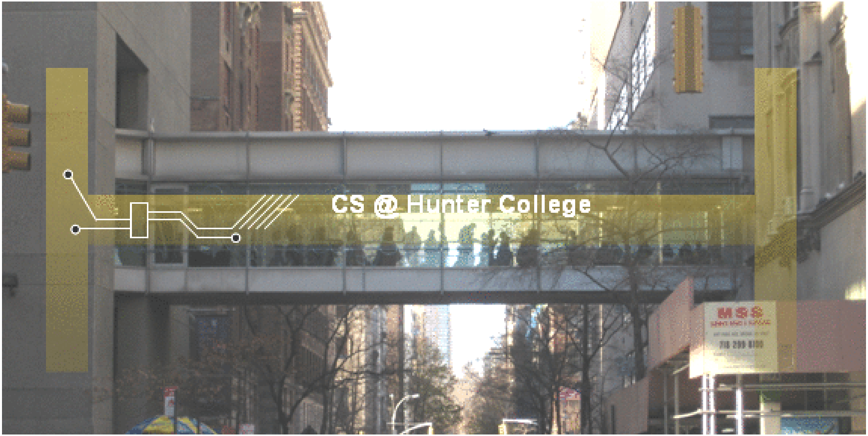
CSci 127: Introduction to Computer Science



hunter.cuny.edu/csci

Announcements

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Today's Topics

- Design Patterns: Searching
- Python Recap
- Machine Language
- Machine Language: Jumps & Loops
- Binary & Hex Arithmetic
- Final Exam: Format

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- **Design Patterns: Searching**
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Predict what the code will do:

```
def search(nums, locate):
    found = False
    i = 0
    while not found and i < len(nums):
        print(nums[i])
        if locate == nums[i]:
            found = True
        else:
            i = i+1
    return(found)

nums= [1,4,10,6,5,42,9,8,12]
if search(nums,6):
    print('Found it! 6 is in the list!')
else:
    print('Did not find 6 in the list.')
```

Python Tutor

```python
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(Demo with `pythonTutor`)

Design Pattern: Linear Search

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- Example of **linear search**.
- Start at the beginning of the list.
- Look at each item, one-by-one.
- Stopping, when found, or the end of list is reached.

Today's Topics

- Design Patterns: Searching
- **Python Recap**
- Machine Language
- Machine Language: Jumps & Loops
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- Final Exam: Format

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
#Date:  September 1, 2017
#This program prints:  Hello, World!

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

← *These lines are comments*

← *(for us, not computer to read)*

← *(this one also)*

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

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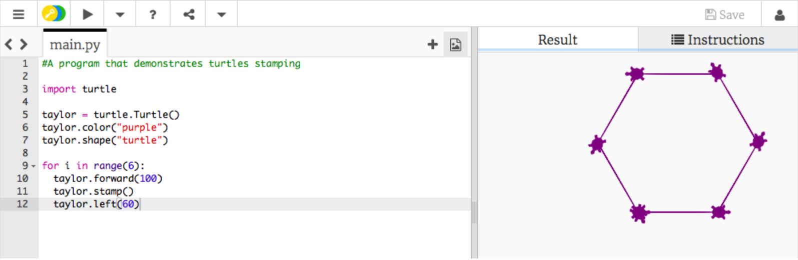
- As well as definite loops & the turtle package:



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

```python
#Predict what will be printed:

for num in [2,4,6,8,10]:
    print(num)

sum = 0
for x in range(0,12,2):
    print(x)
    sum = sum + x

print(sum)

for c in "ABCD":
    print(c)
```

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

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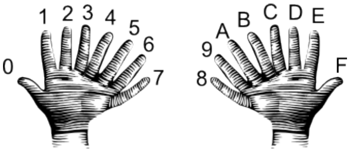
Black	#000000	
Navy	#000080	
DarkBlue	#00008B	
MediumBlue	#0000CD	
Blue	#0000FF	



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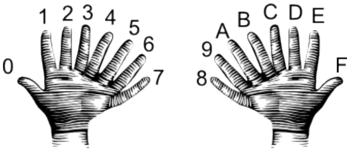

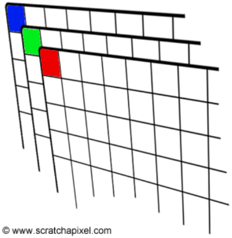

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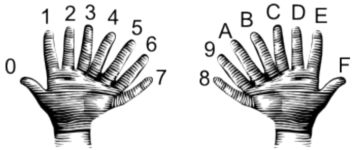
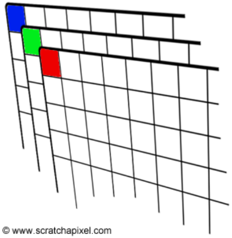


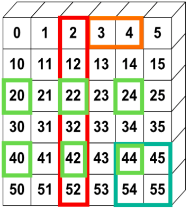



```
>>> a[0,3:5]
array([3,4])

>>> 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]])
```



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  1. Import numpy and pyplot.
  2. Ask user for file names and dimensions for cropping.
  3. Save input file to an array.
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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"):
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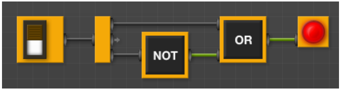
in1		in2	*returns:*
False	and	False	False
False	and	True	False
True	and	False	False
True	and	True	True



Week 6: structured data, pandas, & more design

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`nycHistPop.csv`

In Lab 6

Week 6: structured data, pandas, & more design

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import matplotlib.pyplot as plt
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`nycHistPop.csv`

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Week 6: structured data, pandas, & more design

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import matplotlib.pyplot as plt
import pandas as pd

pop = pd.read_csv('nycHistPop.csv',skiprows=5)
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In Lab 6

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import matplotlib.pyplot as plt
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pop = pd.read_csv('nycHistPop.csv',skiprows=5)

pop.plot(x="Year")
plt.show()
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pop = pd.read_csv('nycHistPop.csv',skiprows=5)

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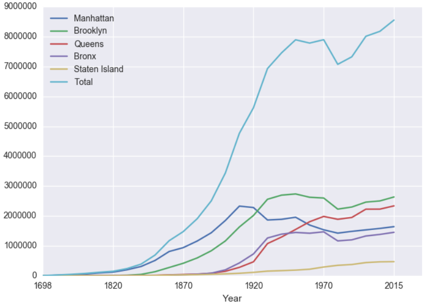

```
Source:  https://en.wikipedia.org/wiki/Demographics_of_New_York_City,,,,,,
All population figures are consistent with present-day boundaries.,,,,,,
First census after the consolidation of the five boroughs,,,,,,
,,,,,,
,,,,,,
Year,Manhattan,Brooklyn,Queens,Bronx,Staten Island,Total
1698,4937,2017,,,727,7681
1771,21863,3623,,,2847,28423
1790,33131,4549,6159,1781,3827,49447
1800,60515,5740,6642,1755,4563,79215
1810,96373,8303,7444,2267,5347,119734
1820,123706,11187,8246,2782,6135,152056
1830,202589,20535,9049,3023,7082,242278
1840,312710,47613,14480,5346,10965,391114
1850,515547,138882,18593,8032,15061,696115
1860,813669,279122,32903,23593,25492,1174779
1870,942292,419921,45468,37393,33029,1478103
1880,1164673,599495,56559,51980,38991,1911698
1890,1441216,838547,87050,88908,51693,2507414
1900,1850093,1166582,152999,200507,67021,3437202
1910,2331542,1634351,284041,430980,85969,4766883
1920,2284103,2018356,469042,732016,116531,5620048
1930,1867312,2560401,1079129,1265258,158346,6930446
1940,1889924,2698285,1297634,1394711,174441,7454995
1950,1960101,2738175,1550849,1451277,191555,7891957
1960,1698281,2627319,1809578,1424815,221991,7781984
1970,1539233,2602012,1986473,1471701,295443,7894862
1980,1428285,2230936,1891325,1168972,352121,7071639
1990,1487536,2300664,1951598,1203789,378977,7322564
2000,1537195,2465326,2229379,1332650,443728,8008278
2010,1585873,2504700,2230722,1385108,468730,8175133
2015,1644518,2636735,2339150,1455444,474558,8550405
```

nycHistPop.csv

In Lab 6



Week 7: functions

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

```python
#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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- 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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Week 9: top-down design, folium, loops, and random()


```python
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: more on loops, max design pattern, random()

```
dist = int(input('Enter distance: '))
while dist < 0:
    print('Distances cannot be negative.')
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- 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)
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- Python's built-in random package has useful methods for generating random whole numbers and real numbers.
- To use, must include: `import random`.
- The max design pattern provides a template for finding maximum value from a list.

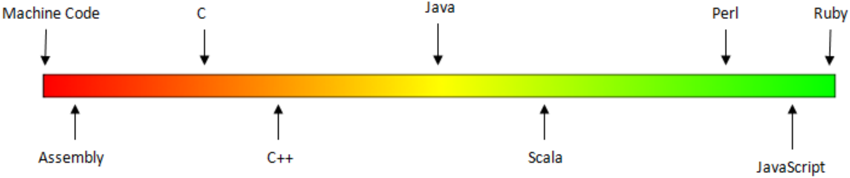
Python & Circuits Review: 10 Weeks in 10 Minutes

- Input/Output (I/O): `input()` and `print()`; pandas for CSV files
- Types:
  - Primitive: int, float, bool, string;
  - Container: lists (but not dictionaries/hashes 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

Today's Topics

- Design Patterns: Searching
- Python Recap
- **Machine Language**
- Machine Language: Jumps & Loops
- Binary & Hex Arithmetic
- Final Exam: Format

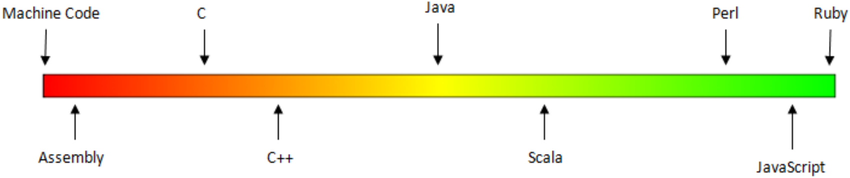
Low-Level vs. High-Level Languages



(codeCommit)

- Can view programming languages on a continuum.

Low-Level vs. High-Level Languages



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- Those that directly access machine instructions & memory and have little abstraction are **low-level languages**

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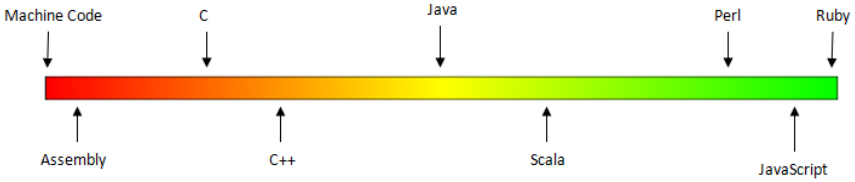

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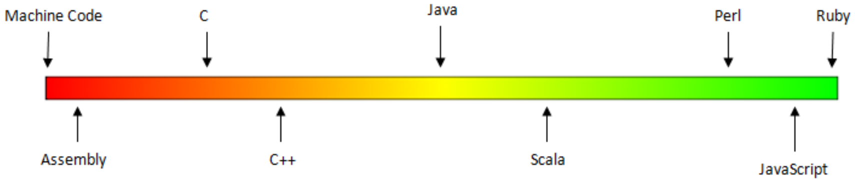

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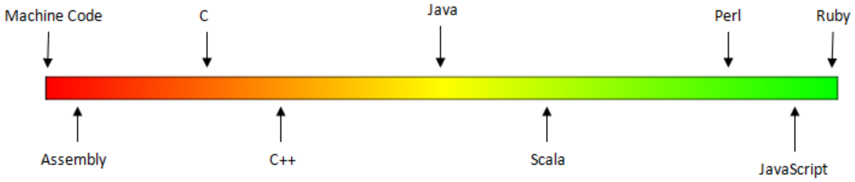

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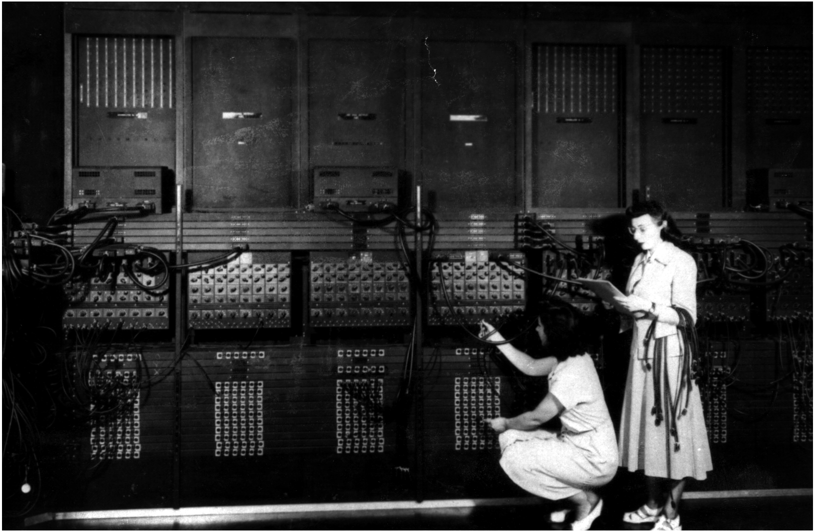
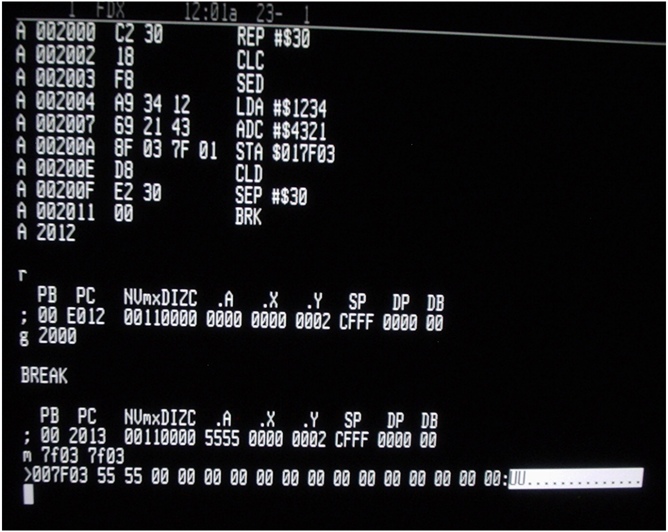
- Some languages, like C, are in between– allowing both low level access and high level data structures.

Machine Language



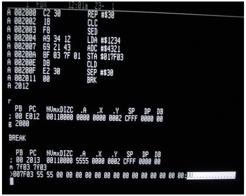
(Ruth Gordon & Ester Gerston programming the ENIAC, UPenn)

Machine Language



(wiki)

Machine Language



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

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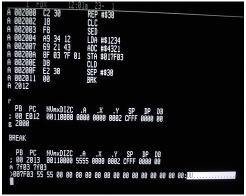

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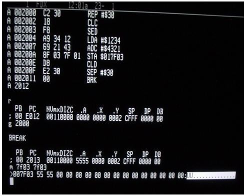

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- Due to its small set of commands, processors can be designed to run those commands very efficiently.

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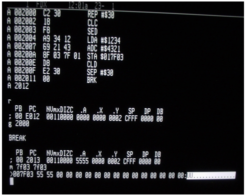

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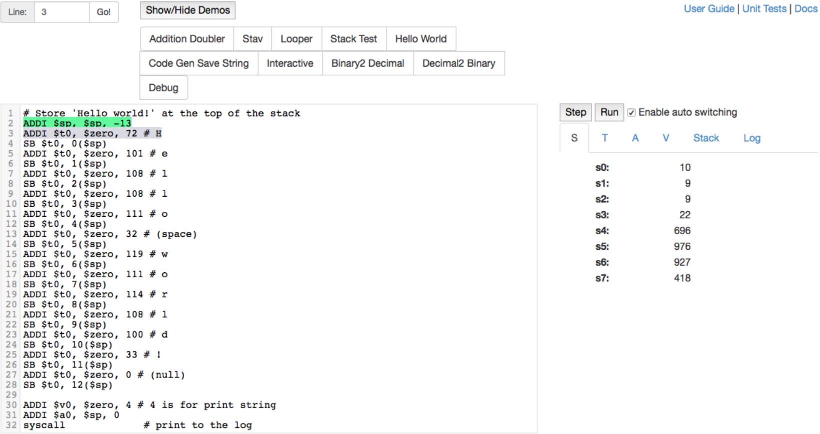
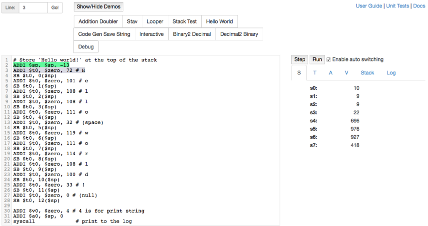
- More in future architecture classes....

"Hello World!" in Simplified Machine Language



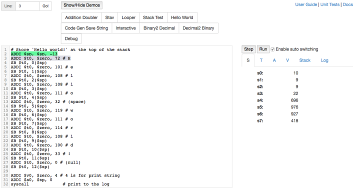
(WeMIPS)

WeMIPS



(Demo with `WeMIPS`)

MIPS Commands



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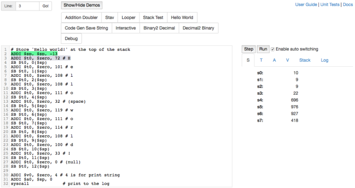
MIPS Commands



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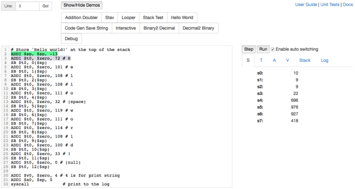

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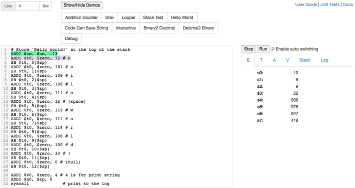

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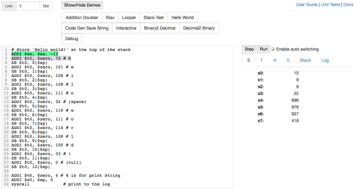

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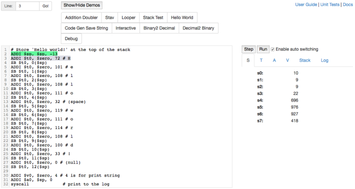

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  `addi $s1, $s2, 100`

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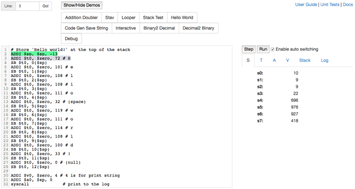

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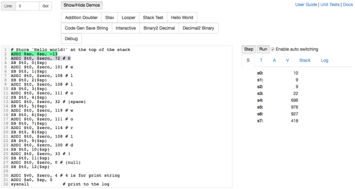
- **I Instructions:** instructions that also use intermediate values.
  `addi $s1, $s2, 100` (Basic form: `OP rd, rs, imm`)
- **J Instructions:** instructions that jump to another memory location.

MIPS Commands



- **Registers:** locations for storing information that can be quickly accessed. Names start with '\$': `$s0`, `$s1`, `$t0`, `$t1`,...
- **R Instructions:** Commands that use data in the registers:
  `add $s1, $s2, $s3` (Basic form: `OP rd, rs, rt`)
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  `addi $s1, $s2, 100` (Basic form: `OP rd, rs, imm`)
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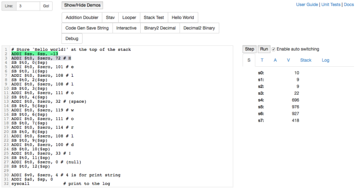
MIPS Commands



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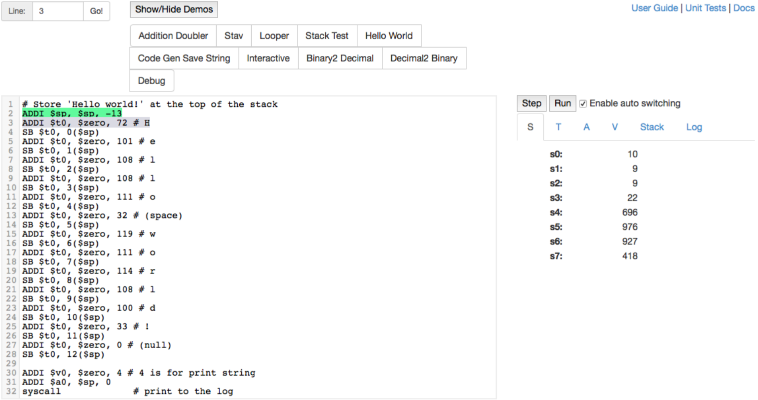
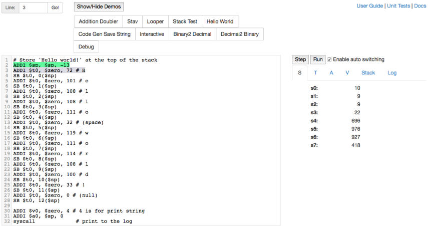
- **J Instructions:** instructions that jump to another memory location.
  `j done` (Basic form: `OP label`)

In Pairs or Triples:



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

WeMIPS

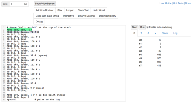


(Demo with `WeMIPS`)

Today's Topics

- Design Patterns: Searching
- Python Recap
- Machine Language
- **Machine Language: Jumps & Loops**
- Binary & Hex Arithmetic
- Final Exam: Format

Loops & Jumps in Machine Language



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Loops & Jumps in Machine Language

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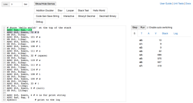
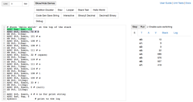


Loops & Jumps in Machine Language



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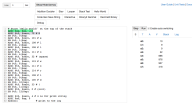

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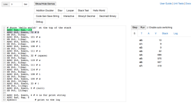
Loops & Jumps in Machine Language



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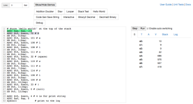

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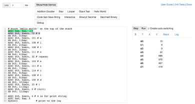
Loops & Jumps in Machine Language



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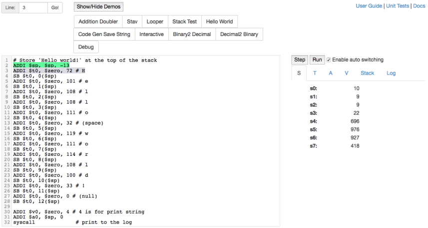
  - See reading for more variations.

Jump Demo

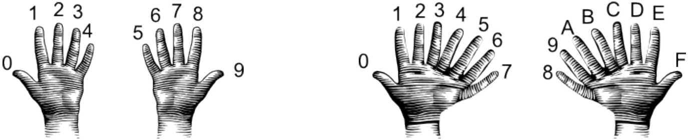


(Demo with `WeMIPS`)

Today's Topics

- Design Patterns: Searching
- Python Recap
- Machine Language
- Machine Language: Jumps & Loops
- **Binary & Hex Arithmetic**
- Final Exam: Format

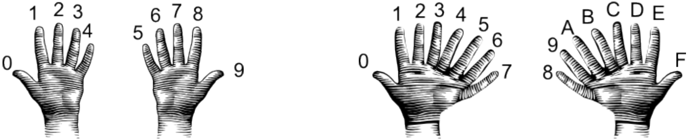
Hexadecimal to Decimal: Converting Between Bases



(from i-programmer.info)

- From hexadecimal to decimal:
  - Convert first digit to decimal and multiple by 16.

Hexadecimal to Decimal: Converting Between Bases



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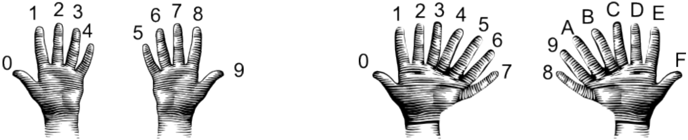

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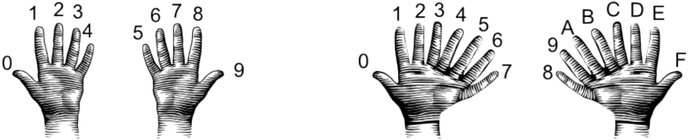

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    `2 in decimal is 2.`

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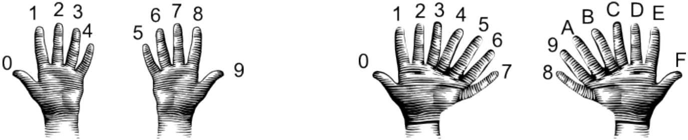

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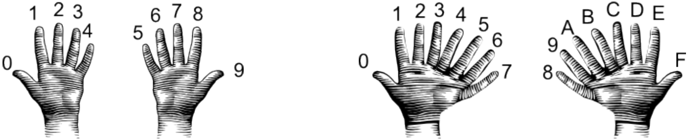

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    `A in decimal digits is 10.`

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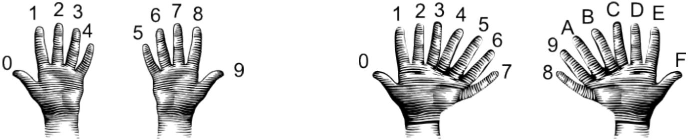

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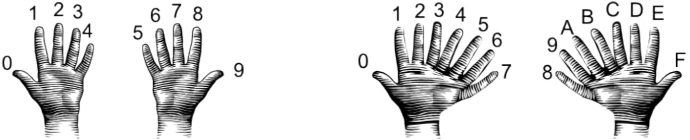
    ```
    2 in decimal is 2. 2*16 is 32.
    A in decimal digits is 10.
    32 + 10 is 42.
    ```

Hexadecimal to Decimal: Converting Between Bases



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    `32 + 10 is 42.`

    Answer is 42.
  - Example: what is 99 as a decimal number?

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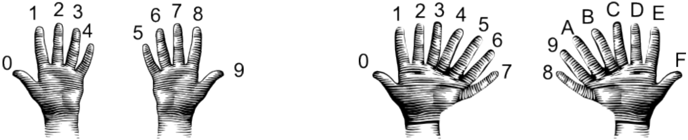

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    `9 in decimal is 9.`

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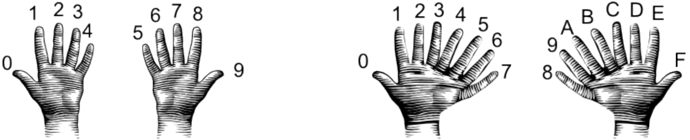

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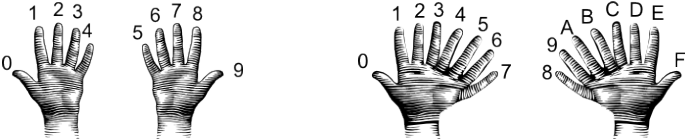

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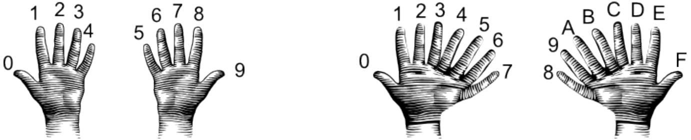

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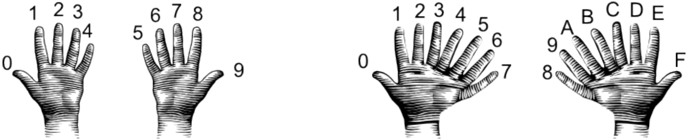

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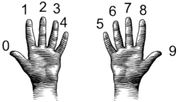
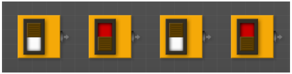
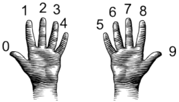
Decimal to Binary: Converting Between Bases

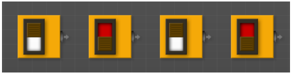




- From decimal to binary:
  - Divide by 128 ($= 2^7$). Quotient is the first digit.

Decimal to Binary: Converting Between Bases





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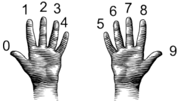

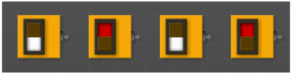

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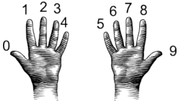

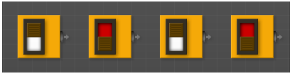

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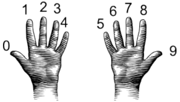

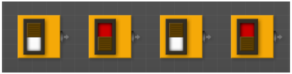

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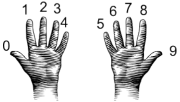

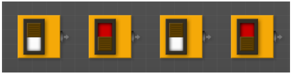

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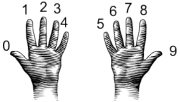
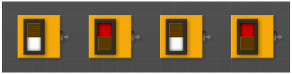
Decimal to Binary: Converting Between Bases





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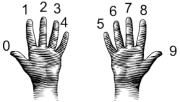

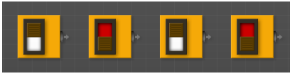

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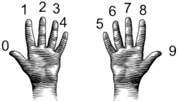
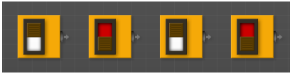
  - Divide remainder by 2 ($= 2^1$). Quotient is the next digit.
  - The last remainder is the last digit.

Decimal to Binary: Converting Between Bases





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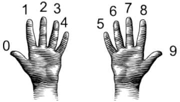

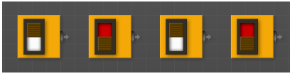

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    130/128 is 1 rem 2.
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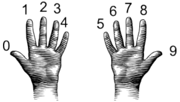

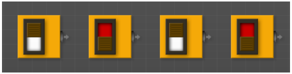

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130/128 is 1 rem 2. First digit is 1:
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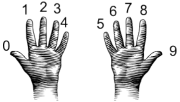

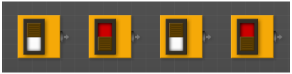

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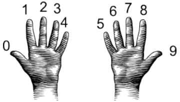

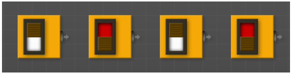

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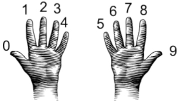

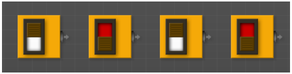

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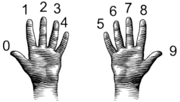

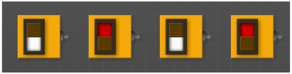

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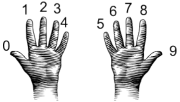

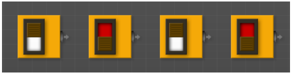

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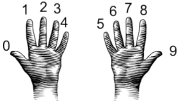

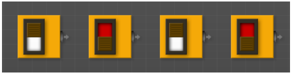

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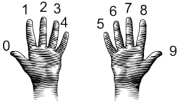

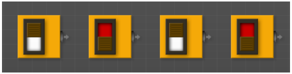

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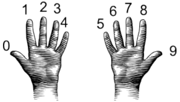

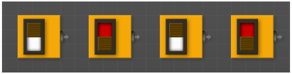

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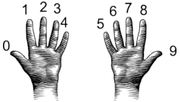

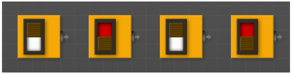

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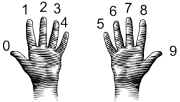

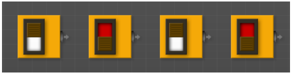

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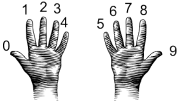

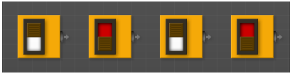

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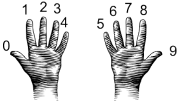

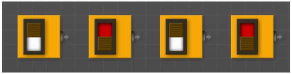

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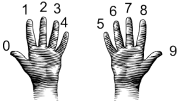

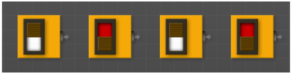

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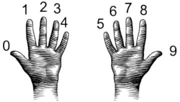

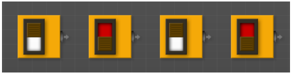

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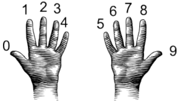

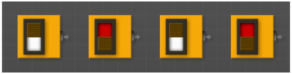

- From decimal to binary:
  - Divide by 128 ($= 2^7$). Quotient is the first digit.
  - Divide remainder by 64 ($= 2^6$). Quotient is the next digit.
  - Divide remainder by 32 ($= 2^5$). Quotient is the next digit.
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  - Divide remainder by 2 ($= 2^1$). Quotient is the next digit.
  - The last remainder is the last digit.
  - Example: what is 130 in binary notation?

```
130/128 is 1 rem 2. First digit is 1:   1...
2/64 is 0 rem 2. Next digit is 0:       10...
2/32 is 0 rem 2. Next digit is 0:       100...
2/16 is 0 rem 2. Next digit is 0:       1000...
2/8 is 0 rem 2. Next digit is 0:        10000...
2/4 is 0 remainder 2. Next digit is 0:  100000...
```

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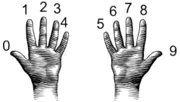

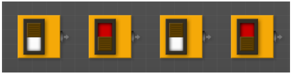

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`2/32 is 0 rem 2. Next digit is 0:`	100 . . .
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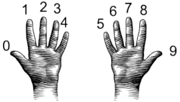

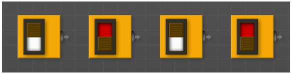

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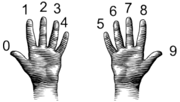

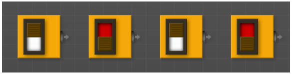

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2/4 is 0 remainder 2. Next digit is 0:   100000...
2/2 is 1 rem 0. Next digit is 1:         1000001...
```

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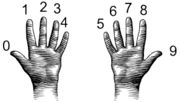

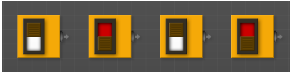

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2/8 is 0 rem 2. Next digit is 0:         10000...
2/4 is 0 remainder 2. Next digit is 0:   100000...
2/2 is 1 rem 0. Next digit is 1:         1000001...
Adding the last remainder:               10000010
```

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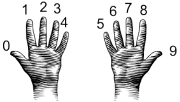

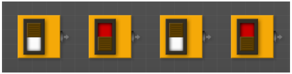

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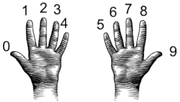

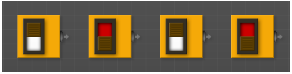

- Example: what is 99 in binary notation?

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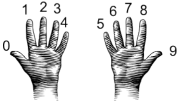

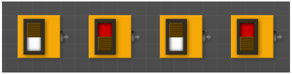

- Example: what is 99 in binary notation?

  `99/128 is 0 rem 99.`

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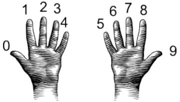

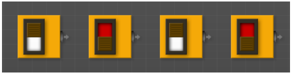

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  `99/128 is 0 rem 99. First digit is 0:`

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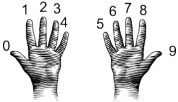

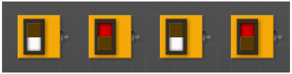

- Example: what is 99 in binary notation?

```
99/128 is 0 rem 99. First digit is 0:    0...
99/64 is 1 rem 35.
```

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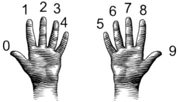

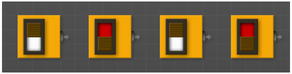

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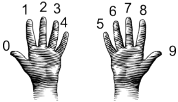

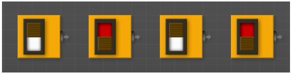

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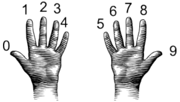

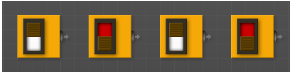

- Example: what is 99 in binary notation?

```
99/128 is 0 rem 99. First digit is 0:    0...
99/64 is 1 rem 35. Next digit is 1:      01...
35/32 is 1 rem 3.
```

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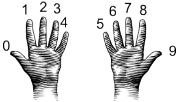

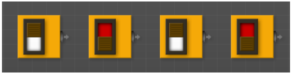

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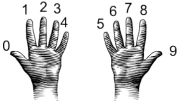

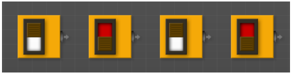

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99/128 is 0 rem 99. First digit is 0:    0...
99/64 is 1 rem 35. Next digit is 1:      01...
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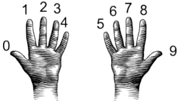

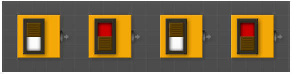

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3/16 is 0 rem 3.
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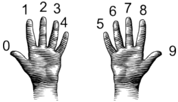

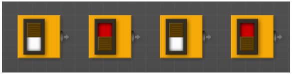

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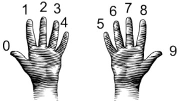

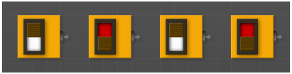

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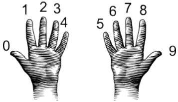

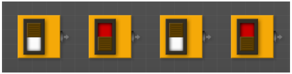

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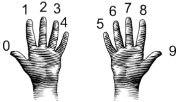

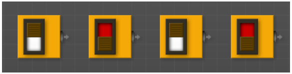

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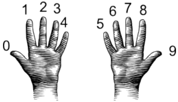

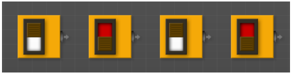

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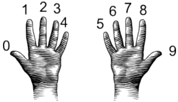

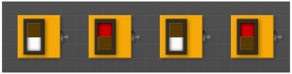

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35/32 is 1 rem 3. Next digit is 1:        011...
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3/4 is 0 remainder 3.
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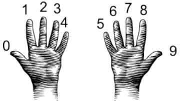

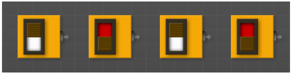

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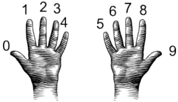
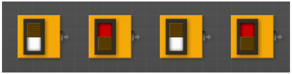
35/32 is 1 rem 3. Next digit is 1:        011...
3/16 is 0 rem 3. Next digit is 0:         0110...
3/8 is 0 rem 3. Next digit is 0:          01100...
3/4 is 0 remainder 3. Next digit is 0:
```

Decimal to Binary: Converting Between Bases

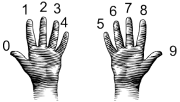


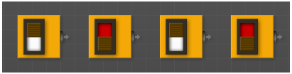


- Example: what is 99 in binary notation?

`99/128 is 0 rem 99. First digit is 0:`	0 . . .
`99/64 is 1 rem 35. Next digit is 1:`	01 . . .
`35/32 is 1 rem 3. Next digit is 1:`	011 . . .
`3/16 is 0 rem 3. Next digit is 0:`	0110 . . .
`3/8 is 0 rem 3. Next digit is 0:`	01100 . . .
`3/4 is 0 remainder 3. Next digit is 0:`	011000 . . .

Decimal to Binary: Converting Between Bases

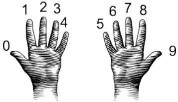


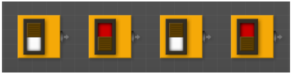


- Example: what is 99 in binary notation?

```
99/128 is 0 rem 99. First digit is 0:    0...
99/64 is 1 rem 35. Next digit is 1:      01...
35/32 is 1 rem 3. Next digit is 1:       011...
3/16 is 0 rem 3. Next digit is 0:        0110...
3/8 is 0 rem 3. Next digit is 0:         01100...
3/4 is 0 remainder 3. Next digit is 0:   011000...
3/2 is 1 rem 1.
```

Decimal to Binary: Converting Between Bases





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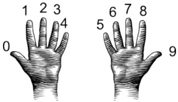
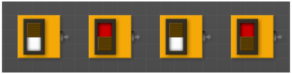
Decimal to Binary: Converting Between Bases





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`99/128 is 0 rem 99. First digit is 0:`	0...
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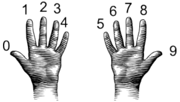
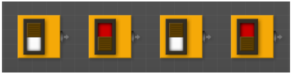
`35/32 is 1 rem 3. Next digit is 1:`	011...
`3/16 is 0 rem 3. Next digit is 0:`	0110...
`3/8 is 0 rem 3. Next digit is 0:`	01100...
`3/4 is 0 remainder 3. Next digit is 0:`	011000...
`3/2 is 1 rem 1. Next digit is 1:`	0110001...

Decimal to Binary: Converting Between Bases





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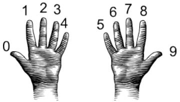
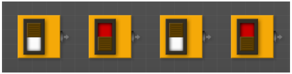
`3/8 is 0 rem 3. Next digit is 0:`	01100...
`3/4 is 0 remainder 3. Next digit is 0:`	011000...
`3/2 is 1 rem 1. Next digit is 1:`	0110001...
`Adding the last remainder:`	01100011

Decimal to Binary: Converting Between Bases





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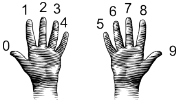
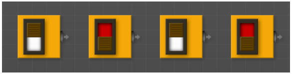
`3/4 is 0 remainder 3. Next digit is 0:`	011000 . . .
`3/2 is 1 rem 1. Next digit is 1:`	0110001 . . .
`Adding the last remainder:`	01100011

Answer is 1100011.

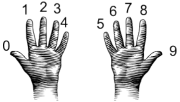
Binary to Decimal: Converting Between Bases

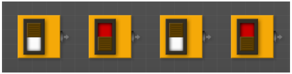




- From binary to decimal:
  - Set sum = last digit.

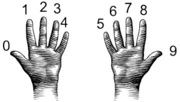
Binary to Decimal: Converting Between Bases

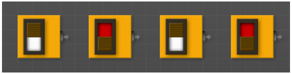




- From binary to decimal:
  - Set sum $=$ last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.

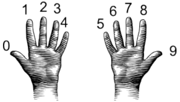
Binary to Decimal: Converting Between Bases

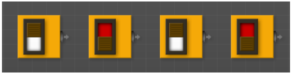




- From binary to decimal:
    - Set sum = last digit.
    - Multiply next digit by $2 = 2^1$. Add to sum.
    - Multiply next digit by $4 = 2^2$. Add to sum.

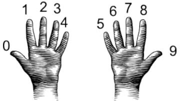
Binary to Decimal: Converting Between Bases

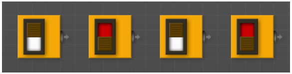




- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.

Binary to Decimal: Converting Between Bases





- From binary to decimal:
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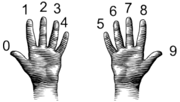
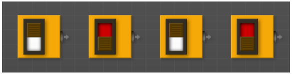
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.

Binary to Decimal: Converting Between Bases





- From binary to decimal:
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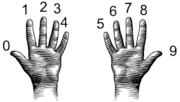
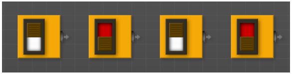
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.

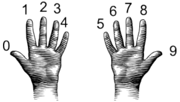
Binary to Decimal: Converting Between Bases

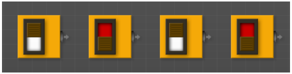




- From binary to decimal:
  - Set sum $=$ last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.

Binary to Decimal: Converting Between Bases





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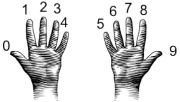
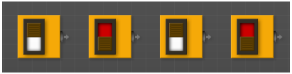
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.

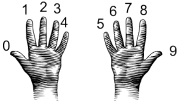
Binary to Decimal: Converting Between Bases

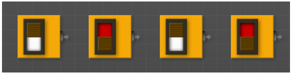




- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.

Binary to Decimal: Converting Between Bases





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  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
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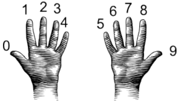
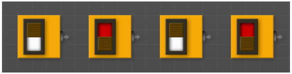
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:
```

Binary to Decimal: Converting Between Bases





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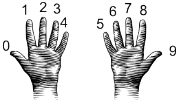
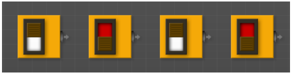
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:            1
0*2 = 0.  Add 0 to sum:
```

Binary to Decimal: Converting Between Bases





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```
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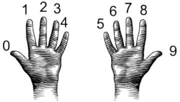
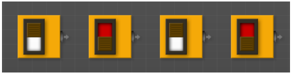
```

Binary to Decimal: Converting Between Bases





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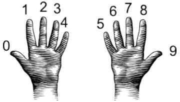
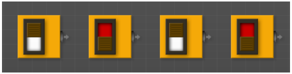
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:            1
0*2 = 0.  Add 0 to sum:     1
1*4 = 4.  Add 4 to sum:
```

Binary to Decimal: Converting Between Bases





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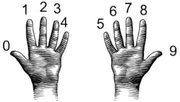
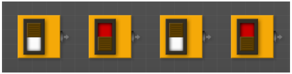
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:          1
0*2 = 0.  Add 0 to sum:   1
1*4 = 4.  Add 4 to sum:   5
```

Binary to Decimal: Converting Between Bases

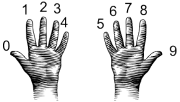


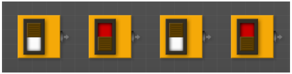


- From binary to decimal:
  - Set sum $=$ last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:          1
0*2 = 0.  Add 0 to sum:   1
1*4 = 4.  Add 4 to sum:   5
1*8 = 8.  Add 8 to sum:
```

Binary to Decimal: Converting Between Bases





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  - Multiply next digit by $2 = 2^1$. Add to sum.
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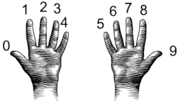
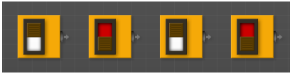
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:           1
0*2 = 0.  Add 0 to sum:    1
1*4 = 4.  Add 4 to sum:    5
1*8 = 8.  Add 8 to sum:    13
```

Binary to Decimal: Converting Between Bases

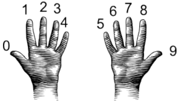


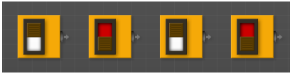


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:            1
0*2 = 0.  Add 0 to sum:     1
1*4 = 4.  Add 4 to sum:     5
1*8 = 8.  Add 8 to sum:     13
1*16 = 16.  Add 16 to sum:
```

Binary to Decimal: Converting Between Bases

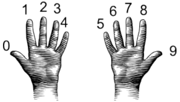


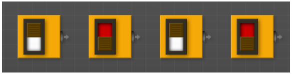


- From binary to decimal:
  - Set sum $=$ last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:          1
0*2 = 0.  Add 0 to sum:   1
1*4 = 4.  Add 4 to sum:   5
1*8 = 8.  Add 8 to sum:   13
1*16 = 16.  Add 16 to sum:  29
```

Binary to Decimal: Converting Between Bases

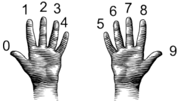


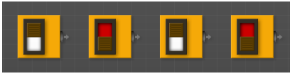


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:          1
0*2 = 0.  Add 0 to sum:   1
1*4 = 4.  Add 4 to sum:   5
1*8 = 8.  Add 8 to sum:   13
1*16 = 16.  Add 16 to sum:  29
1*32 = 32.  Add 32 to sum:
```

Binary to Decimal: Converting Between Bases

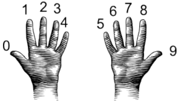


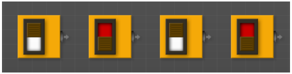


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:             1
0*2 = 0.  Add 0 to sum:      1
1*4 = 4.  Add 4 to sum:      5
1*8 = 8.  Add 8 to sum:      13
1*16 = 16.  Add 16 to sum:   29
1*32 = 32.  Add 32 to sum:   61
```

Binary to Decimal: Converting Between Bases

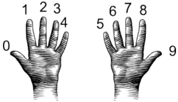


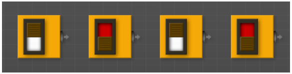


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:             1
0*2 = 0.  Add 0 to sum:      1
1*4 = 4.  Add 4 to sum:      5
1*8 = 8.  Add 8 to sum:      13
1*16 = 16.  Add 16 to sum:   29
1*32 = 32.  Add 32 to sum:   61
```

Binary to Decimal: Converting Between Bases

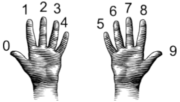


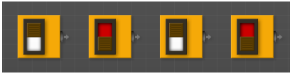


- Example: What is 10100100 in decimal?

  `Sum starts with:`

Binary to Decimal: Converting Between Bases

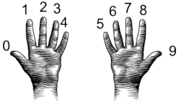


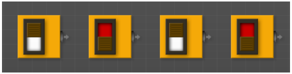


- Example: What is 10100100 in decimal?

```
Sum starts with:              0
0*2 = 0.  Add 0 to sum:
```

Binary to Decimal: Converting Between Bases

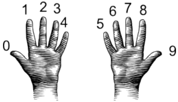


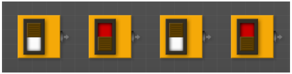


- Example: What is 10100100 in decimal?

```
Sum starts with:              0
0*2 = 0.  Add 0 to sum:       0
```

Binary to Decimal: Converting Between Bases

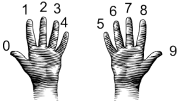


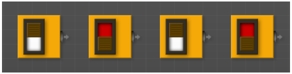


- Example: What is 10100100 in decimal?

```
Sum starts with:                0
0*2 = 0.   Add 0 to sum:        0
1*4 = 4.   Add 4 to sum:
```

Binary to Decimal: Converting Between Bases

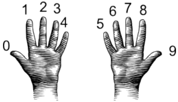


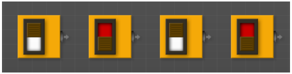


- Example: What is 10100100 in decimal?

```
Sum starts with:              0
0*2 = 0.   Add 0 to sum:      0
1*4 = 4.   Add 4 to sum:      4
```

Binary to Decimal: Converting Between Bases

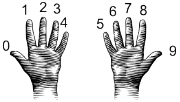


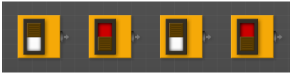


- Example: What is 10100100 in decimal?

```
Sum starts with:            0
0*2 = 0.   Add 0 to sum:    0
1*4 = 4.   Add 4 to sum:    4
0*8 = 0.   Add 0 to sum:
```

Binary to Decimal: Converting Between Bases

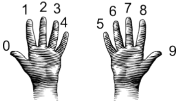


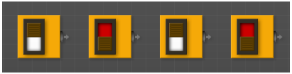


- Example: What is 10100100 in decimal?

```
Sum starts with:            0
0*2 = 0.  Add 0 to sum:     0
1*4 = 4.  Add 4 to sum:     4
0*8 = 0.  Add 0 to sum:     4
```

Binary to Decimal: Converting Between Bases

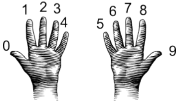


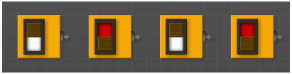


- Example: What is 10100100 in decimal?

```
Sum starts with:             0
0*2 = 0.   Add 0 to sum:     0
1*4 = 4.   Add 4 to sum:     4
0*8 = 0.   Add 0 to sum:     4
0*16 = 0.   Add 0 to sum:
```

Binary to Decimal: Converting Between Bases

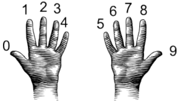


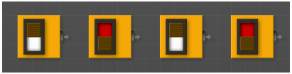


- Example: What is 10100100 in decimal?

```
Sum starts with:              0
0*2 = 0.   Add 0 to sum:      0
1*4 = 4.   Add 4 to sum:      4
0*8 = 0.   Add 0 to sum:      4
0*16 = 0.   Add 0 to sum:     4
```

Binary to Decimal: Converting Between Bases

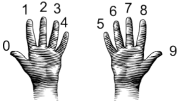


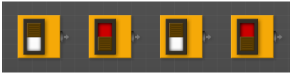


- Example: What is 10100100 in decimal?

```
Sum starts with:             0
0*2 = 0.   Add 0 to sum:     0
1*4 = 4.   Add 4 to sum:     4
0*8 = 0.   Add 0 to sum:     4
0*16 = 0.   Add 0 to sum:    4
1*32 = 32.   Add 32 to sum:
```

Binary to Decimal: Converting Between Bases

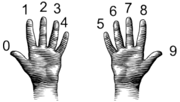


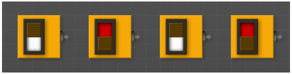


- Example: What is 10100100 in decimal?

```
Sum starts with:               0
0*2 = 0.   Add 0 to sum:       0
1*4 = 4.   Add 4 to sum:       4
0*8 = 0.   Add 0 to sum:       4
0*16 = 0.   Add 0 to sum:      4
1*32 = 32.   Add 32 to sum:    36
```

Binary to Decimal: Converting Between Bases

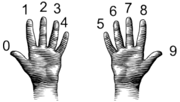


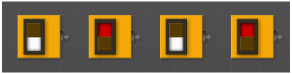


- Example: What is 10100100 in decimal?

```
Sum starts with:             0
0*2 = 0.   Add 0 to sum:     0
1*4 = 4.   Add 4 to sum:     4
0*8 = 0.   Add 0 to sum:     4
0*16 = 0.   Add 0 to sum:    4
1*32 = 32.   Add 32 to sum:  36
0*64 = 0.   Add 0 to sum:
```

Binary to Decimal: Converting Between Bases

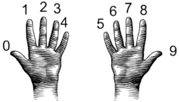


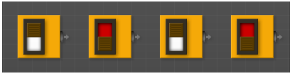


- Example: What is 10100100 in decimal?

```
Sum starts with:               0
0*2 = 0.   Add 0 to sum:       0
1*4 = 4.   Add 4 to sum:       4
0*8 = 0.   Add 0 to sum:       4
0*16 = 0.   Add 0 to sum:      4
1*32 = 32.   Add 32 to sum:    36
0*64 = 0.   Add 0 to sum:      36
```

Binary to Decimal: Converting Between Bases

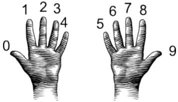


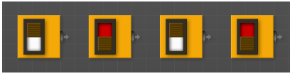


- Example: What is 10100100 in decimal?

```
Sum starts with:              0
0*2 = 0.   Add 0 to sum:      0
1*4 = 4.   Add 4 to sum:      4
0*8 = 0.   Add 0 to sum:      4
0*16 = 0.   Add 0 to sum:     4
1*32 = 32.   Add 32 to sum:   36
0*64 = 0.   Add 0 to sum:     36
1*128 = 0.   Add 128 to sum:
```

Binary to Decimal: Converting Between Bases

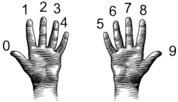


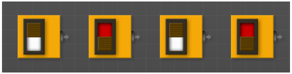


- Example: What is 10100100 in decimal?

```
Sum starts with:              0
0*2 = 0.   Add 0 to sum:      0
1*4 = 4.   Add 4 to sum:      4
0*8 = 0.   Add 0 to sum:      4
0*16 = 0.   Add 0 to sum:     4
1*32 = 32.   Add 32 to sum:   36
0*64 = 0.   Add 0 to sum:     36
1*128 = 0.   Add 128 to sum:  164
```

Binary to Decimal: Converting Between Bases



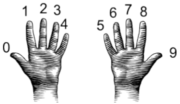


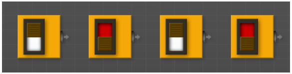
- Example: What is 10100100 in decimal?

```
Sum starts with:               0
0*2 = 0.   Add 0 to sum:       0
1*4 = 4.   Add 4 to sum:       4
0*8 = 0.   Add 0 to sum:       4
0*16 = 0.   Add 0 to sum:      4
1*32 = 32.   Add 32 to sum:    36
0*64 = 0.   Add 0 to sum:      36
1*128 = 0.   Add 128 to sum:   164
```

The answer is 164.

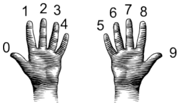
Design Challenge: Incrementers

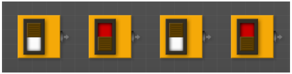




- Simplest arithmetic: add one ("increment") a variable.

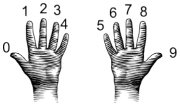
Design Challenge: Incrementers

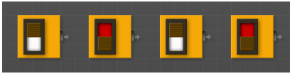




- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

Design Challenge: Incrementers

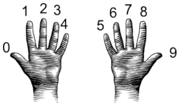


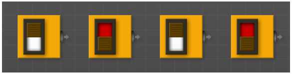


- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

```
def addOne(n):
    m = n+1
    return(m)
```

Design Challenge: Incrementers





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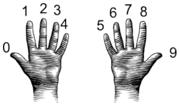

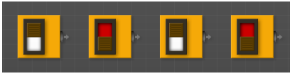

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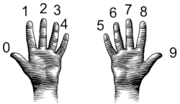

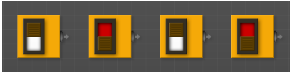

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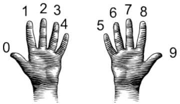

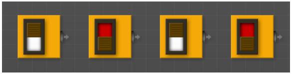

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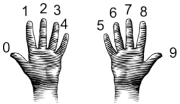

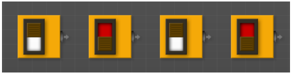

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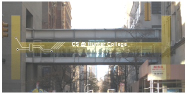
Recap



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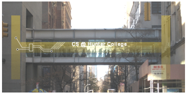

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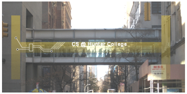

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Today's Topics

- Design Patterns: Searching
- Python Recap
- Machine Language
- Machine Language: Jumps & Loops
- Binary & Hex Arithmetic
- **Final Exam: Format**

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Exam Options

Exam Times:

FINAL EXAM, VERSION 3
CSci 127: Introduction to Computer Science
Hunter College, City University of New York

19 December 2018

Exam Rules

- Show all your work. Your grade will be based on the work shown.
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- Do not open this exam until instructed to do so.

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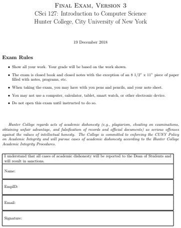

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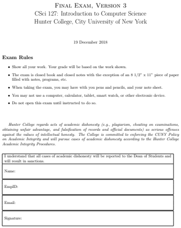

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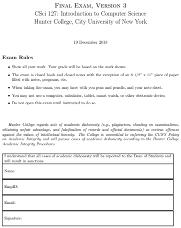

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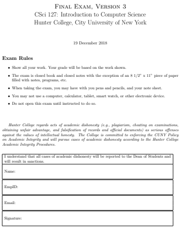

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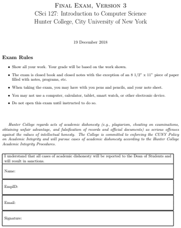

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