = int(input('Enter distance: '))
print('The distance entered is', dist)
```

- Indefinite (while) loops allow you to repeat a block of code as long as a condition holds.

```
import turtle
import random

trey = turtle.Turtle()
trey.speed(10)

for i in range(100):
    trey.forward(10)
    a = random.randrange(0,360,90)
    trey.right(a)
```

Week 10: indefinite loops, searching data, random()

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- Indefinite (while) loops allow you to repeat a block of code as long as a condition holds.
- Very useful for checking user input for correctness.

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Week 10: indefinite loops, searching data, random()

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```

```
import turtle
import random

trex = turtle.Turtle()
trex.speed(10)

for i in range(100):
    trex.forward(10)
    a = random.randrange(0,360,90)
    trex.right(a)
```

- Indefinite (while) loops allow you to repeat a block of code as long as a condition holds.
- Very useful for checking user input for correctness.
- Python's built-in random package has useful methods for generating random whole numbers and real numbers.

Week 10: indefinite loops, searching data, random()

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```

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    trey.right(a)
```

- Indefinite (while) loops allow you to repeat a block of code as long as a condition holds.
- Very useful for checking user input for correctness.
- Python's built-in random package has useful methods for generating random whole numbers and real numbers.
- To use, must include:
`import random.`

Python & Circuits Review: 10 Weeks in 10 Minutes



- Input/Output (I/O): `input()` and `print()`;
pandas for CSV files
- Types:
 - ▶ Primitive: `int`, `float`, `bool`, `string`;
 - ▶ Container: lists (but not dictionaries/hashtes or tuples)
- Objects: turtles (used but did not design our own)
- Loops: definite & indefinite
- Conditionals: `if-elif-else`
- Logical Expressions & Circuits
- Functions: parameters & returns
- Packages:
 - ▶ Built-in: `turtle`, `math`, `random`
 - ▶ Popular: `numpy`, `matplotlib`, `pandas`, `folium`

Python & Circuits Review: 10 Weeks in 10 Minutes



A whirlwind tour with
10 (or so) challenges...

In Pairs or Triples: Week 1

Predict what the code will do:

```
1 #Predict what will be printed:
2
3 for i in range(4):
4     print('The world turned upside down')
5
6 for j in [0,1,2,3,4,5]:
7     print(j)
8
9 for count in range(6):
10    print(count)
11
12 for color in ['red', 'green', 'blue']:
13    print(color)
14
15 print()
16 print()
17
18 for i in range(2):
19     for j in range(2):
20         print('Look around,')
21     print('How lucky we are to be alive!')
```

In Pairs or Triples: Week 2

Predict what the code will do:

```
1 #Predict what will be printed:
2
3 for c in range(65,90):
4     print(chr(c))
5
6 message = "I love Python"
7 newMessage = ""
8 for c in message:
9     print(ord(c)) #Print the Unicode of each number
10    print(chr(ord(c)+1)) #Print the next character
11    newMessage = newMessage + chr(ord(c)+1) #add to the new message
12 print("The coded message is", newMessage)
13
14 word = "zebra"
15 codedWord = ""
16 for ch in word:
17     offset = ord(ch) - ord('a') + 1 #how many letters past 'a'
18     wrap = offset % 26 #if larger than 26, wrap back to 0
19     newChar = chr(ord('a') + wrap) #compute the new letter
20     print(wrap, chr(ord('a') + wrap)) #print the wrap & new lett
21     codedWord = codedWord + newChar #add the newChar to the coded w
22
23 print("The coded word (with wrap) is", codedWord)
```

Decimal	Hex	Char	Decimal	Hex	Char
64	40	@	96	60	`
65	41	A	97	61	a
66	42	B	98	62	b
67	43	C	99	63	c
68	44	D	100	64	d
69	45	E	101	65	e
70	46	F	102	66	f
71	47	G	103	67	g
72	48	H	104	68	h
73	49	I	105	69	i
74	4A	J	106	6A	j
75	4B	K	107	6B	k
76	4C	L	108	6C	l
77	4D	M	109	6D	m
78	4E	N	110	6E	n
79	4F	O	111	6F	o
80	50	P	112	70	p
81	51	Q	113	71	q
82	52	R	114	72	r
83	53	S	115	73	s
84	54	T	116	74	t
85	55	U	117	75	u
86	56	V	118	76	v
87	57	W	119	77	w
88	58	X	120	78	x
89	59	Y	121	79	y
90	5A	Z	122	7A	z
91	5B	[123	7B	{
92	5C	\	124	7C	
93	5D]	125	7D	}
94	5E	^	126	7E	~
95	5F		127	7F	[DEL]

In Pairs or Triples: Week 3

Predict what the code will do:

```
1  import turtle
2  teddy = turtle.Turtle()
3
4  names = ["violet", "purple", "indigo", "lavender"]
5  for c in names:
6      teddy.color(c)
7      teddy.left(60)
8      teddy.forward(40)
9      teddy.dot(10)
10
11  teddy.penup()
12  teddy.forward(100)
13  teddy.pendown()
14
15  hexNames = ["#FF00FF", "#990099", "#550055", "#111111"]
16  for c in hexNames:
17      teddy.color(c)
18      teddy.left(60)
19      teddy.forward(40)
20      teddy.dot(10)
```

In Pairs or Triples: Week 4

Extend this program to also allow drawing in purple & stamping:

```
import turtle

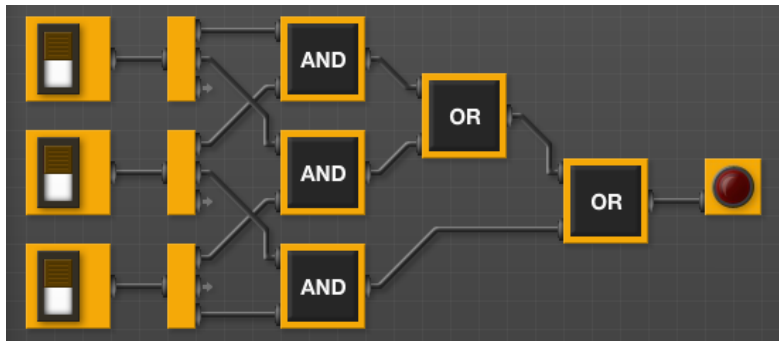
tess = turtle.Turtle()
myWin = turtle.Screen()    #The graphics window
commands = input("Please enter a command string: ")

for ch in commands:
    #perform action indicated by the character
    if ch == 'F':            #move forward
        tess.forward(50)
    elif ch == 'L':          #turn left
        tess.left(90)
    elif ch == 'R':          #turn right
        tess.right(90)
    elif ch == '^':          #lift pen
        tess.penup()
    elif ch == 'v':          #lower pen
        tess.pendown()
    elif ch == 'B':          #go backwards
        tess.backward(50)
    elif ch == 'r':          #turn red
        tess.color("red")
    elif ch == 'g':          #turn green
        tess.color("green")
    elif ch == 'b':          #turn blue
        tess.color("blue")
    else:                    #for any other character
        print("Error: do not know the command:", c)
```

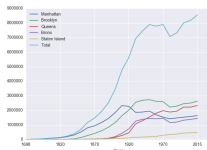
In Pairs or Triples: Week 5

When does this circuit yield true?

That is, what values for the inputs give an output value of true?



In Pairs or Triples: Week 6



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`
- `pop.plot.bar(x="Year")`
- `pop.plot.scatter(x="Brooklyn", y= "Total")`
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`

In Pairs or Triples: Week 7

Fill in the function body:

```
def monthString(monthNum):  
    """  
    Takes as input a number, monthNum, and  
    returns the corresponding month name as a string.  
    Example: monthString(1) returns "January".  
    Assumes that input is an integer ranging from 1 to 12  
    """  
  
    monthString = ""  
  
    #####  
    ### FILL IN YOUR CODE HERE      ###  
    ### Other than your name above, ###  
    ### this is the only section    ###  
    ### you change in this program. ###  
    #####  
  
    return(monthString)  
  
def main():  
    n = int(input('Enter the number of the month: '))  
    mString = monthString(n)  
    print('The month is', mString)
```

In Pairs or Triples: Week 8

```
def bar(n):  
    if n <= 8:  
        return 1  
    else:  
        return 0  
  
def foo(l):  
    n = bar(l[-1])  
    return l[n]
```

- What are the formal parameters for the functions?

- What is the output of:

```
r = foo([1,2,3,4])  
print("Return: ", r)
```

- What is the output of:

```
r = foo([1024,512,256,128])  
print("Return: ", r)
```


In Pairs or Triples: Week 9

What does this code do?

```
import folium
import pandas as pd

cuny = pd.read_csv('cunyLocations.csv')
mapCUNY = folium.Map(location=[40.75, -74.125])

for index, row in cuny.iterrows():
    lat = row["Latitude"]
    lon = row["Longitude"]
    name = row["Campus"]
    if row["College or Institution Type"] == "Senior Colleges":
        collegeIcon = folium.Icon(color="purple")
    else:
        collegeIcon = folium.Icon(color="blue")
    newMarker = folium.Marker([lat, lon], popup=name, icon=collegeIcon)
    newMarker.addTo(mapCUNY)

mapCUNY.save(outfile='cunyLocationsSenior.html')
```

In Pairs or Triples: Week 10

- *Predict what the code will do:*

```
nums = [1,4,10,6,5,42,9,8,12]

maxNum = 0
for n in nums:
    if n > maxNum:
        maxNum = n
print('The max is', maxNum)
```

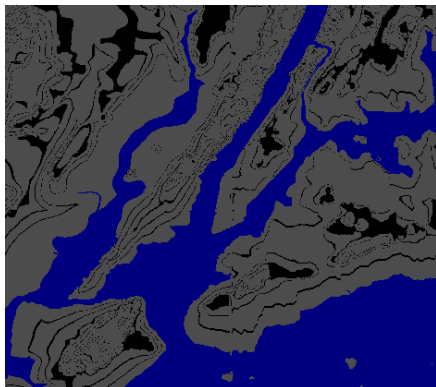
- Write a function that asks a user for number after 2000 but before 2018. The function should repeatedly ask the user for a number until they enter one within the range and return the number.

Python & Circuits Review: 10 Weeks in 10 Minutes



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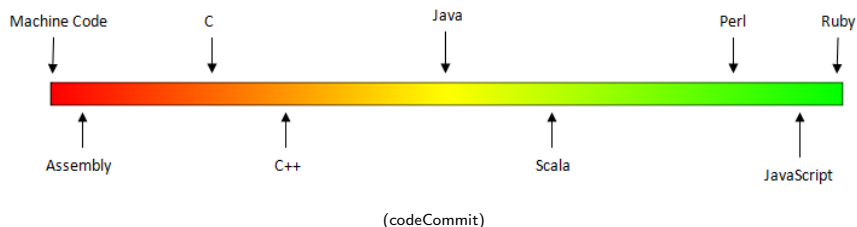
Lecture Slip: Commenting Code



In pairs or triples:

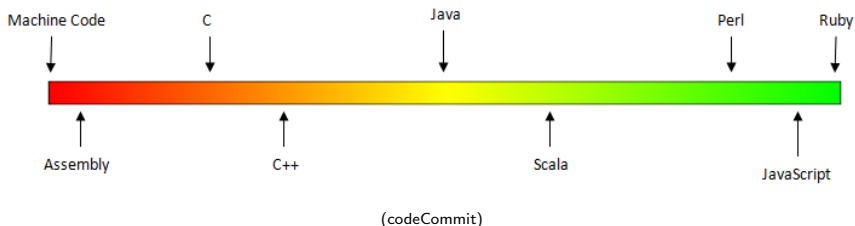
- What does the code do?
- Add comments to explain each line.

Low-Level vs. High-Level Languages



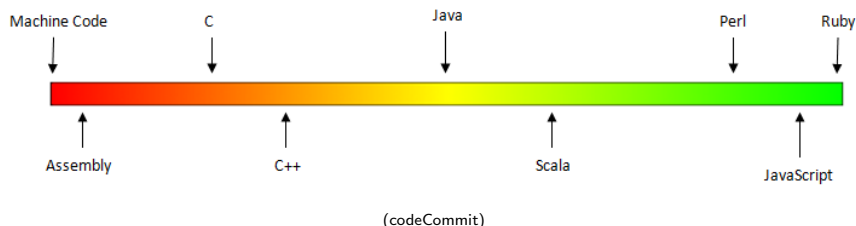
- Can view programming languages on a continuum.

Low-Level vs. High-Level Languages



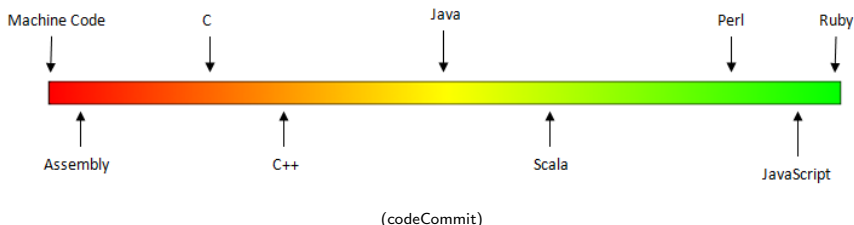
- Can view programming languages on a continuum.
- Those that directly access machine instructions & memory and have little abstraction are **low-level languages**

Low-Level vs. High-Level Languages



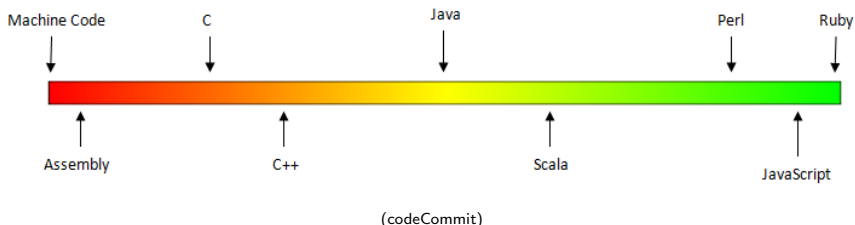
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Low-Level vs. High-Level Languages



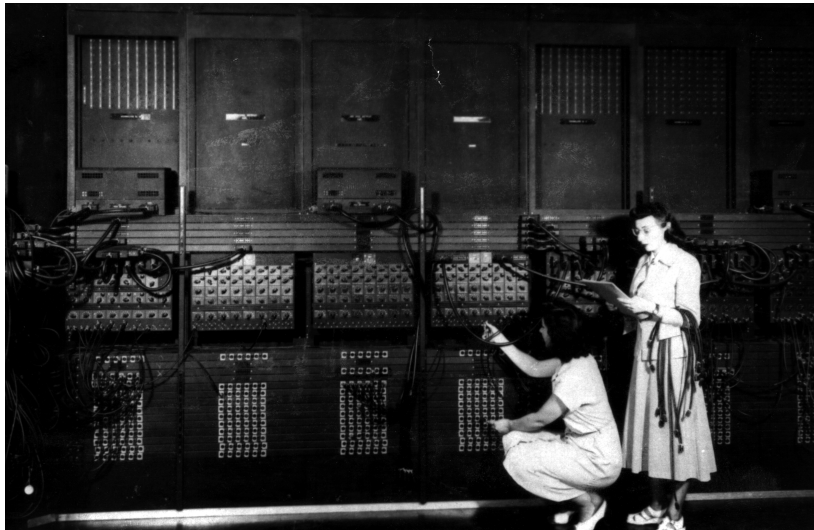
- Can view programming languages on a continuum.
- Those that directly access machine instructions & memory and have little abstraction are **low-level languages** (e.g. machine language, assembly language).
- Those that have strong abstraction (allow programming paradigms independent of the machine details, such as complex variables, functions and looping that do not translate directly into machine code) are called **high-level languages**.

Low-Level vs. High-Level Languages



- Can view programming languages on a continuum.
- Those that directly access machine instructions & memory and have little abstraction are **low-level languages** (e.g. machine language, assembly language).
- Those that have strong abstraction (allow programming paradigms independent of the machine details, such as complex variables, functions and looping that do not translate directly into machine code) are called **high-level languages**.
- Some languages, like C, are in between– allowing both low level access and high level data structures.

Machine Language



(Ruth Gordon & Ester Gerston programming the ENIAC, UPenn)

Machine Language

```
1 FOX 12:01a 23- 1
A 002000 C2 30 REP #$30
A 002002 18 CLC
A 002003 F8 SED
A 002004 A9 34 12 LDA #$1234
A 002007 69 21 43 ADC #$4321
A 00200A 8F 03 7F 01 STA $017F03
A 00200E D8 CLD
A 00200F E2 30 SEP #$30
A 002011 00 BRK
A 2012

r
PB PC NUmxDI2C .A .X .Y SP DP DB
; 00 E012 00110000 0000 0000 0002 CFFF 0000 00
g 2000

BREAK

PB PC NUmxDI2C .A .X .Y SP DP DB
; 00 2013 00110000 5555 0000 0002 CFFF 0000 00
m 7f03 7f03
>007F03 55 55 00 00 00 00 00 00 00 00 00 00 00 00 00:UU.....
█
```

(wiki)

Machine Language

- We will be writing programs in a simplified machine language, WeMIPS.



The screenshot shows a MIPS assembly program in a debugger. The program consists of several instructions: `li $t0, 0x1234`, `li $t1, 0x5678`, `add $t2, $t0, $t1`, `sw $t2, 0($t0)`, `lw $t3, 0($t0)`, `add $t4, $t3, $t2`, `sw $t4, 0($t1)`, `lw $t5, 0($t1)`, `add $t6, $t5, $t4`, `sw $t6, 0($t2)`, `lw $t7, 0($t2)`, `add $t8, $t7, $t6`, `sw $t8, 0($t3)`, `lw $t9, 0($t3)`, `add $t10, $t9, $t8`, `sw $t10, 0($t4)`, `lw $t11, 0($t4)`, `add $t12, $t11, $t10`, `sw $t12, 0($t5)`, `lw $t13, 0($t5)`, `add $t14, $t13, $t12`, `sw $t14, 0($t6)`, `lw $t15, 0($t6)`, `add $t16, $t15, $t14`, `sw $t16, 0($t7)`, `lw $t17, 0($t7)`, `add $t18, $t17, $t16`, `sw $t18, 0($t8)`, `lw $t19, 0($t8)`, `add $t20, $t19, $t18`, `sw $t20, 0($t9)`, `lw $t21, 0($t9)`, `add $t22, $t21, $t20`, `sw $t22, 0($t10)`, `lw $t23, 0($t10)`, `add $t24, $t23, $t22`, `sw $t24, 0($t11)`, `lw $t25, 0($t11)`, `add $t26, $t25, $t24`, `sw $t26, 0($t12)`, `lw $t27, 0($t12)`, `add $t28, $t27, $t26`, `sw $t28, 0($t13)`, `lw $t29, 0($t13)`, `add $t30, $t29, $t28`, `sw $t30, 0($t14)`, `lw $t31, 0($t14)`, `add $t32, $t31, $t30`, `sw $t32, 0($t15)`, `lw $t33, 0($t15)`, `add $t34, $t33, $t32`, `sw $t34, 0($t16)`, `lw $t35, 0($t16)`, `add $t36, $t35, $t34`, `sw $t36, 0($t17)`, `lw $t37, 0($t17)`, `add $t38, $t37, $t36`, `sw $t38, 0($t18)`, `lw $t39, 0($t18)`, `add $t40, $t39, $t38`, `sw $t40, 0($t19)`, `lw $t41, 0($t19)`, `add $t42, $t41, $t40`, `sw $t42, 0($t20)`, `lw $t43, 0($t20)`, `add $t44, $t43, $t42`, `sw $t44, 0($t21)`, `lw $t45, 0($t21)`, `add $t46, $t45, $t44`, `sw $t46, 0($t22)`, `lw $t47, 0($t22)`, `add $t48, $t47, $t46`, `sw $t48, 0($t23)`, `lw $t49, 0($t23)`, `add $t50, $t49, $t48`, `sw $t50, 0($t24)`, `lw $t51, 0($t24)`, `add $t52, $t51, $t50`, `sw $t52, 0($t25)`, `lw $t53, 0($t25)`, `add $t54, $t53, $t52`, `sw $t54, 0($t26)`, `lw $t55, 0($t26)`, `add $t56, $t55, $t54`, `sw $t56, 0($t27)`, `lw $t57, 0($t27)`, `add $t58, $t57, $t56`, `sw $t58, 0($t28)`, `lw $t59, 0($t28)`, `add $t60, $t59, $t58`, `sw $t60, 0($t29)`, `lw $t61, 0($t29)`, `add $t62, $t61, $t60`, `sw $t62, 0($t30)`, `lw $t63, 0($t30)`, `add $t64, $t63, $t62`, `sw $t64, 0($t31)`, `lw $t65, 0($t31)`, `add $t66, $t65, $t64`, `sw $t66, 0($t32)`, `lw $t67, 0($t32)`, `add $t68, $t67, $t66`, `sw $t68, 0($t33)`, `lw $t69, 0($t33)`, `add $t70, $t69, $t68`, `sw $t70, 0($t34)`, `lw $t71, 0($t34)`, `add $t72, $t71, $t70`, `sw $t72, 0($t35)`, `lw $t73, 0($t35)`, `add $t74, $t73, $t72`, `sw $t74, 0($t36)`, `lw $t75, 0($t36)`, `add $t76, $t75, $t74`, `sw $t76, 0($t37)`, `lw $t77, 0($t37)`, `add $t78, $t77, $t76`, `sw $t78, 0($t38)`, `lw $t79, 0($t38)`, `add $t80, $t79, $t78`, `sw $t80, 0($t39)`, `lw $t81, 0($t39)`, `add $t82, $t81, $t80`, `sw $t82, 0($t40)`, `lw $t83, 0($t40)`, `add $t84, $t83, $t82`, `sw $t84, 0($t41)`, `lw $t85, 0($t41)`, `add $t86, $t85, $t84`, `sw $t86, 0($t42)`, `lw $t87, 0($t42)`, `add $t88, $t87, $t86`, `sw $t88, 0($t43)`, `lw $t89, 0($t43)`, `add $t90, $t89, $t88`, `sw $t90, 0($t44)`, `lw $t91, 0($t44)`, `add $t92, $t91, $t90`, `sw $t92, 0($t45)`, `lw $t93, 0($t45)`, `add $t94, $t93, $t92`, `sw $t94, 0($t46)`, `lw $t95, 0($t46)`, `add $t96, $t95, $t94`, `sw $t96, 0($t47)`, `lw $t97, 0($t47)`, `add $t98, $t97, $t96`, `sw $t98, 0($t48)`, `lw $t99, 0($t48)`, `add $t100, $t99, $t98`, `sw $t100, 0($t49)`, `lw $t101, 0($t49)`, `add $t102, $t101, $t100`, `sw $t102, 0($t50)`, `lw $t103, 0($t50)`, `add $t104, $t103, $t102`, `sw $t104, 0($t51)`, `lw $t105, 0($t51)`, `add $t106, $t105, $t104`, `sw $t106, 0($t52)`, `lw $t107, 0($t52)`, `add $t108, $t107, $t106`, `sw $t108, 0($t53)`, `lw $t109, 0($t53)`, `add $t110, $t109, $t108`, `sw $t110, 0($t54)`, `lw $t111, 0($t54)`, `add $t112, $t111, $t110`, `sw $t112, 0($t55)`, `lw $t113, 0($t55)`, `add $t114, $t113, $t112`, `sw $t114, 0($t56)`, `lw $t115, 0($t56)`, `add $t116, $t115, $t114`, `sw $t116, 0($t57)`, `lw $t117, 0($t57)`, `add $t118, $t117, $t116`, `sw $t118, 0($t58)`, `lw $t119, 0($t58)`, `add $t120, $t119, $t118`, `sw $t120, 0($t59)`, `lw $t121, 0($t59)`, `add $t122, $t121, $t120`, `sw $t122, 0($t60)`, `lw $t123, 0($t60)`, `add $t124, $t123, $t122`, `sw $t124, 0($t61)`, `lw $t125, 0($t61)`, `add $t126, $t125, $t124`, `sw $t126, 0($t62)`, `lw $t127, 0($t62)`, `add $t128, $t127, $t126`, `sw $t128, 0($t63)`, `lw $t129, 0($t63)`, `add $t130, $t129, $t128`, `sw $t130, 0($t64)`, `lw $t131, 0($t64)`, `add $t132, $t131, $t130`, `sw $t132, 0($t65)`, `lw $t133, 0($t65)`, `add $t134, $t133, $t132`, `sw $t134, 0($t66)`, `lw $t135, 0($t66)`, `add $t136, $t135, $t134`, `sw $t136, 0($t67)`, `lw $t137, 0($t67)`, `add $t138, $t137, $t136`, `sw $t138, 0($t68)`, `lw $t139, 0($t68)`, `add $t140, $t139, $t138`, `sw $t140, 0($t69)`, `lw $t141, 0($t69)`, `add $t142, $t141, $t140`, `sw $t142, 0($t70)`, `lw $t143, 0($t70)`, `add $t144, $t143, $t142`, `sw $t144, 0($t71)`, `lw $t145, 0($t71)`, `add $t146, $t145, $t144`, `sw $t146, 0($t72)`, `lw $t147, 0($t72)`, `add $t148, $t147, $t146`, `sw $t148, 0($t73)`, `lw $t149, 0($t73)`, `add $t150, $t149, $t148`, `sw $t150, 0($t74)`, `lw $t151, 0($t74)`, `add $t152, $t151, $t150`, `sw $t152, 0($t75)`, `lw $t153, 0($t75)`, `add $t154, $t153, $t152`, `sw $t154, 0($t76)`, `lw $t155, 0($t76)`, `add $t156, $t155, $t154`, `sw $t156, 0($t77)`, `lw $t157, 0($t77)`, `add $t158, $t157, $t156`, `sw $t158, 0($t78)`, `lw $t159, 0($t78)`, `add $t160, $t159, $t158`, `sw $t160, 0($t79)`, `lw $t161, 0($t79)`, `add $t162, $t161, $t160`, `sw $t162, 0($t80)`, `lw $t163, 0($t80)`, `add $t164, $t163, $t162`, `sw $t164, 0($t81)`, `lw $t165, 0($t81)`, `add $t166, $t165, $t164`, `sw $t166, 0($t82)`, `lw $t167, 0($t82)`, `add $t168, $t167, $t166`, `sw $t168, 0($t83)`, `lw $t169, 0($t83)`, `add $t170, $t169, $t168`, `sw $t170, 0($t84)`, `lw $t171, 0($t84)`, `add $t172, $t171, $t170`, `sw $t172, 0($t85)`, `lw $t173, 0($t85)`, `add $t174, $t173, $t172`, `sw $t174, 0($t86)`, `lw $t175, 0($t86)`, `add $t176, $t175, $t174`, `sw $t176, 0($t87)`, `lw $t177, 0($t87)`, `add $t178, $t177, $t176`, `sw $t178, 0($t88)`, `lw $t179, 0($t88)`, `add $t180, $t179, $t178`, `sw $t180, 0($t89)`, `lw $t181, 0($t89)`, `add $t182, $t181, $t180`, `sw $t182, 0($t90)`, `lw $t183, 0($t90)`, `add $t184, $t183, $t182`, `sw $t184, 0($t91)`, `lw $t185, 0($t91)`, `add $t186, $t185, $t184`, `sw $t186, 0($t92)`, `lw $t187, 0($t92)`, `add $t188, $t187, $t186`, `sw $t188, 0($t93)`, `lw $t189, 0($t93)`, `add $t190, $t189, $t188`, `sw $t190, 0($t94)`, `lw $t191, 0($t94)`, `add $t192, $t191, $t190`, `sw $t192, 0($t95)`, `lw $t193, 0($t95)`, `add $t194, $t193, $t192`, `sw $t194, 0($t96)`, `lw $t195, 0($t96)`, `add $t196, $t195, $t194`, `sw $t196, 0($t97)`, `lw $t197, 0($t97)`, `add $t198, $t197, $t196`, `sw $t198, 0($t98)`, `lw $t199, 0($t98)`, `add $t200, $t199, $t198`, `sw $t200, 0($t99)`, `lw $t201, 0($t99)`, `add $t202, $t201, $t200`, `sw $t202, 0($t100)`, `lw $t203, 0($t100)`, `add $t204, $t203, $t202`, `sw $t204, 0($t101)`, `lw $t205, 0($t101)`, `add $t206, $t205, $t204`, `sw $t206, 0($t102)`, `lw $t207, 0($t102)`, `add $t208, $t207, $t206`, `sw $t208, 0($t103)`, `lw $t209, 0($t103)`, `add $t210, $t209, $t208`, `sw $t210, 0($t104)`, `lw $t211, 0($t104)`, `add $t212, $t211, $t210`, `sw $t212, 0($t105)`, `lw $t213, 0($t105)`, `add $t214, $t213, $t212`, `sw $t214, 0($t106)`, `lw $t215, 0($t106)`, `add $t216, $t215, $t214`, `sw $t216, 0($t107)`, `lw $t217, 0($t107)`, `add $t218, $t217, $t216`, `sw $t218, 0($t108)`, `lw $t219, 0($t108)`, `add $t220, $t219, $t218`, `sw $t220, 0($t109)`, `lw $t221, 0($t109)`, `add $t222, $t221, $t220`, `sw $t222, 0($t110)`, `lw $t223, 0($t110)`, `add $t224, $t223, $t222`, `sw $t224, 0($t111)`, `lw $t225, 0($t111)`, `add $t226, $t225, $t224`, `sw $t226, 0($t112)`, `lw $t227, 0($t112)`, `add $t228, $t227, $t226`, `sw $t228, 0($t113)`, `lw $t229, 0($t113)`, `add $t230, $t229, $t228`, `sw $t230, 0($t114)`, `lw $t231, 0($t114)`, `add $t232, $t231, $t230`, `sw $t232, 0($t115)`, `lw $t233, 0($t115)`, `add $t234, $t233, $t232`, `sw $t234, 0($t116)`, `lw $t235, 0($t116)`, `add $t236, $t235, $t234`, `sw $t236, 0($t117)`, `lw $t237, 0($t117)`, `add $t238, $t237, $t236`, `sw $t238, 0($t118)`, `lw $t239, 0($t118)`, `add $t240, $t239, $t238`, `sw $t240, 0($t119)`, `lw $t241, 0($t119)`, `add $t242, $t241, $t240`, `sw $t242, 0($t120)`, `lw $t243, 0($t120)`, `add $t244, $t243, $t242`, `sw $t244, 0($t121)`, `lw $t245, 0($t121)`, `add $t246, $t245, $t244`, `sw $t246, 0($t122)`, `lw $t247, 0($t122)`, `add $t248, $t247, $t246`, `sw $t248, 0($t123)`, `lw $t249, 0($t123)`, `add $t250, $t249, $t248`, `sw $t250, 0($t124)`, `lw $t251, 0($t124)`, `add $t252, $t251, $t250`, `sw $t252, 0($t125)`, `lw $t253, 0($t125)`, `add $t254, $t253, $t252`, `sw $t254, 0($t126)`, `lw $t255, 0($t126)`, `add $t256, $t255, $t254`, `sw $t256, 0($t127)`, `lw $t257, 0($t127)`, `add $t258, $t257, $t256`, `sw $t258, 0($t128)`, `lw $t259, 0($t128)`, `add $t260, $t259, $t258`, `sw $t260, 0($t129)`, `lw $t261, 0($t129)`, `add $t262, $t261, $t260`, `sw $t262, 0($t130)`, `lw $t263, 0($t130)`, `add $t264, $t263, $t262`, `sw $t264, 0($t131)`, `lw $t265, 0($t131)`, `add $t266, $t265, $t264`, `sw $t266, 0($t132)`, `lw $t267, 0($t132)`, `add $t268, $t267, $t266`, `sw $t268, 0($t133)`, `lw $t269, 0($t133)`, `add $t270, $t269, $t268`, `sw $t270, 0($t134)`, `lw $t271, 0($t134)`, `add $t272, $t271, $t270`, `sw $t272, 0($t135)`, `lw $t273, 0($t135)`, `add $t274, $t273, $t272`, `sw $t274, 0($t136)`, `lw $t275, 0($t136)`, `add $t276, $t275, $t274`, `sw $t276, 0($t137)`, `lw $t277, 0($t137)`, `add $t278, $t277, $t276`, `sw $t278, 0($t138)`, `lw $t279, 0($t138)`, `add $t280, $t279, $t278`, `sw $t280, 0($t139)`, `lw $t281, 0($t139)`, `add $t282, $t281, $t280`, `sw $t282, 0($t140)`, `lw $t283, 0($t140)`, `add $t284, $t283, $t282`, `sw $t284, 0($t141)`, `lw $t285, 0($t141)`, `add $t286, $t285, $t284`, `sw $t286, 0($t142)`, `lw $t287, 0($t142)`, `add $t288, $t287, $t286`, `sw $t288, 0($t143)`, `lw $t289, 0($t143)`, `add $t290, $t289, $t288`, `sw $t290, 0($t144)`, `lw $t291, 0($t144)`, `add $t292, $t291, $t290`, `sw $t292, 0($t145)`, `lw $t293, 0($t145)`, `add $t294, $t293, $t292`, `sw $t294, 0($t146)`, `lw $t295, 0($t146)`, `add $t296, $t295, $t294`, `sw $t296, 0($t147)`, `lw $t297, 0($t147)`, `add $t298, $t297, $t296`, `sw $t298, 0($t148)`, `lw $t299, 0($t148)`, `add $t300, $t299, $t298`, `sw $t300, 0($t149)`, `lw $t301, 0($t149)`, `add $t302, $t301, $t300`, `sw $t302, 0($t150)`, `lw $t303, 0($t150)`, `add $t304, $t303, $t302`, `sw $t304, 0($t151)`, `lw $t305, 0($t151)`, `add $t306, $t305, $t304`, `sw $t306, 0($t152)`, `lw $t307, 0($t152)`, `add $t308, $t307, $t306`, `sw $t308, 0($t153)`, `lw $t309, 0($t153)`, `add $t310, $t309, $t308`, `sw $t310, 0($t154)`, `lw $t311, 0($t154)`, `add $t312, $t311, $t310`, `sw $t312, 0($t155)`, `lw $t313, 0($t155)`, `add $t314, $t313, $t312`, `sw $t314, 0($t156)`, `lw $t315, 0($t156)`, `add $t316, $t315, $t314`, `sw $t316, 0($t157)`, `lw $t317, 0($t157)`, `add $t318, $t317, $t316`, `sw $t318, 0($t158)`, `lw $t319, 0($t158)`, `add $t320, $t319, $t318`, `sw $t320, 0($t159)`, `lw $t321, 0($t159)`, `add $t322, $t321, $t320`, `sw $t322, 0($t160)`, `lw $t323, 0($t160)`, `add $t324, $t323, $t322`, `sw $t324, 0($t161)`, `lw $t325, 0($t161)`, `add $t326, $t325, $t324`, `sw $t326, 0($t162)`, `lw $t327, 0($t162)`, `add $t328, $t327, $t326`, `sw $t328, 0($t163)`, `lw $t329, 0($t163)`, `add $t330, $t329, $t328`, `sw $t330, 0($t164)`, `lw $t331, 0($t164)`, `add $t332, $t331, $t330`, `sw $t332, 0($t165)`, `lw $t333, 0($t165)`, `add $t334, $t333, $t332`, `sw $t334, 0($t166)`, `lw $t335, 0($t166)`, `add $t336, $t335, $t334`, `sw $t336, 0($t167)`, `lw $t337, 0($t167)`, `add $t338, $t337, $t336`, `sw $t338, 0($t168)`, `lw $t339, 0($t168)`, `add $t340, $t339, $t338`, `sw $t340, 0($t169)`, `lw $t341, 0($t169)`, `add $t342, $t341, $t340`, `sw $t342, 0($t170)`, `lw $t343, 0($t170)`, `add $t344, $t343, $t342`, `sw $t344, 0($t171)`, `lw $t345, 0($t171)`, `add $t346, $t345, $t344`, `sw $t346, 0($t172)`, `lw $t347, 0($t172)`, `add $t348, $t347, $t346`, `sw $t348, 0($t173)`, `lw $t349, 0($t173)`, `add $t350, $t349, $t348`, `sw $t350, 0($t174)`, `lw $t351, 0($t174)`, `add $t352, $t351, $t350`, `sw $t352, 0($t175)`, `lw $t353, 0($t175)`, `add $t354, $t353, $t352`, `sw $t354, 0($t176)`, `lw $t355, 0($t176)`, `add $t356, $t355, $t354`, `sw $t356, 0($t177)`, `lw $t357, 0($t177)`, `add $t358, $t357, $t356`, `sw $t358, 0($t178)`, `lw $t359, 0($t178)`, `add $t360, $t359, $t358`, `sw $t360, 0($t179)`, `lw $t361, 0($t179)`, `add $t362, $t361, $t360`, `sw $t362, 0($t180)`, `lw $t363, 0($t180)`, `add $t364, $t363, $t362`, `sw $t364, 0($t181)`, `lw $t365, 0($t181)`, `add $t366, $t365, $t364`, `sw $t366, 0($t182)`, `lw $t367, 0($t182)`, `add $t368, $t367, $t366`, `sw $t368, 0($t183)`, `lw $t369, 0($t183)`, `add $t370, $t369, $t368`, `sw $t370, 0($t184)`, `lw $t371, 0($t184)`, `add $t372, $t371, $t370`, `sw $t372, 0($t185)`, `lw $t373, 0($t185)`, `add $t374, $t373, $t372`, `sw $t374, 0($t186)`, `lw $t375, 0($t186)`, `add $t376, $t375, $t374`, `sw $t376, 0($t187)`, `lw $t377, 0($t187)`, `add $t378, $t377, $t376`, `sw $t378, 0($t188)`, `lw $t379, 0($t188)`, `add $t380, $t379, $t378`, `sw $t380, 0($t189)`, `lw $t381, 0($t189)`, `add $t382, $t381, $t380`, `sw $t382, 0($t190)`, `lw $t383, 0($t190)`, `add $t384, $t383, $t382`, `sw $t384, 0($t191)`, `lw $t385, 0($t191)`, `add $t386, $t385, $t384`, `sw $t386, 0($t192)`, `lw $t387, 0($t192)`, `add $t388, $t387, $t386`, `sw $t388, 0($t193)`, `lw $t389, 0($t193)`, `add $t390, $t389, $t388`, `sw $t390, 0($t194)`, `lw $t391, 0($t194)`, `add $t392, $t391, $t390`, `sw $t392, 0($t195)`, `lw $t393, 0($t195)`, `add $t394, $t393, $t392`, `sw $t394, 0($t196)`, `lw $t395, 0($t196)`, `add $t396, $t395, $t394`, `sw $t396, 0($t197)`, `lw $t397, 0($t197`

Machine Language



The screenshot shows a MIPS assembly program being executed in a debugger. The assembly code is as follows:

```
002000 c2 30      REP #030
002002 10          CLC
002003 f0          SED
002004 a0 34 12    L3H #01234
002007 60 21 43    R0C #04321
00200a 0f 03 7f 01 ST0 #017f03
00200c 00        CLJ
00200f e2 30      SEP #030
002011 00        BRX
002012
```

Below the assembly code, the debugger shows the current state of the processor:

```
PC PC Mips32C A X Y SP BP BB
: 00 2012 00110000 0000 0000 0002 c7ff 0000 00
$ 2000
```


A "BREAK" message is displayed, followed by another processor state dump:

```
PC PC Mips32C A X Y SP BP BB
: 00 2013 00110000 6555 0000 0002 c7ff 0000 00
n 1103 7f03
007f03 55 55 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

(wiki)

- We will be writing programs in a simplified machine language, WeMIPS.
- It is based on a reduced instruction set computer (RISC) design, originally developed by the MIPS Computer Systems.

Machine Language

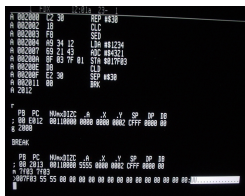


The screenshot shows a debugger window with MIPS assembly code and its corresponding machine code. The assembly code includes instructions like `REP #30`, `CLC`, `SED`, `LDR #01234`, `ROR #4321`, `STW #017F83`, `CLD`, `SEP #30`, and `BRX`. The machine code is displayed in hexadecimal. Below the code, the debugger shows the current state of registers (PC, PC, MEM32C, A, X, Y, SP, BP, BB) and a memory dump.

(wiki)

- We will be writing programs in a simplified machine language, WeMIPS.
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- Due to its small set of commands, processors can be designed to run those commands very efficiently.

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- Due to its small set of commands, processors can be designed to run those commands very efficiently.
- More in future architecture classes....

"Hello World!" in Simplified Machine Language

Line: 3 Go!

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Addition Doubler

Stav

Looper

Stack Test

Hello World

Code Gen Save String

Interactive

Binary2 Decimal

Decimal2 Binary

Debug

```
1 # Store 'Hello world!' at the top of the stack
2 ADDI $sp, $sp, -13
3 ADDI $t0, $zero, 72 # H
4 SB $t0, 0($sp)
5 ADDI $t0, $zero, 101 # e
6 SB $t0, 1($sp)
7 ADDI $t0, $zero, 108 # l
8 SB $t0, 2($sp)
9 ADDI $t0, $zero, 108 # l
10 SB $t0, 3($sp)
11 ADDI $t0, $zero, 111 # o
12 SB $t0, 4($sp)
13 ADDI $t0, $zero, 32 # (space)
14 SB $t0, 5($sp)
15 ADDI $t0, $zero, 119 # w
16 SB $t0, 6($sp)
17 ADDI $t0, $zero, 111 # o
18 SB $t0, 7($sp)
19 ADDI $t0, $zero, 114 # r
20 SB $t0, 8($sp)
21 ADDI $t0, $zero, 108 # l
22 SB $t0, 9($sp)
23 ADDI $t0, $zero, 100 # d
24 SB $t0, 10($sp)
25 ADDI $t0, $zero, 33 # !
26 SB $t0, 11($sp)
27 ADDI $t0, $zero, 0 # (null)
28 SB $t0, 12($sp)
29
30 ADDI $v0, $zero, 4 # 4 is for print string
31 ADDI $a0, $sp, 0
32 syscall # print to the log
```

Step Run ☒ Enable auto switching

S T A V Stack Log

s0:	10
s1:	9
s2:	9
s3:	22
s4:	696
s5:	976
s6:	927
s7:	418

(WeMIPS)

WeMIPS

Line: 3 dis

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Addition Doubler Stop Looper Stack Test Hello World

Code Gen Save String Interactive Binary2 Decimal Decimal2 Binary

Debug

```
1 # Store "hello world!" at the top of the stack
2 ADDUI $a0, $zero, 32 # 0
3 R0 $a0, 0($a0)
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7 ADDUI $t0, $zero, 108 # l
8 R0 $t0, 0($a0)
9 ADDUI $t0, $zero, 108 # l
10 R0 $t0, 0($a0)
11 ADDUI $t0, $zero, 111 # o
12 R0 $t0, 0($a0)
13 ADDUI $t0, $zero, 32 # (space)
14 R0 $t0, 0($a0)
15 ADDUI $t0, $zero, 119 # w
16 R0 $t0, 0($a0)
17 ADDUI $t0, $zero, 114 # u
18 R0 $t0, 0($a0)
19 ADDUI $t0, $zero, 114 # u
20 R0 $t0, 0($a0)
21 ADDUI $t0, $zero, 108 # l
22 R0 $t0, 0($a0)
23 ADDUI $t0, $zero, 108 # l
24 R0 $t0, 0($a0)
25 ADDUI $t0, $zero, 33 # !
26 R0 $t0, 0($a0)
27 ADDUI $t0, $zero, 0 # (null)
28 R0 $t0, 0($a0)
29 ADDUI $t0, $zero, 6 # 6 in for print string
30 ADDUI $a0, $a0, 0
31 syscall # print to the log
```

Step Run v Enable auto-switching

S	T	A	V	Stack	Log
a0:			10		
t0:			9		
a0:			9		
a0:			22		
a0:			695		
a0:			970		
a0:			927		
a0:			418		

(Demo with WeMIPS)

In Pairs or Triples:

Line: 3 Go!

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```

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```

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```

```
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```

```
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```

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```
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```

```
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```

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```
13 ADDI $t0, $zero, 32 # (space)
```

```
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```

```
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```

```
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S	T	A	V	Stack	Log
---	---	---	---	-------	-----

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-----	--	--	--	---	--

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-----	--	--	--	----	--

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-----	--	--	--	-----	--

s5:				976	
-----	--	--	--	-----	--

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-----	--	--	--	-----	--

s7:				418	
-----	--	--	--	-----	--

Write a program that prints out the alphabet: a b c d ... x y z

WeMIPS

Line: 3 dis

Show/Hide Demos

User Guide | Unit Tests | Docs

Addition Doubler Stop Looper Stack Test Hello World

Code Gen Save String Interactive Binary2 Decimal Decimal2 Binary

Debug

```
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21 ADDUI $t0, $zero, 108 # l
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(Demo with WeMIPS)

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- Past exams available on webpage (includes answer keys).

Recap: Python, Languages, & Design

```
#Name: your name here
#Date: October 2017
#This program, uses functions,
#    says hello to the world!

def main():
    print("Hello, World!")

if __name__ == "__main__":
    main()
```

- On lecture slip, write down a topic you wish we had spent more time (and why).

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- Python language
- Logical Circuits
- Simplified Machine Language
- Design: from written description ('specs') to function inputs & outputs ('APIs')

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For each question, write **only the function header (name & inputs) and return values** (often called the Application Programming Interface (API)):

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- Write a function that takes a weight in kilograms and returns the weight in pounds.
- Write a function that takes a string and returns its length.
- Write a function that, given a DataFrame, returns the minimal value in the first column.
- Write a function that takes a whole number and returns the corresponding binary number as a string.
- Write a function that computes the total monthly payment when given the initial loan amount, annual interest rate, number of years of the loan.

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- Write a function that takes a whole number and returns the corresponding binary number as a string.
- Write a function that computes the total monthly payment when given the initial loan amount, annual interest rate, number of years of the loan.

(Hint: highlight key words, make list of inputs, list of outputs, then put together.)

Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that takes a weight in kilograms and returns the weight in pounds.

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- Write a function that takes a weight in kilograms and returns the weight in pounds.

```
def kg2lbs(kg):  
    ...  
    return(lbs)
```


Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that takes a weight in kilograms and returns the weight in pounds.

```
def kg2lbs(kg)
    lbs = kg * 2.2
    return(lbs)
```

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For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

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```
def sLength(str):  
    ...  
    return(length)
```

Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that takes a string and returns its length.

```
def sLength(str):  
    length = len(str)  
    return(length)
```

Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that, given a DataFrame, returns the minimal value in the “Manhattan” column.

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- Write a function that, given a DataFrame, returns the minimal value in the “Manhattan” column.

```
def getMin(df):  
    ...  
    return(min)
```

Final Overview

For each question below, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that, given a DataFrame, returns the minimal value in the “Manhattan” column.

```
def getMin(df):  
    mM = df['Manhattan'].min()  
    return(mM)
```

Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

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- Write a function that takes a whole number and returns the corresponding binary number as a string.

```
def num2bin(num):  
    ...  
    return(bin)
```

Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that takes a whole number and returns the corresponding binary number as a string.

```
def num2bin(num):  
    binStr = ""  
    while (num > 0):  
        #Divide by 2, and add the remainder to the string  
        r = num %2  
        binString = str(r) + binStr  
        num = num / 2  
    return(binStr)
```

Final Overview

For each question, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that computes the total monthly payment when given the initial loan amount, annual interest rate, number of years of the loan.

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- Write a function that computes the total monthly payment when given the initial loan amount, annual interest rate, number of years of the loan.

```
def computePayment(loan,rate,year):  
    ....  
    return(payment)
```

Final Overview

For each question below, write the function header (name & inputs) and return values (often called the Application Programming Interface (API)):

- Write a function that computes the total monthly payment when given the initial loan amount, annual interest rate, number of years of the loan.

```
def computePayment(loan,rate,year):  
    (Some formula for payment)  
    return(payment)
```